Chapter 1

BACKGROUND AND OBJECTIVES

1.1 Introduction

Beef cattle producers make production decisions under uncertainty. Imperfect knowledge of prices and climatic conditions, especially, introduce risk into the decision making environment of farmers. The physical environment as it affects beef cattle production and the relative profitability of alternative enterprises is different between regions in New South Wales. Beef cattle production is not a dominant agricultural industry in any region. The industry must compete for available production resources with other industries such as grain, sheep and dairy production. The mix of farm enterprises tends to differ between regions, depending on soils, topography, temperature and length of growing season. However, while the physical environment is important, changes in the economic environment due to changes in market conditions, technology, technical competence of farmers and attitudes of farmers to risk are likely to affect the relative profitability of alternative farm enterprises. Changes in the structure of rural industries in each region may then be observed.

This study is concerned with inventory response in the cow and heifer portions of the beef herds in the regions of New South Wales. Cow and heifer inventory is of interest because of its dual role as either direct slaughter animals or producers (i.e. breeders) of future slaughter animals. Farmers' decisions whether to commit female beef cattle for slaughter or to keep them in the breeding herd affects the level of production in the longer term. Farmers may modify production decisions in response to changes in the level of uncertainty about expected profits. In other words, output may respond to changes in risk; an aspect of the farmers' decision making environment which is often ignored in econometric studies in the livestock sector.

A description of the environment in which New South Wales' farmers make decisions is contained in this chapter. An hypothesis is also presented based on knowledge of the physical environment and economic theory concerning resource allocation by farm firms. Other studies are reviewed which contribute to our understanding of the problem of low and unstable incomes in the beef cattle and related industries. An outline of the remainder of the thesis is presented in the final section.

1.2 Characteristics of Beef Cattle Production

In this section, the nature of the beef industry and its relationship to other farm enterprises in New South Wales are discussed.

1.2.1 Geographical features of New South Wales

New South Wales covers an area of 0.80 million square kilometres, including 0.66 million square kilometres of rural holdings. The State lies between latitudes 29^{o}S and 38^{o}S and between longitudes 141^{o}E and 154^{o}E. The topography of the land changes from a narrow belt of coastal plains in the east of the State, through tableland plateaux and slopes, to inland plains to the west. The latter landform covers at least one half of the State.

The northern one third of the State receives its rainfall in the summer, whilst the central and southern regions receive rain in winter. Both the amount of rainfall and its reliability are greatest in the coastal regions and decreases across the State from east to west. The average annual rainfall ranges between approximately 750 to 1500 millimetres in the coastal regions, 250 to 1000 millimetres in tablelands regions, 250 to 750 millimetres on the slopes, and zero to 750 millimetres on the plains.

The soil types in New South Wales range from poorer sandstone, schist, shale, podsolic and granite soils to fertile alluvial and basaltic and clay loam soils (e.g. Whittet, 1969). In the main, the State's soil is fertile but is often deficient in phosphorous and nitrogen. Davidson (1967) points out that this deficiency "... is greatest where rainfall is heaviest (i.e. regions with the longest growing season)". The combination of soil-type, rainfall and length of growing season has resulted in pastures that rely on native and naturalized pasture species in the northern regions of the State; larger areas of improved pastures are more prevalent in the Southern regions (e.g. Whittet p.9).

1.2.2 Systems of beef cattle production

There is a high degree of specialization in the State's agriculture due largely to the high ratio of land to labour used (e.g. Davidson, p.29). The environmental factors associated with landuse influence the mix of farm enterprises found throughout New South Wales. Different systems of beef cattle production are also found.

Beef production and dairying are two of the major enterprises on holdings in the Coastal region. Other major agricultural activities are sugar, banana and maize production in the north, and other fruit, vegetable and grain production at various locations scattered throughout the region. As is the case elsewhere in the State, the location of cropping activities depends on the availability of special soil types, in particular, and moisture, temperature and day length. The dominant agricultural activities in the Tablelands regions are beef cattle, wool and sheep meat production. In the Slopes and Plains regions, cattle, sheep and wheat compete for the available land resources. In general, the importance of meat and grains production is greater on the Slopes than on the Plains. Wool production is the dominant activity in the Plains region.

The Bureau of Agricultural Economics (1976a) identified four main beef cattle production systems based on grazing:

(i) breeding and fattening vealers - turn-off of fat young cattle for slaughter of either sex within an age range of six to twelve months;

(ii) breeding and fattening older cattle - turn-off of fat cattle for slaughter aged one year and older (i.e. yearlings, steers and bullocks);

(iii) breeding and selling store cattle - turn-off of cattle that require further fattening, and possibly growing, before slaughter; and

(iv) purchasing of store cattle for fattening - young cattle are purchased and fattened, generally within a twelve month period and turned off for slaughter aged one to two years.

A fifth system, "other", consists of systems which are in a developmental or transitional stage, or are uncommon, or where no one system is dominant. Selected results of a survey undertaken by the Bureau of Agricultural Economics (BAE) in the three-year period 1968-69 to 1970-71 are drawn upon in the following discussion.

The results of the BAE survey indicate that the largest number of beef cattle in New South Wales are in the Slopes regions. The Tablelands regions have a larger population than the Coast; whilst the Plains region has a relatively small population. The largest numbers of cattle in the "breed vealers", "breed fats" and "fatten stores" productions systems are located in the Slopes regions. The Tablelands regions contain the largest number of the beef cattle in the "breed stores" system.

The main systems of beef cattle production in the Coastal region are the breeding of store weaners, with some fattening of bullocks. Store weaners are often sold for fattening in other regions, usually to the south and inland (including Victoria). The breeding and fattening of older cattle comprised 25% of beef cattle numbers in either specialist beef cattle enterprises or enterprises in which the producer was also engaged in off-farm activities during 1968-1969 to 1970-1971. The breeding of vealers is also an important component of the beef industry in the Coastal region; often in conjunction with dairying. Dairy production was the principal enterprise associated with the "other" beef cattle system which accounted for 31% of beef cattle numbers in the region. Since the 1950s, dairying has been concentrated in fertile, alluvial areas along the lower valleys of the rivers of the coastal plains. Beef production is mainly confined to the less fertile, hilly areas of the Coast.

Almost 90% of beef cattle producers surveyed in the Tablelands regions were in the "breed vealers", "breed fats" and "other" systems. The principal enterprise engaged by these producers was sheep production. These systems accounted for 80% of beef cattle numbers in the Tablelands. The results for the South East Queensland region indicate that the breeding and fattening of older cattle is the most important beef production system. Whilst the emphasis is the same in the North Eastern Victoria, the "breed vealers" system was also important since it contained 25% of the cattle compared to 32% in the "breed fats" system. Therefore it is evident that cattle are able to be turned off for slaughter at a younger age in the southern areas of the Tablelands than in the Northern Tablelands where the availability of pasture feed is limiting in winter.

In the Slopes regions, the breeding and fattening of older cattle is the most important beef cattle production system. The BAE found that 57% of the cattle numbers and 47% of beef producers were in the "breed fats" system. The beef enterprise in the Slopes regions was commonly undertaken in conjuction with sheep and cereals enterprises. The characteristics of the bordering regions to the north and south of the Slopes indicate that the northern slopes region is less suited for the turn-off of younger fat cattle. The dominant beef enterprise in the Inland South region of Queensland was breeding and selling of store cattle system. In the northern regions of Victoria, the "breed fats" and "breed vealers" systems were dominant. The reason for the difference between the northern and southern regions appears to be related to the seasonality of rainfall and the availability of suitable pasture species for cattle fattening activities. The combination of winter rainfall and more suitable pasture species in the Southern regions enhances the opportunity to turn-off fat cattle at a younger age. Furthermore, there is often a winter-spring feed shortage in the Northern regions due to the lack of winter rainfall.

Sheep production is the principal enterprise on farms in the Plains region in New South Wales. However, within the beef enterprise in the region the breeding of younger fat cattle appears to be the most important system. As is the case with the other regions in the State, cattle are likely to be turned off for slaughter at a younger age in the south than in the north. This is indicated by the BAE survey results which show that the dominant specialist beef system in the Western region of Queensland was the "breed fats" system whilst in North Western Victoria, both the "breed fats" and "breed vealers" systems were the most important systems.

1.3 Problem and Objectives

In this section the problems of low and unstable incomes of beef industry participants such as farmers and meat processors and the impacts on other sections of society are discussed. It is suggested that variations in beef supply partly destabilize incomes in the beef sector. Since this study is concerned with inventory response in the female portion of the beef herds in New South Wales, the significance of the inventory of female beef cattle on production is discussed. An hypothesis is proposed for empirical analysis in subsequent chapters of this thesis.

1.3.1 The income problem

The dual problems of low and unstable incomes at the farm level in the Australian beef industry has received considerable attention in recent years (e.g. BAE 1975a , 1975b, 1979; KRAU 1978a, 1978b). Low incomes are regarded as a problem because of the effects on the welfare of some beef producers, their families and members of communities providing services to farmers, and the restrictions imposed on economic growth. The BAE (1976b, pp. 22-3) points out that low-income farm families have less scope for reducing consumption in times of downward fluctuations in farm income. As well "... traditional and expected standards of living would ... be lower" (p. 23) among these families. Mandeville and Powell (1976) and the BAE

(1974) indentified relationships between farm incomes and incomes in rural towns. Low and unstable incomes on farms in a region may adversely affect the output, personal income, employment and investment in the region as a whole (e.g. BAE 1976b, p.19; Davis et al. 1979; Lloyd 1978, pp2.8-2.9).

Income instability may lead to a misallocation of resources by those affected by the problem (e.g. BAE 1975a, p.72; BAE 1976b, pp.20-21; Lloyd pp.2.5-2.9). The planning of savings, borrowings, investment and dis-investment usually takes place within an unpredictable environment. Consequently groups such as farmers, farm-input suppliers and meat processors may over- or under-invest in capital items. Over-investment may occur in high income years when perceptions about long-term profitability are likely to be highest. The rate of discount of future profits may be increased by investment planners during low income years leading to under-investment. For example, there was a significant transfer of resources out of sheep and dairy cattle into beef cattle in the early 1970s in New South Wales and other States in response to apparently more favourable prospects for beef (BAE 1975a). In 1974-75, beef cattle prices and incomes fell sharply. During the 1970s, the Industries Assistance Commission (IAC 1975) was instructed to inquire into the question of short-term assistance for beef cattle producers and the Prices Justification Tribunal (PJT 1978) examined the proposition that some of the profits accruing to beef marketing and processing firms between the farm gate and retail levels reduced returns of beef cattle producers. During the low income years of the mid 1970s, it is likely that under-investment occurred, particularly in relation to maintenance of existing capital equipment and livestock (Heffernan 1978). The processing sector provides another example of over-investment in capital items. A number of abattoirs were constructed in New South Wales in the 1950s resulting in some overcapacity (PJT, p.46). The problem was particularly acute in 1981 (AMLC 1981).

1.3.2 Income stabilization

Variations in the prices and quantities of beef cattle sold by farmers cause instability in revenue. Much attention has been directed at the inadequacies of price stabilization and support schemes as a means of stabilizing incomes.[1] Similarly supply control schemes would be inadequate

1. Whilst this is the considered case in the Australian beef industry, other authors provide evidence in support of intervention elsewhere (e.g. Blandford and Currie 1975; Hazell and Scandizzo 1975).

and undesirable (e.g. BAE 1979; IAC; KRAU 1978a, 1978b; PJT). Instead, it is argued that the provision and use of more accurate information on market prices, quantities, trends and developments is an efficient means of managing price and income variability (e.g. Freebairn 1976, 1978; Harris et al. 1974; KRAU 1978a; Lloyd). Information on the structure of supply and demand is important in the generation of forecasts of future market prices and quantities and in the evaluation of proposals for government intervention in the market place. For example, Piggott (1978) found evidence that both supply and demand were significant contributors to the variance of quarterly saleyard revenues in the Australian beef industry. He concluded "... against market interference to stabilize beef prices (because,) ... with volatile supply and demand, the intervention authority would surely require substantial foresight and an atypical run of good fortune for longevity" (p.156). The Bureau of Agricultural Economics depends increasingly on econometric models of Australia's agricultural commodity markets, including the beef market, in its forecasting and policy work (e.g. Kingma et al. 1980).

