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TESTING FOR CHANGES IN THE STRUCTURE OF THE DEMAND FOR MEAT IN AUSTRALIA

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Quarterly data from 1962 to 1983 for beef, lamb, mutton, pig meat and poultry were used to test for constancy in the structure of meat demand in Australia. The cumulative sum, cumulative sum of squares and Farley-Hinich tests were applied to a range of models to ensure that any rejection of stability was not due to an inappropriate functional form or omitted dynamics. Little evidence was found of a marked swing away from consumption of any meat, with the exception of mutton. The results suggest that changes in prices and in total consumer expenditure are far more important than changes in tastes as determinants of meat consumption.

There is a widespread belief that significant changes in the structure of demand for meat have occurred in Australia, with a resulting shift in demand away from red meats (Anon. 1983). Using the results of a recent consumer survey, it has been argued that consumers are now using less red meat (McKinna 1984) because of changes in consumer lifestyles, health attitudes and meat prices. However, econometric research to investigate whether changes in consumption can be explained simply by price and income factors or whether there have been shifts in demand relationships as a consequence of changes in consumer preferences, has not been undertaken in Australia.

Changes in the structure of Australian meat demand have important implications for prices and returns in individual meat industries. These changes are also important from a policy viewpoint, for example, promotional expenditure is often justified as a response to perceived shifts in demand. If the maintained hypothesis of structural stability is not in fact correct, then coefficient estimates obtained for analysis and forecasting purposes are likely to be biased, and the interpretation of tests for the restrictions derived from utility theory (for example, Murray 1984) may also be affected.

The major purpose of the research reported in this paper was to test the hypothesis that the underlying structure of demand for meat in Australia has been stable since the early 1960s. A second and related objective was to estimate the effects of any structural change on the consumption of the various meats. The analysis also provided an opportunity to examine whether tests for the validity of the symmetry restrictions were affected by the presence of structural change in the model.

Structural Change in the Demand for Meat

A systematic change in the aggregate pattern of meat demand may arise from changes in the underlying preferences of individual consumers, changes in the composition of the population, and changes in the nature of the commodities available to consumers. There have been many developments which could have resulted in a systematic change in Australian meat demand (Weeks and Reeves 1983). For example, changing health perceptions appear to have altered the attitudes of some consumers to red meats. In addition, the structure of the population has altered since the early 1960s, with changes in the overall age structure, the size of individual households, the ethnic composition of the population, and the workforce participation patterns. There have also been changes in many consumer products, with new forms of take-away foods being perhaps the most obvious example directly affecting demand for meat.

While there has been no direct analysis of structural changes in Australian demand for meat, some indications of such change are available. Shaw, Dewbre and Reeves (1983) estimated meat demand equations in logarithmic change form, and the constant terms in those equations (which correspond to linear trend terms in double logarithmic equations) were significant in the mutton, bacon and ham, and chicken equations. This analysis was not intended to test the hypothesis of constant parameters, and so these results are not definitive; they do, however, provide an indication of possible changes.

Since many of the factors which might lead to change in meat demand patterns are common to both Australia and the United States, it seems worthwhile to review briefly the body of US literature concerning the subject. Braschler (1983) used a Chow test for structural change and concluded that the structure of US demand for both pork and beef had changed around 1970. Chavas (1983) utilised the Kalman filter and found no evidence of structural change in the 1970-74 period but concluded that there had been significant structural changes in the 1975-79 period, with the price and income elasticities of demand for beef decreasing, the income elasticity of demand for poultry increasing and pork prices having an increasing impact on beef consumption.

Haidacher, Craven, Huang, Smallwood and Blaylock (1982) found a number of differences in patterns of household meat consumption between a 1965 household food consumption survey and a corresponding 1977 survey. They concluded (1982, p.10) that, after allowing for socio-economic and demographic factors, the importance of other factors, such as attitude changes, appeared to be minor.

Moschini and Meilke (1983) examined the stability of US demand for beef, using tests based on recursive residuals (see Brown, Durbin and Evans 1975) and F tests for changing parameters. They concluded that commonly used functional forms resulted in misspecification, which might lead to spurious rejection of the hypothesis of coefficient stability. After allowing for a flexible fuctional form and for residual autocorrelation, the analysis based on recursive residuals provided no indication of parameter instability, while the F tests provided some evidence of structural changes early in the 1970s.

Cornell (1983) examined US aggregate consumption data for table beef, hamburger beef, pork and broilers for the period 1950-82. He found rising own-price flexibilities for table beef and broilers, and a declining direct flexibility for hamburger beef, while pork demand did not appear to change systematically. In conclusion, it appears that there is little consistency between the results obtained in the studies of US meat demand.

In the present study, it was decided to test for structural change in the five major meats used in earlier Australian studies (for example, Fisher 1979), paying particular attention to problems of specification and dynamics. Since most industry attention focuses on the effects of any structural changes on consumption of particular meats, it was also decided to explore this issue, rather than the evaluation of parameter changes which has been the focus of many other studies (for example, Chavas 1983; Cornell 1983).

