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# Factors Affecting the Demand for Meat in New Zealand

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A thesis  
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by  
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## ABSTRACT

Since the late 1970s, New Zealand red meat consumption has declined considerably whereas white meat consumption has gradually increased. The purpose of this research is to determine whether there has been a structural change in the domestic demand for meat in New Zealand. A parametric approach was used as it allows for the estimation of price and expenditure elasticities. The first-differenced form of the Linear Approximate Almost Ideal Demand System (LA/AIDS) model was estimated, using quarterly New Zealand data for the period 1985-2000 on meat consumption, prices and real total expenditure.

The null hypothesis of no gradual shift in the share of each type of meat was tested using a time trend. Although the sign on the coefficients of the time trend in each equation conformed with *a priori* expectations, they were not statistically significant. These results suggest that the empirically observed changes in the pattern of meat consumption in New Zealand can be explained by changes in relative prices and expenditure. Both Marshallian and Hicksian price and expenditure elasticities were estimated. The estimated Marshallian elasticities suggested that the demand for beef and veal is price elastic whereas the demand for poultry is price inelastic. They also suggested that the demand for lamb and mutton is price unitary. Beef and veal, and lamb and mutton were determined to be luxuries whereas pigmeat is a necessity. The estimated Marshallian expenditure elasticity for poultry had an unexpected negative sign but was not statistically significant. The Marshallian cross-price elasticities revealed a complementarity relationship among many of the meats, which contrasted with *a priori* expectations. Results for the estimated Hicksian elasticities were largely

consistent with the Marshallian elasticities. Compared to the Marshallian elasticities, the Hicksian own-price elasticities are smaller in magnitude. In addition, the Hicksian cross-price elasticities indicate a higher degree of substitution than the Marshallian cross-price elasticities.

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# **CHAPTER ONE**

## **RESEARCH PROBLEM**

### **1.1 Introduction**

Beef, lamb, pigmeat and poultry are four major meat industries in New Zealand. Beef and lamb are export oriented industries whereas pigmeat and poultry are produced mainly for domestic consumption. In 1998-99, approximately 91% of the lamb, 79% of the mutton and 83% of the beef produced in New Zealand was exported overseas (Statistics New Zealand, 2000). In contrast, the domestic market absorbs over 99% of the pigmeat and poultry produced in New Zealand. New Zealand's red meat industry has traditionally been the country's largest single earner of overseas revenue earning \$3.8 billion in 1996. It has a total capital investment of \$25 billion, and employs nearly 60,000 people (Meat New Zealand, 1998).

Like many countries, New Zealand has faced a decline in red meat consumption since the late 1970s. The New Zealand Beef and Lamb Marketing Bureau was incorporated in October 1986 to promote meat consumption because of the decline in red meat consumption. It has started a vigorous campaign, such as the iron campaign and the Quality Mark, to reverse the decline in red meat consumption and improve the image of beef and lamb to secure the future profitability of the domestic meat industry.

The pigmeat industry is divided into the two categories of fresh and cured pork (bacon and ham), the latter accounting for approximately seventy percent of pigmeat consumption (Amejde, 1986). Currently the New Zealand Pork Industry Board estimates that 65 percent of the pork in New Zealand is used in the processing industry

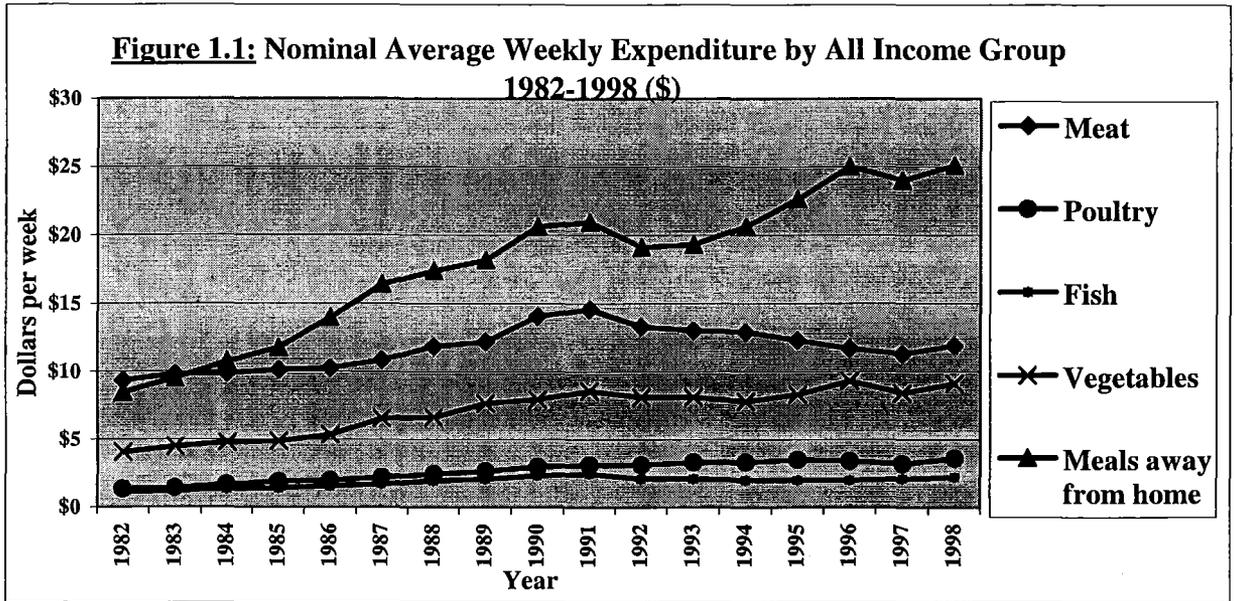
and the rest in the fresh meat market. In 1994, the pig industry contributed \$142 million to the GDP, of a total agricultural contribution of \$5,153 million (Ministry of Agriculture and Forestry New Zealand, 2000). The value of pigmeat is about 3.5 times the farm gate value, estimated at \$500 million in 1995-96.

The poultry industry in New Zealand is also divided into two major sectors; poultry meat production including livestock breeding, and table egg production (Poultry Industry Association New Zealand, 2000). In 1998 the poultry industry produced 98,000 tonnes of poultry meat, almost solely for the domestic market. Of this total, over 95% was chicken meat produced from nearly 65 million broiler chickens; with turkey, duck and roasting fowl making up the remainder (Statistics New Zealand, 2000). There are no imports of fresh poultry meat or table eggs because of the strict quarantine regulations protecting the superior health status of the New Zealand poultry flock. Currently the industry earns almost \$550 million in retail sales and provides about 3000 jobs (Statistics New Zealand, 2000).

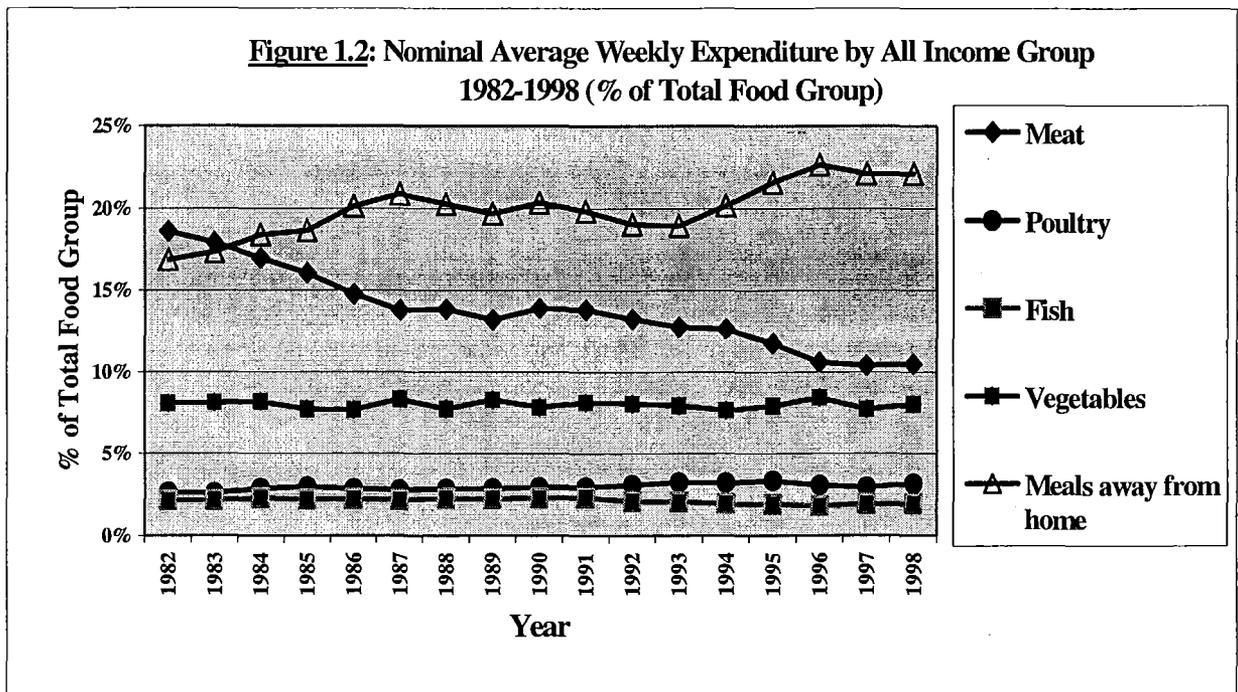
## **1.2 Consumer Expenditures On New Zealand Meat**

Meat is a major item in the diet of New Zealand consumers. However, consumer tastes and preferences for meat appear to be changing. This is demonstrated in Figure 1.1 and 1.2. Average weekly expenditure on meat for the years 1982-1989 was approximately \$10.53. It increased to \$14.06 and \$14.57 in 1990 and 1991 respectively. Expenditure on meat has been trending downward since 1982, however, when it is taken as the percentage of total expenditure on food. When considering total expenditure on food, expenditure on meat was ranked first and second in the period 1982-1983 and 1984-1991 respectively. However, expenditure on meat has declined since 1992 and has not been ranked as the first or second item of total expenditure on food since that time.

In contrast to the decline in expenditure on red meat, expenditure on poultry showed a gradual increase over the period 1982-1998 (Figure 1.2).

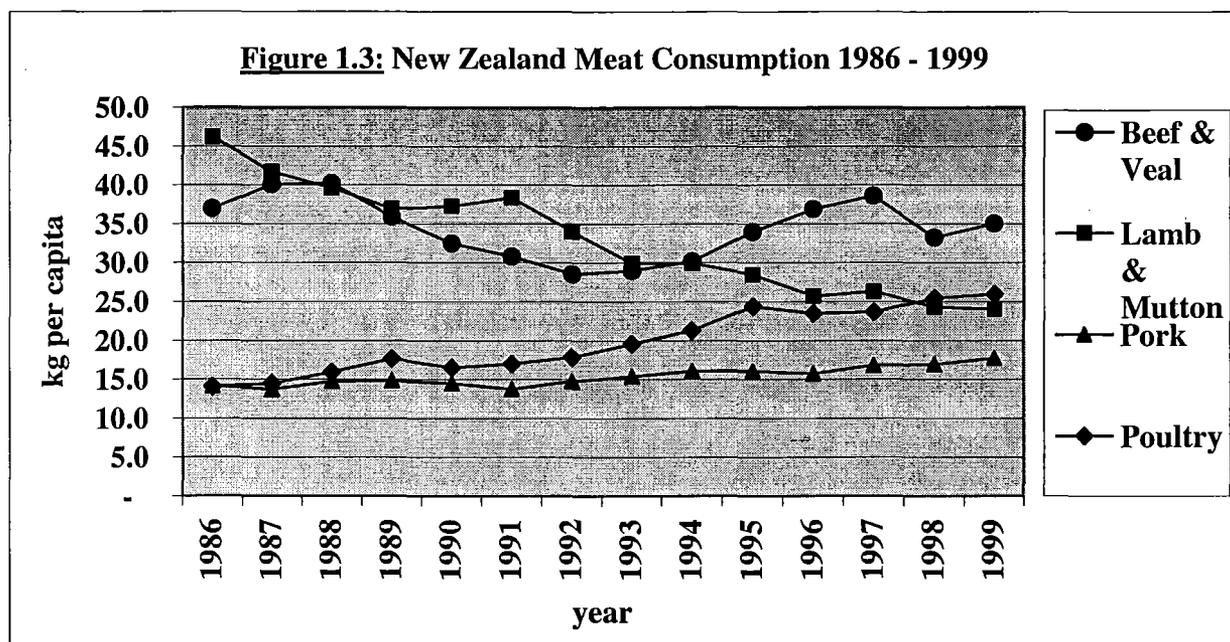


Source: Statistics New Zealand



Source: Statistics New Zealand

Figure 1.3 shows the demand for different types of meat throughout the period 1986-1999. Beef and veal consumption has declined from 37.0 kg per capita in 1986 to 28.5 kg per capita in 1992. Although it reached 38.6 kg per capita in 1997, beef and veal consumption dropped to 33.2 kg per capita (a 14% decline) in 1998. Similarly, lamb and mutton consumption decreased considerably from 46.2 kg per capita in 1986 to 24.0 kg per capita in 1999 (approximately 48%). While the consumption of red meat (beef, veal, lamb and mutton) has declined by 29%, white meat consumption (pigmeat and poultry) has increased by 55% since 1986.



- Sources:**
1. Data for beef & veal, lamb & mutton and pigmeat was obtained from the Ministry of Agriculture and Forestry New Zealand.
  2. Poultry consumption was obtained from Statistics New Zealand. It is measured by poultry production because the poultry industry operates on an "all in all out" system which means all production for a given year is consumed.
  3. The population data was obtained from Statistics New Zealand.

It appears, therefore, that meat consumption patterns in New Zealand have changed since the late 1970s (Prasad *et al.*, 1993). Wallace (1985) also found that there was some evidence of a significant shift away from beef and veal during the 1980s unrelated to changes in income or relative prices. Similarly, a shift away from red meats has also

been found in Australia (Martin and Porter, 1985), Canada (Atkins *et al.*, 1989; Reynolds and Goddard, 1991; Chen and Veeman, 1991), Norway (Rickertsen, 1996), Great Britain (Burton and Young, 1992) and the United States (Chavas, 1983; Eales and Unnevehr, 1988; Moschini and Meilke, 1989).

### **1.3 Justification For The Research**

Meat is a major item in the diet of New Zealand consumers. However, consumer tastes appear to be changing from red meat to white meat. A considerable decline in the consumption of red meat has affected the red meat producers and industry in New Zealand. Such changes in the structure of demand for meat may require corresponding changes in the meat industry. Therefore, it is important to empirically investigate whether there has been a structural change in the domestic demand for meat in New Zealand. A parametric approach will be used for examining the structural change because it allows for the estimation of price and expenditure elasticities.

A number of desirable properties of the Almost Ideal Demand System (AIDS) model makes it more attractive for demand analysis than traditional demand models. Consequently, the AIDS model has become increasingly popular in the analysis of consumer demand for a wide variety of goods. While the AIDS model possesses many desirable properties, it is difficult to estimate because it is non-linear in parameters. Therefore, the Linear Approximate Almost Ideal Demand System (LA/AIDS) using the Laspeyres price index was used to estimate a system of demand equations for meat in New Zealand.

In previous studies on the demand for meat, the datum has usually been aggregated into 4 categories. These categories are beef, lamb, pork and chicken (or poultry). Beef and veal, lamb and mutton, pigmeat and poultry were examined in this research because they are the major items of New Zealand consumer expenditure on meat. These categories were also frequently used in both New Zealand and overseas studies. Therefore, results of this investigation should be comparable to previous work. Poultry consumption, which is approximated by chicken production, was used in this research because of the availability of the data. Chicken is a good proxy for poultry in New Zealand because it represents the vast majority of all poultry consumed. The poultry industry in New Zealand operates on an "all in all out" system, all production for a given year is consumed, which means that production should be equivalent to consumption. In addition, Eales *et al.* (1998) found that either chicken or poultry could be used when modelling poultry demand.

A time trend variable was included in the model for capturing any structural change that may have occurred in the domestic demand for New Zealand meat. Both direct factors such as prices and income (or expenditure) and indirect factors such as population were included in the model so that their effects on New Zealand meat demand can be examined. Although advertising and product innovation are increasingly important for the meat industry, datum on these factors is not available, so they could not be included in the model. In addition, stationarity and autocorrelation tests were conducted in this research. Producers and industry organisations should be particularly interested in the results of this research, as it will provide valuable information on trends in demand and consumer responsiveness to relative price changes.