1.3.3 Importance of inventory response study

In this thesis, the focus of attention is on the supply side of the beef cattle sector. Beef cattle producers require information on future prices to assist in their planning of future production. This information is provided by both public and private organizations. A basic requirement of these forecasting agencies is quantitative knowledge of relationships between factors affecting beef cattle production. Information on future supplies of beef cattle are required by meat processors and exporters. Processors use estimates of cattle numbers when making long-term investment decisions relating to buildings, equipment and workforce skills. Exporters and government authorities engaging in trade negotiations require estimates of beef supplies in future months, and possibly years, in order to determine shipping requirements, prices and hedging opportunities.

In a critique of econometric models of the agricultural sector, King (1975) includes the treatment of inventories in the livestock sector and the use of risk variables as important developments in supply response studies. In the beef industry, the inventory of beef cattle is defined as the stocks from which animals are slaughtered for consumption. The biological nature of beef cattle production means that there is a lag between the time of planning to increase the numbers of cattle for slaughter and actual slaughterings. This lag ranges from one year in the case of calf slaughterings to more than two years in the case of older cattle. As well as being conditioned by the age composition, the potential level of slaughterings is conditioned by the sex composition of the inventory.

The female portion of a beef cattle herd is particularly important. The action of withholding females from slaughter reduces beef production in the short term. The use of these cattle to produce a calf which is then 'grown out', fattened and slaughtered increases beef production in the longer term. Knowledge of changes in the female portion of the beef herd is important in understanding the structure of the industry and in forecasting (e.g. Weeks and Reynolds 1981). Ehrich (1966, p.25) suggests that incremental increases or decreases in the size of the breeding herd signal changes in the rate of planned production, and alter future prices because of changes in realized production. Inventory relationships such as models of female inventory "... describe the behaviour of producers in response to economic stimuli, describe the path of response, and provide estimates that can be used to predict future changes" (Ehrich, p.14).[2]

1.3.4 Importance of risk variables in econometric models

Imperfect knowledge of future profits necessitates farmer decision making on the basis of 'expected' output prices, yields and costs (e.g. Anderson, Dillon and Hardaker 1977; Hildreth 1977). Farmers may modify production decisions in response to changes in the level of uncertainty about expected profits (e.g. Blandford and Currie; Sandmo 1971; Turnovsky 1973). In other words, output may respond to changes in risk; an aspect of the farmers' decision making environment which is often ignored in econometric studies in the livestock sector.[3] An exception is an econometric

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2. Inventory response in the male portion of the beef cattle herd is not studied in this thesis. Whilst such investigation should contribute to knowledge of the factors affecting beef supply, some limits to the scope of the study in hand had to be set. Thus emphasis is placed on female beef cattle based on the assumption that changes in female numbers have a greater impact than changes in male numbers on annual beef production in New South Wales.

3. It is useful at this stage to make some distinction between 'uncertainty' and 'risk'. Here uncertainty is defined as occuring as a result of the (unknown) difference between 'expected' and 'actual' values of a variable in a given period. In other words, decision makers in aggregate are uncertain that their expectations of some future event will be realized. Some function of the difference between the values of 'expected' and 'actual' observations on the event is defined as a measure of risk.

study of the cattle and sheep sectors of New South Wales by Freebairn (1973). He found evidence "... that cattle producers as an aggregate are risk averters" (p.66). An implication of this result is that "... the introduction of uncertainty causes a reduction in (beef cattle) output" (Miller and Romeo 1979, p.202). This is consistent with received economic theory and other quantitative studies which support the assumption that, in reality, farmer behaviour is better represented by the maximization of some utility function rather than some neoclassical profit function (e.g. Lin et al. 1974; Markowitz 1959; Officer and Halter 1968). Indeed, a utility function for farmers is likely to contain a profit function (e.g. Miller and Romeo; Just 1975a).

Just (1974a, 1974b, 1975b) provides two specific reasons why risk variables should be included in positive response studies. The first relates to deficiencies in an alternative approach, the Nerlovian adaptive expectations model. The second relates to policy evaluation.

Numerous studies in livestock supply response have employed the Nerlove (1958) 'adaptive expectations model' (e.g. Askari and Cummings 1976, 1977; Nerlove 1979):

$$(1.1) \quad P^*_t - P^*_{t-1} = \theta(P_{t-1} - P^*_{t-1}), \quad 0<\theta<1$$

$$(1.2) \quad Q_t = a_o + a_1 P^*_t + u_t$$

where

P^*_t = expected 'normal' price in period t;
P_{t-1} = actual price in period t-1;
Q_t = quantity supplied in period t;
θ = constant of proportionality called the 'coefficient of expectation'.

Equation (1.2) is equivalent to the proposition that "... farmers revise their previous expectations of 'normal' price in each period in proportion to the difference between actual price and what was previously considered to be 'normal'" (Nerlove 1958, pp.231-2). Nerlove shows that equations (1.1) and (1.2) may be manipulated to provide the so-called Nerlovian model,

$$(1.3) \quad Q_t = a_o + a_1 \theta \sum_{k=0}^{\infty} (1-\theta)^k P_{t-k-1} + u_t$$

or its reduced form,

$$(1.4) \quad Q_t = a_o\theta + (1-\theta)Q_{t-1} + a_1\theta P_{t-1} + u_t - (1-\theta)u_{t-1}$$

The Nerlovian model enables the explicit consideration of price uncertainty. If the coefficient of expectation, θ , is unity, then there is no uncertainty surrounding the expected value of price in period $t(P_t)$ as it is identical to the actual price in the previous period (P_{t-1}). As θ approaches zero, expected prices become less related to actual prices in the past.

Although the Nerlovian model is concerned with measuring decision makers' subjective evaluation of the <u>means</u> of uncertain variables, one form of the model implicitly incorporates the real phenomenon of chance <u>variation</u> in decision variables. In his work, Just often obtained good fit with the reduced forms of the standard Nerlovian model (such as equation (1.4)) and a special case of the so-called 'adaptive risk model'. The general form of the adaptive risk model may be written as

$$(1.5) \qquad Q_t = a_o + a_1 P_t^* + a_2 W_t^* + u_t$$

where

$$P_t^* = \theta \sum_{k=0}^{\infty} (1-\theta)^k P_{t-k-1}$$

= decision makers subjective evaluation of price in period t;

$$W_t^* = \phi \sum_{k=0}^{\infty} (1-\phi)^k (P_{t-k-1} - P_{t-k-1}^*)^2$$

= decision makers' subjective evaluation of price variance (risk) in period t;

and $0<\phi<1$ is an expectations parameter which may well differ from $0<\theta<1$. (Equation (1.5) is simply the structural form of the Nerlovian model extended to include an expression for subjective risk.)

In the case where $\phi = \theta$, the reduced form of the adaptive risk model would be

$$(1.6) \qquad Q_t = a_o\theta + (1-\theta)Q_{t-1} + a_1\theta P_{t-1} + a_2\left(P_{t-1} - \theta\sum_{j=0}^{\infty}(1-\theta)^j P_{t-j-2}\right)^2 + u_t - (1-\theta)u_{t-1}$$

Just contends that the reason for the similarity between results obtained using equations (1.4) and (1.6) is that the term $(1-\theta)Q_{t-1}$ in the latter model

> "... additionally carries some of the effects of variation in subjective risk. Moreover, when θ is close to zero ..., almost all the effects of changing subjective risk may enter through $(1-\theta)Q_{t-1}$. Hence, one might be able to

> obtain results that appear to be quite satisfactory by estimating the standard Nerlovian model in its reduced form when in actuality, much of the real explanation is lost with the exclusion of risk." (Just 1974a, p.24)

He suggests that one should "... exercise caution in interpreting reduced-form estimation results for the standard Nerlovian model." (p.25)

Just (1975b) questions the validity of models, used to evaluate policies that may have significant impacts on agricultural risk, which do not recognise the possible response to changing price (and yield) risk. There are no policies aimed directly at incomes and prices in the beef cattle sectors in New South Wales or, for that matter, other Australian States. However, from time to time, intervention has been suggested and evaluated as discussed earlier. Lin (1977) argues that "... (an) important application of risk response studies is to assess the distribution of welfare gains and losses from stabilization" (p.906). However, such assessment is difficult (e.g. Anderson, Hazell and Scandizzo 1977).

1.3.5. Objectives and hypothesis

It is suggested above that the behaviour of farmers to changes in their economic environment may lead to undesirably low and unstable incomes from beef production. More accurate information on the causes and effects of changes in prices and quantities is needed to assist industry participants such as farmers, meat processors and exporters in making production and marketing decisions. Policy makers require similar information to assist in the formulation and evaluation of policies such as price and income stabilization schemes. As discussed in section 1.3.3, the explanation of variations in the numbers of female beef cattle would contribute to knowledge on the causes of low and unstable incomes among beef industry participants.

The major aim of this study is to develop and empirically estimate a model to explain variations in the numbers of female beef cattle in New South Wales. Emphasis is placed on the significance of risk variables. Few studies have considered the responsiveness of livestock industry outputs to changes in farmers' subjective evaluations of risk. Those which have incorporated risk variables include the work of Freebairn, as already mentioned, Freebairn and Rausser (1975) and Reeves (1980). A number of studies have been concerned with response to risk in annual crop industries (e.g. Behrman 1966, 1968; Just 1974a, 1974b, 1976; Fletcher and Gellatly 1977; Ryan 1977; Traill 1978; Prosser 1980; Wilson et al. 1980; Brennan 1981); but these industries are not characterized by dynamically complex production processes such as found in the livestock sector. Fleming (1982) considered risk in a study of the supply response of a perennial crop.

Response to changing risk is more likely to be significant in empirical work if relatively disaggregated units are studied. Just (1975b) suggests two reasons for this situation. Firstly, the more narrow the class of competing decision variables, the less is the likelihood that the losses incurred from one risky project are offset by gains from an alternative risky project. For example, if farmers are risk averse and diversification of farm enterprises is possible, then total returns are likely to be less variable (e.g. Tobin 1965). Consequently, response to changes in risk may not be observable. The second reason for disaggregation relates to 'noise' in risk terms. Just shows how aggregation of response functions "... introduces noise in the aggregate risk term which prevents accurate estimation of risk coefficients and biases the associated statistics towards insignificance." (p.841)

It is hypothesized that the annual inventory of female beef cattle in the regions of New South Wales is affected by farmers' subjective evaluations of prices and risks of both beef cattle and alternative enterprises; and other shift variables such as the inventory in the previous year and pastoral conditions. As discussed previously, the set of variables which is important in determining inventories of female beef cattle is not the same for all regions. Jarvis (1974) points out that input costs are not equal among beef producing regions in Argentina. Beef cattle breeding usually takes place in regions "... where the opportunity cost of feeding is cheap" (Jarvis, p.505). More efficient management practices would be required in regions with more favourable physical environments in order to make breeding more competitive with alternatives enterprises including beef cattle fattening. Similarly, there are variations in the physical environment and the systems of beef cattle production throughout New South Wales. Consequently, the influence of the explanatory variables is likely to differ among the regions.

It is expected that response to changing risk will be significant in the regions where the beef breeding enterprise is dominant. This follows Just's argument that response to changing risk is likely to be significant if the class of competing decision variables is small. Therefore, if diversification of farm enterprises is possible, then changes in the riskiness of beef breeding may not cause farmers to adjust inventory.

The study of female cattle inventory at the regional rather than State level should provide more information on the structure of the beef industry. A secondary objective of this study is to compare estimates of inventory response for the State provided by the aggregation of results from the regional model with those obtained from estimating a similar model of the State as a whole.