Methodology

The null hypothesis to be tested is that the parameters determining consumer demand for meat were constant during the sample period. This is basically a hypothesis about the parameters of consumers' utility functions. However, these functions are unobservable and, so, the investigation was undertaken using the observable demand functions. The most likely alternative hypothesis is that demand changed gradually over time, but it is possible that changes could have occurred abruptly in response to random shocks (Chavas 1983).

Three approaches to testing the stability of model parameters against a general alternative hypothesis have been outlined by Pagan (1977, p.10). They involve considering: (a) whether there is autocorrelation in the residuals, since most types of parameter variation result in this problem; (b) test statistics for which there is no precise alternative, such as the cumulative sum (cusum) and cumulative sum of squares (cusum of squares) (Brown, Durbin and Evans 1975); and (c) recursive estimates of the parameters. An additional test, the Farley-Hinich test (Farley, Hinich and McGuire 1975), was used in this paper, together with the first two approaches suggested by Pagan.

A weakness of these approaches is that it is frequently difficult to distinguish between the effects of true structural change and model misspecification (Hendry 1978). To overcome this problem, most of the analysis was undertaken using models in which economically relevant variables were retained, even if they did not appear to be statistically significant, and flexible functional forms and dynamic specifications were considered. The problems of multicollinearity resulting from inclusion of large numbers of explanatory variables are much less serious for the prediction-based cusum and cusum of squares tests than they would be for the estimation of parameters in structural analysis. The testing was undertaken using single equation methods to avoid the spillover of any misspecification from one equation to another.

The first two tests applied in the analysis were the cusum and cusum of squares tests which are both based on the one-step-ahead forecast errors derived using recursively updated parameter estimates. Following a change in the structure over time, these recursive residuals no longer have a zero mean, and the cusum and cusum of squares of these residuals (after standardisation) can be used to test for structural change. The output of these procedures is presented graphically, with confidence bounds set according to a predetermined significance level. If the plot of the cusum or cusum of squares crosses the confidence bounds, then rejection of the hypothesis of constant coefficients is indicated (assuming that the model specification is correct). The role of the two tests is somewhat different, with the cusum of squares test more oriented toward random parameter variation than the cusum test. The cusum of squares test is reported to be more powerful than the cusum test (Garbade 1977, p.57). The Farley-Hinich test was also applied. This essentially provides a test of the null hypothesis against the alternative hypothesis that the parameters evolve linearly over time and, hence, is relevant to systematic rather than random parameter changes.

The double logarithmic specification was used in the initial investigation, primarily because of its popularity in previous research. Houthakker-Taylor dynamic versions of these equations (Phlips 1974) were also estimated and tested for coefficient stability, to ensure that any rejection of stability was not due to a lack of dynamic specification in the models used. Functional form was then examined, using the Box-Cox procedure, to ensure that this was not the cause of any rejection of stability.

In addition to formal testing of the hypothesis of constant parameters, investigation of the effects of structural changes on consumption was undertaken, using simulation experiments with parameter estimates obtained from double logarithmic models estimated over varying portions of the sample. Estimation of the equations as a system over varying subsamples also provided an opportunity to assess whether tests for the validity of the symmetry restrictions were affected by apparent structural change.

The analysis was undertaken using the TROLL time-series data analysis system.

Data

Quarterly data for the period 1962 (1) to 1983 (1) were used in the analysis. Apparent consumption statistics for beef, mutton, lamb and pig meat were derived from Griffith, Freshwater and Smith (1983) for the period 1965 (1) to 1982 (2). Data after June 1982 were obtained from the Australian Meat and Live-stock Corporation. The series were extended backward to 1962 (1) using the basic approach of Griffith, Freshwater and Smith (1983). Poultry meat consumption data were obtained from the Bureau of Agricultural Economics (BAE 1983) and were converted to a per person basis by dividing by population figures obtained from the Australian Bureau of Statistics (ABS 1982).

The explanatory variables used included the retail prices of beef, mutton, lamb, pork and chicken. These price series were obtained from the Bureau of Agricultural Economics (BAE 1983). The other explanatory variables were private final consumption expenditure (ABS 1983*a*) and three seasonal dummies. An expenditure variable rather than an income variable was used to avoid the bias which results from applying ordinary least squares to measured income in a consumption model (Judge, Griffith, Hill and Lee 1980, pp. 509-14). While consumer expenditure is largely dependent upon consumer incomes, the dynamic link between consumer income and meat demand (Martin, Dewbre and Baer 1984) was not represented in the equations used in this analysis. Homogeneity of degree zero in prices and total expenditure was imposed by deflating the price and expenditure variables by the consumer price index (ABS 1983*b*).

