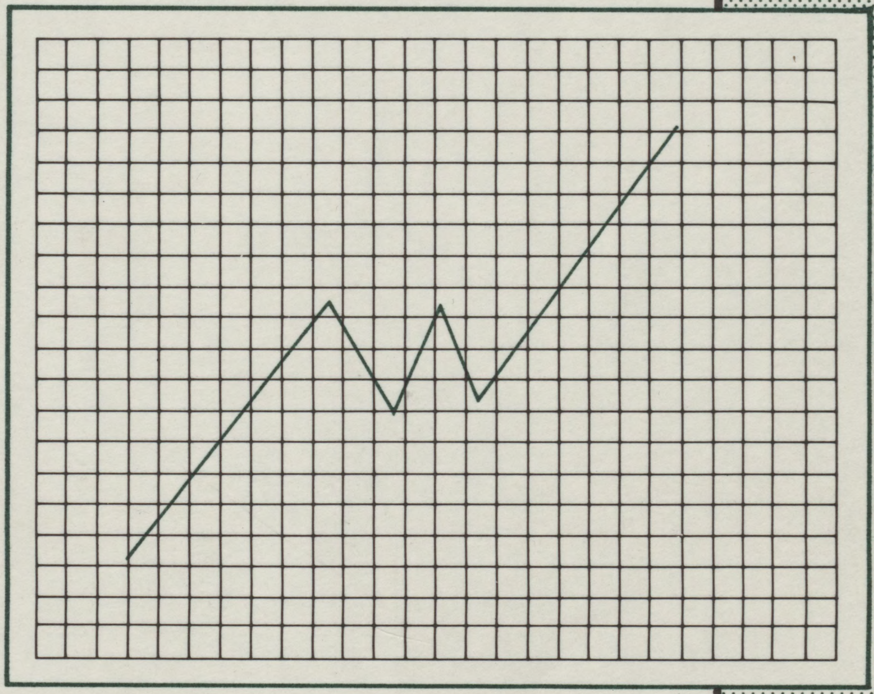

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PRICE INTER-RELATIONSHIPS IN THE SOUTH AFRICAN MEAT MARKET II: AN EMPIRICAL APPLICATION

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ABSTRACT

Price inter-relationships in the South African meat market were analysed. The meat market as a whole shows a great measure of mutual dependence. Price leadership was found in beef. All meat prices, excepting beef, take more than a month to adapt fully to changed market conditions. It can therefore be deduced that the meat market as a whole functions in a poor form of effectivity. The total adaptation time in respect of pork, mutton and fish prices is twelve, eight and twelve weeks, respectively. It appears that beef prices lead poultry prices, but that poultry prices follow shortly after. The whole effect takes twelve weeks to filter through. It appears, however, that poultry prices have effectively succeeded in moving closely with beef prices.

INTRODUCTION

The theoretical and empirical aspects basic to the determination of price inter-relationships, price leadership and the period that it takes before prices or changes react, as set out in a previous article (Van Heerden *et al.*, 1989), are in this article applied to the South African meat market.

An effort is therefore made to determine which product is the price leader and what interactions and relationships may be found in the market in respect of product prices. The time it takes for various prices to react to changes in the prices of other types of meat is also calculated.

The product prices that are analysed are those for beef, mutton, pork, poultry, fish and eggs. Eggs are included as a protein control product. The short-term interaction between the prices is determined by analysing the dynamic changes in the prices. The relationships between the prices are identified and the existence of a market price leader or leaders is determined by using the Haugh-Pierce chi-squared causality test and autoregressive (AR) models. How the reaction takes place over time, in other words, how fast the prices in a market segment react and adapt to new information, is also determined. In this way the degree of effective functioning in the South African meat market is indicated.

The model described by Van Heerden *et al.* (1989) was used in the analysis.

DATA USED

The data used are continuous quantitative data with an ordinal component, which distinguishes the specific grades. The prices used are the weighted mean monthly retail trade prices of beef (super A), mutton (super lamb), pork (grade 1), chicken (cleaned), fish (frozen hake) and eggs (grade 1 large) in twelve urban areas of the Republic of South Africa, which are regarded by the Central Statistical Service as a representative sample. The prices are expressed in cents per kilogram. The great majority of the data is taken from *South African Statistics* in various years and from the monthly *Bulletin of Statistics*. Certain data were, however, taken from the annual reports of the Meat Board and the Egg Board. The price of eggs was converted by a factor of 1,39 from a figure per dozen to a figure per kilogram. Monthly information from March 1980 to June 1986 was used.