1.4 Other Studies

1.4.1 Cattle inventory response studies

A number of studies have been concerned with the nature of the underlying structural factors which are expected to influence beef cattle inventory. A selection of these studies have been discussed by, for example, Askari and Cummings (1976), Bain (1977), and Reeves et al. (1980). A summary of a (not exhaustive) survey of relevant studies undertaken within the last two decades is tabulated in Appendix 1. The Australian studies referred to are Powell and Gruen (1967), White (1972), Davidson (1973), Freebairn (1973), Riggs (1973), Throsby (1974), Longmire and Main (1978), Harris (1979), Reeves (1980), and Reeves et al. (1980). Reutlinger (1966), Crom (1970), Kulshreshtha and Fisher (1972), Tryfos (1974), Freebairn and Rausser (1975), Kulshreshtha (1976), Bain (1977), and Martin and Haack (1977) are concerned with various aspects of the Northern American beef cattle sector. Lattimore and Schuh (1979) study the Brazilian sector; Jarvis (1974) is concerned with Argentina; Rich (1979) studies the sector in New Zealand; whilst Jones (1965) and Evans (1971) model aspects of the U.K. cattle sector. Some of these studies use (either in part or in full) quarterly and biannual data time series and are henceforth ignored.

Typically, inventories are modelled as a system of identities within a multi-equation modelling framework. The behavioural decisions are slaughterings and natural increase and these correspond with decisions about inventory. Sometimes, however, stochastic equations explaining inventories are estimated. Generally, the equations specified to explain variations in the annual inventory of breeding cows have, as independent variables, the dependent variable lagged one year, expected prices of beef and alternative commodities,[4] and other shift variables peculiar to the local industry such as weather conditions, level of technology, and feed grain supplies. Variance of beef prices was included by Freebairn, Freebairn and Rausser, and Reeves.

Generally, inventory of calves has been expressed as a function of the previous year's inventory of adult female cattle, prices of beef, and occasionally (depending on the country) other shift variables such as the previous year's inventory of calves, prices of alternative outputs, feed grain prices and output, calf prices and slaughterings, and weather.

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4. Expected price is typically defined as actual price in the current or some past period, or as some function of these prices.

The favoured specification of slaughterings of adult female cattle has tended to include variables for the previous year's inventory of adult female cattle, beef prices (either actual or expected) and prices of alternative outputs (either actual or expected), feed grain prices (e.g. North America) and weather conditions (e.g. Australia and Argentina).

1.4.2 Risk response studies

Studies incorporating farmers' subjective evaluations of risk in output response in recent literature employ a variety of formulations of the risk variable. Risk has been defined as some moving standard deviation of past outcomes (i.e. prices or revenues) (e.g. Behrman 1966, 1968; Freebairn and Rausser; Traill; Prosser; Ryan; Brennan), or some function of the deviations between actual and expected outcomes (e.g. Just 1974a, 1974b, 1976, 1977; Fletcher and Gellatly; Trail; Prosser; Brennan; Harrison 1981; Fleming), or the range of outcomes over a finite period (e.g. Freebairn, Brennan), or some area of a moving probability distribution (e.g. Traill).

The alternative definitions of riskiness are indeed diverse. Economic theory does not provide any precise and firm indication of a formulation of risk. Behrman used the standard deviation of relative prices and yields of subsistence crops in Thailand based on the proposition that near-subsistence farmers are risk averse. Hence, the second central moments of the farmers' subjective probability distributions of relative prices and yields were arbitrarily incorporated in a Nerlovian-type structural supply response model. Brennan, Freebairn and Rausser, Prosser, and Traill experimented with alternative formulations of the risk variable. Neither Brennan nor Traill found a formulation which was clearly superior. However, Traill concluded that "...(the) definition based on deviations between actual and expected prices is theoretically more appealing than the approximation provided by the moving standard deviation definition..." (p.61). Freebairn and Rausser selected a three year moving standard deviation of current and historical prices as a measure of risk after appraisal involving "... a subjective weighting of consistency of signs and magnitudes of the estimated parameters, compared to a priori reasoning and previous studies, statistical significance of the estimates, and explanatory power of the estimated equations." (p.678) Prosser used a weighted three-year moving average standard deviation incorporating geometrically declining weights.

One possible formulation of risk is a 'weighted coefficient of variation' of past prices of the commodity. It is determined by dividing the m-period moving weighted standard deviation definition of risk by the m-period average price (e.g. Ryan, p.39). Ryan enriched the equation containing this specification of risk by including variations on a term which allows for interaction between the subject commodity and competing commodities. The interaction concerned is between the covariance of the prices of the subject commodity and competing commodities, the level of the subject commodity's prices and the variability of competing commodities' prices. Ryan derives specifications of the risk variables from "... a simple model of producer behaviour under uncertainty." (p.35) The model is based on a quadratic utility function reflecting valuation of the level and variance of expected profits for a decision maker who is assumed to be an expected utility maximizer.

Just developed the so-called 'adaptive risk model' in which decision makers' subjective evaluations of prices (or returns) and risk are defined by imposing geometrically declining weights on past means, variances and covariances of prices (or returns). The model is more general than others since it is "... based on a changing subjective knowledge of the economic environment in which the decision maker operates." (1974<u>b</u>, p.2.) Fletcher and Gellatly, Harrison and Fleming, employ Just's model. Moreover, it is employed in this thesis for reasons discussed further in Chapter 3.

1.5 Chapter Outline

A description of the biological and economic environments which are assumed to influence decisions concerning female beef cattle inventory is provided in the next chapter. It is assumed that the decision-making process can be represented by elements of EV portfolio analysis. A theoretical EV model is presented in section 2.3.1. Restrictions imposed on this model because certain data are not available are discussed in section 2.3.2.

In Chapter 3, the positive approach to economic analysis adopted in this thesis is outlined and discussed. The approach involves the specification of an econometric model which, among others, contains risk variables. The so-called adaptive risk model is discussed in more detail since it is used in the empirical analysis. Methods of estimating models incorporating risk variables are also presented.

A model which can be analysed empirically is developed in Chapter 4. The chapter is also concerned with a description of the data used in estimating coefficients in the model, interpretation of the model parameters, and expected results of the empirical estimation.

The results of the empirical analysis are presented and discussed in Chapter 5. The results are used to obtain estimates of elasticities of the inventories of female beef cattle in the various regions and the State.

The final chapter contains a summary and conclusions of the study. Suggestions for further research are also presented.

Chapter 2

RISK IN LIVESTOCK INVENTORY ANALYSIS

2.1 Introduction

Response to changing risk in the livestock sector has received little attention in the literature. A number of studies have been concerned with response to risk in annual crop industries but these industries are not characterized by dynamically complex production processes such as found in livestock industries. In this chapter, the dynamics of beef cattle production and the decision making environment of beef cattle producers are discussed. This provides the basis for the specification of a dynamic model to explain changes in the inventories of female beef cattle in the regions of New South Wales.

2.2 Dynamics of Beef Cattle Production

The inventory of female beef cattle at any point in time consists of animals for breeding, slaughtering, or 'growing out' purposes. At the end of some finite period, the female portion of the beef cattle herd consists of cows, heifers, and female calves (aged one year or less). Gains and losses to the total number of female cattle in the herd[5] during a period occur through purchases, sales, slaughterings, mortalities, births and net agistments.

An observation period of one year is a convenient length of time to consider changes in the size of the female herd. Young (1968a) found that bulls are paddocked with cows for approximately three months in commercial beef cattle herds in New South Wales. Add to this the length of the gestation period for cattle which is nine months. Further Young (1968b) reports that the most common joining age of heifers in the State is 24 to 27 months. This suggests that farmers make decisions about female cattle numbers annually because of the length of the in-built biological lags in cattle production.

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5. A 'herd' is the total number of cattle within a given area (e.g. farm, region, State).

Breeding cows and heifers are defined as those females which produce a calf in a given year. At the end of the year, the breeders either become the cows to be carried on into the next year, or animals to be culled for slaughter. Some may be kept in the herd, but not in-calf, for more than one year before slaughter; however, this is rarely likely to occur. The heifers in the herd may either maintain their status from one year to the next, or enter the breeding portion as replacement heifers or be culled for slaughter.

2.2.1 Biological relationships

A system of identities and biological relations provides the basis for the specification of economic relations which are hypothesized to explain variations in the numbers of female cattle. The identities equate the gains and losses to the total number of female cattle in year t through purchases, sales, slaughterings, mortalities, births and net agistments. Since the area units of study are the regions of New South Wales, then for any given region,

$$(2.1)\qquad IFC_t = IFC_{t-1} + SSFC_t + NAFC_t + CF_t$$

$$(2.2)\qquad SSFC_t = YFC_t - XFC_t - SFC_t - MFC_t$$

$$(2.3)\qquad NAFC_t = QFC_t - RFC_t$$

$$(2.4)\qquad CF_t = \Omega\delta\psi(IB_{t-1} + YB_t + QB_t)$$

where

IFC = closing number of all female beef cattle;

SSFC = annual number of purchases less sales, slaughterings and mortalities of all female beef cattle;

NAFC = net annual closing number of female beef cattle agisted in the region;

CF = number of female beef calves born per annum;

YFC = annual purchases of all female beef cattle;

XFC = annual sales of all female beef cattle;

SFC = annual slaughterings of all female beef cattle;

MFC = annual mortalities of all female beef cattle;

QFC = closing annual number of all female beef cattle agisted in the region plus the number returned to the region after being agisted out the previous year;

RFC = closing annual number of all female beef cattle agisted out of the region plus the numbers moved out of the region after being agisted in the previous year;

IB = closing annual number of beef breeding cows and heifers;

YB = annual purchases of beef breeding cows and heifers;

QB = closing annual number of beef breeding cows and heifers agisted in the region plus the number returned to the region after being agisted out the previous year;

Ω = proportion of calves born as females;

δ = birth rate of breeding cows and heifers;

ψ = proportion of breeders reaching parturition per annum before sale, agistment out of the region, slaughtering or death;

t = time period of length one year (denotes inventories at end of year t; for all other variables, the subscript denotes averages or totals during year t).

Equation (2.1) states that the closing inventory of female beef cattle in year t is the summation of the closing inventory in the previous year, the net gain or loss in numbers through purchases, sales, slaughterings and mortalities, (i.e. equation (2.2)), and the net gain or loss in numbers through agistment into or out of the region recorded at the close of year t (as represented by equation (2.3)). Equation (2.4) relates the numbers of calves born in year t to the numbers of breeding cows and heifers available from the opening inventory, purchases and 'agisted in' categories which are present in the region for at least nine months (i.e. the gestation period) after mating.

A number of constraints affect both the level and rate of change in annual cattle numbers. These constraints arise because of resource limitations and technical production factors and may be represented by farmers' production functions (e.g. Anderson, Dillon and Hardaker 1977; Dillon 1968). Those considered to be important in this study are calving rate, cow slaughter rate, heifer slaughter rate, female calf slaughter rate, breeding cow replacement rate, heifer growth rate, land availability, pasture resources and seasonal conditions. Clearly, the variables are not mutually exclusive. The relationships assumed to underlie this study are adapted from constraint functions used by Freebairn (1973, p.84).

Some of the above constraints have been either implicitly or explicitly imposed in equation (2.4). They are largely technical production factors influenced by the physical environment, genetics and disease. Calving rate (Ω) and the proportion of calves born as females (δ) are explicitly included as variables.

Constraints which limit the inventory of breeding cows and heifers among the total inventory of cows and heifers are breeding cow replacement rate and heifer growth rate; these are implicit in equation (2.4). Breeder replacement rate is influenced by the age distribution of the breeding herd and the length of breeding life. Heifer growth rate may be influenced by nutrition, health and breed.

Land availability is important in beef cattle production. It is a constraint which may limit the extent to which alternative enterprises, particularly cropping, can share other resources. Although land is not explicitly considered in this study, one of its components - pasture resources - provides the basis for the inclusion of other explanatory variables. The pasture resources which are available for utilization by livestock are assumed to be related to seasonal conditions and the area of improved pasture. Thus

$$(2.5)\quad PR_t = g(SI_t, IP_t)$$

where

PR = pasture resources in year t;

SI = seasonal conditions in year t;

IP = area of improved pastures in year t.