TABLE 1

Estimated Quarterly Demand Functions for Meat: 1962 (1) to 1983 (1)[a]

Per person consumption	Beef price	Mutton price	Lamb price	Pork price	Chicken price	Consumption expenditure	Intercept	Quarterly dummy variables 2nd quarter	3rd quarter	4th quarter
				Ordinary least squares (double logarithmic model)						
1. Beef	−1.13	0.20	0.06	0.63	0.19	0.68	−2.38	0.02	0.05	−0.14
	(−14.45)	(1.44)	(0.36)	(4.01)	(1.70)	(4.45)	(−1.25)	(1.26)	(1.22)	(−5.14)
								$\bar{R}^2=0.89$	$DW=2.20$	$Q(12)=8.33$
2. Mutton	1.55	1.39	−3.64	1.35	0.35	−3.59	20.85	−0.01	0.25	0.24
	(5.36)	(2.21)	(−4.90)	(1.92)	(0.72)	(−5.24)	(2.45)	(−0.10)	(2.70)	(2.06)
								$\bar{R}^2=0.87$	$DW=2.00$	$Q(12)=6.73$
3. Lamb	0.68	0.41	−1.88	0.53	0.70	−0.13	3.04	0.037	0.087	0.084
	(11.98)	(3.29)	(−12.89)	(3.86)	(0.72)	(−0.94)	(1.81)	(2.01)	(4.87)	(3.62)
								$\bar{R}^2=0.90$	$DW=1.96$	$Q(12)=16.24$
4. Pig meat	0.38	0.07	0.09	−1.09	−0.28	0.25	3.52	0.04	0.052	0.13
	(12.50)	(1.00)	(1.10)	(−14.54)	(−5.31)	(3.47)	(3.89)	(4.22)	(5.41)	(10.09)
								$\bar{R}^2=0.95$	$DW=1.73$	$Q(12)=24.55$
5. Poultry	0.19	0.02	0.10	−0.63	−0.85	2.13	−7.56	−0.04	−0.042	−0.16
	(3.05)	(0.12)	(0.62)	(−4.12)	(−7.96)	(14.29)	(−4.09)	(−2.30)	(−2.08)	(−6.18)
								$\bar{R}^2=0.98$	$DW=0.67$	$Q(12)=53.4$
				Ordinary least squares (all variables in logarithmic difference form)						
6. Poultry	0.18	0.04	0.002	−0.15	−0.31	0.343	−0.012	0.043	0.043	0.012
	(1.07)	(0.22)	(0.014)	(−0.72)	(−2.79)	(0.80)	(−0.28)	(0.70)	(0.92)	(0.16)
								$\bar{R}^2=0.43$	$DW=2.12$	$Q(12)=9.36$
7. Poultry	0.17				−0.31	0.46		0.028	0.030	−0.011
	(1.63)				(−2.8)	(5.0)		(2.89)	(3.22)	(−1.04)
								$\bar{R}^2=0.45$	$DW=2.10$	$Q(12)=9.99$

[a] t-statistics are shown in parentheses below coefficients. DW denotes the Durbin-Watson statistic, while $Q(12)$ is the Ljung-Box Q statistic (Ljung and Box 1978) for white noise residuals up to order 12. In this case, it is distributed with 12 degrees of freedom and a critical value of 21.0 at the 5 per cent level.

Results

The seven equations reported in Table 1 provided the basis for initial testing for stability. The equations were first examined, to assess the suitability of their specification, and then tested for stability. The beef equation appeared to be satisfactory, with all the price and expenditure coefficients having the expected signs and being plausible in magnitude, with an apparent absence of residual autocorrelation.

The mutton equation was a much greater problem. While the residuals of the equation appeared to be a white noise, the coefficients on the mutton and lamb price variables and the expenditure variable were significantly different from zero and had signs that conflicted with prior expectations. Extensive experimentation with specification and functional form was undertaken, but was not successful, and so the original equation (2) was retained. The three most likely causes of the unexpected coefficients in this equation were believed to be multicollinearity (despite the high t-statistics), structural change and inappropriate functional form or dynamics. The first two problems presented relatively little difficulty for the methodology used, and the third problem is directly addressed later in this paper.

The lamb equation appeared satisfactory, with the small negative expenditure elasticity being consistent with results obtained in a number of other studies (for example, Fisher 1979, p.229).

All the parameter estimates in the pig meat equation were plausible. However, examination of the autocorrelation and partial autocorrelation fuctions revealed significant autoregressions at fifth-order and sixth-order lags (t-statistics of -1.9 and -2.0, respectively) and significant sixth-order partial autocorrelation (t-statistic of -2.1). This surprising result may be spurious, or may reflect problems arising from attempting to explain the aggregate combining pork, bacon and ham in a single dependent variable. The equation was re-estimated after correction of the data for autocorrelation, to see if the correction removed indications of parameter instability.

The original poultry equation, equation (5), was unsatisfactory with serious autocorrelation of the residuals, and unexpected signs on the expenditure and pork price coefficients. However, estimation of this equation in logarithmic difference form appeared to overcome the autocorrelation problem. Most emphasis in subsequent testing was placed on this equation (equation (6)). The retention of the full equation is justified, even though most of its coefficients had very low t-values, because arbitrary deletion of variables is likely to lead to model misspecification and, hence, to spurious rejection of coefficient stability. The equation was also respecified as equation (7) with a subset of regressors, to ensure that the model did contain individually significant coefficients.