EMPIRICAL RESULTS

After the various time series had been seasonally adjusted, identification for autocorrelation was carried out in the time series and the autocorrelation was found to be strongly present. The deterministic nature of the time series was transformed into stationary-stochastic components by means of differencing.

Univariate autoregressive models of the order p were calculated for each of the stationary time series (see Table 1 for example).

If the AR(p) filter is sufficient, the calculated Q statistic (Box & Pierce, 1970: 1509-1526) will assume a value that is less than the chi-squared value and it can be accepted that the residues are transformed to white noise by the specific order AR filter (Table 2).

Chi-squared values were obtained from statistical tables such as those calculated and compiled by Stoker (1974). The chi-squared values were obtained with 15 degrees of freedom and with 90% confidence or, put in another way, at a 10% level of significance.

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TABLE 1. Example of the calculation of applicable autoregressive model and Q statistic for beef

Residual auto-correlation (AC)		Residual partial autocorrelation (PAC)		Lags	AC (Residues)	PAC (Residues)
(Differential model)						
***		***		1	-0,3324	-0,3324
*		***		2	-0,1488	-0,2914
	*			3	0,1390	-0,0267
**		**		4	-0,1666	-0,1964
*		***		5	-0,0954	-0,2567
	**			6	0,2214	0,0087
**		**		7	-0,1656	-0,1643
	*			8	0,0899	0,0028
*		**		9	-0,0543	-0,0929
	*		*	10	0,0908	0,0929
*		*		11	-0,1072	-0,1134
*		**		12	-0,0756	-0,1938
	*	*		13	0,0708	-0,0998
	*			14	0,0952	0,0186
**		**		15	-0,1800	-0,1576

Standard error = 0,114 7; Q statistic (15 lags) = 26,566 5

None of the residues was already white noise. There is therefore no AR(O) process. Although the Q statistic is not within the chi-squared size, it is accepted that the AR(2) process is the best to cause a white noise process in beef and pork prices (underlined values in Table 2).

A further differentiation only causes a greater standard deviation, as may be seen in Table 2. All the other prices use an AR(1) process (underlined values in Table 2) and although some Q statistics are also outside the significance interval, it is accepted that an AR(1) process is the best to cause white noise in these residues.

Given these results, the Haugh-Pierce causality tests are calculated from the autoregressive residues. The zero hypothesis in Table 3 is no causality, no dependence or immediate cause.

TABLE 2. Calculated Q statistic applied to the residues of an AR(p) filter of every series

Price	Order of AR(p) filter			
	0	1	2	3
Beef	372,5	36,7	28,7	47,7
Mutton	475,5	11,2	19,9	39,8
Pork	530,2	55,7	26,7	71,3
Chicken	266,3	27,6	31,3	68,9
Fish	433,1	30,1	81,82	97,5
Eggs	584,7	10,7	26,00	40,3
χ^2 15; ,10	22,3	21,0	19,8	18,5

The causality test results indicate that all meat types influence one another significantly, at least immediately. The weakest relationship is between eggs, which were included as a protein control product, and the various types of meat. These findings indicate that the price of eggs is not influenced by price changes in the meat market and/or that the reverse is also true. There is therefore no causal relationship. This is further confirmed by the zero hypothesis for independence not being rejected in respect of eggs and the various types of meat. The zero hypothesis in respect of independence between all the types of meat is rejected at the 10 % level of significance.

It appears that in respect of specific series causality, beef prices do affect the mutton and pork prices. The pork prices in turn affect mutton and beef prices, while there is a two-way causality between mutton prices and fish prices. Chicken prices affect both pork prices and fish prices. This may be represented schematically as follows:

After the Haugh-Pierce causality results were obtained, multivariate autoregressive models were calculated, from which long-term multipliers could be calculated. These were used to analyse the dynamic relationships between the various types of meat in South Africa. These calculated long-term