#### **1.4 Purpose Of The Research**

The overall objective of this research is to examine the factors affecting the domestic demand for meat in New Zealand. The specific objectives include.

1.4.1 Determining whether there has been a structural change in the domestic demand for meat in New Zealand.

1.4.2 Estimating the Marshallian and Hicksian price and expenditure elasticities.

1.4.3 Explaining how price and expenditure factors affect consumer meat buying decisions.

1.4.4 Drawing out the policy implications related to the findings.

## **1.5 Outline Of The Research**

Chapter Two of this research reviews the relevant literature in the area of the demand for meat. Demand analysis for meat in general and in New Zealand in particular is reviewed. A more specific review of structural changes and factors affecting the demand for meat are also discussed. Chapter Three outlines the research methodology employed to examine structural change in the demand for New Zealand meat. Specifically, this chapter presents the empirical model, the postulated hypotheses, the data, the data collection method and the various statistical tests of the model. The results and policy implications related to the findings are presented in Chapter Four. Finally, Chapter Five concludes the research, summarises the findings, provides an overview of the research and gives suggestions for future research.

## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **2.1 Introduction**

Chapter One established the background of the research, the justification for the research and an overview of the objectives. Chapter Two is organised as follows: the following section provides an overview of the literature on demand analysis for meat. This section focuses on various levels of aggregation for meat. In addition, previous estimates of demand elasticities from overseas are discussed. This is followed by an overview of New Zealand meat demand studies. Finally, past research on structural change in meat demand and important factors influencing meat demand are reviewed.

#### **2.2 Literature On Demand Analysis For Meat In General**

The demand for meat has been studied at various levels of aggregation (Heien *et al.*, 1996; Piggott *et al.*, 1996; Gao *et al.*, 1997). The analysis of consumer demand for meat at aggregated levels has been conducted for four common types of meat, that is beef, lamb, pork and chicken (or poultry) (Choi and Sosin, 1990; Kesavan *et al.*, 1993; Moschini and Meilke, 1989). On a more disaggregated level, meat can be categorised into many kinds of major meat products, for example beef can be classified as steak, roast, ground beef and table cut, pork can be disaggregated into fresh pork, ham and bacon and turkey is usually analysed as the disaggregated meat for poultry (Nayga and Capps, 1994; Gao and Spreen, 1994; Eales *et al.*, 1998). Although the demand for meat has been widely studied at the aggregated level, disaggregation provides a more precise analysis of the demand interrelationships among the various types of meat (Cashin, 1991). However, data limitations preclude disaggregation for this study.

Previous studies on the demand for meat exist in many countries such as the U.S., Canada, Australia and the U.K.. In the past, researchers used various systems techniques to estimate consumer demand for meat. The AIDS and the Rotterdam models have frequently been used in these studies (Gao *et al.*, 1997; Eales *et al.*, 1998; Tiffin and Tiffin, 1999). The AIDS model has also been widely used to investigate the demand for meat in Japan, South Korea, Norway, Belgium and Greece. The results from overseas studies are valuable for the current research in that they provide estimates of elasticities and some insights into which variables to include in a meat demand function.

The estimated own-price elasticities suggested that the demand for beef, chicken and pork was inelastic in the U.S. (Mittelhammer *et al.*, 1996; Kinnucan *et al.*, 1997; Eales *et al.*, 1998). The own-price elasticities varied from  $-0.27$  to  $-0.971$ ,  $-0.04$  to  $-0.276$  and  $-0.16$  to  $-0.801$  for beef, chicken and pork respectively. However, the estimated own-price elasticity for beef was elastic in the findings of Kesavan *et al.* (1993) and McGuirk *et al.* (1995). Many previous studies on the demand for meat in the U.S. showed that the cross-price elasticities were smaller in absolute value than the own-price elasticities (Eales and Unnevehr, 1993; Kesavan *et al.*, 1993; Eales *et al.*, 1998). The estimated expenditure elasticities, which varied from 0.344 to 1.447, 0.211 to 2.444 and 0.278 to 1.041 for beef, chicken and pork respectively, suggested that meat was a necessity in the U.S.. The estimated own-price and expenditure elasticities for poultry (Brester and Wahlgenant, 1991; Brester and Schroder, 1995; Eales *et al.*, 1998) were consistent with these elasticities for chicken (Eales and Unnevehr, 1988; Moschini and Meilke, 1989; Eales and Unnevehr, 1993). However, the own-price elasticity for chicken was greater than 1.0 in absolute value in a study which estimated the long-run demand for meat in the U.S. (Kesavan *et al.*, 1993). All elasticities from the AIDS estimates which account for the supply side were more own-price elastic and more income elastic than were

those from equations which do not account for the supply side (Ealses and Unnevehr, 1993).

The studies on the demand for meat in Australia showed that the demand for beef, lamb, pork and mutton were price elastic (Martin and Porter, 1985; Alston and Chalfant, 1987; Cashin, 1991). The estimated own-price elasticities for beef, lamb and pork varied from  $-1.11$  to  $-1.954$ ,  $-1.294$  to  $-1.88$  and  $-1.02$  to  $-1.866$  respectively. The own-price elasticity for mutton was approximately  $-1.106$  (Murray, 1984) which was lower than the elasticity estimated for lamb. However, Australian pork was price inelastic in the empirical work of Cashin (1991) and Piggott *et al.* (1996). While an early Australian study suggested that the demand for chicken was elastic (Murray, 1984), more recent studies revealed that the demand for chicken was inelastic, varying from  $-0.31$  to  $-0.469$  (Alston and Chalfant, 1987; Cashin, 1991; Piggott *et al.*, 1996). The estimated own-price elasticity of poultry (Martin and Porter, 1985) was consistent with the elasticities of chicken (Alston and Chalfant, 1987; Cashin, 1991; Piggott *et al.*, 1996). The relatively low values for the own-price elasticity of chicken in both aggregated and disaggregated models were consistent with a high proportion of chicken consumption in Australia being fast food and/or reserved for special occasions (Murray, 1984; Cashin, 1991). All meats appeared to be normal goods except for mutton (Martin and Porter, 1985), and chicken and pork (Alston and Chalfant, 1987). These unexpected results for mutton, chicken and pork might have reflected such problems as multicollinearity, structural change and inappropriate functional form (Martin and Porter, 1985; Alston and Chalfant, 1987). Many previous studies indicated that beef was a luxury meat whereas chicken, lamb and pork were necessities in Australia (Murray, 1984; Martin and Porter, 1985; Alston and Chalfant, 1987; Cashin, 1991; Piggott *et al.*, 1996).

In Canada, previous studies on meat demand suggested that beef, pork and chicken were price inelastic (Chen and Veeman, 1991; Reynolds and Goddard, 1991; Xu and Veeman, 1996). These results were consistent with studies on meat demand in the U.S.. Most of the previous studies showed that Canadian meats were normal goods with relatively low income elasticities (Yeh, 1961; Hassan and Johnson, 1979; Chen and Veeman, 1989). However, Reynolds and Goddard (1991) and Xu and Veeman (1996) found that beef and pork were luxury goods. Similarly, Alston and Chalfant (1991) found that beef was a luxury good. In addition, pork and chicken were viewed as luxury goods in the findings of Chen and Veeman (1991).

In the U.K., the demand for beef, lamb and pork appeared to be price elastic (Bewley and Young, 1987; Burton and Young, 1992; Tiffin and Tiffin, 1999). The own-price elasticity of demand for chicken was inelastic (Bewley and Young, 1987; Burton and Young, 1992). However, Burton and Young (1992) found that the demand for chicken was elastic in the long run when applying a dynamic AIDS model. This result was consistent with the recent study of Tiffin and Tiffin (1999). In addition, Tiffin and Tiffin (1999) found that the demand for U.K. lamb was inelastic. This was possibly due to the seasonal availability of lamb which would have been particularly marked in the early years of the sample used in the study. Thus, it was likely that lamb would be bought when it was available and somewhat price insensitive. All meats appeared to be normal goods with relatively high income elasticities.

The demand for Wagyu beef in Japan appeared to be price elastic whereas the demand for import-quality beef, pork, chicken and fish appeared to be price inelastic (Wahl and Hayes, 1990; Hayes *et al.*, 1990). Wahl and Hayes also found that the own-price elasticities for each meat increased when prices were assumed to be endogeneous, with

the exception of the pork price elasticity. When upward-sloping meat supplies were assumed, Wagyu beef and fish were found to be necessities whereas import-quality beef, pork and chicken were found to be luxury meats. Results from Hayes *et al.* (1990) suggested that Japanese Wagyu beef was considered a separate commodity relative to imported beef and dairy beef. Their results also indicated that fish could be treated as separable in the Japanese meat demand system.

The results of a study conducted on South Korean data suggested that the demand for beef, chicken and marine products was price inelastic while the demand for pork was price elastic (Hayes *et al.*, 1991). Estimated expenditure elasticities showed that beef and marine products were luxury goods whereas pork and chicken were necessities. The estimated own-price and expenditure elasticities for beef suggested that income growth, rather than price changes, was the major factor influencing the demand South Korean beef.

In Italy, results from an AIDS model showed that the demand for beef was price elastic whereas the demand for pork and chicken were price inelastic (Dono and Thompson, 1994). The own-price elasticities for beef and pork appeared to be relatively high, with beef displaying the larger value, while the chicken own-price elasticity was lower. The high own-price elasticities of beef and pork indicated that consumers' purchases were more sensitive to changes in the prices of these items than they were to changes in the price of chicken. Meat-expenditure elasticities for beef and pork were near unity while the meat-expenditure elasticity for chicken was slightly larger than 1.0. Meat-expenditure elasticities of nearly 1.0 displayed considerable stability over the same period suggesting that stability in consumer preferences was a reasonable proposition. This study included the proportion of employed women, which was specified as a

demographic variable in the AIDS model. This variable was a plausible proxy for the increasing opportunity cost of time spent preparing meals. The results showed that beef had a negative demographic elasticity while pork and chicken displayed positive demographic elasticities, with chicken displaying the stronger response. This indicated that the consumption of these two meats would increase with an increment in employed women. Although the demographic-induced changes in all three meats might not be explicable in terms of the opportunity cost of time for preparing meals, growth in chicken consumption, particularly individual pieces and processed parts, appeared to be consistent with the findings.

A study of Norwegian meat consumption, over the period 1960 to 1992, indicated that there has been a gradual change in the demand for meat and fish during the 1980s. Results showed that the demand for beef, lamb, chicken and fish were price inelastic whereas the demand for pork was price elastic after the structural change was completed (Rickertsen, 1996). Beef, lamb, chicken and fish appeared to be necessities while pork appeared to be a luxury good in Norway. Both own-price and expenditure elasticities were calculated for the period after the structural change was completed. The results of structural change also suggested that the own-price and expenditure elasticities for lamb and chicken changed over time whereas the own-price and expenditure elasticities for the other meats were stable over the specified period. The absolute value of the own-price elasticity of demand decreased for both lamb and chicken. The expenditure elasticity decreased from 0.33 to 0.08 for lamb and increased from 0.18 to 0.69 for chicken. The bias test of structural change also revealed that the change was biased in favour of fish and chicken and against beef.

Peeters *et al.* (1997) found that the demand for Belgian beef and veal appeared to be price elastic whereas the demand for pork and poultry appeared to be price inelastic. All meats appeared to be normal goods in each alternative dynamic model structure. A striking feature of this study was that the estimated elasticities were not very sensitive to the specification of the dynamic adjustment mechanism.

In Greece, the demand for beef appeared to be price elastic, pork had an almost unitary elasticity, whereas the demand for mutton and lamb, chicken and sausages appeared to be price inelastic in the short-run (Karagiannis *et al.*, 2000). In the long-run, beef and pork were found to have a demand elasticity greater than one, whereas mutton and lamb, chicken and sausages still had inelastic demands. Regardless of the time horizon, beef and chicken were considered luxuries while mutton and lamb and pork were considered necessities.

### **2.3 Literature On Demand Analysis For Meat In New Zealand**

Previous studies on New Zealand meat demand used both single demand equation models and systems of equations. Double logarithmic models were frequently used in New Zealand studies. Using a demand sub-system, Court (1967) estimated both linear and double logarithmic demand equations for New Zealand's beef, mutton and pigmeat using annual data from 1950-1963. Court's estimated expenditure elasticities suggested that beef was as an inferior good and that mutton and pigmeat were necessities. However, the estimated expenditure elasticities for beef were not statistically different from zero regardless of whether symmetry restrictions were imposed. The own-price elasticities of each meat appeared to be inelastic.

Yandle (1968) estimated a double logarithmic demand model for beef, pork and mutton in New Zealand. Yandle estimated a dynamic model using quarterly data covering the period 1950-1963. His study involved the simultaneous estimation of both meat consumption and associated retail price equations. His results suggested that pork was a luxury meat with high own-price elasticity. On the other hand, beef and mutton were found to be necessities with inelastic own-price elasticities.

Kakwani and Court (1970) investigated the demand for New Zealand beef and mutton over the period 1950/51 to 1965/66 using a simultaneous model. Theoretical restrictions upon the demand functions were imposed in this study. Demand functions were specified to be linear in logarithms of all variables and a two-stage least squares procedure was used to estimate the demand equations. Their results suggested that the own-price elasticities of demand for beef and mutton were inelastic. In addition, beef and mutton appeared to be necessities.

Horn (1981) focused on the retail demand for pigmeat in New Zealand particularly the demand for fresh pork and cured pigmeat. Two linear single-equations models for fresh pork and cured pigmeat were estimated using quarterly observations for the period 1970 to 1979. Both static and dynamic models were estimated in Horn's study. The resulting own-price elasticities indicated that fresh pork was more sensitive to price changes than cured pigmeat. In contrast, the income elasticity for fresh pork was very low.

Wallace (1985) estimated consumption equations for beef and veal, and mutton and lamb over the period 1958 –1985 using a single demand equation model. Demand equations were specified to be linear in logarithms for all variables. Wallace included dummy variables for the demand shift factors in an attempt to capture health concerns.

His results suggested that all three red meats were price inelastic. The estimated income elasticities suggested that beef and veal, and lamb were normal goods while mutton was an inferior good. However, the estimated income elasticity for mutton was not significantly different from zero. Wallace also found some evidence of a significant shift away from beef and veal during the 1980s unrelated to changes in income or relative prices.

Amejde (1986) attempted to measure the effect of industry promotion on the demand for pigmeat in New Zealand using quarterly data over the period 1973 to 1983. The consumption of pigmeat was modelled through the use of both sales and market share functions. Dummy variables for capturing the effect of industry promotion were included in the demand models. While the sales model for both fresh and cured pigmeat were specified as single demand equations, the market share model was specified as a simultaneous system. Ordinary Least Squares was applied to the sales model whereas Seemingly Unrelated Regression was used to estimate a system of market shares equations. His results showed that little evidence was found to support the hypothesis that product group promotion significantly increased the consumption of pigmeat in New Zealand. The estimated price elasticity for fresh pigmeat appeared to be elastic in both sales and market share models. However, the estimated price elasticity for cured pigmeat appeared to be inelastic in the sales models but the elasticity estimates were positive and statistically insignificant in the market share model. Results from this study supported the hypotheses that both fresh and cured pigmeat were normal goods.

Prasad *et al.* (1993) estimated the demand for meat (including beef, lamb, chicken and pigmeat), fish and milk for the period 1967-1992. The meat consumption model was initially estimated in a linear form using Ordinary Least Squares and subsequently

estimated in natural logarithms. It was found that lamb, chicken and pigmeat were price elastic whereas beef, mutton and milk were price inelastic with fish being almost unit elastic. The estimated expenditure elasticities suggested that fish, chicken and beef were quite expenditure elastic while pigmeat and mutton were inelastic. Prasad *et al.* included health considerations as dummy variables in the meat model. Their results suggested that health factors were important in determining beef and veal consumption. In addition, there was evidence of a significant shift away from beef and veal since the late 1970s unrelated to changes in relative prices or consumption expenditure.