2.2.2 Economic aspects

The other constraints which are important in this study are the slaughtering rates of female beef cattle. These are largely economic decision variables. "If the value of a female as a breeding animal rises relative to its value as a slaughter animal, some females formerly destined for slaughter will be withheld, and vice versa." (Jarvis 1974, p.498) Therefore, a useful approach in cattle supply response study is to regard cattle as 'capital goods' and farmers as 'portfolio managers' (e.g. Colman 1978; Evans 1971; Hildreth and Jarrett 1955; Jarvis 1974; Nerlove 1979; Watson 1970). The female cattle herd is an example of a stock of capital or plant. Economic theory suggests that farmers' decisions to purchase or slaughter female cattle are the result of attempts to maximize some utility function. The amount of capital invested in livestock is a component of a farmer's investment 'portfolio'. Farmers are faced with the task of choosing a portfolio containing alternative farm enterprises and, probably, off-farm investments. To alter the amount of capital invested in any one enterprise, the farmer must select a new portfolio. Risk is also a salient feature of alternative farm-firm portfolios.

2.3 Inventory Planning Under Risk

To assume that farmers behave as utility maximizers is to accept the proposition that they seek to maximize the satisfaction (or utility) of the farm household, rather than seeking to maximize farm profits (e.g. Ritson 1977, p.87). The assumption of profit maximizing behaviour implies that farmers make decisions under conditions of zero risk. This is unrealistic.

2.3.1 EV portfolio analysis

In selecting a portfolio it is assumed that the farmer maximizes the expected utility of net present value of n risky prospects. Included among these prospects is a female beef cattle herd. It is assumed that the farmer's utility function is expressed in terms of the mean and variance of the stream of net cash flows from on-farm investments; that is, the utility function is quadratic.[6] Expressed algebraically, the farmer maximizes

$$(2.6) \qquad U = E\left[U(PV)\right]$$

where

U = farmer's expected utility;

E = expected value operator;

U(.) = utility function;

PV = net present value, i.e. discounted value of a stream of net cash flows

Following Anderson, Dillon and Hardaker, total present value depends on the set of projects adopted (from the set of n risky prospects which are available given some budget constraint). Now

$$(2.7) \qquad PV = \sum_{t=0}^{t} (PV)_t = \sum_{t=0}^{t} \sum_{i=n}^{t} C_{it} x_i \alpha^t$$

where

$(PV)_t$ = present value of the total cash flow occurring at time t;

C_{it} = net cash flow of the ith project in period t;

x_{i_t} = ith project in period t (= 0 implies the ith project is not undertaken);

α^t = discount factor per period.

Substituting equation (2.7) into (2.6),

6. Although the consideration of only the first two moments may be strongly criticized (e.g. Borch 1969; Feldstein 1969) an extension to higher moments is too cumbersome and may not be practical (e.g. Anderson, Dillon and Hardaker 1977; Just 1977; Samuelson 1967).

$$(2.8) \quad U = E\left[U\left(\sum_{t=0}^{T} \sum_{i=1}^{I} C_{it} x_i \alpha^t\right)\right]$$

Given the assumption of quadratic utility, analysis of equation (2.8) may proceed in terms of the first two moments of the probability distributions of PV conditional on the vector $(x_1, x_2, \ldots, x_I)$. This is often called (E,V) portfolio analysis where E is the mean of some portfolio of risky prospects, x, and V is the variance of x. In the problem at hand,

$$(2.9) \quad E = E(PV) = \sum_{t=0}^{T} \sum_{i=1}^{I} E(C_{it}) x_i \alpha^t$$

and

$$(2.10) \quad V = V(PV) = E\left[PV - E(PV)\right]^2$$
$$= \sum_{t=0}^{T} V\left((PV)_t\right) + 2\sum_{s=0}^{T-1} \sum_{t=s+1}^{T} \text{Cov}\left((PV)_s, (PV)_t\right)$$

where

$$V\left((PV)_t\right) = V\left(\sum_{i=1}^{I} C_{it} x_i \alpha^t\right)$$

The problem is to find both the set of values (C_{it}) that maximizes equation (2.8) and the set (i.e. portfolio) of risky prospects which is efficient. A portfolio is efficient if the set of adopted projects has maximum E(PV) for given V(PV) or minimum V(PV) for given E(PV).

2.3.2 Restrictions imposed in empirical study

Equation (2.10) takes account of the covariance between the cash flows of different periods. In beef cattle production, there are biologically determined lags greater than one year which are likely to lead to such covariances in annual models. Anderson, Dillon and Hardaker (p.260) suggest that the problem caused by this serial correlation can be overcome by working with the distribution of PV rather than the distribution of $(PV)_t$. Different approaches have been adopted in the literature to measure the stream of net cash flows or profitability of beef cattle enterprises. In general, the profit equations are included in theoretical decision models. The empirical models derived from the theoretical models and subsequently estimated include as explanatory variables those important uncertain economic parameters faced by farmers for which time series data are available; namely prices (e.g. Evans; Freebairn 1973; Jarvis; Nerlove 1979; Nerlove et al. 1979) or returns (e.g. Malcolm 1981). In this study, variations in cash flows are represented by observations on prices. This restriction is necessary due to lack of data on regional outputs of beef and input use. The implications of this assumption relate to the exclusion of variations in output and input costs to explain variations in inventory of female beef cattle. However, these variations are likely to be accounted for by the variables associated with pasture production and alternative enterprises, respectively. These variables are discussed in Chapter 4.

Most often, supply response studies rely on technological and institutional factors to induce lags (e.g. Just 1974b, p.2). The form of the distribution of the lag is most often determined in an ad hoc manner (e.g. Nerlove 1979). Just (1974a, 1974b, 1976, 1977) provides a model in which the lags in economic behaviour are based on the decision maker's behaviour. If technological and institutional factors are associated with the particular problem being studied, they can be combined with Just's model. This model, the so-called adaptive risk model, forms the basis for the specification of expected prices and price variances (risk) variables in this study. It is discussed in the next chapter.

Chapter 3

RESPONSE TO RISK: EMPIRICAL STUDY METHODS

3.1 Introduction

The rapid and widespread adoption of the Nerlovian adaptive expectations model as a tool in empirical agricultural supply response study is undeniable (e.g. Askari and Cummings 1976, 1977). However, its ad hoc nature is often criticized (e.g. Nerlove 1972, 1979; Wickens and Greenfield 1973). This criticism most often relates to the implicit assumption in the model of geometrically declining weights on lagged values of the explanatory variable (e.g. price). An area of criticism generally ignored is farmer reaction to risk. This deficiency was noted by Askari and Cummings (1977, p.261). An early attempt to provide some empirical measure of risk is the work of Reutlinger (1964) who noted "... that if the first moment of the (probability) distribution (of price) is important in explaining ... supply, then the higher moments of that distribution should also have explanatory power." (p.25). In this chapter, we review some of the methods of explicitly incorporating risk in empirical econometric models in the literature. In addition to the declining geometric lag scheme, other approaches have been adopted in specifying the distribution of weights on past mean values of explanatory variables. Similarly, there is no concensus regarding the specification of the distribution of lagged risk variables.

3.2 Positive Versus Normative Analyses

The technology of including response to risk in normative studies is well-documented. A useful list of references on mathematical programming modelling is provided by Anderson, Dillon and Hardaker (Ch.7). Normative risk response studies are largely confined to the microlevel such as individual farms (e.g. Just 1975b, p.838; Lin 1977, p.905). Hazell and Scandizzo (1974, 1977) have subsequently suggested and applied a linear programming approach which incorporates risk averse behaviour to study aggregate risk response. The aggregate supply function may be obtained by summing supply functions over all farms. The slow development of methodology for estimating aggregate utility functions is generally given as the major reason for the slow development of the normative approach (e.g. Just, p.839; Lin, p.905).

However, this slow development could be attributable to the difficulty of the problem or simply to lack of interest given past results. Shumway and Chang (1977) provide empirical evidence to challenge the conclusions of many normative (they prefer the term 'conditional predictive') studies: they argue that "... conditionally predictive supply relationships generally result in larger and more variable estimates of the direct elasticity and less accurate predictions of actual supply levels than positive supply equations."(p.356) These studies assume that farmers are risk neutral.

The methodology for estimating positive risk response models does not face the same problems as the normative approach. Just (1975b) suggests that the "... positive approach ... is more direct ... because information about (decision makers') objective criteria need not be specific and because the formulation of producers' subjective evaluation of risk need not be specified (completely) in advance."(p.839) As well, it is not necessary to explicitly specify the production function of the unit being investigated. Positive analysis "... operates directly upon the aggregate supply data which are the object of interest for projection purposes" (Colman 1978, p.16) or other objectives, such as explanation of industry structure and the calculation of elasticity estimates. Consequently, the task of collecting and manipulating data for estimation purposes is likely to be less arduous. Of course, the last point presupposes that records are kept on the phenomenon being studied. However, the positive approach is deficient, for example, when evaluating policies which introduce new variables or constraints for which historical data are not available (e.g. Just, p.841). It is also necessary to assume that the structural parameters remain unchanged during the sample period for evaluation of ex ante predictions and that this structure continues into the future for ex post analyses.

3.3 Risk Variables in Econometric Models

Economic theory does not provide any precise and firm definitions concerning measures of risk or attitudes to risk. Recent studies which consider response to changing risk in agriculture have adopted various approaches in specifying risk variables. These approaches are considered in this and the next section.

3.3.1 General model

Consider a simple model in which some quantity variable (Q_t), such as current inventory of female beef cattle, is a function of current price (P_t); that is,

$$(3.1) \qquad Q_t = a_o + a_1 P_t + u_t$$

where u_t is the disturbance term in period t. Equation (3.1) implies that quantity responds to changes in its own price within the same time period. In beef cattle production, this is unlikely to be the case if t represents a time period of less than one year. Rather the response is likely to be spread over time. This leads to the concept of the distributed lag. The general form of a distributed lag model with only lagged means of exogenous variables expresses the endogenous variable as a function of current and lagged exogenous variables. Thus equation (3.1) can be modified as

$$(3.2) \qquad Q_t = a_o + a_1 \sum_{i=0}^{\infty} \beta_i P_{t-i} + u_t.$$

Models which include decision-makers' subjective evaluation of the variances of exogenous variables permit response to changes in the perceived (normal) distribution of future values of these variables. This provides more information on decision-makers' behaviour than is the case in estimating response to a single parameter in that distribution, namely the expected value. An extension of equation (3.2) to account for decision-makers' subjective evaluation of risk is

$$(3.3) \qquad Q_t = a_o + a_1 P_t^* + a_2 W_t^* + u_t$$

where $P_t^* = \sum_{i=0}^{\infty} \beta_i P_{t-i}$

= decision-makers' subjective evaluation of the mean of price in period t;

W_t^* = decision-makers' subjective evaluation of price risk in period t.

Various specifications of P_t^* and W_t^* are outlined in sections 3.3.2 and 3.3.3, respectively.

3.3.2 Specifications of expected price

Expected price may be estimated by

(i) imposing no restriction on the distribution of coefficients on lagged values of the mean term; or

(ii) assuming that the weights can be approximated by some function.

By adopting schemes which make no assumption as to the form of the distributed lag, one hopes to determine the length of the lag from fitting a fairly long lag of the form $\sum_{i=o}^{\infty} \beta_i P_{t-i}$ and examining the significance of the coefficients of various lagged values of the price variable. This raises problems because economic time series are typically highly autocorrelated and, if the sample is small, long lags may leave very few degrees of freedom for the estimation process. In addition, results of estimated models similar in form to equation (3.2) are often erratic; and this is likely to be a characteristic of similar approaches to estimating equation (3.3). These problems make interpretation of the estimated model difficult.

Numerous schemes have been proposed for assigning values to the weights of lagged means of variables. A comprehensive discussion of such schemes is provided by Johnston (1972, Ch.10) and Koutsoyiannis (1973, Ch.13). Among these, the declining geometric lag scheme restricts the weights to the form of a declining geometric progression. The arithmetic progression is used in the declining arithmetic lag scheme. Equal weights are given to the lagged values of the explanatory variable for the rectangular scheme. In the 'inverted V' lag scheme, it is assumed that the weights are initially increasing at a constant rate, and subsequently declining at the same rate (e.g. De Leeuw 1962). The weights of the 'inverted V' lag scheme may be defined on the basis of the 'Pascal lag distribution' (Solow 1960). Under certain conditions, the Pascal lag distribution reduces to a geometric lag distribution (e.g. Koutsoyiannis p.307). Jorgenson (1966) generalized the Pascal lag model to provide the 'rational distributed lag model'. Almon (1965) has suggested a polynomial lag scheme for the specification of expected prices. The scheme assumes that weights can be approximated by a polynomial function of fairly low degree.