TABLE 3. Haugh-Pierce chi-squared size

Meat prices		Zero hypothesis			
Series 1	Series 2	Series 1 on Series 2	Series 2 on Series 1	No immediate cause	Independent
Beef	Mutton	24,5*	9,0	17,8***	51,3**
Beef	Pork	28,1**	41,2***	36,5***	105,88***
Beef	Chicken	9,1	21,1	15,2***	45,4**
Beef	Fish	10,0	2,1	0,7	12,8
Beef	Eggs	5,1	13,5	0,0	18,6
Mutton	Pork	8,0	37,3***	21,4***	66,7***
Mutton	Chicken	16,3	22,0	4,1**	41,4*
Mutton	Fish	23,0*	26,4**	4,5**	53,9***
Mutton	Eggs	9,6	13,7	0,1	23,4
Pork	Chicken	17,4	35,6***	14,0***	67,0***
Pork	Fish	19,3	11,2	0	30,5
Pork	Eggs	5,9	9,0	1,4	16,3
Chicken	Fish	24,3*	13,0	0,2	37,4
Chicken	Eggs	11,2	19,2	0,5	30,9
Fish	Eggs	10,3	11,0	0,0	21,3
Rejection of the zero hypothesis at					
* = 10 % level of significance		22,3	22,3	2,7	41,4
** = 5 % level of significance		25,0	25,0	3,8	45,0
*** = 1 % level of significance		30,6	30,6	6,6	52,0

TABLE 4. Schematic representation of causal relationships

Item	Affector					
	Beef	Mutton	Pork	Chicken	Fish	Eggs
Beef			X***			
Mutton	X*		X***		X***	
Pork	X**			X***		
Fish		X*		X*		
Eggs						

* = 10%; ** = 5%; *** = 1% level of significance

multipliers are given in Table 5.

The long-term multipliers are calculated on the hypothesis that one variable is endogenous towards another variable that is exogenous, in other words, a regressive analysis of an endogenous variable on an exogenous variable with maximum lag.

TABLE 5. Long-term multipliers as calculated from multivariate AR(p) models

Prices		Multipliers*	Period of adjustment**
Series 1	Series 2	Series 1 on Series 2	Series 1 on Series 2
Beef	Mutton	0,753 (0,023)	8
Beef	Pork	1,208 (0,064)	12
Beef	Chicken	2,336 (0,177)	12
Beef	Fish	1,178 (0,069)	12
Mutton	Pork	1,995 (0,083)	8
Mutton	Chicken	3,634 (0,300)	8
Mutton	Fish	2,00 (0,072)	12
Pork	Chicken	1,867 (0,156)	12
Pork	Fish	1,00 (0,048)	8
Chicken	Fish	0,565 0,047	12
Chicken	Pork	0,574 (0,048)	12
Fish	Mutton	0,467 (0,082)	12

*Gives the cents change in price j that can be expected over time as a result of a 1 cent change in price i. Standard errors between brackets

**Number of weeks necessary for intermediate multiplier to stabilise within 5% of long-term multiplier

This represents the long-term multiplier. The long-term multipliers are compared with the intermediate multipliers, which are calculated in a similar way. The intermediate lag multiplier, which stabilises within 5% of the long-term multiplier, is chosen as the period of adjustment. The long-term multiplier is calculated first, and an intermediate multiplier which stabilises within 5% of the value of the long-term multiplier is then considered. The periods of adjustment are deduced from this.

To determine whether the long-term multiplier is statistically significant, its t-value is calculated. The t-value is calculated by dividing the regressive co-efficient by the standard error given in brackets.

DISCUSSION OF RESULTS

Egg prices

The results of the Haugh-Pierce chi-squared causality test indicates a weak relationship between eggs and all the various types of meat (beef, mutton, pork, chicken and fish). These findings indicate that price changes in the meat market exercise no causal effect on the prices of eggs. This is further confirmed by the zero hypothesis for independence in respect of eggs and the various types of meat not being rejected at a 10% level of significance. According to results obtained from multivariate autoregressive models, there is no long-term multiplier effect of egg prices on the various prices of meat that varies significantly from zero.

This confirms the finding that there are no causal relationship between egg prices and meat prices. It can therefore be accepted, concerning the price interactions between egg prices and the various meat prices, that these findings suggest that there is no significant competition between eggs and the various types of meat and that no economically or statistically significant interaction occurs between these prices.