The residuals from each equation were plotted against time to give an indication of whether the assumption of homoscedasticity implicit in the testing procedure was justified. There was no indication that any rejection of stability was due to non-constancy of the error variance.

The cusum and cusum of squares plots for the beef equation are reported in Figures 1 and 2. The results of these tests, and of the Farley-

Hinich test presented in Table 2, were consistent with the null hypothesis of coefficient stability.

The coefficients in the mutton equation, by contrast, appeared to be highly unstable. Unfortunately, the different procedures varied substantially in their implied timing of structural change, with the cusum test result providing evidence of structural change only at the end of the sample period. From the cusum of squares test, on the other hand, it appears that structural change may have occurred throughout the sample period. In addition, the Farley-Hinich test statistic presented in Table 2 provides evidence in favour of rejection of the hypothesis of stability.

TABLE 2

Calculated F Statistics from the Farley-Hinich Test for Structural Stability: 1962 (1) and 1983 (1)

		Double logarithmic	Dynamic	Box-Cox
Beef		1.37	0.79	1.35
Mutton		9.05†	4.93†	6.47†
Lamb		3.71†	2.97†	5.30†
Pig meat –	Ordinary least squares	2.06*	3.64†	0.50*
	Generalised least squares (5th and 6th order)	2.96†		
Poultry –	Ordinary least squares	9.35†	1.66	19.35†
	Logarithmic change	0.86		
	Respecified logarithmic change	0.63		

* Significant at the 5 per cent level.
† Significant at the 1 per cent level.

No indication of structural change was provided by the cusum plot for lamb, while some evidence of structural change around the middle of the sample period was seen in the cusum of squares. Rejection of stability was also suggested by the Farley-Hinich test result.

Rejection of the null hypothesis of stability was not indicated by the cusum and cusum of squares plots for the pig meat equation; the confidence bounds were not crossed. The Farley-Hinich test, however, did indicate rejection of stability at the 5 per cent level. After allowing for fifth-order and sixth-order residual autoregression, the cusum of squares plot and the Farley-Hinich test statistic of 2.96 were both consistent with rejection of the null hypothesis. Only the result of the cusum test did not imply rejection of stability. Clearly, correction for autocorrelation did not remove indications of parameter instability in this case.

Because of the strong autocorrelation in the double logarithmic equation for poultry, most attention was focused on the equations estimated in logarithmic difference form. The cusum and cusum of squares plots for the complete logarithmic difference equation do not cross the confidence bounds, and the Farley-Hinich test was also below the critical value for rejection of stability. The estimated constant term in this equation was small and insignificant, consistent with the absence of any trend in consumption, and the hypothesis of stability was not rejected for a modified version of this equation with the constant set to zero. Finally,