## **2.4 Structural Change In Meat Demand Analysis**

Structural change is an important issue in demand studies because structural change may require corresponding changes in the meat industry (Reynolds and Goddard, 1991). The hypotheses of structural change are often framed in terms of changing tastes and preferences (Moschini and Moro, 1996). With regards to meat, changes in tastes and preferences are usually related to health concerns, particularly the cholesterol intake from food and, perhaps, an attention to quality and an increased demand for convenience (Moschini and Moro, 1996; Rickertsen, 1996; Gao *et al.*, 1997). In addition, the sources of structural change may come from changes in demographic and socioeconomic factors or technological changes. The results of McGuirk *et al.* (1995) suggested that increases in cholesterol awareness and a higher proportion of married working females were associated with a significantly decreased beef consumption, and have generally caused people to switch to chicken and pork. Kinnucan *et al.* (1997) also found that the major factor governing U.S. meat consumption patterns over the past two decades was related to health-information. Dono and Thompson (1994) found that shifts in demographic characteristics of the population, such as the percentage of employed women in the total population, had a substantial impact on meat consumption

in Italy. Similarly, Peeters *et al.* (1997) included two demographic variables (the percentage of women participating in the labour force and the percentage of households with children) to explain structural changes in the demand for meat in Belgium. A considerable portion of the observed change in meat expenditure patterns was explained by these two structural-change variables. Gao *et al.* (1997) applied the latent taste demand model to the demand for U.S. beef using data from two USDA Household Food Consumption Surveys (1977-78 and 1987-88). Their null hypothesis that consumer tastes for beef were unchanged between the two periods was rejected, providing evidence that consumer tastes change over time.

Supply or marketing strategies such as advertising and product innovation can also cause changes in the preferences individuals display (Rickertsen, 1996; Chavas, 1983; Eales and Unnevehr, 1988). However, Eales and Unnevehr (1993) cautioned that gradual structural change in supply also could appear as a demand shift. For example, increased broiler feed efficiency and higher beef carcass dressed weights probably have shifted supply curves for meats steadily outward, and may have contributed to an appearance of demand growth unrelated to prices and expenditures. However, their empirical results showed that when livestock production costs and technical change were included in estimation, neither the AIDS or IAIDS (The Inverse Almost Ideal Demand System) models supported significant demand trend shifts in the mid 1970s.

Structural change in demand analysis may be investigated by means of parametric or nonparametric methods (Moschini and Moro, 1996; Rickertsen, 1996). The nonparametric approach does not rely on a specific functional form. Instead, it entails testing for consistency of the data with the weak, strong or generalised axioms of revealed preference (WARP, SARP and GARP respectively). Failure to meet the

requirements for these axioms may be interpreted as an indication of structural change in demand (Moschini and Moro, 1996). The most important feature of the nonparametric approach is that it allows one to draw inferences on the particular data set without making assumptions about the functional form of the demand functions (Moschini and Moro, 1996). Nevertheless, Burton (1994) pointed out that this advantage was negated somewhat if one could not identify the power of the technique in cases where theory was accepted. He suggested that the power statistic used in his study would overcome this difficulty. The power of a nonparametric test relates to the capability of the test to detect violations of consistency when, in fact, there is structural change (Moschini and Moro, 1996). However, nonparametric tests have a disadvantage since structural change is not very likely to be detected when the growth in total expenditure is relatively large compared to price variation in the data (Chalfant and Alston, 1988; Moschini and Moro, 1996; Rickertsen, 1996). Another shortcoming of the nonparametric tests is that- in the case where the data are consistent with stable preferences – they do not give any clues as to the nature of those stable preferences, how to identify the functional form and parameters of the demand equations, nor whether the results from estimation will be plausible (Alston and Chalfant, 1991).

In contrast to nonparametric methods, a specific functional form has to be selected for parametric demand analysis (Moschini and Moro, 1996 and Rickertsen, 1996). There are at least three alternative ways of examining structural change issues (Moschini and Moro, 1996): explicit modelling of structural change by a trend or other economic variables, consistency analysis and parameter instability analysis.

Incorporating a time trend or demographic dummy variables is the simplest version of the parametric approach (Moschini and Moro, 1996). The dummy variable approach

implies that the change in consumption patterns occurs abruptly (Xu and Veeman, 1996). Lewbel (1989) (cited in Dono and Thompson, 1994), suggested that a time trend might be a more appropriate proxy for demographic changes. This was because demographic variables by their nature changed slowly through time. Thus they are highly correlated with trend variables. In addition to a time trend or demographic dummy variables, switching regression techniques and the one-time-only shift in demand curve have been applied in previous parametric analyses of structural change in meat demand. These techniques allow for a gradual shift from one regime to the next. Moschini and Moro (1996) argued that modelling structural change by a trend was an unpleasant shortcut, because it does not allow the researcher to identify the true source of the structural change. When the data is available, direct modelling of preference shifters is the preferred alternative, especially when dealing with issues of demographic or dynamic effects in demand. Similarly, Peeters *et al.* (1997) pointed out that incorporating demand shifters representing structural (preferences) changes over time in a demand system was preferred over the use of a (logarithmic) time trend.

Consistency analysis involves testing whether a body of data satisfies the theoretical restrictions of demand theory, such as homogeneity of degree zero in prices and income, and symmetry. Testing for these properties is, indeed, the parametric counterpart of checking the satisfaction of WARP, SARP, or GARP. However, Moschini and Moro (1996) pointed out that few studies seemed to have taken this approach. This was perhaps due to the recognition that other sources of misspecification could affect the outcome of such tests, including separability assumptions, aggregation conditions, omitted variables, distributional assumptions, and functional form choice.

Testing for parameter instability has been a common way to test structural change. The tests include the classical Chow test, the Cumulative Sum (CUSUM) and the Cumulative Sum of Squares (CUSUM Squares) tests, the Farley-Hinich test and the Fluctuation test (Moschini and Moro, 1996). Applications in meat demand analysis include Atkins *et al.* (1989), Chen and Veeman (1991) and Rickertsen (1996). The test involves splitting the data set into sub-groups and testing for structural stability of the parameters. This requires either a search over all possible points of structural break, or an *a priori* belief of the point at which the structural change occurs. Although the parametric approach may be the simplest way to detect structural change, it was found that if an incorrect functional form was used, there was a greater risk of finding structural change where none occurred (Alston and Chalfant, 1991).

A number of studies have tested the hypothesis of structural change in meat demand (Burton and Young, 1992; Sakong and Hayes, 1993; Eales and Unnevehr, 1993). Previous tests for structural change in the U.S. and Canada generally found a significant shift towards fish and chicken and away from beef after 1974 (Atkins *et al.*, 1989; Chen and Veeman, 1991; Mittelhammer *et al.*, 1996). Wallace (1985) and Prasad *et al.* (1993) found a significant shift away from beef and veal in New Zealand during the 1980s and since the late 1970s, respectively. This was roughly consistent with the finding of Rickertsen (1996) who investigated structural change in the demand for meat and fish in Norway. Additionally, Burton and Young (1992) found that tastes had changed in favour of chicken and fish and against red meats in the U.K. after the mid 1970s. Throughout the period 1961 to 1987, the effect of taste changes had been to reduce the budget shares of pork and of lamb, while raising the share of chicken. In contrast, taste changes favoured beef at the beginning of the data but tastes moved against beef consumption after the mid 1970s.

However, little evidence was found of a marked swing away from the demand for any meat, with the exception of mutton, in Australia (Martin and Porter, 1985). In addition, Moschini and Meilke (1984) found that tests based on both parametric and nonparametric methods provided little evidence of structural change, and suggested that the recent decline in U.S. beef consumption might be explained by changes in relative prices. Dahlgran (1987) also found that the demand for U.S. meat displayed considerable stability. Furthermore, Wohlgenant (1985) found that recent shifts in the demand for U.S. beef could be attributed to changes in the relative prices of competing meats, especially poultry. Chalfant and Alston (1988) also found no evidence of structural change in meat consumption patterns in the U.S. or Australia when applying a nonparametric method. This was consistent with the nonparametric tests applied to meat consumption data from Canada (Alston and Chalfant, 1991). Similarly, using nonparametric tests, Burton and Young (1991) accepted the hypothesis that the data was consistent with stable preferences. This implied that all variations in U.K. meat consumption could be fully explained by prices and expenditure changes. Dono and Thompson (1994) also found that meat consumption behaviour at the national level in Italy did not display detectable changes in consumer preferences. In addition, when livestock production costs and technical change were included in the estimation, neither the results from the AIDS nor IAIDS models supported the hypotheses of significant shifts in the demand for U.S. meat (Eales and Unnevehr, 1993). Moschini and Meilke (1989) pointed out that evidence from previous studies was mixed because of the variety of methods and data employed. Dahlgran (1987) (cited in Atkins *et al.*, 1989) suggested that the contradictory results were due to differences in models, data assumptions and definitions of structural change. Similarly, Alston and Chalfant (1991) attributed the variety of results, with many contradictions, to differences in model

specification. Their results reinforced the observation that conclusions about structural change were sensitive to the functional form used in the estimation.

A number of authors have examined the impact of structural change on demand elasticities (Moschini and Meilke, 1989; Reynolds and Goddard, 1991; Xu and Veeman, 1996). In Canada, it was clear that the estimated elasticities have changed through time (Reynolds and Goddard, 1991 and Xu and Veeman, 1996). These studies suggested that after the structural change, the expenditure elasticity increased for pork and beef and decreased for chicken. The absolute value of the own price elasticity of demand increased for chicken but decreased for pork and beef. In addition, the pairs of meats, chicken and beef, and chicken and pork changed from being gross complements to gross substitutes. This indicated that a substitutability relationship was more evident between these pairs of meats. In the U.S., Chavas (1983) found little change occurred in the elasticity for pork when no structural change was identified. However, substantial change occurred in the estimated elasticities for beef and poultry. Structural change in the demand for beef was reflected in a decreasing own-price elasticity, an increasing cross-price elasticity with respect to pork, and a dramatically decreasing income elasticity. On the other hand, structural change in the demand for poultry was reflected in an increasing income elasticity and a decreasing cross-price elasticity with respect to pork. The results of structural change in the demand for beef were partly in contrast with those obtained by Moschini and Meilke (1984) who found that U.S. consumers have moved to a point on their demand surface characterized by a higher own-price elasticity and higher cross-price elasticities with respect to other meats. Moschini and Meilke (1984) pointed out those differences in results could be accounted for by the different methodologies used, the different sample period, and the fact that Chavas's base model assumed constant price and expenditure elasticities so that his evidence of

structural change might partly reflect a functional form problem. However, Moschini and Meilke (1989) proceeded to test whether structural change in U.S. meat demand significantly affected demand elasticities and found that structural change did not affect the estimated elasticities.

Evidence of structural change is of considerable interest for the red meat industry. This is because changes in the structure of meat demand have important implications for prices and returns in individual meat industries (Martin and Porter, 1985). In addition, evidence of structural change implies that the red meat industry may need to consider the possibility of a quality adjustment in production, or increased efforts in promotion and marketing (Martin and Porter, 1985; Moschini and Meilke, 1989). Therefore, it is crucial for this research to empirically investigate whether there has been a structural change in the demand for New Zealand meat. This study utilises a parametric approach to examine structural change because Rickertsen (1996) suggested that neither method was unambiguously superior. In addition, Dono and Thompson (1994) pointed out that parametric models, which explicitly accounted for aggregation across consumers by including demographic variables, for example, might be capable of explaining more about consumer behaviour than nonparametric tests based solely on observations of prices and quantities of goods. Besides, the parametric approach has an additional advantage in that it allows one to estimate elasticities which should be of interest to those in the meat industry. Time trend variables were used in this research to test for structural change because of a lack of data on specific demographic effects.

## **2.5 Factors Affecting the Demand For Meat**

Evidence from previous studies showed a number of factors which should be included in a model of meat demand. Based on consumer demand theory, the price of various

meats, the price of competing meats and consumer income (or expenditure) are considered to be important factors affecting consumer purchases of a particular meat. Demand theory suggests that the price of a commodity is inversely related to the quantity demanded, whereas income (or expenditure) has a positive effect on the quantity demanded for commodities that are normal goods. Therefore, prices and income (or expenditure) have been employed as the major determinants of meat demand in previous studies.

Previous empirical studies showed that prices and income (or expenditure) appeared to be the major factors affecting consumer purchases of a particular meat in many countries including New Zealand (Prasad *et al.*, 1993; Heien *et al.*, 1996; Abdulai *et al.*, 1999). Most of the previous studies adjusted the price of meat for inflation using a price index instead of using the nominal price. Although income and expenditure were employed in previous meat demand studies, expenditure had more explanatory power (Chen and Veeman, 1989). Chen and Veeman (1989) pointed out that expenditure was also supported as an explanatory variable by non-nested tests.

In addition to direct factors such as price and income (or expenditure), population has been included in meat demand models as an indirect factor. Some studies employed population indirectly by expressing meat consumption on a per capita basis (Moschini and Meilke, 1989; Eales and Unnevehr, 1993; Prasad *et al.*, 1993). The growth of the consuming population may cause the demand for meats to shift. Hence, expressing meat consumption on a per capita basis can remove the change in demand for meats resulting from the increase in population (Yeh, 1961).

Advertising factors have been extensively incorporated into demand models for goods other than meat (Kinnucan, 1987; Chang and Kinnucan, 1991; Brown and Lee, 1993). In New Zealand, little evidence was found to support the hypothesis that product group promotion has significantly increased the consumption of pigmeats (Ameyde, 1986). However, the New Zealand Beef and Lamb Marketing Bureau has a major promotional campaign aimed at changing consumer's attitudes towards beef and lamb consumption. Consumer surveys have recorded a rise in a positive attitude towards both beef and lamb consumption since these campaigns have begun (Meat New Zealand, 1998-1999). Piggott *et al.* (1996) employed advertising effects (Australian Meat and Livestock Corporation advertising (of beef and lamb): AMLC and Australian Pork Corporation: APC) in both single equation models and complete demand systems models. Their empirical results showed that AMLC advertising had a statistically significant positive effect on beef demand and statistically negative effects on chicken demand, while APC advertising did not have any statistically significant effects. Piggott *et al.* (1996) suggested that the negative effect of AMLC advertising on chicken demand might be consistent with the objectives of the beef and lamb industry, and the effect could be economically important. In addition, Ward and Lambert (1993) found that generic advertising increased the demand for meat in the U.S. and it increased demand enough to more than cover the costs of the advertising expenditure.

However, Brester and Schroeder (1995) found that generic beef and pork advertising had no effect on beef or pork demand and negatively affected the demand for poultry. In contrast to generic advertising, branded beef, pork and poultry advertising elasticities were each significantly different from zero. Nevertheless, the results showed that own-advertising elasticities were between seven and ninety times smaller than own-price elasticities. Kinnucan *et al.* (1997) suggested that the estimated effects of generic

advertising were modest and fragile in the demand for meat in the U.S.. They pointed out that the fragility of advertising parameters might be due to advertising's minor role in meat consumption behaviour. Another reason might be related to advertising measurement. Finally, Kinnucan and Belleza (1991) (cited in Kinnucan *et al.*, 1997) suggested that tracking data reported by Leading National Advertisers, Inc. might understate actual expenditures.

Product innovation has increasingly been the focus of the meat industry since consumers are more interested in convenience and less time-consuming products (Goerne, 1992; Litwak, 1995; Pollack, 1997; Turcsik, 1999). In New Zealand, product quality, which relates to the inherent characteristics of the product as well as the added-value characteristics (eg., adherence to specification, convenience, and reliability of supply), has been set as one of the key issues in the strategic direction of the New Zealand red meat industry (Meat New Zealand, 1998). However, there are few studies which investigate product innovation factors on the demand for meat (Anderson and Shugan, 1991; Menkhaus *et al.*, 1993; Manrique and Jensen, 1997). Value-added meat products, such as ready to cook entrees can be described as product innovation in the meat industry. Empirical results showed that the higher the value of a woman's time, the more likely the household would be to consume convenience meat goods (Manrique and Jensen, 1997). In addition, a lack of convenience characteristics, such as goods which cannot be prepared in a microwave or cannot be easily stored, significantly and adversely affected the quality perception of beef (Menkhaus *et al.*, 1993). Anderson and Shugan (1991) pointed out that convenience itself was an interesting and important topic as evidenced by the growing literature addressing the importance of time in consumer consumption behaviour. Their empirical findings revealed that increased demand for convenience contributed to poultry's success rather than health awareness.