Beef prices

The Haugh-Pierce chi-squared causality test indicates that mutton and pork prices are led by beef prices, by the rejection of the zero hypothesis at a 10% level of significance (see Table 3). The test further indicates that there is a particularly high mutual dependence between beef, mutton, pork and chicken prices, as indicated by the large cross-correlation coefficients of the present period (epoch), as represented in Table 3, column 6. According to the results in Table 3, there is an instantly adjusted causality in respect of beef vs. mutton prices and beef vs. pork prices. The instantly adjusted causality is very prominent (strong) particularly between beef and chicken prices, since there is no specific price leader between the two, but a high dependence is nevertheless found between the two product prices. A possible explanation for this is that beef may to a certain extent be regarded as the price leader in the meat market in respect of chicken, and that chicken prices (which are not controlled) have the ability to react quickly and effectively to changes specifically in the beef market. This property indicates, according to Fama's classification of market effectivity (1970), at least a semi-strong market effectivity regarding chicken prices, in particular, to adjust to new information in the market.

According to results obtained from the multivariate autoregressive models, the long-term multiplier effect of beef prices on the rest of the meat market varies significantly from zero. Although beef prices do not have a causality relationship with fish prices according to the Haugh-Pierce chi-squared size test, the significant long-term multiplier findings can possibly be explained by the fact that there is a significant dependence between beef prices, mutton prices and chicken prices and that there is, on the other hand, a causal relationship between mutton prices and fish prices and between chicken prices and fish prices, with the former in each case the price leader.

The long-term multiplier effect indicates that a change of one cent in the price of beef will result in a change of 0,75 cents in the price of mutton and that the whole effect will take eight weeks to filter through. The findings also indicate that a change of one cent in the price of beef will result in a change of 1,21 cents, 2,34 cents and 1,20 cents in the prices of pork, chicken and fish, respectively. In all three cases, the total effect will take 12 weeks to make itself fully felt. These findings confirm the causality tests in the sense that beef prices can be regarded as market price leaders in the meat market (including fish) and that there is a significant mutual dependence in the meat market, with price leadership firmly resting with beef in respect of the whole meat market.

These findings correspond to the findings of Du Toit (1982) and Hancock *et al.*, (1984) to the extent to which cross-elasticity is comparable with causality relationships and long-term multipliers. Du Toit (1982) and Hancock *et al.*, (1984) both identified significant cross-elasticities in respect of beef and mutton, and beef and pork.

The results in Table 3 suggest that, of all meat prices, it is only chicken prices that may be significantly influenced by beef prices and then only in an instantly adjusted causality relationship at a 1 % level of significance (99 % confidence). However, price leadership could not be determined in the case of chicken vs. beef prices.

Mutton prices

The Haugh-Pierce chi-squared causality test indicates a high mutual dependence between prices of mutton, chicken, pork and fish. This is deduced from the high cross-correlation values in column 6 of Table 3. It is clear from the schematic representation in Table 4 that there is a two-way causal relationship between mutton prices (X_1) and fish prices (X_2) which may be represented as follows ($X_1 \longleftrightarrow X_2$). With mutton prices as the effector, the zero hypothesis is rejected at a 10 % level of significance and the zero hypothesis is rejected at a 5 % level of significance with fish prices as effector. Since there is a two-way causality between the two prices, with a high degree of instantly adjusted causality, and since the zero hypothesis of independence is rejected at a 1 % level of significance, it is dangerous to distinguish a price leader between mutton prices and fish prices. Again it should be kept in mind that mutton is a controlled product, but that fish is not controlled by any of the agricultural control boards. This phenomenon may influence these findings.

This two-way causality is also encountered in the long-term multiplier effect. This effect indicates that a change of one cent in the price of mutton will result in a change of two cents in the price of fish and that it will take 12 weeks for the whole effect to filter through in the market. The multiplier effect similarly indicates that a change of one cent in the price of fish will lead to a change of 0,47 cents in the price of mutton, which will take 12 weeks before the whole effect is felt in the market. The relationship is confirmed in respect of the quantity change expressed as a percentage, since in both of the above cases a change of approximately 50 % occurs after a one cent change in one or the other.