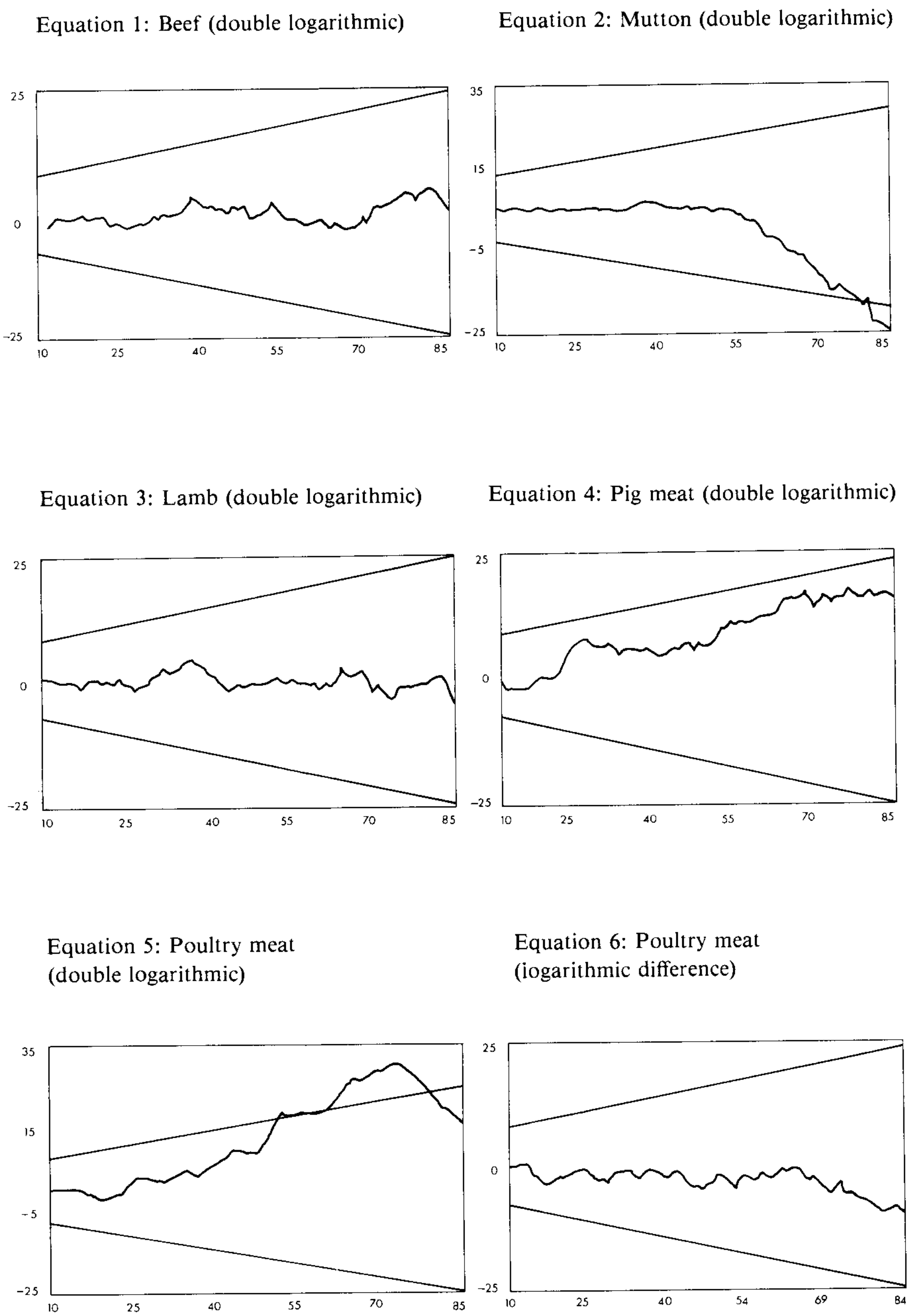

FIGURE 1—Foreword Cusum Plots: 5 per cent Significance Bounds.