Seasonal variables may also play an important role in the demand for meat (Heien *et al.*, 1996; Piggott *et al.*, 1996; Abdulai *et al.*, 1999). Seasonality is a cyclical behaviour that occurs on a regular calendar basis (Pindyck and Rubinfeld, 1998). Seasonal variables have been incorporated as dummy variables in order to account for seasonality in consumption when using time series data. The demand for meat may exhibit a strong peak during winter. This might be due to the fact that some people consume more meat in order to generate energy for the cold weather. It also may exhibit a strong peak in summer because of barbecue activity. Bennett (1993), for example, pointed out that summer had been a strong selling season for U.S. chicken. Summer was also statistically significant in the demand for meat, fish and eggs in urban areas of India (Abdulai *et al.*, 1999). In addition, the autumn season often marks a general downturn in U.S. supermarket sales.

Another important factor in the demand for meat is demographic effects. Family size and age composition were all major determinants of household consumption patterns (Pollack and Wales, 1981; Chatterjee *et al.*, 1994; Abdulai *et al.*, 1999). Demographic factors (family size, age, wage earners and food stamp) and health information have also been shown to influence the demand for some food groups in the U.S. (Feng and Chern, 2000).

Household characteristics and socio-economic variables have been shown to have a significant impact on the demand for U.S. and Indian meats (Gao and Spreen, 1994, Gao *et al.*, 1997; Abdulai *et al.*, 1999). The most significant variables included region, ethnic background, household size, urbanization, food planner, health information, female household head employment status, and away-from-home food consumption (Gao *et al.*, 1997). This was consistent with the empirical results of Gao and Spreen

(1994) in that the changes in demographic composition of the population and other socioeconomic variables had a significant impact on U.S. consumer preferences and demand for meat. In addition to region and household size, the education level of the household head and seasonality were generally significant in the demand for Indian meat, fish and eggs (Abdulai *et al*, 1999). Household demographic variables were one of the important demographic determinants of both purchase and expenditures on convenience meat (Manrique and Jansen, 1997). In New Zealand, household size affected positively, but less than proportionately, the expenditure on food and miscellaneous services (Michelini, 1997). However, this factor was insignificant in the New Zealand household consumption model of Michelini and Chatterjee (1997). This nonsignificant result provided evidence that household size had poor explanatory power in the New Zealand household consumption model.

Another factor that may influence the demand for meat is habit persistence. Habit persistence variables were found to be significant in the demand for Canadian meat (Chen and Veeman, 1991). This suggested that habit persistence variables, as well as price and expenditure effects, had some influence on Canadian consumers' budget share allocation for beef, pork and chicken. However, incorporating habit persistence factors generated inconsistent empirical results in New Zealand studies. Yandle (1968) found that habit persistence was significant in the demand for beef and pork in New Zealand but insignificant in the demand for mutton when applying retail prices. When using wholesale prices, habit formation was significant in the demand for beef and mutton but insignificant in the demand for pork and lamb. In a more recent study, Horn (1981) found that habit formation was insignificant in the demand for pork in New Zealand.

Previous literature suggested that many factors may affect the demand for meat. However, the most significant factors are likely to be prices and income (or expenditure). Although household size and habit formation were empirically investigated in New Zealand household consumption and meat demand models respectively, they appeared to be statistically insignificant. Hence, prices and income (or expenditure) are employed in this research. Population is indirectly employed in the model by expressing meat consumption on a per capita basis. Seasonal variables will also indirectly be incorporated in the model by using a program to deseasonalise variables in the model. Although advertising expenditure and product innovation may also influence the demand for meat, these factors could not be included in the current study because of lack of data.

## **2.6 Summary And Relation To Research**

Chapter Two reviewed previous studies on consumer demand for meat as well as empirical evidence on structural change and factors influencing the demand for meat. Previous literature supports a parametric approach to the investigation of structural change because it can provide estimated elasticities which are valuable for producers and industry organisations. A time trend variable will be used in this research to capture any structural change that may have occurred in the demand for meat. According to the literature, prices and income (or expenditure), advertising expenditure, product innovation and seasonal variables appear to be major factors influencing the demand for meat. Because there is no data available on advertising expenditure and product innovation, however, these variables could not be included in this research. Details of both the theoretical and empirical methodologies, data, and data collection methods used in this research will be discussed in the next chapter.

# **CHAPTER THREE**

## **RESEARCH METHODOLOGY**

### **3.1 Introduction**

Chapter Two reviewed past studies on the consumer demand for meat in overseas countries and in New Zealand. Literature on structural change and factors affecting the demand for meat were also reviewed. Chapter Three begins with a theoretical framework which is based on the consumer demand theory of utility maximisation developed by Alfred Marshall. The empirical framework for this research is the Almost Ideal Demand System (AIDS) model which was developed by Deaton and Muellbauer (1980a, 1980b). This will be discussed in detail in section 3.2.2. This is followed by discussion of the *a priori* expectations, postulated hypotheses, the data and data collection methods, and the statistical tests of the model.

### **3.2 The Theoretical Framework**

#### **3.2.1 Demand Theory**

The underlying theoretical framework for this research is based on the consumer demand theory of utility maximization (Varian, 1992). The Law of Demand states that other things being equal, the higher the price of a good, the lower the quantity demanded (McTaggart *et al.*, 1992).

### 3.2.1.1 Consumer Preferences

- Standard Assumptions on Preferences

Let  $X^i = (X_1, X_2, \dots, X_n)$  be any bundle available, where  $X_n$  is the quantity of good  $n$  consumed in alternative  $X^i$ :

- $X^1 \succeq X^2$  denotes that  $X^1$  is at least as good as  $X^2$ ,
  - $X^1 \succ X^2$  denotes that  $X^1$  is preferred over  $X^2$ , and
  - $X^1 \sim X^2$  denotes that the consumer is indifferent between  $X^1$  and  $X^2$ .
1. Completeness:  $X^1 \succeq X^2$ ,  $X^2 \succeq X^1$  or both  $\forall X^1, X^2 \in X$ . We assume that any bundle can be compared to any other.
  2. Reflexive:  $X^i \succeq X^i \forall X^i \in X$ . We assume that any bundle is at least as good as itself.
  3. Transitive: If  $X^1 \succeq X^2$  and  $X^2 \succeq X^3$  then  $X^1 \succeq X^3 \forall X^1, X^2, X^3 \in X$ .

From the above three assumptions, the consumer is therefore able to rank all alternatives in  $X$  and is asserted to choose the bundle that gives the highest satisfaction.

#### Additional Assumptions to simplify consumer preferences analysis

4. Continuous: For any  $X^1, X^2 \in X$ , the sets  $C_u = \{X^2 \mid X^2 \succeq X^1\}$  and  $C_e = \{X^2 \mid X^2 \leq X^1\}$  are closed. It follows that  $C_u^+ = \{X^2 \mid X^2 \succ X^1\}$  and  $C_e^+ = \{X^2 \mid X^2 \prec X^1\}$  are open.
5. (Strong) Monotonicity : for any  $X^1, X^2 \in X$ , if  $X^1 \succeq X^2$  and  $(X^1 \neq X^2)$  then  $(X^1 \succ X^2) \implies X^1 \succeq X^2$
6. Non-satiation: for any  $X^1 \in X$ , then there exists a  $X^2 \in X$  such that  $X^2 \succ X^1$  where  $|X^2 - X^1| < \varepsilon$ .

7. (Strict) convexity: If  $(X^1 \neq X^2) X^1 \succeq X^3$  and  $X^2 \succeq X^3$  then

$$\alpha X^1 + (1-\alpha)X^2 (\succ) \succeq X^3 \quad \forall X^1, X^2, X^3 \in X$$

If consumer preferences are complete, reflexive, transitive, continuous, and strongly monotonic then they can be represented by a continuous utility function. That is, a continuous function  $U(X): X \rightarrow R$  such that  $X^1 \succ X^2$  if  $U(X^1) > U(X^2)$ . Convexity is a generalisation of the neoclassical assumption of diminishing marginal rate of substitution. This assumption is usually made to yield utility functions that are quasi-concave and demand curves that are 'nicely' behaved.

Combining preferences with the conventional linear budget constraint, the choice problem reduces to the standard utility maximisation problem:

$$\text{Maximize } U(X_1, X_2, X_3, \dots, X_n)$$

$$\text{subject to } \sum_{i=1}^n P_i X_i = M \quad (1)$$

Solving the above optimisation problem by the method of Lagrange results in a system of Marshallian demand functions (Silberberg, 1990)

$$X_i^M = g_i(P_1, P_2, \dots, P_n, M) \quad \text{where } i = 1, 2, \dots, n \quad (2)$$

The demand system approach involves estimating an entire system of demand equations, as in (2). The demand system is specified and estimated as a system rather than separate individual demand curves.

### 3.2.2 The Empirical Framework

Previous studies on consumer demand for meat have used both single demand equation models and systems of demand equations (Alston and Chalfant, 1987; Burton and Young, 1992; Ward and Lambert, 1993; Piggott *et al.*, 1996). Single equation models were extensively used in early demand studies (Deaton and Muellbauer, 1980a). Although single equation models are relatively easy to estimate, they are criticised because demand theory plays a relatively minor role in their development (Deaton and Muellbauer, 1980a; Thomas, 1993). Relative to a single-equation approach, a complete system of demand equations is much more directly relevant to theory (Deaton and Muellbauer, 1980a).

A systems approach is primarily concerned with the interdependency of demand for various goods (Barten, 1977; Piggott *et al.*, 1996). This makes it possible to explore the relationships among the goods of interest, such as whether they are substitutes or compliments. Economic theory also imposes a number of restrictions on demand functions. These restrictions are adding-up, homogeneity, negativity and symmetry (Barten, 1977; Thomas, 1993). These restrictions arise partly because of the existence of the consumer's budget constraint and partly because of the assumption of utility maximisation (Thomas, 1993). Adding-up and homogeneity are consequences of the specification of a linear budget constraint. Symmetry and negativity, on the other hand, derive from the existence of consistent preferences. Although a system of equations is not guaranteed to satisfy the restrictions implied by theory, an advantage of many of the systems models is that they can statistically be used to test whether the consumer preferences are consistent with theory.

The adding-up restriction is immediately placed on the Marshallian demand system because of the existence of the consumer's budget constraint. It relies on the assumption that the total value of what is consumed is equal to total expenditure (Deaton and Muellbauer, 1980a). This implies that changes in total expenditure and prices cause rearrangement in purchases that do not violate the budget constraint. The homogeneity condition amounts to the assumptions that the Hicksian demands are homogeneous of degree zero in prices and the Marshallian demands are homogeneous of degree zero in total expenditure and prices (Deaton and Muellbauer, 1980a). This condition is also known as the 'absence of money illusion' which implies that the units in which prices and outlay are expressed have no effect on purchases (Deaton and Muellbauer, 1980a). Homogeneity also implies that the sum of all price elasticities plus the total expenditure elasticity equals zero.

Negativity and symmetry are properties of Hicksian demands. Negativity implies that the own-price derivatives are negative, while symmetry implies that the cross-price derivatives are symmetric. These properties stem from the fact that the Hicksian demand functions can be derived by differentiating the indirect expenditure function twice. Because the expenditure function is assumed to be concave, its matrix of second derivatives is negative semidefinite, as well as symmetric. The Slutsky equation allows us to express the negativity and symmetry properties in terms of Marshallian demands, so they can be empirically tested (Deaton and Muellbauer, 1980a).

In terms of using the theory to empirically estimate demand functions, only the homogeneity property and the negativity property can be imposed and/or tested with a single equation model. The adding up and symmetry restrictions are cross-equation restrictions, so their imposition requires the simultaneous estimation of all demand

equations in the system (Thomas, 1993). A number of models have been specified which allow for the empirical estimation of complete systems of demand equations. These models have the advantage of being much more consistent with demand theory. It is also possible to use some of the more flexible models to test whether the data satisfy the restrictions imposed by theory. In effect, they allow us to empirically test whether preferences are consistent with the neoclassical theory of demand.

The most popular approaches to the estimation of complete systems of demand equations are the Linear Expenditure System (LES), the Rotterdam Model, the Translog Models, and the Almost Ideal Demand System (AIDS). The LES represents one of the first attempts to develop empirically estimate a system of demand equations. It can be derived from an additive direct utility function, so it automatically satisfies all of the theoretical restrictions implied by theory. It expresses quantity demanded for each good in the system as a linear function of real total expenditure and of relative prices, which makes it relatively easy to estimate. Despite these advantages, the LES lacks flexibility in two respects (Ward, 2000c). Firstly all income elasticities must be positive, so no good can be inferior. Secondly all cross price elasticities are restricted to be positive, so all goods must be substitutes. These restrictive properties stem from the additivity assumption. A related problem with the LES is that it has too few parameters to give it a reasonable chance of fitting the data, so that care must be taken when interpreting the results (Deaton, 1986). The LES was commonly used several years ago, but the limitations mentioned above mean that it is rarely used today (Ward, 2000b).

In contrast to the LES, the Rotterdam Model can be derived by totally differentiating a logarithmic demand function. The resulting system is more general than the LES, because it is derived without explicitly specifying a functional form for the original

demand equation or the underlying utility function. An advantage of the Rotterdam system is therefore that it can be used to statistically test the restrictions imposed by theory. However, the Rotterdam model has been criticised because it was not explicitly derived from a utility maximisation problem, and so it is not necessarily fully consistent with demand theory (Ward, 2000c).

Another critique of the Rotterdam model relates to the parameterisation of the marginal propensity to consume and the product of budget share and the 'income-compensated' elasticity of demand in the Rotterdam model (Thomas, 1993). Unpublished results by McFadden, which were discussed in Deaton and Muellbauer (1980a), showed that the parameterisation of these terms, which is required for empirical estimation, has implication for a differential demand system that were not originally anticipated. Specifically, under these conditions, expenditure on any good is a constant proportion of total expenditure, no matter what the structure of relative prices. Such expenditure proportionality is not a plausible description of consumer behaviour. Another problem with parameterised differential demand functions is that they can be derived from an additive direct utility function, and will therefore satisfy the theoretical restrictions implied by theory automatically.

The above criticisms have to do with a differential system in which the marginal propensity to consume and the product of each budget share and the 'income-compensated' elasticity of demand are held constant. In empirical versions of the Rotterdam model, however difference equations are used to approximate differentials. Results from these models do not suggest expenditure proportionality claimed by McFadden.

A desire to statistically test the hypotheses implied by demand theory in a consistent manner, without imposing undue restrictions on consumer preferences led to the development of the so called 'flexible functional forms'. The basic idea of flexible functional forms is that the choice of functional form should be such as to allow one free parameter for the measurement of each effect of interest (Deaton, 1986). The two specifications of the translog model are an example of the use of flexible functional forms. In the direct translog model, the negative of the logarithm of the direct utility function is approximated by a function which is quadratic in the logarithm of the quantities consumed (Thomas, 1993). It expresses the budget shares of the  $n$  goods in the system as function of the logarithms of the quantities consumed. In the indirect translog model, the logarithm of the indirect utility function is approximated by a function that is quadratic in the logarithm of the ratios of prices to total expenditure. It expresses the budget shares as functions of the logarithms of the price-expenditure ratios. Deaton and Muellbauer (1980a) pointed out that demand functions derived from the indirect translog model are complicated and clumsy to estimate whereas the direct translog model is usually estimated under the practically nonsensical assumption that for all goods, prices are determined by quantities rather than the other way around. The translog models have been used on occasion, but most of the empirical work has been carried out using either the Rotterdam or the AIDS models (Ward, 2000b).

The Almost Ideal Demand System, developed by Deaton and Muellbauer (1980a, 1980b), is another example of the use of a flexible functional form. The starting point for this model is the indirect expenditure function. The AIDS model leads to a system of demand equations which express budget shares,  $w_i$ , of the  $n$  goods as linear functions of the logarithms of relative prices and the logarithm of real total expenditure. The AIDS model gives an arbitrary first-order approximation to any demand system (Deaton

and Muellbauer, 1980b); Thomas, 1993). This makes the AIDS model as general as the other flexible forms such as the translog or the Rotterdam models. In addition, the AIDS model satisfies the axioms of choice exactly, allows consistent aggregation of microlevel demands up to a market demand function, and does not require additive preferences. Another desirable property of the AIDS model is that its functional form is consistent with known household-budget data. Additionally, the AIDS model is simple to estimate, largely avoiding the need for non-linear estimation (Deaton and Muellbauer, 1980b). Thomas (1993) also pointed out that the AIDS model is easier to estimate than the budget share equations arising from the translog model. Like the Rotterdam model, the AIDS model is a good vehicle for testing the theoretical restrictions implied by demand theory (Deaton and Muellbauer, 1980b; Thomas, 1993).