3.3.3 Specifications of risk variables

Various specifications of price risk have to be employed in published empirical studies. Freebairn (1973) and Brennan (1981) defined risk, or 'anticipated variability' in Freebairn's terms, as the moving range of prices in the current and immediate past two periods; that is, (3.4) $\quad W_t^* = \text{Range}(P_t, P_{t-1}, P_{t-2}).$

Freebairn noted that "... a more appropriate measure would be a variance estimate" (p.56) which indeed has been favoured in other studies.

While employing a different approach to the general model given by equation (3.3), Reutlinger (1964) defined risk as a function of the range of prices in the past. Reutlinger derived a so-called 'minimax' supply model "... based on the assumption that firms act as if they know the range of the price they are to receive for their product and proceed to minimize the maximum loss in net revenue as a result of uncertainty about the future."(p.12)

The standard deviation of past prices (or returns) as a measure of risk has been used by Reutlinger (1964), Behrman (1966, 1968), Freebairn and Rausser (1975), Ryan (1977), Traill (1978), Wilson et al. (1980) and Brennan (1981). For example, risk has been specified as:

(i) a moving standard deviation of past prices of the subject commodity,

$$(3.5) \quad W_t^* = \left(\frac{1}{m-1} \sum_{k=1}^{m} (P_{t-k} - \bar{P})^2\right)^{\frac{1}{2}}$$

where $\bar{P}_t$ is the average price over the preceeding m periods.

(ii) a weighted moving standard deviation of past prices of the subject commodity,

$$(3.6) \quad W^* = \left(\sum_{k=1}^{m} \alpha_k \, (P_{t-k} - \bar{P}_t)^2\right)^{\frac{1}{2}}$$

where α_k is an arbitrary weight imposed on the squared deviation between actual price in period k and the m-period average price. The weights may be imposed in the form of declining, rectangular, 'inverted-V' or Fisher lag schemes.

(iii) a weighted coefficient of variation of past prices (or returns) of the subject commodity determined by dividing the weighted moving standard deviation definition by the preceding m-period average price, i.e.,

$$(3.7) \quad W_t^* = \frac{\left(\sum_{k=1}^{m} \gamma_k (P_{t-k} - \bar{P}_t)^2\right)^{\frac{1}{2}}}{\bar{P}_t}$$

Ryan used an EV specification of the decision-maker's objective function along the lines proposed by Hazell and Scandizzo (1974, pp.236-7) to derive theoretical specifications of the risk variable. Four alternative specifications were defined:

$$(3.8.1)\quad W^*_{1,t} = \sigma^2_{i,t}/P^*_{i,t}$$

$$(3.8.2)\quad W^*_{2,t} = \sigma_{ij\ ,t}/(P^*_{i,t}\,\sigma^2_{j,t})$$

$$(3.8.3)\quad W^*_{3,t} = (\sigma^2_{i,t}\,\sigma^2_{j,t})/(P^*_{j,t}\ \sigma_{ij,t})$$

$$(3.8.4)\quad W^*_{4,t} = \sigma_{ij\ ,t}/P^*_{j,t}$$

where the variances of prices of the subject commodity i and competing commodity j (viz, σ^2_i and σ^2_j) and their covariances (σ_{ij}) were weighted using a Fisher lag scheme in empirical analysis;

$$\text{e.g.}\quad W^*_{1,t} = \left(\sum_{k=1}^{3} W_k(P_{i,t-k} - \bar{P}_{i,2})^2\right) /P^*_{i,t}$$

Traill used the Almon polynomial lag scheme to impose weights on lagged values of the absolute difference between expected and actual prices. Thus

$$(3.9)\quad W^*_t = \sum_{k=0}^{m} \gamma_k \left|P^*_{t-k-1} - P_{t-k-1}\right|$$

where γ_k are weights provided by a polynomial of degree r, i.e.

$$\gamma_k \doteq a_o + a_1k + a_2k^2 + \ldots + a_rk^r,$$

$$k = 0,1, \ldots,s,\ r<s$$

Brennan also experimented with the scheme.

Other functional forms may be imposed on the deviations between actual and expected prices in specfying risk variables. Traill has suggested that there is "... no theoretical basis on which to choose the exact functional form of the relationship ... but usually investigators look at either the squared or absolute value of the deviations." (p.55) He appears to have overlooked the theory underlying Just's adaptive risk model.

Just (1974a, 1974b, 1976, 1977) imposed geometrically declining weights on past observations on variances and covariances of prices of the subject commodity and competing commodities. Because of the nature of the theoretical foundations of the method and its application in this study, Just's model is considered in more detail in the next section.

One further specification of risk in positive empirical study is to express riskiness in terms of the probability of price falling below some predetermined low level. Traill considered the following definition of the risk variable:

$$(3.10) \qquad W_t^* = Pr(P<\alpha)_t,$$

where α is the predetermined low price level.

3.3.4 Methods of estimation

Various estimation procedures have been employed in previous studies incorporating the above risk specifications. Methods adopted include ordinary least squares (e.g. Brennan; Freebairn and Rausser; Ryan; Wilson et al.), two-stage least squares (e.g. Freebairn), three-stage least squares (e.g. Freebairn and Rausser), and maximum likelihood estimators (e.g. Behrman; Just; Reutlinger). The choice of an estimator is generally related to assumptions concerning the presence of autocorrelation and non-linear parameters in the hypothesized model; or the author's approach to choosing a preferred specification of the model.

The alternative definitions of expected price and risk are indeed diverse. The selection of a specification of these variables for inclusion in past studies has been largely based on experimentation. Selvin and Stuart (1966) refer to such an approach as 'fishing'; that is, using the same sample data to choose among a number of variables or specifications of one variable for inclusion in an explanatory model. The problem with the approach is that it "... affects the probability levels of all subsequent tests based on that model on the same data" and "... it may destroy unbiasedness and alter mean-square-error in estimation" (p.21).

The method of estimation used in this study was influenced by the specification of the hypothesized model. Both are based on the workings of Just as outlined in the remaining sections of this chapter.

3.4 Adaptive Risk Model

Since the pioneering works of Koyck (1954), Cagan (1956) and Nerlove (1958), several authors have applied models based on the assumption of a declining geometric lag in empirical supply response studies (e.g. Askari and Cummings 1976, 1977). This form of lag has been favoured for a number of reasons. It is intuitively appealing and simple estimation methods such as ordinary least squares and generalized least squares can often be used. Good statistical fit is usually obtained if the model specification is 'correct' given the restrictions imposed. There is a savings in degrees of freedom for the estimation process (e.g. Johnston 1972, p.293). The assumption of geometric weights leads to the correction of persistent errors in forecasting without responding very much to random disturbances (e.g. Muth 1960, p.299)[7]. However, these studies usually assume a situation of constant risk so that only the means of observed information variables (such as prices) are included as explanatory variables.

Just (1974a, 1974b, 1976, 1977) opts for a "... more generally applicable class of models ... based on a changing subjective knowledge of the economic environment in which the decision-maker operates" (1974b, p.2). Thus the lags in economic behaviour are based on the decision maker's behaviour. Most often, supply response studies rely on technological and institutional factors to induce lags. If any such factors are associated with a particular problem being studied, then they can be combined with Just's adaptive risk model.

The main assumption underlying the adaptive risk model is that the true state of the economic environment is viewed by decision makers' as a Markov process; that is, the true state of the environment is assumed to vary through time in a generalized, sequential manner as a result of random influences such as changes in technology and tastes and preferences. In any one period, t, decision makers are assumed to update beliefs formulated in the previous period, t-1. The modification is based on the observed state of the environment or the information received on the state of the environment in period t; and is given by Bayes' theorem.[8] Since the environmental process is assumed to be a Markovian process, the updated beliefs (posterior personal probability density function) in period t are used in forming prior beliefs for period t+1; and using Bayes' theorem the personal probability for events in period t+1 can be formulated.

This decision process provides the theoretical base for Just's adaptive

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7. In a more pragmatic approach, Fisher and Tanner (1978) found empirical evidence in the Australian rural sector for the use of geometric lags.

8. Anderson, Dillon and Hardaker (1977) state Bayes' theorem as: "... the posterior probability of the ith state, given that the kth prediction has been made, is equal to the product of (1) the prior probability of the state and (2) the likelihood probability of the prediction given the state, divided by all such products summed over all the states" (p.50).

risk model. Just (1974b) shows that temporal variation in parameters of the observed state of the environment upon which entrepreneurs make decisions (such as prices paid, prices received, and productivity of various production processes) can be adequately explained by the geometric lag distribution. Geometric weightings are attached to the means and variances of observed information variables in a situation of changing risk; thereby including variables to explain the decision maker's personal or subjective probability density function of the state of the economic environment in an econometric model.

Just's adaptive risk model forms the basis for the specification of expected prices and risk variables in this study. Expected price of beef and expected price of alternative commodities in year t are each given by the general term,

$$(3.11) \qquad X_t^* = \theta \sum_{k=0}^{\infty} (1-\theta)^k X_{t-s-k-1}, \qquad 0<\theta\leq 1$$

where X_t^* is the decision-makers' subjective expectations for the mean of prices of some commodity in year t; X_t is the observed price of the same commodity in year t. The parameter s is the delay prior to the commencement of the geometrically declining weights on lagged prices. This is discussed in section 4.4. For convenience, and because it seems reasonable, θ is assumed to have the same value in the expressions for the expected prices of beef and alternative commodities. This means that the same weight is used to form expectations about the prices of different commodities.

Risks in beef prices and the prices of alternative commodities in year t are given by the general term,

$$(3.12) \qquad W_t^* = \phi \sum_{k=0}^{\infty} (1-\phi)^k W_{t-s-k-1}, \qquad 0<\phi\leq 1$$

where W_t^* is the decision-makers' subjective evaluation of the variance of prices of some commodity in year t; and W_t is the variance of the observed prices of the same commodity in year t. The term W_t^* is given by $(X_t - X_t^*)^2$ and defines risk in terms of the most recent observations on actual and expected prices. In this case, W_t is a variable representing uncertainty which occurs as a result of the unknown difference between the actual and expected outcomes in a given period. The parameter ϕ, like θ, is the same for all risk variables.[9]

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9. Hereinafter, 'risk' refers to the decision-makers' subjective evaluation of the variance of price.

3.5 Estimation Method

The chosen method of estimation for the study is based on Just (1976). The method allows the direct estimation of the non-linear model resulting from the assumption of geometrically declining lag schemes for expected price and risk. The method requires the division of the expected price and risk variables into observable and unobservable parts similar to the approach taken by Klein (1958). That is, if we have T+1 observations indexed by t = 0,1,2,..., T, than equation (3.11) may be rewritten as,

$$(3.13) \qquad X_t^* = \theta \sum_{k=0}^{t-s-1} (1-\theta)^k X_{t-s-k-1} + (1-\theta)^{t-s} X_s^*$$

for t = s+1, s+2, ..., T, and X_s^* is a parameter which can be estimated or set to some fixed value. In this thesis, X_s^* is set to some fixed value because this makes maximization of the likelihood function easier and it does not affect the asymptotic properties of the estimates (W.E. Griffiths, personal communication, 1982). The same disaggregation process is also applied to the risk variable, W_t^* in equation (3.12) (e.g. Just 1976, p.676). Maximum Likelihood (ML) estimates of the coefficients of the model, under the assumption of normally and independently distributed disturbances, may then be found; the ML estimates being obtained via non-linear least squares using the Gauss-Newton algorithm (e.g. Judge et al. 1980 pp.735-6).