Findings in respect of the multiplier effect indicate that price changes in the mutton market result in price changes in the pork and chicken markets. The Haugh-Pierce chi-squared test does not identify the same causal relationship, however. This test does indeed point to an instantly adjusted causality and dependence between mutton, pork and chicken prices. In this case it should again be emphasised that two of the above types of meat, mutton and pork, are subject to statutory market interference in terms of the Marketing Act, which could have a distorted effect on the results. These slightly conflicting results of the Haugh-Pierce chi-squared causality test and the long-term multiplier can also be caused by the fact that all three of these markets and the beef price have a very strong causality and dependence relationship, which could lead to misleading findings. In view of the above, and since the findings of the Haugh-Pierce causality test and the long-term multipliers, as calculated from multivariate autoregressive models, are slightly in conflict and do not confirm each other, it is accepted that there are no significant price inter-relationships between mutton, pork and chicken prices. Research material could unfortunately not be found to indicate relationships between mutton and fish and comparison with other research material is therefore impossible.

Chicken prices

It should immediately be emphasised in respect of this type of meat that there is no talk of controlled (administered) prices and the enormous increase of chicken's share of the market, as found by Laubscher & Kotze (1984), should be noted. Findings and results should be considered and interpreted against this background.

The schematic representation of causal relationships in Table 4 indicates chicken prices as price leaders (effectors) in respect of pork and fish prices. If one looks at the Haugh-Pierce chi-squared quantities in Table 3, however, it may be noted that the quantity is a borderline case in respect of the causal relationship between chicken prices (X_1) and mutton prices (X_2) ($X_1 \longrightarrow X_2$), that falls just outside the 10% level of significance (value of 22,0 as against quantity of 22,3). It would therefore appear that chicken prices are potential price leaders after beef prices and act as catalysts (parameters) for the other price movements.

Regarding chicken and pork prices, the Haugh-Pierce test indicates a very high mutual dependence between them. The zero hypothesis is rejected in this case at a 1 % level of significance.

This dependence is confirmed by the high cross-correlation coefficient in Table 3, column 6. This test further indicates that the zero hypothesis for no instantly adjusted causality is rejected at a 1 % level of significance. With respect to chicken and fish prices Table 3 indicates that there is a causal relationship between the two products, with chicken prices having price leadership. The zero hypothesis is not rejected in respect of no immediate cause and independence. The long-term multiplier effect, which varies significantly from zero, confirms this causality between chicken, pork and fish prices. The long-term multiplier effect indicates that a one cent change in the price of chicken will result in a change of 0,574 cents in the price of pork and 0,565 cents change in the price of fish. In both cases it will take twelve weeks for the full effect to filter through in the market.

From the above it is clear that the change in chicken prices has a definite effect on pork and fish prices. The Haugh-Pierce chi-squared test indicates a significant dependence between chicken prices and mutton prices and also indicates that instantly adjusted causality is present between the two products. As in the case of beef prices, a price leader cannot be distinguished between chicken prices and mutton prices. The price inter-relationship is therefore, by and large, immediate in nature, as in the case of beef and chicken prices. The long-term multipliers indicate that changes in mutton prices have an effect on chicken prices. These results do therefore indicate that price leadership may possibly be found in the mutton price. Since the Haugh-Pierce chi-squared test does not confirm this, it is only assumed that a strong instantly adjusted causality and dependence may be found between these two product prices.

Taking the above into account and the results of Laubscher & Kotze (1984), it is clear that there is a very strong inter-relationship between chicken prices and the prices of the other types of meat. It is possibly this ability of chicken that puts it in a position to enlarge its market share. The above results and finding are a further indication of the semi-strong market effectivity of the chicken market to adjust to new information in the meat market.

Pork prices

The schematic representation of the causal relationships in Table 4 indicates that pork prices have a causal effect on beef prices and mutton prices and therefore show price leadership. These findings are slightly contradictory, however, since they represent double price leadership. If one looks at Table 3 (the Haugh-Pierce chi-squared sizes), the results are as follows:

- the zero hypothesis with regard to pork prices having no causal effect on beef prices is rejected at a 1 % level of significance.
- The zero hypothesis with regard to pork prices having no causal effect is rejected at a 1 % level of significance.
- The zero hypothesis with regard to there being no instant causality and dependence between these products is also rejected at a 1 % level of significance.

The zero hypothesis is therefore always rejected at 99 % confidence. What should be kept in mind here is that there is a very strong dependence between the three product prices, with high cross-correlation.

Since beef prices can be regarded as market price leaders, as was suggested by both the Haugh-Pierce test and the long-term multipliers, there is a possibility that one-way causality has converted to a distorted two-way causality. Sims (1977) warns specifically against cases where the expected *future* changes in one variable influence the change of another variable, which may affect the direction of causality.