Both the Rotterdam and the AIDS models have been used extensively in the study of meat demand (Gao *et al.*, 1997; Eales *et al.*, 1998; Abdulai *et al.*, 1999; Tiffin and Tiffin, 1999). Their popularity can be attributed to their flexibility, their ease of estimation and their consistency with demand theory (Ward, 2000e). However, the AIDS model has the additional advantage that it aggregates exactly over consumers (Ward, 2000b). Economic theory does not provide a basis for choosing between the AIDS and Rotterdam models (Ward, 2000b). In addition, they are difficult to compare using statistical goodness of fit measures because the two models have different dependent variables (Ward, 2000b). Nevertheless, a number of desirable properties of the AIDS makes it more attractive than other flexible functional forms. Therefore, this research will use the AIDS model to estimate a system of demand equations.

### 3.2.2.1 The AIDS model

The expenditure share equations for each commodity or commodity group are derived by differentiating an expenditure function of the form (Deaton and Muellbauer, 1980a):

$$\ln e(u, P) = \alpha_0 + \sum_k \alpha_k \ln P_k + \frac{1}{2} \sum_k \sum_j \gamma_{kj}^* \ln P_k \ln P_j + u \beta_0 \prod_k P_k^{\beta_k} \quad (3)$$

Where  $e(u, P)$  is the expenditure function for utility  $u$ , and price vector  $P$ . Applying Shephard's lemma to the expenditure function yields the budget shares in terms of utility and price:

$$w_i = \alpha_i + \sum_j \gamma_{ij} \ln P_j + \beta_i u \beta_0 \prod_k P_k^{\beta_k} \quad (4)$$

$$\text{Where } \gamma_{ij} = \frac{1}{2} (\gamma_{ij}^* + \gamma_{ji}^*) \quad (5)$$

Since utility is unobservable, the resulting demand system cannot be estimated. However, using the inverse of the expenditure function to express utility in terms of expenditures and prices (the indirect utility function) results in the budget shares as a function of prices and expenditures:

$$w_i = \alpha_i + \sum_j \gamma_{ij} \ln P_j + \beta_i \ln(x/P) \quad (6)$$

Where  $w_i$  is budget share of good  $i$ ,  $P_j$  is price of good  $j$ ,  $x$  is total expenditure and  $P$  is a price index defined by:

$$\ln P = \alpha_0 + \sum_{k=1} \alpha_k \ln P_k + \frac{1}{2} \sum_k \sum_j \gamma_{kj} \ln P_k \ln P_j \quad (7)$$

Using the price index as defined in equation (7), the system of equations (6) becomes non-linear and requires the estimation of a large number of parameters. To avoid these

problems,  $P$  is most often approximated using the Stone price index ( $P^* = \sum_{k=1}^n w_k \ln P_k$ ), yielding the Linear Approximate Almost Ideal Demand model (LA/AIDS).

However, Asche and Wessells (1997) pointed out that the Stone index approximation has been shown by several authors to yield inconsistent parameter estimates. Pashardes (1993) found that the Stone index approximation could result in biased parameter estimates, particularly when the AIDS model is applied to microdata. In addition, use of the Stone index in the AIDS model can violate the symmetry restrictions of consumer demand for most combinations of prices and expenditure (Hahn, 1994). Furthermore, Buse (1994) pointed out that the Stone index linearisation has error-in-variables implications. His results reveal that not only is the standard Seemingly Unrelated Regression (SUR) estimator inconsistent but, within the standard instrumental variable (IV) framework, a consistent IV estimator cannot be constructed.

To avoid bias, Hahn (1994) suggested that the LA/AIDS model should be estimated with simultaneous equation techniques. Another alternative is to use a price index whose weights do not depend on current budget shares. Similarly, Moschichi (1995) suggested that several alternative price indices can be used instead of the Stone price index. Asche and Wessells (1997) pointed out that the Laspeyres index, which was developed by Moschini (1995), removes the potential to introduce a simultaneity problem because, unlike other linear indices, it does not include the budget share of good  $i$  on the left-hand side of the equation

Therefore, this research will use the Laspeyres index instead of the Stone price index.

The Laspeyres index can be defined as follows:

$$\ln P_t^L = \sum_{i=1}^n w_i^0 \ln (P_{i,t}) \quad (8)$$

The variable  $w_i^0$  is the budget share in the base period, the variable  $P_{i,t}$  is the price of the  $i$ th meat and  $t$  is the time series data. Moschini (1995) suggested that one can use a specific observation period for the base (eg., the first observation) or, perhaps, mean values can be used for the base. Feng and Chern (2000) applied the Laspeyres index in the LA/AIDS model and used the sample means of the data series as the base period for the shares. This research will also use the sample means of budget shares as the base period for the Laspeyres index.

The theoretical properties of adding-up, homogeneity in prices and income, and symmetry of the cross price effects of demand functions, imply the following parametric restrictions on equation (4):

$$\text{Adding-up} \quad \sum_{i=1}^n \alpha_i = 1; \quad \sum_{i=1}^n \gamma_{ij} = 0; \quad \sum_{i=1}^n \beta_i = 0 \quad (9a)$$

$$\text{Homogeneity} \quad \sum_{j=1}^n \gamma_{ij} = 0 \quad (9b)$$

$$\text{Symmetry} \quad \gamma_{ij} = \gamma_{ji} \quad (9c)$$

Applying the LA/AIDS model to the aggregated data for New Zealand meat, results in the following share equations:

$$w_{i,t} = \alpha_i + \sum_{j=1}^n \gamma_{ij} \ln P_{j,t} + \beta_i \ln \left( \frac{M_t}{P_t} \right) + \phi_i T + \varepsilon_t \quad (10)$$

where  $\varepsilon_t \sim NID(0, \sigma_\varepsilon^2)$

where, in time  $t$ ,  $w_{i,t}$  is the expenditure share of the  $i$ th meat,  $P_{j,t}$  is the price of the  $j$ th meat,  $M_t$  is the total expenditure on meat in the system, reflecting the weak separability assumption, and  $P_t$  is approximated by the Laspeyres index,  $i$  is equal to 1 (beef and veal), 2 (lamb and mutton), 3 (pigmeat) and 4 (poultry),  $T$  is a time trend variable,  $t$  indicates the time period of the observation,  $\alpha_i$  is the intercept and  $\gamma_{ij}$ ,  $\beta_i$  and  $\phi$  are the coefficients of  $\ln P_{j,t}$ ,  $\ln\left(\frac{M_t}{P_t}\right)$  and  $T$  respectively.

Seasonal variables will not be included in equation (10) in order to save degrees of freedom. However, all variables in the model will be adjusted for seasonality by using EZX11 version 2b (C1988 –1989 Doun Associates; X11 seasonal adjustment adapted from United States Census Bureau Publications).

Note that the model implicitly assumes separability of the meat group and instantaneous adjustment.

### 3.2.2.2 Elasticities in the AIDS model

Lewbel (1997) pointed out that raw demand system parameters are usually difficult to interpret directly because of the complexity of empirically adequate specifications. It is therefore useful to report estimated price and income elasticities at various points of the data (eg. at the mean of observed prices).

Following Chalfant (1987) and Abdulai *et al.* (1999), the uncompensated or Marshallian price elasticities for the AIDS model are given as:

$$e_{ij}^m = \frac{\gamma_{ij}}{w_i} - \frac{\beta_i w_j}{w_i} - \delta_{ij} \quad (11)$$

where  $\delta_{ij}$  is equal to one when  $i = j$ , otherwise  $\delta_{ij} = 0$ .

Expenditure elasticities are obtained from:

$$e_i = 1 + \frac{\beta_i}{w_i} \quad (12)$$

Using the Slutsky equation, the compensated, or Hicksian price elasticities,  $e_{ij}^h$ , can be computed as:

$$e_{ij}^h = e_{ij}^m + w_j e_i \quad (13)$$

This research will calculate elasticities at the sample mean of budget shares. In addition, standard errors for the elasticities will be calculated by using the method proposed by Chalfant (1987). Standard errors for expenditure elasticities are given by:

$$SE(\hat{\beta}_i) = SE(1 + \hat{\beta}_i / W_i) = (1/W_i)SE(\hat{\beta}_i) \quad (14)$$

Standard errors for the own-price ( $SE(\hat{e}_{ii})$ ) and cross price ( $SE(\hat{e}_{ij})$ ) Marshallian elasticities of demand are obtained from the following equations:

$$SE(\hat{e}_{ii}) = (1/W_i)SE(\hat{\gamma}_{ii}) + SE(\hat{\beta}_i) \quad (15)$$

$$SE(\hat{e}_{ij}) = (1/W_i)SE(\hat{\gamma}_{ij}) + (W_j/W_i)SE(\hat{\beta}_i) \quad (16)$$

Standard errors for the own-price ( $SE(\hat{e}_{ii}^h)$ ) and cross price ( $SE(\hat{e}_{ij}^h)$ ) Hicksian elasticities are calculated as:

$$SE(\hat{e}_{ii}^h) = (1/W_i)SE(\hat{\gamma}_{ii}) \quad (17)$$

$$SE(\hat{e}_{ij}^h) = (1/W_i)SE(\hat{\gamma}_{ij}) \quad (18)$$

### 3.2.2.3 Variables to be Included in the Model

The dependent variable for each equation is the expenditure share of each type of meat. The independent variables are the relative prices for each type of meat, real total expenditure on meat and a time trend.

- The expenditure share of each type of meat ( $w_{i,t}$ ) is expressed as the proportion of consumer expenditure on each type of meat divided by total expenditure on meat in the system ( $w_{i,t} = P_{i,t} q_{i,t} / M_t$ ). Consumer expenditure on each type of meat is measured by multiplying the quarterly meat price index by quarterly per capita consumption of meat. Per capita consumption of meat is calculated by dividing the total domestic disappearance of meat by total population.
- The price of the  $j$ th meat ( $P_{j,t}$ ) is measured by the quarterly price index of meat. Note that  $j = 1$  for beef and veal,  $j = 2$  for lamb and mutton,  $j = 3$  for pigmeat and  $j = 4$  for poultry.
- The real total expenditure on meat in the system ( $\frac{M_t}{P_t}$ ) is expressed as a proportion of total expenditure on meat divided by a Laspeyre price index ( $\ln P_t^L = \sum_{i=1}^n w_i^0 \ln(P_{i,t})$ ). Total expenditure on meat is measured by the sum of consumer expenditure on each type of meat ( $M_t = \sum_i P_{i,t} q_{i,t}$ ).
- The time trend variable ( $T$ ) is measured by the value of 1 for the first observation, with increments of 1 in each observation.

### **3.3 A Priori Expectations**

The expected sign of  $\gamma_{ij}$  ( $i = j$ ) is *negative* as postulated by the law of demand. Other things being equal, an increase in the own-price of meats can be expected to decrease the expenditure share of each type of meat. In contrast, other things being equal, an increase in the cross-price of meats can be expected to increase the expenditure share on each meat because each type of meat is a substitute for another. Therefore  $\gamma_{ij}$  can be expected to be positive for  $i \neq j$ .

The expected sign of  $\phi_i$  is *negative* for the beef and veal, and lamb and mutton equations whereas it is *positive* for the pigmeat and poultry equations. This is because a gradual shift from red meat towards white meat is expected to have occurred in New Zealand. This hypothesis is supported by the New Zealand literature. Prasad *et al.* (1993) found that the coefficient of a dummy variable which represented health concerns in the demand for New Zealand beef and veal was statistically significant. This provides evidence of a shift away from beef and veal since the late 1970s unrelated to changes in relative prices or consumption expenditure. In addition, Wallace (1985) found a significant shift in the demand for New Zealand beef in the 1980's.

### **3.4 Postulated Hypotheses**

Based on the literature and the theoretical framework, the null hypotheses of this research can be stated as follows:

- H1: The expenditure share of each type of meat is inversely related to its own price ( $\gamma_{ii} < 0$ ).
- H2: The expenditure share of each type of meat is positively related to the cross-price for each type of meat ( $\gamma_{ij} > 0, i \neq j$ ).

- H3: There is likely to be a gradual positive shift in the expenditure share of poultry and pigmeat ( $\phi_i > 0, i = 3,4$ ).
- H4: There is likely to be a gradual negative shift in the expenditure share of beef and veal, and lamb and mutton ( $\phi_i < 0, i = 1,2$ ).

### **3.5 Statistical Tests of the Model**

#### **3.5.1 Testing for Stationarity**

Before applying the LA/AIDS model to the New Zealand data, it is important to check the expenditure share, the log of prices and the log of real total expenditure series for stationarity. This is because regressing one random walk against another can lead to spurious results in that conventional significance tests will tend to indicate a relationship between the variables when in fact none exists (Pindyck and Rubinfeld, 1998). In addition, if the series follow a random walk, the effects of a temporary shock will not dissipate after several years but instead will be permanent. Finally, Lewbel (1997) pointed out that a substantial problem that has been ignored in the vast majority of empirical demand analysis is nonstationarity of prices. Therefore, the Augmented Dickey-Fuller (ADF) test will be applied in this research. The ADF test requires a negative and significant test statistic. If a test fails to reject the hypothesis of nonstationary or unit root at the 5% significance level then the data will be first differenced and tested again. If evidence is found in the sample data against the validity or truth of the hypothesis of nonstationary at the 5% significance level, it implies that the first-difference of the variables do not exhibit unit root. This would imply that each series is integrated at order 1 (i.e.  $y_t \sim I(1)$ ).

### **3.5.2 Testing for Autocorrelation**

Autocorrelation is a situation in which the disturbances in one period are correlated with disturbances from one or more of the preceding periods. It frequently occurs in time-series data, possibly due to excluding important variables from the model or using an incorrect functional form (Gujarati, 1995). In the presence of autocorrelation, the OLS estimates are still linear-unbiased as well as consistent, but they are no longer efficient (ie., minimum variance). There is no consensus in the literature as to an appropriate test for autocorrelation when dealing with a consistent system of equations. Therefore, Burton and Young (1992) suggested that conventional single equation test statistics can be used as a guide for testing autocorrelation in systems of equations. The Breusch-Godfrey (BG) Lagrange Multiplier test, which is a conventional single equation test statistic, will be used in this research.

The BG test has an advantage in that it can be used to test for higher-order autocorrelation, so it is not limited to testing for autocorrelation of order 1. However, a drawback of the BG test is that the value of the length of the lag cannot be specified *a priori* (Gujarati, 1995). Therefore, some experimentation with the value of the length of the lag is inevitable. The null hypothesis for testing autocorrelation is that all autoregressive coefficients ( $\rho_i$ ) are simultaneously equal to zero, that is, there is no autocorrelation of any order. The test statistic is, asymptotically, the sample size ( $n$ ) times the  $R^2$  which follows the chi-square distribution with  $\rho$  (number of autoregressive coefficient) degrees of freedom. If the computed value of the BG statistic ( $nR^2$ ) exceeds the critical chi-square value at the 5% significance level, we can reject the null hypothesis, in which case at least one  $\rho$  is significantly different from zero.

### **3.5.3 Testing for Homogeneity and Symmetry**

The Likelihood ratio test (LR), the Wald test and the Lagrange multiplier test (LM) test are three approaches for testing the parameter restrictions implied by demand theory. These approaches follow from the Maximum likelihood method of estimation (Thomas, 1993). All three tests are equivalent in that the test statistic associated with each of these tests follows the chi-square distribution. A choice between LR, Wald and LM tests normally has to be made on the grounds of computational convenience (Thomas, 1993). On these grounds, the Wald and LM tests are generally preferred to the LR test, because the latter requires estimation of both restricted and unrestricted equations. Choice between the LM and Wald tests depends on whether the restricted or the unrestricted equation is the easier to estimate. The LM test is particularly useful when imposition of the restrictions leads to a considerable simplification of the estimating equations. Since the LA/AIDS model in this research does not need the restrictions for simplification, the Wald test will be carried out to test the linear restrictions on the parameters of the LA/AIDS model. Under the null hypotheses of valid homogeneity and symmetry restrictions, the Wald statistic has a  $\chi^2$  distribution with h degrees of freedom where h is the number restrictions being jointly tested. The Wald test does, however, have a disadvantage. Since the Wald test statistic is much greater than the LR and LM statistics, it might lead to a greater chance of rejecting the null hypothesis of valid restrictions.