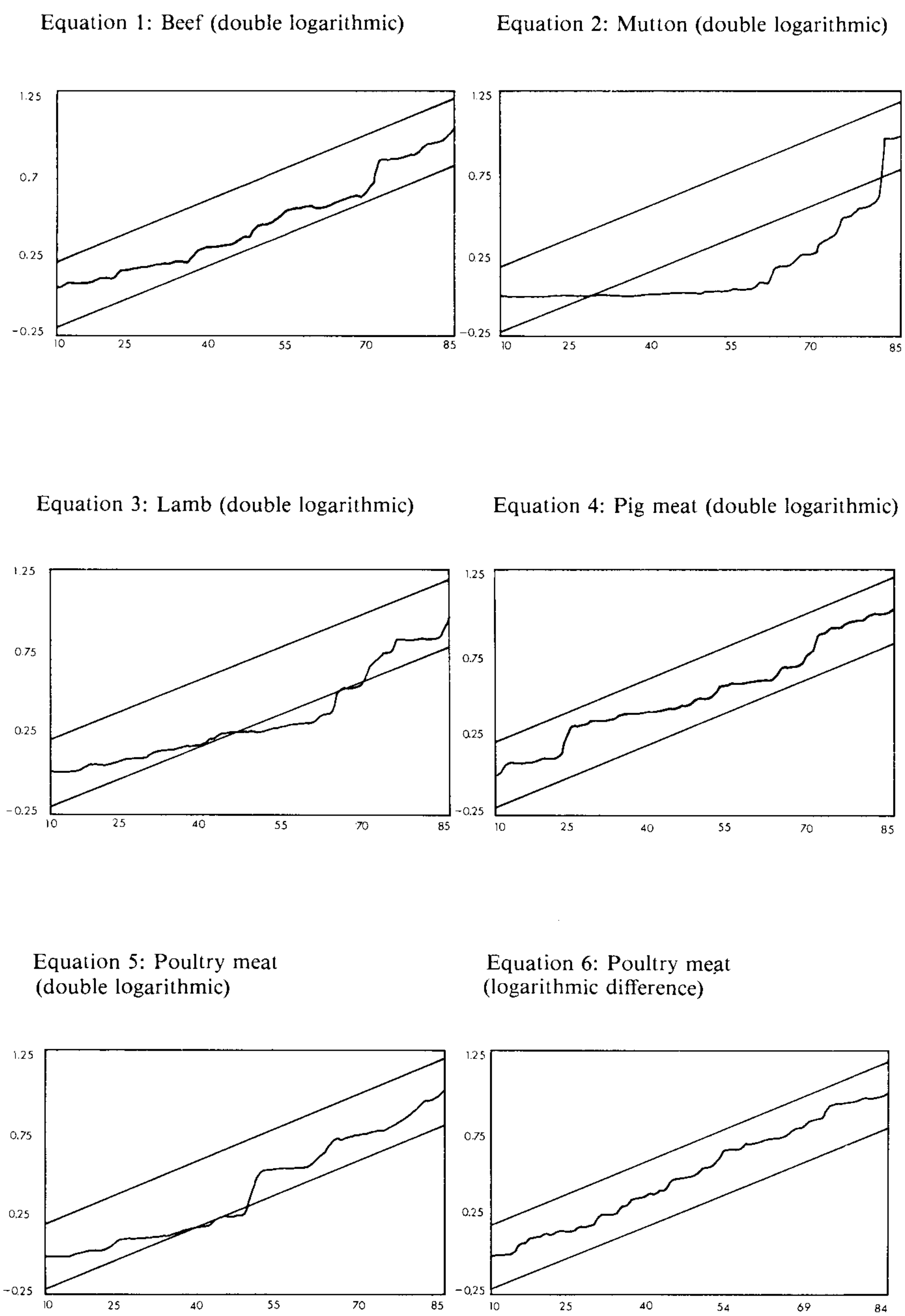

FIGURE 2—Forward Square of Cusum Plots: 5 per cent Significance Bounds.

the respecified poultry equation was examined. Stability was not rejected in this equation using either the cusum or cusum of squares test and the Farley-Hinich test also failed to reject stability. This (difference) equation does not include a constant term, implying that a trend term (in addition to price and expenditure) is not needed to explain the level of poultry consumption.

In summary, the results of this preliminary investigation were: beef—no indication of structural change; mutton—strong evidence of change; lamb—some evidence of change; pig meat—some evidence of structural change; and poultry meat—no evidence of structural change once the model was estimated in logarithmic change form.

Dynamic Respecification of the Model

The models considered in the previous section may in some cases have resulted in spurious rejection of stability simply because they did not account adequately for dynamic patterns in consumer behaviour. To assess whether this was in fact the case, models incorporating dynamic behaviour were also analysed.

The Houthakker-Taylor model provides a plausible dynamic model specification allowing for habit-persistence or stock-holding behaviour on the part of consumers. Unrestricted linear equations of this form (Phlips 1974) were esimated and tested. Unfortunately, space limitations prevent presentation of the cusum and cusum of squares plots, but the Farley-Hinich tests are presented in Table 2. Although the cusum and cusum of squares tests are only asymptotically valid in the presence of a lagged dependent variable, it was felt that they would probably give a reasonable indication of whether any problems in the initial equations were merely the result of neglected dynamics. Examination of Durbin's h-statistics, the autocorrelation functions and the $Q\,(12)$ statistic did not reveal evidence of residual autocorrelation for any equation but the beef equation.

The results for the dynamic models were similar to those for the static models. In the beef equation, there was again no evidence of instability in any test. Stability was rejected using the cusum of squares test and the Farley-Hinich test on the mutton equation, although to a less marked extent than in the original equation. The lamb equation also appeared to be unstable using the cusum of squares and the Farley-Hinich tests.

In the pig meat equation, stability was not rejected using the cusum or the cusum of squares tests and it appeared that the incorporation of dynamics into the specification had overcome the autocorrelation problems. The result of the Farley-Hinich test, however, indicated rejection of stability in this equation.

The dynamic equation for poultry appeared to be acceptable with respect to both autocorrelation and stability. The marked improvement in the performance of this equation over the original double logarithmic model is particularly encouraging, because it suggests that the apparent misspecification of the original equation may have been due to the neglect of dynamics. While use of the logarithmic difference model appears to overcome this problem in an *ad hoc* manner, it is reassuring that use of the explicitly dynamic Houthakker-Taylor model can overcome the problem.

Overall, the results for the dynamic equations do not suggest that the exclusion of dynamic behaviour from the original estimating equations was the cause of any rejection of stability. Despite the inclusion of a reasonably general dynamic specification, the hypothesis of stability was clearly rejected for both mutton and lamb. The dynamic equation for pig meat consumption appeared to be stable in two of the three tests used. In the dynamic poultry equation, as in the simpler logarithmic difference model, the hypothesis of stability was not rejected.

Functional Form

Another potential source of model misspecification is the imposition of an inappropriate functional form. The Box-Cox transformation (Maddala 1977, pp.315-17) provides great flexibility in functional form and was used to ensure that any rejection of stability was not merely a consequence of an inappropriate functional form.

The Box-Cox algorithm in TROLL allows for separate transformation parameters (λ and μ) in the left-hand and right-hand sides of the estimating equations, with the transformation of the dependent variable being

$$(y^*) = (y^\lambda - 1)/\lambda$$

and for the explanatory variables

$$(x^*) = (x^\mu - 1)/\mu$$

Unfortunately, it does not allow for the inclusion of seasonal dummy variables when μ has a zero or negative value. Accordingly, the data were first seasonally adjusted using the X-11 procedure to avoid the misspecification which would result from simply omitting the seasonal dummy variables.

The Box-Cox procedure was first used to search for the most appropriate functional form, and to evaluate that functional form against more readily interpreted forms such as the linear, semi-logarithmic and double logarithmic. Then, the equations using the 'best' functional form were tested for parameter constancy. The chi-square statistics used in the evaluation of functional form are presented in Table 3.