Two computer programs were used to obtain the ML estimates. The first program restricted the values of θ and ϕ to six alternative values within a specified range (Griffiths 1980b). After searching across a grid containing 36 combinations of values of θ and ϕ, those values of θ and ϕ for which the likelihood function was a maximum, were chosen and the corresponding estimates of the other parameters were noted. These latter estimates and the maximizing values of θ and ϕ were then used as starting values for the program (Griffiths 1980a) which found ML estimates via the Gauss-Newton algorithm. Initially, the Gauss-Newton algorithm was used without the preliminary grid search technique but this was found to be unsatisfactory because, frequently, the program converged to a local maximum or failed to converge at all. The preliminary grid search technique seemed to be a successful method for locating the neighbourhood of the global maximum and, therefore, for choosing efficient starting values for the parameters.

Chapter 4

EMPIRICAL MODEL

4.1 Introduction

In this chapter, we draw upon the theoretical models and discussion presented in Chapters 2 and 3 to develop a model which can be analysed empirically. At times, it is necessary to depart from a preferred specification of an empirical model which is a real representation of the underlying hypothesis in the study. Such restrictions are imposed by both the state-of-the-art of the methodology and the quality and quantity of data pertaining to the problem at hand. Separate models are developed for the cow and heifer portion and the female calf portion of the beef cattle herds in each region of New South Wales. A priori and prior expectations of the outcome of empirical estimation of these models are also presented. A description of the data series used in estimation is provided in section 4.3.

4.2 General Empirical Model

The identity given in equation (2.1) provides the basis for the specification of relations to explain the nature of the underlying structural factors which are hypothesized to influence female beef cattle inventory response for region i in New South Wales,

$$(4.1) \qquad IFC_{i,t} = IFC_{i,t-1} + SSFC_{i,t} + NAFC_{i,t} + CF_{i,t}$$

where the variables are as earlier defined. Ideally, one would like to disaggregate IFC, SSFC, and NAFC into breeding cow, fattener (or cull) female, unjoined heifer and female calf components. Economic models could then be estimated accordingly. However, statistics are not available. Therefore, the approach adopted is to restrict the analysis to the two categories for which statistics exist:

(i) the inventory of cows and heifers aged one year and older, and

(ii) the inventory of female calves aged less than one year.

Thus, the disaggregation of equation (4.1) to reflect these two categories is given by the following system of identities:

(4.2) $IFC_{i,t} = ICH_{i,t} + IFV_{i,t}$

(4.3) $ICH_{i,t} = IFC_{i,t-1} + SSCH_{i,t} + NACH_{i,t}$

(4.4) $IFV_{i,t} = CF_{i,t} + SSFV_{i,t} + NAFV_{i,t}$

where

$ICH_{i,t}$ = closing inventory of cows and heifers aged one year and over at 31 March in year t in region i;

$IFV_{i,t}$ = closing inventory of female calves aged less than one year at 31 March in year t in region i;

$SSCH_{i,t}$ = annual net change in cow and heifer numbers in region i through purchases, sales, slaugterings and mortalities in year t, including heifers which were calves at the beginning of the year;

$NACH_{i,t}$ = annual net numbers of cows and heifers on agistment both in and out of region i in year t, including heifers which were calves at the beginning of the year;

$SSFV_{i,t}$ = annual net change in the number of female calves in region i through purchases, sales, slaughterings and mortalities in year t;

$NAFV_{i,t}$ = annual net number of female calves on agistment both in and out of region i in year t.

Farmers must make decisions whether to slaughter, purchase or sell female beef cattle. Furthermore, the number of mortalities may be influenced by decisions concerning feeding, particularly during drought, and veterinary care. The calf-birth rate is affected by mating decisions. Thus, intuitively, the factors causing variation in slaughterings, purchases, sales, mortalities and births of female cattle are the same as those determining closing inventories. In essence, such decisions are economic in nature but constrained by biological aspects of both beef cattle and alternative enterprises. Equations (4.3) and (4.4) may be enhanced by the inclusion of economic parameters and other shift variables. It is assumed that

(4.5) $SSCH_{i,t} = f_2(IFC_{i,t-1}, PB_{i,t}, VB_{i,t}, PA_{i,t}, VA_{i,t}, SI_{i,t}, IP_{i,t})$

(4.6) $NACH_{i,t} = f_3(PB_{i,t}, VB_{i,t}, PA_{i,t}, VA_{i,t}, SI_{i,t}, IP_{i,t})$

(4.7) $SSFV_{i,t} = f_4(CF_{i,t}, PB_{i,t}, VB_{i,t}, PA_{i,t}, VA_{i,t}, SI_{i,t}, IP_{i,t})$

(4.8) $NAFV_{i,t} = f_5(PB_{i,t}, VB_{i,t}, PA_{i,t}, VA_{i,t}, SI_{i,t}, IP_{i,t})$

$$(4.9) \quad CF_{i,t} = f_6 \ (ICH_{i,t-1})$$

where, in region i in year t,

$PB_{i,t}$ = expected price of beef;
$VB_{i,t}$ = price variance (risk) of beef;
$PA_{i,t}$ = expected weighted price of alternative farm commodities;
$VA_{i,t}$ = price variance (risk) of alternative commodities;
$SI_{i,t}$ = seasonal conditions;
$IP_{i,t}$ = area of improved pastures.

The dynamic model given by equations (4.2) to (4.9) inclusive, implies that the closing inventory of female beef cattle in region i in year t is equal to the sum of the previous year's closing inventory and the net change in numbers due to herd rebuilding and liquidation parameters. The values of these decision parameters are determined by the maximization of the aggregate utility functions of beef cattle producers in region i. This utility function is also composed of economic and physical environment variables and subject to biological constraints. Firstly, there are expectations about future profits to be accrued through the maintenance or build-up of current inventory compared to the returns from the liquidation (through slaughterings and sales) of current inventory. Secondly, there are risks associated with actually realizing expected profits which in turn affects farmers' actions in maintaining, building-up or liquidating inventories. Thirdly, there are expectations and risks associated with profits from alternative enterprises which compete with female beef cattle for available resources. Fourthly, pasture availability affects inventory in that it may influence turn-off rate, stocking rate, and mortality rate.

It was earlier assumed that farmers wish to maximize utility as represented by the mean and variance of some stream of profits from available alternative enterprises. Profits, in turn, are composed of the income and costs associated with the production of output from the adopted enterprises. Variations in profit will arise from non-counteracting variations in output, output prices, inputs and input prices. Due to lack of data on regional output of beef and input use it is necessary to represent profit by observations on prices. The implications of this assumption relate to the exclusion of variations in production and input costs to explain variations in inventory. However, these variations are likely to be accounted for by the variables associated with pasture production and alternative commodities, respectively. That is, production is affected by pasture availability. The mean and variance of prices of alternative commodities are surrogates for the distribution of the opportunity costs of beef breeding (e.g. Tomek and Robinson 1972, p.62); for example, an increase in input costs for beef production may effect a shift in resources to alternative enterprises which exhibit a higher marginal value product.

Thus, the net change in inventory of cows and heifers through slaughterings, sales, mortalities and purchases is assumed to be influenced by closing inventory of all female cattle in year t-1, expected prices and price variances of beef and alternative commodities in year t, seasonal conditions in year t, and the area of improved pastures in year t. In the case of female calves, the same assumptions apply except that the variable, closing inventory of all female beef cattle, is replaced with the closing inventory of cows and heifers only. The expected beef price distribution in year t is given by the expected mean and variance variables and represents the uncertainty about future prices of beef resulting in part from current decisions. The variables associated with alternative enterprises to beef breeding are PA and VA.

The net number of agisted cows, heifers and calves in year t is assumed to be related to price expectations and risks which in turn are assumed to be measures of the value of these animals as capital goods. Decisions about the level of net agistment are, of course, influenced by availability of pastures; hence the inclusion of the variables (SI and IP) to account for pasture resources.

Substituting the expressions for net change in inventory of cows and heifers in year t into the closing inventory function yields the following:

$$(4.10) \quad ICH_{i,t} = f_6(IFC_{i,t-1}, PB_{i,t}, VB_{i,t}, PA_{i,t}, VA_{i,t}, SI_{i,t}, IP_{i,t})$$

Similarly, upon substitution the closing inventory function for female calves is as follows:

$$(4.11) \quad IFV_{i,t} = f_7(ICH_{i,t-1}, PB_{i,t}, VB_{i,t}, PA_{i,t}, SI_{i,t}, IP_{i,t})$$

Functions (4.10) and (4.11) can be empirically analysed using available data. Empirical analysis of functions (4.5) to (4.8), inclusive, is not possible because statistics on regional purchases, sales, slaughterings, mortalities, agistments and births are not available. Thus it is hypothesized that closing inventory of beef cows and heifers (aged less than one year) in region i in year t is a function of opening inventory of total female beef cattle in the region, expected means and variances of prices of beef and alternative commodities in the region, seasonal conditions,[10] and area of improved pasture. The closing inventory of female beef calves (aged less than one year) in region i in year t is assumed to be related to the opening inventory of beef cows and heifers (aged one year and over), expected means and variances of prices of beef and alternative commodities, seasonal conditions and the area of improved pasture, in the region.

4.3 Regional Equations and Data

New South Wales is divided into six regions for the purposes of this study. The regions are: (i) Coast, (ii) Northern Tablelands, (iii) Central and Southern Tablelands, (iv) Northern Slopes and Plains, (v) Central and Southern Slopes, and (vi) Western Plains. Each region is regarded as being relatively homogeneous in terms of land use and length of growing season. The boundaries are adapted from the regional classifications used by the Bureau of Agricultural Economics (e.g. Longmire et al. 1979, pp 30-5; Davidson 1967) and the Statistical Agricultural Areas of New South Wales used by the Australian Bureau of Statistics (e.g. ABS 1979). The regions are defined in Appendix 2.

The inventory of female beef cattle in the study is defined as the number of cows and heifers mainly for beef production aged one year and over and half the number of beef calves aged less than one year at 31 March in each year. The time period used is from 1950 to 1978 inclusive.

Wool and wheat production are assumed to be the major competing enterprises affecting female beef cattle inventory in all regions with the exception of the Coast region. Revenue from wool production in the Northern Tablelands and Central and Southern Tablelands regions ranges between 60 per cent and 100 per cent of total revenue from wool and wheat in the period 1950 to 1978. In the Central and Southern Slopes and Northern Slopes

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10. Whilst imperfect knowledge about future seasonal conditions is likely to cause uncertainty in the decision making environment of farmers, their subjective evaluations of the mean and variance of future seasonal conditions are not considered in this study. It is likely that farmers consider climatic uncertainty when choosing among alternative enterprises and planning the desired level of output of the chosen enterprises. However, it is assumed that farmers expect 'normal' annual average seasonal conditions to occur in future years. Therefore, changes in the annual numbers of female cattle are assumed to be caused in part by changes in annual seasonal conditions as they occur rather than changes in expected annual seasonal conditions.

and Plains regions, revenue from wheat production is greater than wool revenue in all years except 1958. There has tended to be a shift over time in the relativity between wool and wheat revenues in the Western Plains region; prior to the mid 1960s, wool contributed the greater proportion. Unfortunately, statistics on beef output in the various regions are not available, thus preventing comparisons between revenues from beef production and alternative enterprises.

Although dairy production is a major industry in the Coast region, changes in expected price and risk of dairy products did not significantly influence beef cow and heifer numbers in preliminary estimation. The probable reason for these results is that most beef cattle breeding enterprises in the region are confined to the poorer hilly areas which are unsuitable for dairying. Another major industry in the region is sugar production. However, sugar and beef cattle do not actively compete for the same land resources. Beef breeding enterprises in the Coast region are assumed to have no major competitors in the following empirical analysis.

The same beef, wool and wheat prices are used for each region. Average prices for the year ending 30 June, 1950 to 1978, for export quality ox at Homebush, and greasy wool at auction and wheat at the farm gate in New South Wales are used. All prices are deflated by the index of Prices Paid by Farmers for the State. Observations on the weighted price of alternative commodities are obtained by constructing a Paashe price index series (e.g. Tomek and Robinson, p.206) using annual prices and quantities of the major alternative commodities in each region. Percentage variation from the 'normal' annual average rainfall in each region is used as a surrogate for seasonal conditions. Improved pastures are measured in terms of the areas of sown grasses and clovers in each region at 31 March in each year. The data series and sources are presented in Appendix 3.