### **3.5.4 Testing the Estimated Coefficients**

The null hypotheses in this research are that there is no relationship between the dependent variable and independent variables. The 5% significance level ( $\alpha = 0.05$ ) will be chosen for the tests. T-test statistics will be used for testing the null hypotheses because the true population variance ( $\sigma^2$ ) is unknown. The computed value of the t-

statistics will then be compared to their critical value under the null hypotheses. If the computed value of the t-statistic is greater than its critical value under the null hypotheses, we will reject the null hypotheses, otherwise, we do not reject the null hypotheses. Rejecting the null hypotheses implies that we find evidence in the sample data against the validity or truth of the null hypotheses. Under these circumstances we would conclude that the independent variable in question does have some explanatory power.

The additional null hypotheses, which are the parameters of own-price elasticities equal negative one, are tested if the estimated own-price elasticity coefficients are near unity in absolute value. By definition, a unitary own-price elasticity is equal to negative one, implying that a price increase will bring about a quantity decrease which is proportionally identical in magnitude (Nicholson, 1995). The t-test statistics will be used for testing the null hypothesis and the 5% significance level will be chosen for the test. Rejecting the null hypothesis implies that the own-price elasticity can be either price elastic or price inelastic.

### **3.6 The Data and Data Collection Methods**

Quarterly time series from September 1985 to June 2000 was used in this research because of data availability.

- The quarterly meat price index and the New Zealand population were collected from Statistics New Zealand. The *de facto* population estimates were applied from the period September 1985 to December 1991 whereas the resident population estimates were applied from the period March 1991 to March 2000. This is because Statistics New Zealand does not have a complete series of either *de facto*

population estimates or resident population estimates for the period covered by this research.

- Quarterly domestic consumption for beef and veal, lamb and mutton, and pigmeat were collected from the Ministry of Agriculture and Forestry, New Zealand. However, quarterly consumption on poultry was collected from Statistics New Zealand. This datum is approximated by chicken production because the poultry industry operates on an 'all in all out' system which means all production for a given year is consumed. In addition, over 95% of the poultry meat produced in 1998 were chicken meat; with turkey, duck and roasting fowl making up the remaining 5%.

The Seemingly Unrelated Regression (SUR) Estimation procedure is appropriate for estimating this system of equations (Pindyck and Rubinfeld, 1998). The SUR model has two distinguishing properties. Firstly, it assumes that there are no endogenous regressors. Secondly, the cross-equation error terms are assumed to be contemporaneously correlated. The equations appear to be unrelated because of the first property but they are actually related because of the second property (Ward, 2000d). Since each equation in this research has the same set of parameters, SUR applied to the system will still yield identical results as applying OLS to each equation separately unless some cross-equation restrictions are imposed on the parameters. The LA/AIDS model was estimated by an iterative Seemingly Unrelated Regression method using Microfit 4.0. The adding-up conditions result in a singular residual variance/covariance matrix (Brester and Schroder, 1995). This is usually handled by dropping one equation from the system and recovering its parameters from the parameters of the other equations through the symmetry and homogeneity conditions (Dahlgran, 1987 and Lewbel, 1997). In this system the pigmeat equation will be dropped because it is

associated with the smallest budget share. The homogeneity and symmetry restrictions will be imposed and tested using the Wald criterion.

### **3.7 Summary**

Chapter Three described both the theoretical and empirical methodologies used in this research. The *a priori* expectations, postulated hypotheses, data and data collection methods, and statistical tests of the model were also discussed. Chapter Four will present the empirical findings, the results of the hypothesis testing, and a discussion of the results.

# CHAPTER FOUR

## RESEARCH FINDINGS

### 4.1 Introduction

Chapter Three described both the theoretical and empirical methodologies used in this research. Details of the *a priori* expectations, postulated hypotheses, the data and data collection method and statistical tests of the model were also discussed. This chapter presents the empirical findings which were generated using Microfit 4.0. The findings will be compared and contrasted with previous studies.

### 4.2 Testing for Stationarity

Prior to estimating the demand system, each series was tested for stationarity. The results of the ADF test are presented in table 4.1. The budget share of beef and veal, budget share of pigmeat, log of beef and veal price index, pigmeat and poultry price indices appeared to be stationary in levels. Hence, they are all integrated at order 0 (i.e.  $y_t \sim I(0)$ ). However, the budget share of lamb and mutton, budget share of poultry, log of lamb and mutton price index and real total expenditure on meat appear to be nonstationary in levels. As a result, this research proceeded to test the first-difference of these four variables for possible stationarity. The results showed that there was statistically significant evidence of first-difference stationarity for these four series. Therefore, the degree of integration is 0 when these four series are first differenced (i.e.  $\Delta y_t \sim I(0)$ ). In other words, they are all integrated at order 1 (i.e.  $y_t \sim I(1)$ ).

Since the budget share of lamb and mutton, budget share of poultry, log of lamb and mutton price index and real total expenditure on meat appeared to be I(1), the LA/AIDS model as equation (10) was transformed to the first-differenced form and then reestimated as:

$$dw_{i,t} = \sum_{j=1}^n \gamma_{ij} d \ln p_{j,t} + \beta_i (d \ln M_t - \sum_{j=1}^n w_j^0 d \ln p_j) \quad (19)$$

with all variables are in the first differences. The theoretical properties of adding up, homogeneity, and symmetry in this system imply, respectively, that

$$\sum_{i=1}^n \beta_i = 0, \sum_{i=1}^n \gamma_{ij} = 0; \sum_{j=1}^n \gamma_{ij} = 0; \text{ and } \gamma_{ij} = \gamma_{ji}.$$

Note that a time trend variable in equation (10) was reduced to a new intercept in equation (19). The coefficient of an intercept in each equation indicates a time trend effect in the levels. Equation (19) including an intercept was therefore estimated by the iterative seemingly unrelated regression (SUR) method using Microfit 4.0. Since adding-up conditions result in a singular residual variance/covariance matrix, the pigmeat equation whose budget share is the lowest was dropped for estimation.

Table 4.1 Stationarity test for each variable

| Series                             | Levels <sup>a</sup>  |                     | First Difference <sup>b</sup> |                     |                          |
|------------------------------------|----------------------|---------------------|-------------------------------|---------------------|--------------------------|
|                                    | $\tau_{\tau}$<br>(1) | $\tau_{\mu}$<br>(2) | $\tau_{\tau}$<br>(3)          | $\tau_{\mu}$<br>(4) | I(d) <sup>c</sup><br>(5) |
| Budget share of beef and veal      | -5.8396*             | -1.9781             | -                             | -                   | -                        |
| Budget share of lamb and mutton    | -2.8623              | -2.3585             | -8.3452*                      | -8.4065*            | 0                        |
| Budget share of pigmeat            | -8.5200*             | -2.3312             | -                             | -                   | -                        |
| Budget share of poultry            | -2.9910              | -1.8863             | -11.4014*                     | -11.4722*           | 0                        |
| Log of beef and veal price index   | -2.5437              | -3.0023*            | -                             | -                   | -                        |
| Log of lamb and mutton price index | -2.6155              | -2.7134             | -3.5586*                      | -3.6349*            | 0                        |
| Log of pigmeat price index         | -4.3825*             | -4.5908*            | -                             | -                   | -                        |
| Log of poultry price index         | -4.1636*             | -3.8561*            | -                             | -                   | -                        |
| Real total expenditure on meat     | -2.5606              | -2.6612             | -11.9446*                     | -12.0349*           | 0                        |

Notes : The lag lengths are chosen based on AIC maximising criterion.

<sup>a</sup> 95 % critical values are  $\tau_{\tau}$  (-3.4919) and  $\tau_{\mu}$  (-2.9147) for the given sample size.

<sup>b</sup> 95 % critical values are  $\tau_{\tau}$  (-3.4935) and  $\tau_{\mu}$  (-2.9157) for the given sample size.

<sup>c</sup> d is the order of co-integration.

\*Significant at the 5 percent significance level

### 4.3 Autocorrelation Test

Table 4.2 Autocorrelation test for each equation

| Equations       | Breusch – Godfrey Statistic |
|-----------------|-----------------------------|
| Beef and Veal   | 15.748*                     |
| Lamb and Mutton | 4.361                       |
| Pigmeat         | 7.594                       |
| Poultry         | 3.470                       |

Notes: \* Reject the hypothesis of no autocorrelation at 5 percent significance level. Critical value is  $\chi^2_{(4,.05)} = 9.49$

Autocorrelation tests based on the Breusch – Godfrey statistic showed no evidence of autocorrelation in all equations except the beef and veal equation (Table 4.2 and Appendix 1). All variables in the beef and veal equation were then corrected for autocorrelation using the Cochrane-Orcutt method (Appendix 2). However, Microfit cannot provide the results from the unrestricted LA/AIDS model when using the corrected variables in the beef and veal equation because they created a problem with multicollinearity. Therefore, the original variables in the beef and veal equation had to be used in the estimation despite the autocorrelation. This decision is consistent with prior work by Feng and Chern (2000) who used Durbin-Watson statistics for testing autocorrelation in their demand system for selected healthy food in the United States. Their results indicated the presence of the autocorrelation for the poultry equation which had the lowest DW statistic. However, the DW statistics for the other groups indicated that there was no autocorrelation in the other equations. Therefore, Feng and Chern proceeded with their analyses assuming that there was no serious problem of first-order autoregressive errors in the system. Unfortunately in the presence of autocorrelation the

resulting estimators remain unbiased and consistent but may no longer be efficient (Gujarati, 1995; Thomas, 1993). That is the estimators may no longer have minimum variance in the class of all linear unbiased estimators. The implication of this finding for hypothesis testing is that we may likely to declare a coefficient statistically insignificant even though in fact it may be significant (Gujarati, 1995).

#### **4.4 Homogeneity and Symmetry Test**

The results of the tests for homogeneity, symmetry and joint homogeneity and symmetry are presented in Table 4.3. The results indicated that all restrictions cannot be rejected at the 5 % significance level. This implies that the data are consistent with the theory of a representative utility-maximizing consumer. The restrictions were therefore imposed in estimating the first-difference form of the LA/AIDS with an intercept. The regression results with homogeneity and symmetry imposed are reported in Table 4.4. The last column in Table 4.4 represents the parameters of pigmeat which were obtained by using adding-up condition.

**Table 4.3 Homogeneity and Symmetry Tests**

| Restrictions                      | Wald statistic |
|-----------------------------------|----------------|
| Homogeneity (3 d.f.)              | 3.4200         |
| Symmetry (3 d.f.)                 | 3.9465         |
| Homogeneity and symmetry (6 d.f.) | 5.8002         |

**Note:** Critical values are  $\chi^2_{(3,.05)} = 7.81$ ;  $\chi^2_{(6,.05)} = 12.59$

#### **4.5 Estimated Parameters**

The coefficient of determination ( $R^2$ ) values for the pigmeat and poultry equations are quite good. However, the independent variables in the beef and veal, and the lamb and

mutton equations do not explain as much of the variation in the dependent variables as expected. Additional data would improve the  $R^2$  results, but it is not available. Note that a low  $R^2$  does not necessarily mean mis-specification (McGuirk and Driscoll, 1995). Therefore, the model appears to be adequate.

The estimated coefficients of total expenditure on meat for all meat were significantly different from zero at the 5% level of significance. The results imply that the demand for beef and veal, and lamb and mutton is more elastic with respect to total expenditure on meat than that for poultry and pigmeat. This will be demonstrated when analysing the expenditure elasticities in section 4.7. Unfortunately, about half of the estimated own and cross price coefficients are insignificant at 10% level of significance. This suggests that prices have less influence over budget shares than expected. While the lack of significance for the estimated parameters in the LA/AIDS model are disappointing results, they are consistent with other studies (Cashin, 1991; Reynolds and Goddard, 1991 and Hayes *et al.*, 1991).

#### **4.6 Structural Change Test**

Evidence regarding structural change in the demand for meat was found in the intercept results in Table 4.4. The results showed that all intercepts had signs as expected. The shares of beef and veal and lamb and mutton have shown a small decline over time whereas the shares of poultry and pigmeat have shown a small increase over time. However, none of the intercepts were significant at a 10% level. This indicates that there is no significantly gradual shift in the share of each type of meat. Therefore, the variation in meat consumption for this data set can be attributed to changes in relative prices and movements in expenditure. These results are consistent with Dahlgran (1987), Chalfant and Alston (1988) and Burton and Young (1991). These authors used a

variety of models to test for structural change in meat demand, and found that no such change had occurred. In contrast to this research, Eales and Unnevehr (1988) using the first-differenced LA/AIDS model and a time trend, found a significant exogenous shift in the demand for chicken. Preferences for other meats, however, were determined to be stable.

Table 4.4 Parameter estimates for the restricted LA/AIDS  
(Homogeneity and Symmetry), quarterly data of 1985Q4-2000Q2

| Variable descriptions          | Beef & veal<br>Equation | Lamb & mutton<br>Equation | Poultry<br>Equation  | Pigmeat<br>Equation  |
|--------------------------------|-------------------------|---------------------------|----------------------|----------------------|
| Constant                       | -0.0007<br>(-0.25)      | -0.0016<br>(-0.75)        | 0.0017<br>(1.48)     | 0.0005<br>(0.59)     |
| Beef and veal price            | 0.0265<br>(0.29)        | 0.0759<br>(0.95)          | -0.0454<br>(-1.11)   | -0.0571**<br>(-1.73) |
| Lamb and mutton price          | 0.0759<br>(0.95)        | 0.0374<br>(0.45)          | -0.0490**<br>(-1.25) | -0.0644**<br>(-1.98) |
| Pigmeat price                  | -0.0571**<br>(-1.73)    | -0.0644**<br>(-1.98)      | -0.0073<br>(-0.28)   | 0.1288*<br>(3.85)    |
| Poultry price                  | -0.0454<br>(-1.11)      | -0.0490<br>(-1.25)        | 0.1017*<br>(2.77)    | -0.0073<br>(-0.28)   |
| Real total expenditure on meat | 0.1875*<br>(7.37)       | 0.1730*<br>(8.32)         | -0.2268*<br>(-19.88) | -0.1337*<br>(-15.72) |
| R <sup>2</sup>                 | 0.49                    | 0.56                      | 0.87                 | 0.83                 |
| D-W                            | 2.55                    | 2.41                      | 2.08                 | 2.41                 |
| System Log-likelihood          | 572.28                  | 572.28                    | 572.28               | 572.28               |

**Notes:** \* ,\*\* denotes significance at a 5% and 10% levels, respectively. Numbers in parentheses are t-statistics.

#### **4.7 Estimated Elasticities**

The Marshallian price and expenditure elasticities for the LA/AIDS model with the restrictions imposed are presented in Table 4.5. All the estimated Marshallian own-price elasticities carried the expected negative signs but only the estimated own-price

elasticities for beef and veal, and poultry were significantly different from zero at the 5% and 10% levels respectively. These results suggested that the demand for beef and veal is price elastic whereas the demand for poultry is price inelastic.

Table 4.5 Budget Shares and estimated Marshallian (uncompensated) price and expenditure elasticities (Symmetry and homogeneity imposed)

| Demand        | Budget Share | Marshallian (uncompensated) Price Elasticities |                                 |                    |                     | Expenditure Elasticity |
|---------------|--------------|--|---------------------------------|--------------------|---------------------|------------------------|
|               |              | Beef & veal                                    | Lamb & mutton                   | Pigmeat            | Poultry             |                        |
| Beef & veal   | 0.343        | -1.110*<br>(0.324)                             | 0.075<br>(0.254)                | -0.256*<br>(0.108) | -0.255**<br>(0.136) | 1.547*<br>(0.074)      |
| Lamb & mutton | 0.268        | 0.062<br>(0.326)                               | -1.033 <sup>++</sup><br>(0.329) | -0.346*<br>(0.134) | -0.328*<br>(0.164)  | 1.646*<br>(0.078)      |
| Pigmeat       | 0.164        | -0.068<br>(0.218)                              | -0.174<br>(0.212)               | -0.081<br>(0.213)  | 0.139<br>(0.172)    | 0.185*<br>(0.052)      |
| Poultry       | 0.225        | 0.144<br>(0.200)                               | 0.053<br>(0.188)                | 0.133<br>(0.125)   | -0.321**<br>(0.174) | -0.008<br>(0.051)      |

Notes: \* ,\*\* denotes significance at a 5% and 10% levels, respectively.