In Table 3, the 'best' functional form is indicated by a zero value of the likelihood ratio test statistic, while the test statistics for the simpler functional forms provide a test of the suitability of these specific models. For beef, the double logarithmic form used in the initial analysis could not be rejected, and the 'best' Box-Cox version of the equation ($\lambda = 0.75$, $\mu = -0.25$) also appeared to be stable.

For mutton, the double logarithmic form ($\lambda = 0$, $\mu = 0$) was decisively rejected in favour of a functional form closer to linearity ($\lambda = 1.0$, $\mu = 0.75$), although this equation possibly suffers from autocorrelation, with the Durbin-Watson statistic of 1.56 falling into the inconclusive region. The stability of the parameters for this equation was rejected by both cusum of squares test and the Farley-Hinich test, while the cusum test did not allow rejection at the 5 per cent level. Taken as a whole, these results support the original conclusion that there has been structural change in the demand for mutton.

TABLE 3

Chi-square Statistics for Likelihood Ratio Tests for Functional Form[a]

λ	μ	Beef	Mutton	Lamb	Pig meat	Poultry
			Selected functional forms			
1	1	7.9	0.0	3.8	0.4	40.1
0	0	1.6	104.4	4.7	7.8	0.7
0	1	4.2	99.8	3.5	7.5	7.1
1	0	1.1	1.9	1.6	0.7	51.5
			'Best' functional forms			
0	−0.5					0
0.5	0.5			0		
0.75	−0.25	0				
1	0.5				0	
1	0.75		0			
DW		2.17	1.56	1.73	1.84	0.62

[a] Critical values for the chi-square with two degrees of freedom are 5.49 at the 5 per cent level and 9.21 at the 1 per cent level.

For lamb, the double logarithmic form was not rejected. The 'best' functional form and the results of stability testing for this equation were very similar to those for the double logarithmic equation, with rejection in the cusum of squares and Farley-Hinich tests, but not in the cusum test.

The double logarithmic functional form was rejected for pig meat at the 5 per cent level, but not at the 1 per cent level and there was no indication of residual autocorrelation in the Box-Cox equation. For that equation, none of the tests undertaken indicated rejection of coefficient stability, suggesting that the original indication of coefficient instability may have been due to inappropriate functional form.

For the poultry equation, the double logarithmic form was not rejected against a general Box-Cox alternative, but the 'best' Box-Cox equation was not satisfactory because it suffered from serious autocorrelation problems. This result, together with the results for the dynamic equations, suggests that the problem with the double logarithmic poultry equation is one of omitted dynamics, rather than of inappropriate functional form.

Overall, this experimentation with functional form resulted in only slight revision of the earlier conclusions. The previous acceptance of stability in the beef equation and rejection of stability in the mutton equation were supported. For the pig meat equation, no indication of parameter instability was found in the Box-Cox equation.

Investigating the Effects of Structural Change

The primary interest in studying structural change in meat demand lies in its effects on the consumption levels of particular meats, effects which may result from change in any of the model coefficients. To obtain an indication of the extent to which demand changes have affected consumption, demand functions were first estimated over varying portions of the sample. Initial coefficient estimates were made over the period 1962 (1) to 1970 (4), and subsequent estimates were made by moving the nine-year sample period forward two years at a time.

A simple extension of this approach allowed investigation of the effects of apparent structural change on tests for the validity of the symmetry restrictions. In common with Chavas (1983), the authors believed that structural change was not likely to be a major factor before 1970. No evidence of structural change was revealed when a sample from 1962 (1) to 1970 (4) was used. The restrictions were then tested for this period and for the period 1974 (1) to 1982 (4), in which structural change was evident. The testing was done by a likelihood ratio procedure using the full information maximum likelihood estimator in TROLL. For the period 1962 (1) to 1970 (4), the chi-squared test statistic had the value 12.0 (with 10 degrees of freedom) and did not suggest rejection. For the period 1974 (1) to 1982 (4), the test statistic, was 24.4, implying rejection of the restrictions at the 1 per cent level. Baldwin, Hadid and Phillips (1983, p.87) noted that the symmetry restrictions are frequently rejected in empirical studies, and suggested that this might be due to the test procedures used, inapplicability of the homogeneity restrictions, or inappropriate dynamics. The results of this study suggest that structural change may be a factor contributing to rejection of the symmetry restrictions in at least some cases.

The estimated coefficients from each of the overlapping sample periods were also used to simulate the levels of meat demand, given particular levels of prices and total consumer expenditure. The first such experiment was performed using simulations over the final four quarters of the sample, 1982 (2) to 1983 (1). Obviously, the effects of some types of structural change depend upon the prevailing levels of prices and expenditure and, to assess the effects under a more widely representative range of prices and expenditure, a second experiment was performed, using the final ten years of sample data. Because of secular changes in the real price of chicken and in consumer expenditure levels, the experiment was not extended beyond this ten-year period. The resulting forecasts are presented in Table 4. Where the structure is changing, the estimated coefficients can be thought of as averages centred on the mid-point of each subsample. Thus, the evolution of the parameter estimates and their forecasts should give an indication of the direction and magnitude of the effects of structural changes on the demand for particular meats.