Since beef occupies 50 % of the whole meat market and shows strong price leadership, it is possible that this may very well be the case with the above products. Sims (1977: 23-43) qualifies the above statement as follows: If this is the case, in other words, that the future changes in one variable affect the change in another variable, there is a possibility that a one-way causality system would react rather as a two-way causality system. Table 3 identifies a great mutual dependence between beef, mutton and pork. This phenomenon increases the possibility that the interaction indicated by Table 3 in respect of pork prices vs. beef prices and pork prices vs. mutton prices could be an example of the gap that exists in respect of the Haugh-Pierce causality test, as pointed out by Sims (1977). It may therefore be accepted that, as a result of the above possibility, the findings with regard to pork prices vs. beef prices and pork prices vs. mutton prices cannot be regarded in this study as fully correct or well-founded. Pork is therefore regarded as a price-follower, with little or no price leadership found in this type of meat.

Fish prices

The inter-relationships suggested by the results in respect of fish prices and the rest of the meat market are very interesting and even slightly unexpected. The two-way causality found between fish prices and mutton prices has already been partially discussed. The long-term multipliers imply that a change of one cent in the fish price will result in a change of 0,470 cents in the price of mutton. Similarly, the reverse implies a change of 2,00 cents in the fish price. The proportional change shows a great measure of correspondence. Although fish prices do show an interaction with beef prices, with the latter as market price leader, there is a very definite relationship between fish prices and mutton prices. This relationship is reflected by the Haugh-Pierce test and the long-term multiplier effect.

GAPS IN THE STUDY

Since gaps in certain of the tests have been pointed out by a number of writers, trouble was taken to prevent gaps from passing unnoticed in some of the findings. As a result of these gaps, the results have been interpreted not only according to pure statistical rules and laws, but have been carefully evaluated on a basis of economic realism and logic, as recommended by Grant *et al.*, (1983).

As a result of the above, however, it is possible that certain aspects could have been specified incorrectly or ignored. In spite of such possible shortcomings, useful information can nevertheless be drawn from the model.

A shortcoming (gap) that should receive specific attention is the data. Although weekly prices could be obtained in respect of beef, mutton and pork, such information did not seem to be available in respect of chicken, fish and eggs. Future research using this price-interaction model should preferably use daily or weekly information. This would be particularly useful in determining the time aspect from the long-term multipliers. It is also a pity that no research could be found which contained suitable findings in respect of fish.

CONCLUSION

It was found, by means of the Haugh-Pierce causality test, that the meat market as a whole showed a strong measure of mutual dependence. If the Haugh-Pierce causality tests and the long-term multipliers, as calculated from multivariate AR(p) models, are interpreted together, the results indicate that price leadership rests with beef. All meat prices (excluding beef prices) take more than a month to adjust to changed market conditions, and as a result of this it can be deduced that the meat market as a whole, functions in a weak form of effectivity. These findings are confirmed by the instantly adjusted causality comprising a small portion of the Haugh-Pierce chi-squared size for independence, which implies that little economic adjustment occurs within a month. The long-term multipliers, as calculated by using multivariate autoregressive models of order p, suggest that the total adjustment period in respect of pork, mutton and fish prices is 12 weeks, 8 weeks and 12 weeks, respectively. Since the Haugh-Pierce causality test suggests no price leadership between beef and chicken prices, this is in itself an indication of a semi-strong form of effectivity which may be found in the market segment. Taking into account the results obtained in respect of beef prices and chicken prices, it may be accepted that beef prices do lead chicken prices, but that chicken prices follow shortly after, and that the whole effect takes 12 weeks (three months) to make itself felt.

An important finding of the study is that chicken prices have succeeded very effectively in moving in close connection with the market price leader, beef. This study has proved empirically this ability of chicken prices beyond all doubt. It may be this very ability of chicken that has made it possible for this type of meat to enlarge its market share at the cost of mutton and pork. Since chicken prices show a causal relationship with those of mutton, pork and fish, the importance of chicken in the meat market is suggested.

The results of the Haugh-Pierce chi-squared causality test and the long-term multipliers, as calculated by using multivariate autoregressive models of the order p, indicate that there is no statistically significant relationship between eggs, which were included as a protein control product, and the various types of meat.

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