<sup>++</sup> not significantly different from -1 at a 5% level.

Standard errors are calculated using a method proposed by Chalfant (1987). Equations for standard errors are presented in Chapter 3 (Equations 14-18).

The results also indicated that the estimated own-price elasticity for lamb and mutton is near unity (-1.033). The additional null hypothesis, which is the parameter of own-price elasticity of lamb and mutton equals negative one, is therefore tested. The hypothesis testing suggested that the estimated own-price elasticity for lamb and mutton was not significantly different from negative one at the 5% level. This implies that the demand for lamb and mutton is price unitary.

Therefore, consumers are more sensitive to changes in beef and veal prices than to changes in lamb and mutton, and poultry prices. Previous New Zealand studies examined the demand for lamb and the demand for mutton separately. Their results suggested that beef and veal, and lamb and mutton were price inelastic (Court, 1967; Kakwani and Court, 1970; Wallace, 1985). Previous studies also found that the demand for poultry in New Zealand were nearly price unitary (Ameyde, 1986), and price elastic (Prasad *et al.*, 1993). These results contrast with the results of the Marshallian own-price elasticities for beef and veal, and lamb and mutton, and poultry in this study. However, the responsive Marshallian demand elasticities for beef and veal and poultry in this research are consistent with previous studies (Martin and Porter, 1985; Cashin, 1991; Peeters *et al.*, 1997). The lack of significance on the estimated own-price elasticities for pigmeat in this research is consistent with a previous study which used the LA/AIDS model (Rickertsen, 1996).

The Marshallian cross-price elasticities showed a stronger complementarity relationship than expected. Half of the estimated cross-price elasticity coefficients had negative signs and most of the negative cross-price elasticities were statistically significant at the 5% level. The cross-price elasticities indicated the strongest substitution effect was between beef and veal, and lamb and mutton, and between poultry and pigmeat but none of the elasticities were statistically significant at a 5% significance level. The results of a complementarity relationship are consistent with Moschini and Meilke (1989) and Reynolds and Goddard (1991) who found most of the cross-price elasticities (both before and after structural changes) were negative when applying the LA/AIDS model.

All the estimated real total expenditure elasticities were statistically significant and carried the expected positive signs except for poultry. The estimated expenditure

elasticities for beef and veal, and lamb and mutton are much greater than the expenditure elasticities for pigmeat. This implies a large demand response for beef and veal, and lamb and mutton when real total expenditure on meat changes. Beef and veal, and lamb and mutton may be considered luxuries whereas pigmeat is a necessity. The expenditure elasticities of beef and veal, and lamb and mutton, and pigmeat are consistent with previous New Zealand studies (Wallace, 1985; Prasad *et al.*, 1993). *A priori*, poultry was expected to have a relatively high expenditure elasticity because of the high price of chicken in the New Zealand market. Although, the negative sign of the estimated expenditure elasticity for poultry suggests that poultry is an inferior good, the lack of significance actually implies there is a good chance that the true elasticity could be positive but small in magnitude. The unexpected result for the expenditure elasticity on poultry is consistent with a previous study by Alston and Chalfant (1987). However, poultry appears to be a normal good in many other studies (Kinnucan *et al.*, 1997; Peeters *et al.*, 1997; Eales *et al.*, 1998). Martin and Porter (1985), who found negative expenditure elasticities in both lamb and mutton, pointed out the unexpected results may have reflected such problems as multicollinearity, structural change or inappropriate functional form.

The Hicksian price elasticities for the LA/AIDS model with the restrictions implied by demand theory imposed are presented in Table 4.6. All the estimated Hicksian own-price elasticities carried the expected negative signs and were statistically significant at the 10% level except for pigmeat. Compared to the Marshallian own-price elasticities, the Hicksian own-price elasticities are smaller in magnitude. The estimated Hicksian own-price elasticities suggested that the demand for beef and veal, and lamb and mutton are price inelastic. The inelastic Hicksian demand for beef and veal, and lamb and

mutton in this research are consistent with previous New Zealand studies (Court, 1967; Kakwani and Court, 1970; Wallace, 1985).

Table 4.6 Budget Shares and estimated Hicksian (compensated) price and elasticities (Symmetry and homogeneity imposed)

| Demand        | Budget Share | Hicksian (compensated) Price Elasticities |                     |                   |                     |
|---------------|--------------|---|---------------------|-------------------|---------------------|
|               |              | Beef & veal                               | Lamb & mutton       | Pigmeat           | Poultry             |
| Beef & veal   | 0.343        | -0.579**<br>(0.299)                       | 0.490*<br>(0.234)   | -0.002<br>(0.096) | 0.093<br>(0.120)    |
| Lamb & mutton | 0.268        | 0.627*<br>(0.299)                         | -0.592**<br>(0.308) | -0.076<br>(0.121) | 0.042<br>(0.146)    |
| Pigmeat       | 0.164        | -0.005<br>(0.201)                         | -0.124<br>(0.199)   | -0.051<br>(0.204) | 0.181<br>(0.160)    |
| Poultry       | 0.225        | 0.141<br>(0.182)                          | 0.051<br>(0.174)    | 0.132<br>(0.117)  | -0.323**<br>(0.163) |

Notes: \* , \*\* denotes significance at a 5% and 10% levels, respectively.

Standard errors are calculated using a method proposed by Chalfant (1987). Equations for standard errors are presented in Chapter 3 (Equations 14-18).

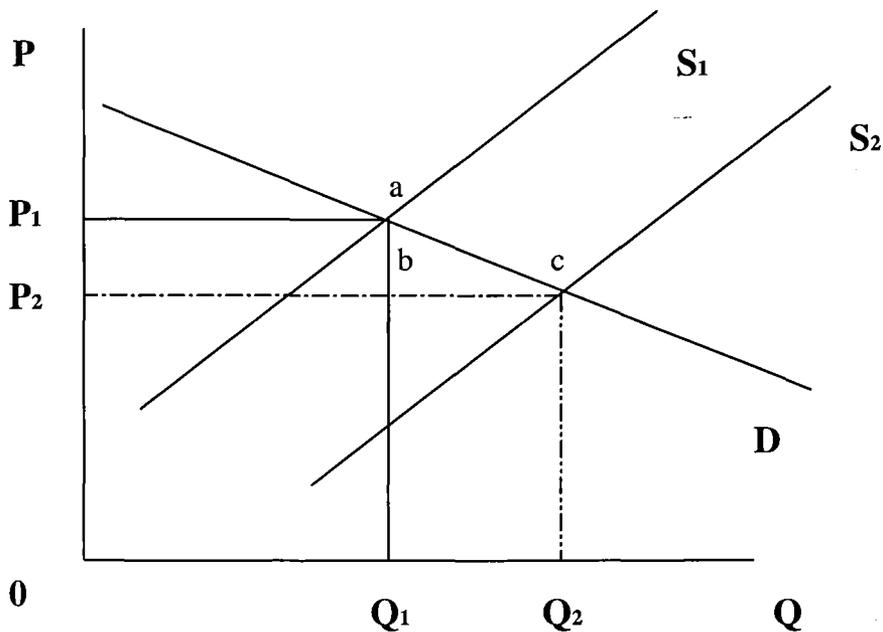
The Hicksian cross-price elasticities indicated a higher degree of substitution than the Marshallian cross-price elasticities. This is because the Hicksian elasticities are a measure of substitution effects net of income (Molina, 1994; Abdulai *et al.*, 1999). The strongest substitutability relationships were between beef and veal, and lamb and mutton; between beef and veal and poultry; between lamb and mutton, and poultry; and between poultry and pigmeat. However, only the substitution relationships between beef and veal, and lamb and mutton were statistically significant at a 5% level. This implies that the prices of lamb and mutton appear to have influenced the consumption of beef and veal. Conversely, the prices of beef and veal have influenced the consumption of lamb and mutton.

## 4.8 Policy Implications

The findings of this research should be of interest to producers and trade organisations in the meat industry. Findings of stable preferences in this research would suggest that research into innovations that will ultimately lower the marginal cost of production or processing might be a better investment than attempting to shift consumer preferences that are in fact rather stable. These results are consistent with several other studies (Wohlgenant, 1985; Chalfant and Alston; 1988).

Since the Marshallian demand for beef and veal is elastic, total revenue received by the meat industry can be expected to increase when prices fall. This can be illustrated using Figure 4.1.

**Figure 4.1 : Effect of Production Innovation on Total Revenue**



In Figure 4.1, the original equilibrium is (a). At the equilibrium point,  $Q_1$  units are demanded at the price  $P_1$ . The meat industry gains total revenue in the area  $OP_1aQ_1$ .

Production innovation on meat, for example innovation in technologies, will result in a reduction in marginal cost, and consequently shift the supply curve from  $S_1$  to  $S_2$ . The equilibrium will change from  $a$  to  $c$  and price will then fall from  $P_1$  to  $P_2$ . When the price drops to  $P_2$ , quantity increases from  $Q_1$  units to  $Q_2$  units and total revenue changes from  $OP_1aQ_1$  to  $OP_2cQ_2$ . As a result, the meat industry gains revenue in area  $Q_1bcQ_2$  whereas they lose revenue in area  $P_2P_1ab$ . Since the demand for beef and veal is elastic, the gain in total revenue ( $Q_1bcQ_2$ ) outweighs the loss in total revenue ( $P_2P_1ab$ ). Therefore, the meat industry will benefit from the research into production innovations.

Both price and expenditure elasticities provide a better understanding of consumer behaviour with regards to meat purchases and consumption patterns. The estimated own-price elasticities of demand yield valuable information about the effect of a price change on total revenue (Blair and Kenny, 1987). For example, results in Table 4.5 suggest that the demand for poultry is inelastic. When the price for poultry falls by one percent, quantity demanded rises by less than one percent. The increase in total revenue associated with the rise in quantity is overwhelmed by the decrease in total revenue associated with the fall in price. Consequently, total revenue falls. The opposite is true for a rise in the price of poultry. In the case of beef and veal, a one percent decline in price leads to an increase in total revenue. The unitary Marshallian demand for lamb and mutton suggests that a one percent fall in lamb and mutton prices will cause the quantity demanded to rise by one percent, leaving total revenue unchanged.

## **4.9 Summary**

Chapter Four presented the empirical findings as well as the implications of the findings. The conclusion and summary of the research will be presented in the next

chapter. The limitation of this research and the suggestions for future research will also be discussed in Chapter Five.

# **CHAPTER FIVE**

## **RESEARCH CONCLUSIONS**

### **5.1 Introduction**

Chapter 4 presented the results of the empirical model and statistical tests of the model. The implications of the results were also discussed. Chapter Five begins with an overview of the research, including a summary of the major findings of this research. The research limitations and suggestions for future research are also discussed.

### **5.2 Overview and Summary**

Since the late 1970s, red meat consumption has declined considerably whereas white meat consumption has gradually increased. These trends have affected the revenue of all those in the New Zealand meat industry. Results from this research suggest that the changes in meat consumption may be due to changes in relative prices and income. While factors such as health concerns, increased demand for convenience and advertising may have affected the demand for meat in New Zealand, the data were not available to test specific hypotheses.

The overall purpose of this research is to examine factors affecting the domestic demand for meat in New Zealand. There are four specific research objectives in this research:

- 5.2.1 To determine whether there has been a structural change in the domestic demand for meat in New Zealand.
- 5.2.2 To estimate the Marshallian and Hicksian price and expenditure elasticities.

5.2.3 To explain how price and expenditure factors affect consumer meat buying decisions.

5.2.4 To draw out the policy implications related to the findings.

The stationarity test results revealed that the budget share for lamb and mutton, the budget share for poultry, the log of the lamb and mutton price index and real total expenditure on meat appeared to be integrated of order 1. Therefore, the LA/AIDS model was transformed to the first-difference form. Based on the coefficient of determination ( $R^2$ ), the resulting model appeared to be statistically adequate. In addition, there appeared to be no serious problem of autocorrelation in the system with the exception of the beef and veal equation. The results in this study are still unbiased, but the autocorrelation problem might lead to misleading conclusions about the significance of the explanatory variables. The theoretical properties of homogeneity and symmetry were supported by the data.

The null hypotheses of no gradual shift in the share of each type of meat cannot be rejected at the 5% significance level. This indicates the absence of structural changes in the demand for New Zealand meat. In other words, the trends observed in the data can be explained by changes in relative prices and changes in expenditure.

Based on the estimated Marshallian elasticities, it was found the demand for beef and veal is price elastic whereas the demand for poultry is price inelastic. It was also found that the demand for lamb and mutton is price unitary. The magnitude of the elasticities implies a fairly large demand response for beef and veal, and lamb and mutton to changes in their relative prices and real total expenditure on meat. Beef and veal, and lamb and mutton were determined to be luxuries whereas pigmeat is a necessity. The

estimated Marshallian expenditure elasticity for poultry was negative, implying that poultry is an inferior good. However, the elasticity was small in magnitude and statistically insignificant. The Marshallian cross-price elasticities revealed a complementarity relationship among many of the meats, which contrasted with *a priori* expectations.

Compared to the Marshallian elasticities, the Hicksian own-price elasticities are smaller in magnitude. In addition, the Hicksian cross-price elasticities indicate a higher degree of substitution than the Marshallian cross-price elasticities. The estimated cross-price elasticities between beef and veal, and lamb and mutton carried a positive sign and were significantly different from zero. This implies that they are substitutes and the demand for one meat item will increase if the price of the other increases.

The findings of this research should be of interest to producers and trade organisations in the meat industry. Research into production innovations which would shift the supply curve may be a better investment for the red meat industry as the domestic demand for New Zealand meat was found to be relatively stable. Estimated price and expenditure elasticities provide a better understanding of consumer behaviour with regards to meat purchases and consumption patterns. In addition, the estimated own-price elasticities of demand yield valuable information about the effect of a price change on total revenue.

## **5.5 Suggestions For Future Research**

This analysis of factors affecting the demand for New Zealand meat was limited by a lack of data on factors other than prices and expenditure. A better understanding of consumer behaviour could be obtained if data on factors such as advertising and product innovation could have been included in the analyses. Although advertising expenditure

for beef and lamb and pigmeat is reported, the time series are not long enough for estimation purposes and the data are not consistently reported. In addition, advertising expenditure on poultry is undertaken by individual poultry companies so the data is not publicly available. One direction for future research would therefore be to develop a survey instrument to collect primary data on advertising expenditure and product innovation so that these factors can be explicitly modelled.

Since this research applied a static LA/AIDS model, it does not provide short-run and long-run elasticities. Therefore, another recommendation for future research is to investigate the factors influencing demand for New Zealand meat using an Error Correction Model, which would yield additional information about the relationship between short-run dynamic adjustment procedures and long-run equilibrium.

Using a parametric approach on a relatively limited data set, this research found no evidence of structural change in the demand for meat in New Zealand. It would be interesting to test the structural change hypothesis using non-parametric methods, as those results would not depend on the choice of functional form.