The results of the simulation experiment, using price and expenditure levels from the final four quarters of the sample, are consistent with a structural shift toward higher beef consumption at these prices and expenditure levels. It must be remembered that the parameter values used are only sample estimates and that the results may have been affected by spurious variation in these estimates. In contrast, a marked shift away from mutton consumption was evident, with forecast consumption falling from 12.5 kg in the sample centred on 1966 to 3.3 kg in the sample centred on 1978. From the lamb equation, it appears that structural change may have tended to lower lamb consumption slightly, although the pattern was somewhat erratic. Consistent with the results from the Box-Cox equation, there was no evidence of a trend in pig meat consumption in this experiment. In the forecasts for poultry, as in the formal tests, there is no evidence of structural change in this equation. It ap-

TABLE 4

Predicted Shifts in Demand Using Different Sets of Demand Parameters Estimated for Varying Sample Periods (kg per person per year)

Sample period for estimation	Time period for simulation: 1982(2) to 1983(1)	1973(2) to 1983(1)	1982(2) to 1983(1)	1973(2) to 1983(1)	1982(2) to 1983(1)	1973(2) to 1983(1)
	Beef		Mutton		Lamb	
1962(1)-1970(4)	45.5	47.5	12.5	12.2	18.0	15.6
1964(1)-1972(4)	43.2	44.8	11.7	10.7	20.9	19.9
1966(1)-1974(4)	54.8	63.3	9.1	8.1	19.1	17.2
1968(1)-1976(4)	50.9	55.3	11.0	9.3	16.1	15.3
1970(1)-1978(4)	50.2	54.9	9.1	8.4	16.5	15.6
1972(1)-1980(4)	55.8	56.8	4.2	5.2	17.6	15.7
1974(1)-1982(4)	52.9	56.5	3.3	5.0	17.0	15.7
	Pig meat		Poultry		Total meat	
1962(1)-1970(4)	12.4	11.5	19.6	17.3	108.1	104.2
1964(1)-1972(4)	14.9	13.8	19.5	17.3	110.3	106.8
1966(1)-1974(4)	14.7	13.7	19.5	17.2	117.2	119.6
1968(1)-1976(4)	15.0	13.9	19.5	17.2	112.5	111.2
1970(1)-1978(4)	15.0	13.9	19.6	17.2	110.4	110.2
1972(1)-1980(4)	15.3	14.0	19.4	17.1	112.3	109.0
1974(1)-1982(4)	14.9	14.0	19.4	17.1	107.5	108.4

pears, therefore, that the dramatic increase in poultry consumption (Weeks and Reeves 1983) in Australia has been due to price and income factors rather than to a change in preferences.

The results from the simulation experiment using price and expenditure levels from the longer 1973 (2) to 1983 (1) period were broadly comparable with the simulation results for the period 1982 (2) to 1983 (1), suggesting that the effects of structural change on consumption may not be very price sensitive. As in the short-period simulation, mutton consumption declined, pig meat changed relatively little and poultry was apparently very stable. Again, the results were consistent with a shift toward greater beef consumption as a result of structural changes in demand. One noticeable difference in the results of the two simulations occured in the lamb equation, where there was much less evidence of a decline in consumption, using the set of prices and expenditure included in the longer sample.

Summary and Conclusions

In this study, a structured procedure was used to test for and evaluate structural change in meat demand. Repeated testing failed to reveal any evidence of significant structural change in the demand for beef. In contrast, the hypothesis of constant parameters was rejected for mutton and for lamb. Once allowance had been made for functional form, the pig meat equation appeared to be stable, as did poultry demand, after allowing for the effects of dynamics.

An analysis of the effects of systematic structural change on consumption of various meats was made. It appears that structural changes may have caused a substantial decline in demand for mutton (8-9 kg per person over 12 years) without apparently changing pig meat or poultry consumption. At the prices prevailing during the final four quarters of the sample, there was evidence of a decline in demand for lamb (1-2 kg per person over 12 years). However, when the analysis was repeated for a wider range of price and expenditure outcomes, there was little indication of a demand shift away from lamb. Although a statistically significant structural change in the beef equation was not revealed by the test procedures, the overlapping sample forecasts were consistent with an increase in demand for beef over the total sample period. However, this was not a consistent trend and probably reflects random variation in the statistical estimates used. The symmetry restrictions were rejected for a subsample period characterised by structural change, but were not rejected in an earlier period, in which structural change was not evident.

The research was aimed at testing whether the parameters determining demand for meat in Australia have changed and at gaining an initial estimate of the effects of any changes on the consumption of individual meats. The conclusion is that there have been structural changes in the demand for some meats. However, the shifts in demand were estimated to have had relatively small effects on the consumption of all meats except mutton. It appears that the main factors leading to changes in the consumption of particular meats have been changes in relative prices and in levels of consumer income.

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