4.4 Interpretation of the Model

The general form of the adaptive risk model estimated in this study is

$$(4.12) \quad Y_t = \alpha_o + \sum_{j=1}^{N} \alpha_j Z_{j,t} + \sum_{j=1}^{M} \beta_j X^*_{j,t} + \sum_{j=1}^{M} \gamma_j W^*_{j,t} + u_t \ ,$$

$$t = 0,1,2,\ldots T$$

where

Y_t = an inventory variable in time period t;

$X^*_{j,t}$ = expected mean of the price variable X_j in time period t formed in period t-s-1. It is assumed to be formed adaptively, i.e.

$$\begin{aligned} X^*_{j,t} &= \theta X_{j,t-s-1} + (1-\theta)X^*_{j,t-1}, \quad 0<\theta\leq 1 \\ &= \theta\sum_{k=0}^{\infty} (1-\theta)^k X_{j,t-s-k-1} \\ &= \theta\sum_{k=0}^{t-s-1} (1-\theta)^k X_{j,t-s-k-1} + (1-\theta)^{t-s} X^*_{j,s} \quad ; \end{aligned}$$

$W^*_{j,t}$ = variance of the price variable X_j in time period t formed in period t-s-1. It is also assumed to be formed adaptively, i.e.

$$\begin{aligned} W^*_t &= \phi\, W_{j,t-s-1} + (1-\phi)\, W^*_{j,t-1}, \quad 0<\phi\leq 1 \\ &= \phi \sum_{k=0}^{\infty} (1-\phi)^k W_{j,t-s-k-1} \\ &= \phi \sum_{k=0}^{t-s-1} (1-\phi)^k W_{j,t-s-k-1} + (1-\phi)^{t-s} W^*_{j,s} \end{aligned}$$

where

$$W^*_{j,t} = (X_{j,t} - X^*_{j,t})^2 \quad ;$$

$Z_{j,t}$ = any other non-price shift variable;

$X^*_{j,s}$ and $W^*_{j,s}$ are presample expectations of X_j and W_j, respectively, to be set prior to estimation;

α_j (j = 0,1,...N), β_j (j = 1,2,...M), γ_j (= 1,2,...M), θ and ϕ are parameters to be estimated;

u_t is a well-behaved disturbance term.

The set of X_j variables to be considered for each region (i = 1,2,...6) contains the price of beef and the weighted price of alternative commodities. Correspondingly, the W_j variables are the price risks of beef and alternative commodities, respectively. The expected prices and risk variables are specified with a 'lag' of s years.[11] That is, expectations are formed for year t in period t-s-1. These expectations depend on prices in all time periods up to and including t-s-1. The length of delay before the beginning of the geometric lag structure in the cow and heifer equations is expected to be determined by both the biological nature of beef cattle breeding and the system of production. In regions where it is common practice to breed replacement heifers and older slaughter cattle (that is, over two years old), the lag is expected to be three years. This is the approximate period of time that it takes to achieve an outcome following a decision to increase the sizes of the breeding herd or slaughter turnoff. Young (1968a) found that bulls are paddocked with cows for approximately three months in commercial beef herds in New South Wales. Add to this the length of the gestation period for cattle which is nine months. Further, Young (1968b) reported that the most common joining age of heifers in the State is 24 to 27 months. This gives a total of approximately three years. The lag would be shorter during periods of herd liquidation. However, such responses have only occurred twice during the period of observation: in the mid 1960s due to drought and the late 1970s due to a decline in beef prices. A lag of s = 1 or 2 is expected in regions oriented towards the breeding and turnoff of younger cattle (i.e. vealers and yearlings). In the case of the response of female calf inventory, a lag of s=1 is expected since the length of time between a decision to mate cows and bulls and the birth of calves is about one year.

It is expected that there is a positive relationship between the expected price of beef and both the closing inventory of cows and heifers and the closing inventory of female calves. *Ceteris paribus*, it is reasonable to assume that an increase in expected beef prices will cause farmers to divert resources away from other enterprises which are now less profitable and into beef cattle production. The expected increase in prices would need to occur at least s years into the future to affect decisions made in the current year. However, if historically there have been unsatisfactory (in the utilitarian sense) differences between actual and expected prices, the farmer may be averse to increasing inventories even with an increase in expected mean prices. Hence, a negative relationship is expected between changes in price risk and changes in cow and heifer and female calf inventories.

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11. Annual data are used in the empirical analysis.

Where alternative farm enterprises are available, there are expected to be negative relationships between the expected prices of the output of those enterprises and female cattle inventories. Positive relationships are expected to be obtained between the price risk of the alternative commodities and female cattle inventories. The reasons supporting these hypotheses are inversions of the own price and risk case. Farmers are likely to divert resources, for example, away from beef cattle breeding and into other enterprises if there is an increase in expected prices, or a decrease in expected price riskiness, of alternative commodities, *ceteris paribus*.

The closing inventory of all female beef cattle lagged one year, seasonal conditions, and the area of improved pastures constitute the set of other shift variables included in equations to explain variations in the closing inventory of cows and heifers in year t in the six regions. The closing inventory of cows and heifers lagged one year replaces the explanatory variable for total numbers of females in the female calves equations. All of these explanatory variables are expected to be positively related to the dependent variables. Increases in opening stocks of female cattle are expected to lead to increases in closing stocks of cows and heifers and female calves, *ceteris paribus*. Improved seasonal conditions and increases in the area of improved pasture are the two main factors likely to increase pasture resources and, consequently, enhance growth in the size of the herd.

The results of an empirical analysis of the model are presented in the next chapter.

Chapter 5

RESULTS AND EVALUATION

5.1 Introduction

In this chapter, the results of empirical estimation of the model developed in Chapter 4 are presented and evaluated. Preliminary estimation indicated that the theoretical model given by equations (4.10) and (4.11) was not consistent with the available data in all regions. The results reported were obtained by firstly experimenting with different lengths of delay before imposing the geometric lag structure on the formation of expected prices and risk. The criteria used in comparing alternative lengths of delay were the signs on the estimated coefficients in terms of prior expectations, and measures of 'goodness of fit' (R^2) and autocorrelation (Durbin-Watson statistic).[12] Explanatory variables with insignificant estimated coefficients were then omitted where their exclusion did not unduly affect the interpretation of the other estimates. Elasticities computed from the estimated coefficients of the model are presented in section 5.4.

5.2 Estimated Equations

The estimated coefficients of the cow and heifer inventory equation for each region are presented in Table 5.1. The ratios of the coefficient estimates to their asymptotic standard errors are given in parentheses. The presample values of the expected prices and risk variables were set as follows:

$$PB^*_{i,1} = 15,\ VB^*_{i,1} = 5,\ PA^*_{i,1} = 1.0,\ VA^*_{i,1} = .2,\ i = 1,2,\ldots 6.$$

where the expected prices are approximately equal to actual prices in the period immediately preceding and sample period, and the risk variables are approximately equal to the square of the difference between actual prices in the first two periods before the sample period. That is, the starting values were based on the naive expectations concept.

The estimated coefficients in Table 5.1 have the expected signs. In

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12. The relevance of R^2 and the Durbin-Watson statistic for testing hypotheses about the estimates is questionable. However, in the absence of more conclusive tests, these measures are used to indicate possible serious statistical errors (e.g. Judge *et al*. 1980, p.255; Kenkel 1974).

Table 5.1 Non-linear Least Squares Estimates of Annual Cow and Heifer Inventories in the Regions of New South Wales: 1950 to 1978[a]

Explanatory Variables[b]	Regions: Coast	Northern Tablelands	Northern Slopes & Plains	Central & Southern Tablelands	Central & Southern Slopes	Western Plains
Constant	-91	-215	-341	-588	-295	-66
IFC_{t-1}	0.78 (34.71)	0.32 (1.82)	0.19 (0.82)	0.35 (3.07)	0.39 (5.84)	0.58 (11.59)
PB_t	2.96 (3.31)	7.38 (1.81)	20.73 (1.62)	15.45 (1.83)	17.42 (2.72)	2.47 (4.25)
VB_t	-0.06 (-2.06)	-1.30 (-2.12)	-2.21 (-1.52)			
PA_t			-470 (-1.32)		-806 (-1.42)	-37.06 (-1.34)
VA_t			947 (0.93)		3922 (0.75)	53.31 (1.02)
SI_t			0.81 (1.42)	0.78 (3.72)	1.16 (6.21)	0.25 (4.34)
IP_t		0.17 (2.79)	0.62 (2.24)	0.15 (3.25)	0.08 (1.96)	0.38 (2.08)
θ	0.61 (2.01)	0.39 (3.80)	0.42 (4.26)	0.15 (2.00)	0.17 (3.26)	0.63 (5.02)
ϕ	1[c]	0.39 (2.45)	0.48 (1.75)		0.13 (0.96)	1[c]
s^d	1	3	3	2	1	2
R^2	0.99	0.99	0.98	0.99	0.99	0.99
D.W.	1.72	2.18	1.57	1.72	1.69	1.90

a. Figures in parentheses are ratios of coefficient estimates to their standard errors.

b. Descriptions of the variables are provided in the text.

c. Restricted Maximum Likelihood estimates were obtained at the boundary point $\phi=1$, i.e. $W_t^*=W_{t-s-1}$.

d. s is the delay in lag, i.e. period t-s is the beginning of the geometric declining lag scheme on past price means and variances.

each region, both the opening inventory of all female beef cattle and the expected price of beef are positively related to closing numbers of cows and heifers. Negative coefficients were obtained on the beef risk variables in the equations for the coastal and northern regions. The expected weighted prices of alternative commodities have a negative effect on cow and heifer numbers in the Slopes and Plains regions; whilst the corresponding risks variables have a positive effect in these regions.

The improved pastures variable was omitted from the reported equation for the Coast region. The most likely reason that this variable is superfluous is that the physical factor most limiting upon beef production in that region is soil fertility. The adoption of technologies to increase soil fertility and improve pastures has not been extensive. Estimated coefficients on seasonal conditions are not significant in the Coast and Northern Tablelands regions. A suggested reason for these results is that stocking rates are relatively low in these regions, enabling breeding cattle to more readily withstand drought conditions.

Response to own-price variance is not significant in central, southern and western regions of the State; whilst response to cross-price variance is not significant in the Tablelands (and Coast) regions. A possible reason for these results is that the level of aggregation of the regions is too high. Thus, certain enterprises may not be sufficiently important to obtain significant responses to changes in their price risk in estimating the model used in this study (e.g. Just 1974a). The ratio of the coefficient estimate for cross-price variance to its asymptotic standard error in the Northern Slopes and Plains region is low. Attempts to omit this variable led to results which were less satisfactory.

The values of s reported in Table 5.1 conform to expectations. The Coast and Central and Southern Slopes are considered to be regions where the major turnoff is young cattle; that is, weaners and vealers. For these regions, $s=1$. The northern regions, namely the Northern Tablelands and the Northern Slopes and Plains, tend to turn off older cattle. In the estimated equations for these latter regions, $s=3$.

The results obtained in estimating the female calf inventory equations are presented in Table 5.2. There is a significant positive relationship between the opening inventory of cows and heifers in each region and the closing inventory of female calves. The expected price of beef cattle

Table 5.2 Non-linear Least Squares Estimates of Annual Female Calf Inventories in the Regions of New South Wales: 1950 to 1978[a]

Explanatory Variables[b]	Regions					
	Coast	Northern Tablelands	Northern Slopes & Plains	Central & Southern Tablelands	Central & Southern Slopes	Western Plains
Constant	-46	-66	11	-61	16	-26
ICH_{t-1}	0.25 (22.07)	0.12 (1.48)	0.24 (7.40)	0.27 (9.50)	0.30 (16.91)	0.24 (8.18)
PB_t	1.21 (3.80)	2.03 (1.56)	3.72 (3.58)	1.43 (2.34)	1.40 (2.33)	0.59 (2.79)
VB_t		-0.43 (-1.92)	0.18 (1.98)		-0.09 (-1.57)	0.01 (2.50)
PA_t			-388 (-2.71)		-139 (-2.11)	
VA_t			2060 (2.83)		926 (1.82)	
SI_t		0.09 (1.30)	0.28 (2.77)	0.14 (2.51)	0.22 (2.81)	0.04 (2.43)
IP_t		0.06 (2.44)		0.02 (1.49)		0.10 (1.66)
θ	0.89 (2.77)	0.50 (3.55)	0.47 (6.24)	0.44 (1.69)	0.63 (4.40)	0.58 (1.96)
ϕ		0.45 (2.38)	0.24 (4.93)		0.25 (3.14)	1[c]
s[d]	1	3	1	1	1	1
R^2	0.97	0.97	0.98	0.99	0.99	0.98
D.W.	1.44	2.17	1.92	1.16	1.23	1.49

See footnotes to Table 5.1

also has a significant positive effect on the inventory of female beef calves in each region.