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**APPENDIX ONE**

**Autocorrelation Test**

# APPENDIX ONE: Autocorrelation Test

**Table A1.1** Ordinary Least Squares Estimation: Auxiliary regression: Beef and veal equation (#1)

```

*****
Dependent variable is UHAT1
55 observations used for estimation from 1986Q4 to 2000Q2
*****
Regressor      Coefficient      Standard Error      T-Ratio[Prob]
CONS           -.8793E-3        .0027009            -.32557[.746]
DLPBVDS1      -.023122         .10204              -.22659[.822]
DLPLMDS1      .070863          .11821              .59949[.552]
DLPPMDS1      -.091609         .13012              -.70401[.485]
DLPPYDS1      .025285          .13316              .18988[.850]
DRMTDS        -.0095099        .025831             -.36816[.714]
UHAT1(-1)     -.53210          .15026              -3.5411[.001]
UHAT1(-2)     -.44944          .16310              -2.7556[.008]
UHAT1(-3)     -.28527          .16851              -1.6929[.097]
UHAT1(-4)     .064871          .17120              .37892[.707]
*****
R-Squared                .28632      R-Bar-Squared                .14358
S.E. of Regression       .018133    F-stat. F(9,45)              2.0059[.061]
Mean of Dependent Variable -.3556E-3  S.D. of Dependent Variable   .019594
Residual Sum of Squares  .014796    Equation Log-likelihood      148.0283
Akaike Info. Criterion   138.0283   Schwarz Bayesian Criterion   127.9916
DW-statistic             1.9698
*****

```

### Diagnostic Tests

```

*****
Test Statistics          LM Version          F Version
*****
A:Serial Correlation    CHSQ(4) = 6.6814[.154]    F(4, 41) = 1.4174[.245]
B:Functional Form       CHSQ(1) = .20639[.650]    F(1,44) = .16573[.686]
C:Normality            CHSQ(2) = 1.4349[.488]    Not applicable
D:Heteroscedasticity   CHSQ(1) = .50455[.478]    F(1, 53) = .49070[.487]
*****

```

- A:Lagrange multiplier test of residual serial correlation
- B:Ramsey's RESET test using the square of the fitted values
- C:Based on a test of skewness and kurtosis of residuals
- D:Based on the regression of squared residuals on squared fitted values

### BG statistics

$$BG = nR^2 \underset{asy}{\overset{H_0}{\sim}} \chi^2_{(p)} = 55 * 0.28632 = 15.7476$$

95% critical value for  $\chi^2_{(4)} = 9.48773$

**Table A1.2** Ordinary Least Squares Estimation : Auxiliary regression: Lamb and mutton equation (#2)

\*\*\*\*\*

Dependent variable is UHAT2

55 observations used for estimation from 1986Q4 to 2000Q2

\*\*\*\*\*

| Regressor | Coefficient | Standard Error | T-Ratio[Prob] |
|-----------|-------------|----------------|---------------|
| CONS      | -.9785E-3   | .0025333       | -.38627[.701] |
| DLPBVDS1  | -.038756    | .095573        | -.40551[.687] |
| DLPLMDS1  | .039104     | .11036         | .35432[.725]  |
| DLPPMDS1  | .046185     | .11961         | .38612[.701]  |
| DLPPYDS1  | -.020393    | .12477         | -.16344[.871] |
| DRMTDS    | .0095243    | .023625        | .40315[.689]  |
| UHAT2(-1) | -.25200     | .15477         | -1.6282[.110] |
| UHAT2(-2) | -.048494    | .15756         | -.30779[.760] |
| UHAT2(-3) | -.13730     | .16319         | -.84136[.405] |
| UHAT2(-4) | .064323     | .16439         | .39128[.697]  |

\*\*\*\*\*

|                            |           |                            |              |
|----------------------------|-----------|----------------------------|--------------|
| R-Squared                  | .079283   | R-Bar-Squared              | -.10486      |
| S.E. of Regression         | .016869   | F-stat. F( 9, 45)          | .43055[.911] |
| Mean of Dependent Variable | -.2302E-3 | S.D. of Dependent Variable | .016049      |
| Residual Sum of Squares    | .012806   | Equation Log-likelihood    | 152.0014     |
| Akaike Info. Criterion     | 142.0014  | Schwarz Bayesian Criterion | 131.9647     |
| DW-statistic               | 1.9491    |                            |              |

\*\*\*\*\*

#### Diagnostic Tests

\*\*\*\*\*

| Test Statistics      | LM Version              | F Version              |
|----------------------|-------------------------|------------------------|
| A:Serial Correlation | CHSQ(4) = 14.1938[.007] | F(4,41) = 3.5653[.014] |
| B:Functional Form    | CHSQ(1) = 1.2950[.255]  | F(1,44) = 1.0610[.309] |
| C:Normality          | CHSQ(2) = .35461[.838]  | Not applicable         |
| D:Heteroscedasticity | CHSQ(1) = .16842[.682]  | F(1,53) = .16279[.688] |

\*\*\*\*\*

A:Lagrange multiplier test of residual serial correlation

B:Ramsey's RESET test using the square of the fitted values

C:Based on a test of skewness and kurtosis of residuals

D:Based on the regression of squared residuals on squared fitted values

#### BG statistics

$$BG = nR^2 \underset{asy}{\overset{H_0}{\sim}} \chi^2_{(p)} = 55 * 0.079283 = 4.361$$

$$95\% \text{ critical value for } \chi^2_{(4)} = 9.48773$$

**Table A1.3** Ordinary Least Squares Estimation :Auxiliary regression: Pigmeat equation (#3)

\*\*\*\*\*

Dependent variable is UHAT3

55 observations used for estimation from 1986Q4 to 2000Q2

\*\*\*\*\*

| Regressor                  | Coefficient | Standard Error             | T-Ratio[Prob]        |
|----------------------------|-------------|----------------------------|----------------------|
| CONS                       | .7677E-3    | .9768E-3                   | .78590[.436]         |
| DLPBVDS1                   | .0099606    | .036606                    | .27210[.787]         |
| DLPLMDS1                   | -.0066211   | .043621                    | -.15178[.880]        |
| DLPPMDS1                   | -.019623    | .045805                    | -.42839[.670]        |
| DLPPYDS1                   | -.8383E-3   | .047937                    | -.017487[.986]       |
| DRMTDS                     | -.0064362   | .0092616                   | -.69494[.491]        |
| UHAT3(-1)                  | -.32110     | .15536                     | -2.0668[.045]        |
| UHAT3(-2)                  | -.33762     | .16616                     | -2.0319[.048]        |
| UHAT3(-3)                  | -.18391     | .16715                     | -1.1003[.277]        |
| UHAT3(-4)                  | -.11546     | .16126                     | -.71597[.478]        |
| *****                      |             |                            |                      |
| R-Squared                  | .13808      | R-Bar-Squared              | -.034301             |
| S.E. of Regression         | .0064845    | F-stat.                    | F(9,45) .80102[.617] |
| Mean of Dependent Variable | .2368E-3    | S.D. of Dependent Variable | .0063761             |
| Residual Sum of Squares    | .0018922    | Equation Log-likelihood    | 204.5857             |
| Akaike Info. Criterion     | 194.5857    | Schwarz Bayesian Criterion | 184.5490             |
| DW-statistic               | 1.9826      |                            |                      |
| *****                      |             |                            |                      |

**Diagnostic Tests**

\*\*\*\*\*

| Test Statistics      | LM Version             | F Version               |
|----------------------|------------------------|-------------------------|
| A:Serial Correlation | CHSQ(4) = 3.3058[.508] | F(4, 41) = .65548[.626] |
| B:Functional Form    | CHSQ(1) = 1.4158[.234] | F(1, 44) = 1.1626[.287] |
| C:Normality          | CHSQ(2) = 1.3745[.503] | Not applicable          |
| D:Heteroscedasticity | CHSQ(1) = .13973[.709] | F(1, 53) = .13499[.715] |

\*\*\*\*\*

- A:Lagrange multiplier test of residual serial correlation
- B:Ramsey's RESET test using the square of the fitted values
- C:Based on a test of skewness and kurtosis of residuals
- D:Based on the regression of squared residuals on squared fitted values

**BG statistics**

$$BG = nR^2 \underset{asy}{\sim} \overset{H_0}{\chi^2}_{(p)} = 55 * 0.13808 = 7.594$$

95% critical value for  $\chi^2_{(4)} = 9.48773$

**Table A1.4** Ordinary Least Squares Estimation: Auxiliary regression: Poultry equation (#4)

\*\*\*\*\*

Dependent variable is UHAT4

55 observations used for estimation from 1986Q4 to 2000Q2

\*\*\*\*\*

| Regressor | Coefficient | Standard Error | T-Ratio[Prob] |
|-----------|-------------|----------------|---------------|
| CONS      | .9570E-3    | .0013962       | .68548[.497]  |
| DLPBVDS1  | .010476     | .052898        | .19804[.844]  |
| DLPLMDS1  | -.044000    | .062273        | -.70657[.483] |
| DLPPMDS1  | -.0086862   | .063044        | -.13778[.891] |
| DLPPYDS1  | .022429     | .066493        | .33731[.737]  |
| DRMTDS    | -.0048456   | .012932        | -.37470[.710] |
| UHAT4(-1) | -.10647     | .15378         | -.69236[.492] |
| UHAT4(-2) | .052837     | .14945         | .35355[.725]  |
| UHAT4(-3) | .048071     | .14774         | .32538[.746]  |
| UHAT4(-4) | -.19346     | .14993         | -1.2904[.204] |

\*\*\*\*\*

|                            |          |                            |              |
|----------------------------|----------|----------------------------|--------------|
| R-Squared                  | .063085  | R-Bar-Squared              | -.12430      |
| S.E. of Regression         | .0091914 | F-stat. F(9, 45)           | .33666[.958] |
| Mean of Dependent Variable | .3489E-3 | S.D. of Dependent Variable | .0086685     |
| Residual Sum of Squares    | .0038017 | Equation Log-likelihood    | 185.3985     |
| Akaike Info. Criterion     | 175.3985 | Schwarz Bayesian Criterion | 165.3619     |
| DW-statistic               | 1.9777   |                            |              |

\*\*\*\*\*

#### Diagnostic Tests

\*\*\*\*\*

| Test Statistics      | LM Version             | F Version               |
|----------------------|------------------------|-------------------------|
| A:Serial Correlation | CHSQ(4) = 2.1337[.711] | F(4, 41) = .41369[.798] |
| B:Functional Form    | CHSQ(1) = .31336[.576] | F(1,44) = .25213[.618]  |
| C:Normality          | CHSQ(2) = 1.3086[.520] | Not applicable          |
| D:Heteroscedasticity | CHSQ(1) = 1.4111[.235] | F(1, 53) = 1.3956[.243] |

\*\*\*\*\*

- A:Lagrange multiplier test of residual serial correlation
- B:Ramsey's RESET test using the square of the fitted values
- C:Based on a test of skewness and kurtosis of residuals
- D:Based on the regression of squared residuals on squared fitted values

#### BG statistics

$$BG = nR^2 \underset{asy}{\overset{H_0}{\sim}} \chi^2_{(p)} = 55 * 0.063085 = 3.470$$

95% critical value for  $\chi^2_{(4)} = 9.48773$

## APPENDIX TWO

### Remedial response to Autocorrelation

C

## APPENDIX TWO: Remedial response to Autocorrelation

- Re-estimate the beef and veal equation with EGLS. This is done by transforming the beef and veal equation by applying the filter  $(1 - \rho L)$  where  $L^i Z_t = Z_{t-i}$
- The estimates  $\rho$  can be obtained from Cochrane-Orcutt method.

**Table A2.1** Test of Serial Correlation of Residuals (OLS case)

```

*****
Dependent variable is DWBVDS11
List of variables in OLS regression:
CONS      DLPBVDS1  DLPLMDS1  DLPPMDS1  DLPPYDS1
DRMTDS
59 observations used for estimation from 1985Q4 to 2000Q2
*****
Regressor      Coefficient   Standard Error   T-Ratio[Prob]
OLS RES(- 1)   -.50928       .14453           -3.5236[.001]
OLS RES(- 2)   -.42959       .15729           -2.7312[.008]
OLS RES(- 3)   -.25970       .16168           -1.6062[.114]
OLS RES(- 4)   .078995      .16637           .47481[.637]
*****
Lagrange Multiplier Statistic      CHSQ(4) = 16.0230[.003]
F Statistic                          F(4,49) = 4.5671[.003]
*****

```

**Table A2.2** Cochrane-Orcutt Method AR(2) converged after 3 iterations

```

*****
Dependent variable is DWBVDS11
59 observations used for estimation from 1985Q4 to 2000Q2
*****
Regressor      Coefficient   Standard Error   T-Ratio[Prob]
CONS           -.0011692    .0015597        -.74963[.457]
DLPBVDS1      .0071465    .077165         .092612[.927]
DLPLMDS1      .035966     .087030         .41326[.681]
DLPPMDS1      -.050665    .10420         -.48621[.629]
DLPPYDS1      .22230     .11748         1.8923[.064]
DRMTDS        .19651     .032600        6.0279[.000]
*****
R-Squared          .62491  R-Bar-Squared      .57133
S.E. of Regression .018280  F-stat.  F(7, 49)      11.6623[.000]
Mean of Dependent Variable -.5299E-3  S.D. of Dependent Variable .027509
Residual Sum of Squares .016373  Equation Log-likelihood 151.5422
Akaike Info. Criterion 143.5422  Schwarz Bayesian Criterion 135.2321
DW-statistic      2.2103
*****

```

### Parameters of the Autoregressive Error Specification

```

*****
U= -.44314*U(-1) + -.35435*U(-2)+E
   (-3.2696)[.002] (-2.5777)[.013]
T-ratio(s) based on asymptotic standard errors in brackets
*****

```

$DWBVDS11C = DWBVS11 - (-.44314) * DWBVS11(-1) - (-.35435) * DWBVS11(-2);$   
 $CONSC = CONS - (-0.44314) - (-0.35435);$   
 $DLPBVDS1C = DLPBVDS1 - (-.44314) * DLPBVDS1(-1) - (-.35435) * DLPBVDS1(-2);$   
 $DLPLMDS1C = DLPLMDS1 - (-.44314) * DLPLMDS1(-1) - (-.35435) * DLPLMDS1(-2);$   
 $DLPPMDS1C = DLPPMDS1 - (-.44314) * DLPPMDS1(-1) - (-.35435) * DLPPMDS1(-2);$   
 $DLPPYDS1C = DLPPYDS1 - (-.44314) * DLPPYDS1(-1) - (-.35435) * DLPPYDS1(-2);$   
 $DRMTDSC = DRMTDS - (-.44314) * DRMTDS(-1) - (-.35435) * DRMTDS(-2);$

**Table A2.3** Ordinary Least Squares Estimation (All variables are corrected for autocorrelation)

\*\*\*\*\*

Dependent variable is DWBVDS11C

57 observations used for estimation from 1986Q2 to 2000Q2

\*\*\*\*\*

| Regressor | Coefficient | Standard Error | T-Ratio[Prob] |
|-----------|-------------|----------------|---------------|
| CONSC     | -.0011692   | .0015287       | -.76486[.448] |
| DLPBVDS1C | .0071464    | .075034        | .095242[.924] |
| DLPLMDS1C | .035966     | .084807        | .42409[.673]  |
| DLPPMDS1C | -.050665    | .10157         | -.49884[.620] |
| DLPPYDS1C | .22230      | .11448         | 1.9418[.058]  |
| DRMTDSC   | .19651      | .031569        | 6.2247[.000]  |

\*\*\*\*\*

|                            |           |                            |              |
|----------------------------|-----------|----------------------------|--------------|
| R-Squared                  | .45015    | R-Bar-Squared              | .39624       |
| S.E. of Regression         | .017918   | F-stat. F(5,51)            | 8.3505[.000] |
| Mean of Dependent Variable | -.6940E-3 | S.D. of Dependent Variable | .023060      |
| Residual Sum of Squares    | .016373   | Equation Log-likelihood    | 151.5422     |
| Akaike Info. Criterion     | 145.5422  | Schwarz Bayesian Criterion | 139.4131     |
| DW-statistic               | 2.2103    |                            |              |

\*\*\*\*\*

Diagnostic Tests

\*\*\*\*\*

| Test Statistics      | LM Version             | F Version               |
|----------------------|------------------------|-------------------------|
| A:Serial Correlation | CHSQ(4) = 6.7223[.151] | F(4,47) = 1.5710[.198]  |
| B:Functional Form    | CHSQ(1) = .24446[.621] | F(1,50) = .21536[.645]  |
| C:Normality          | CHSQ(2) = 2.7590[.252] | Not applicable          |
| D:Heteroscedasticity | CHSQ(1) = 1.6892[.194] | F(1, 55) = 1.6798[.200] |

\*\*\*\*\*

A:Lagrange multiplier test of residual serial correlation

B:Ramsey's RESET test using the square of the fitted values

C:Based on a test of skewness and kurtosis of residuals

D:Based on the regression of squared residuals on squared fitted values

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