The expected prices of alternative enterprises has a significant negative influence, as expected, only in the Northern Slopes and Plains, and Central and Southern Slopes regions. Prices of alternative enterprises have been omitted from the estimated equations for female calf inventories in the Coast and Tablelands regions. Similar restrictions were imposed on the estimated equations for cow and heifer inventories in these regions. Of course, the coefficient on expected prices of alternative commodities in the Coast region was restricted to zero, a priori. In the case of the Tablelands regions, greater weight is given to wool prices than wheat prices in constructing the price variables for alternative enterprises. The lack of significance of this variable in the Tablelands may be explained in terms of the management practice of running cattle and sheep on the same pasture. Such a practice appears to enhance the total productivity of available pasture and the cycling of nutrients in the ecosystem (e.g. Whittet 1969, pp.420-2). Thus cattle and sheep possess characteristics of both substitute and complementary enterprises in the Tablelands regions. The empirical results suggest that the effects of these characteristics are counteracting. Consequently, response to cross-price is insignificant. The estimated relationship between female calf inventory and expected price of alternative commodities in the Western Plains region was found to be positive and of relatively low significance during preliminary analysis. Subsequent omission of this cross-price variable did not unduly affect the interpretation of the other coefficient estimates.

The estimates of the coefficient on the beef price risk variables in the female calf equations for the Northern Tablelands and Central and Southern Slopes regions have negative signs as expected. However, the results suggest that there is a positive relationship between beef price risk and the inventory of females calves in the Northern Slopes and Plains and Western Plains regions. The omission of this risk variable from these latter two equations leads to unsatisfactory results overall.

Risk in prices of alternative commodities in the estimated equations for female calf inventory response is significant in only two regions: the Northern Slopes and Plains and the Central and Southern Slopes. The relationships are positive. The comparison of these results with those relating to the expected prices of alternative commodities indicates that where alternative commodities significantly affect female calf inventory, there is response to changes in the farmers' subjective evaluations of both the mean and variance of these prices. The same situation occurs in the models of cow and heifer inventory response.

In the female calf equations, seasonal conditions are important in all regions except the Coast. The argument relating to cow and heifer numbers and seasonal conditions is also likely to be applicable here. Calves in the Coast region may be able to more readily withstand drought because stocking rates are relatively low. Estimated coefficients on the improved pastures variables are not significant in the Coast , Northern Slopes and Plains, and Central and Southern Slopes regions.

The delay in the lag, s, is one year as expected in all regions except the Northern Tablelands. The value of s in the latter case is three years. It is possible that this result arises through misspecification of the model. It is unlikely that there is a lag of three years between the formation of expectations for prices and changes in calf numbers given that the gestation period for cattle is less than one year.

For the purposes of comparison with aggregates of estimates arising from the regional equations, the results of the estimation of equations to explain cow and heifer and female calf inventories in New South Wales as a whole (excluding the Sydney Metropolitan area) are presented in Table 5.3. The price risk variables were not significant in the State-wide cow and heifer inventory equation. The estimated coefficients of the other variables have the expected signs. The ratios of coefficient estimates to their standard errors are not entirely satisfactory in the cases of the lagged inventory variable in each equation. These variables were not omitted from the reported equations because their exclusion unduly affects the interpretation of other estimates. The value of s in the cow and heifer inventory equation is the midpoint of the range of estimates obtained in the regional equations. This value, s = 2, seems reasonable. The value of s in the female calf inventory equation is 3 years. As pointed out above, such a long lag is unrealistic. Whilst the State-wide equations are not entirely satisfactory in comparison with the regional equations, they are included for completeness. Estimates of elasticities obtained from the regional and State-wide equations are compared in section 5.4.

Table 5.3 Non-linear Least Squares Estimates of Annual Female Cattle Inventories in New South Wales : 1950 to 1978[a,e]

Explanatory Variables[b]	Cows and Heifers	Explanatory Variables	Female Calves
Constant	- 1730	Constant	- 477
IFC_{t-1}	0.08 (0.54)	ICH_{t-1}	0.08 (0.81)
PB_t	204 (1.31)	PB_t	17.85 (1.38)
VB_t		VB_t	-2.72 (-1.38)
PA_t	-11770 (-1.42)	PA_t	- 559 (-1.04)
VA_t		VA_t	1473 (0.91)
SI_t	4.25 (3.26)	SI_t	1.20 (1.62)
IP_t	0.44 (3.37)	IP_t	0.12 (2.56)
θ	0.04 (1.90)	θ	0.45 (3.23)
ϕ		ϕ	0.47 (1.56)
s^d	2	s^d	3
R^2	0.99	R^2	0.98
D.W.	1.26	D.W.	1.82

a, b, d. See footnotes to Table 5.1

e, The presample values of the expected prices and risk variables were set the same as those in the regional equations (see section 5.2).

5.3 Evaluation

The actual and predicted values of the cow and heifer inventory equations at the regional level are plotted over time in Figures 5.1 to 5.6. A similar set of plots of actual and predicted values from the female calf equations are presented in Figures 5.7 to 5.12. The plots of actual and predicted values indicate that the regional equations track the actual regional inventories reasonably well, particularly in terms of the number of 'gross' errors defined as differences between actual and predicted values in excess of 20 per cent of the actual values. The numbers of 'gross' errors in each of the equations are presented in Table 5.4. Among the cow and heifer inventory equations, three do not have any 'gross' errors, whilst the other three have only one such forecast error. Two of the female calf equations do not have any 'gross' errors; three equations have one of these forecast errors, and the remaining equation has two such errors. The tracking performance of the regional equations in terms of another test, the number of turning point errors, is not as satisfactory. The number of turning points missed and the total number of turning points for each regional equation are also presented in Table 5.4 Only two of the cow and heifer inventory equations miss less than 20 per cent of the corresponding number of turning points estimated. However, four of the female calf inventory equations satisfy the 20 per cent level of the test. Among all of the equations reported, the equation for female calf inventory in the Northern Tablelands has the largest proportion of turning point errors - 40 per cent. As stated earlier, it is possible that the latter equation has not been specified correctly.

For cow and heifer inventory in New South Wales, the aggregate of predicted values from the regional equations and the predicted values from the equation for the State in aggregate are plotted in Figures 5.13 and 5.14, respectively. Plots of the differences between the actual and predicted values from the two State-wide models as a percentage of actual values of cow and heifer inventory are presented in Figure 5.15. There are no 'gross' errors (i.e. errors in excess of 20 per cent of actual values). Figure 5.15 indicates that more often than not, the aggregation of the predicted values from the regional equations results in a smaller forecast error expressed as a percentage of the actual value than the estimation of the State-wide equation. Furthermore, the 'aggregative model' (i.e. regional equations) approach results in three turning point errors compared to four errors from the estimated equation for the State as a whole.

Table 5.4 'Gross' and Turning Point Errors in the Estimated Model of the Annual Inventories of Female Cattle in the Regions of New South Wales : 1950 to 1978

Category and Region	Year(s) in which 'Gross' Errors Occur[a]	No. of Turning Point Errors	No. of Turning Points
Cow and Heifer Inventory			
Coast	None	6	27
Northern Tablelands	None	7	25
Northern Slopes & Plains	1959	8	25
Central & Southern Tablelands	1954	4	26
Central & Southern Slopes	None	3	27
Western Plains	1966	8	26
Female Calf Inventory			
Coast	1966	8	27
Northern Tablelands	1953	10	25
Northern Slopes & Plains	1966	3	27
Central & Southern Tablelands	None	5	27
Central & Southern Slopes	None	3	27
Western Plains	1966, 1967	5	27

a. 'Gross' error is defined as the difference between actual and predicted values in excess of 20 per cent of the actual value.

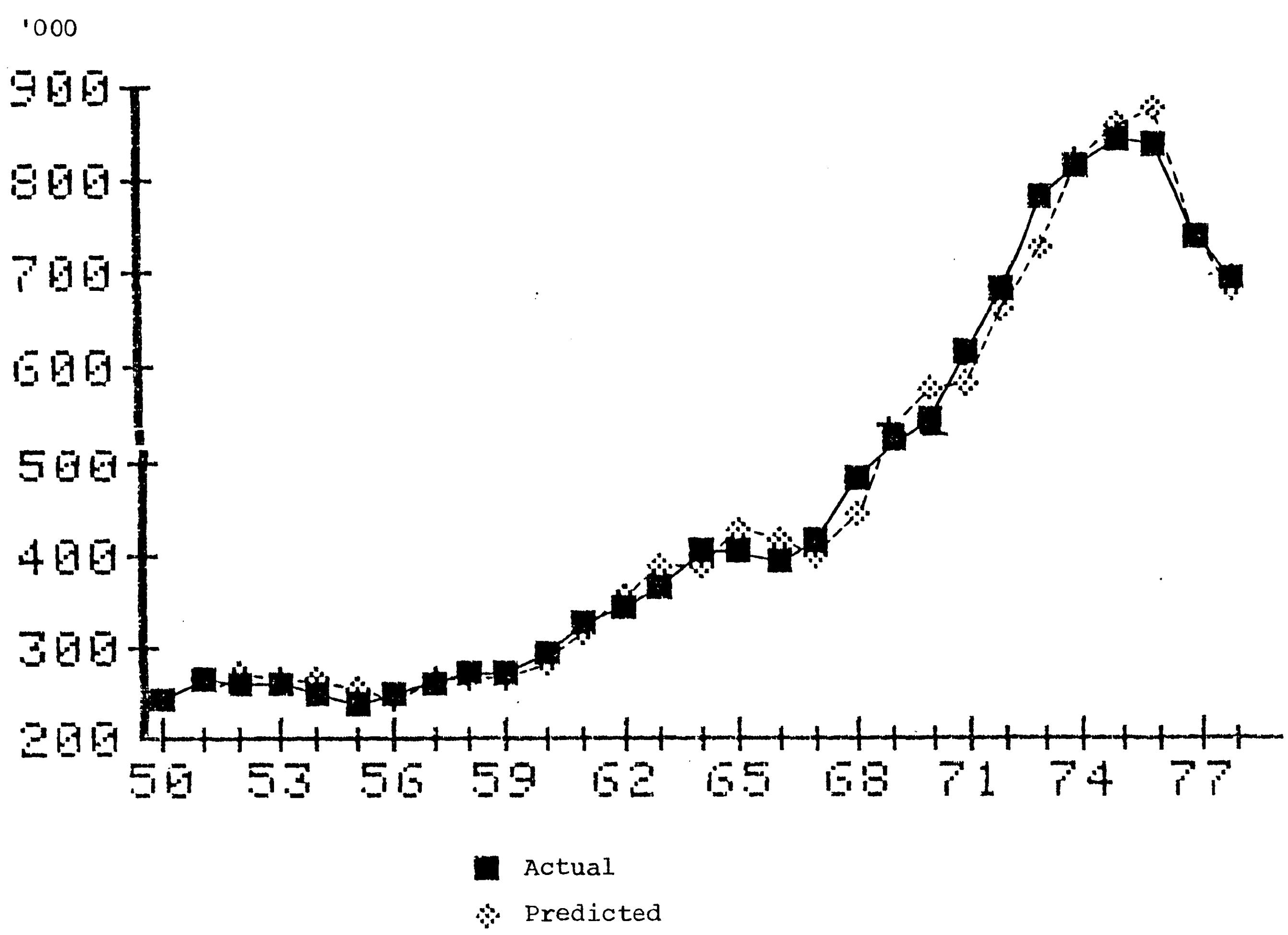

Figure 5.1 Number of Cows and Heifers in the Coast Region.

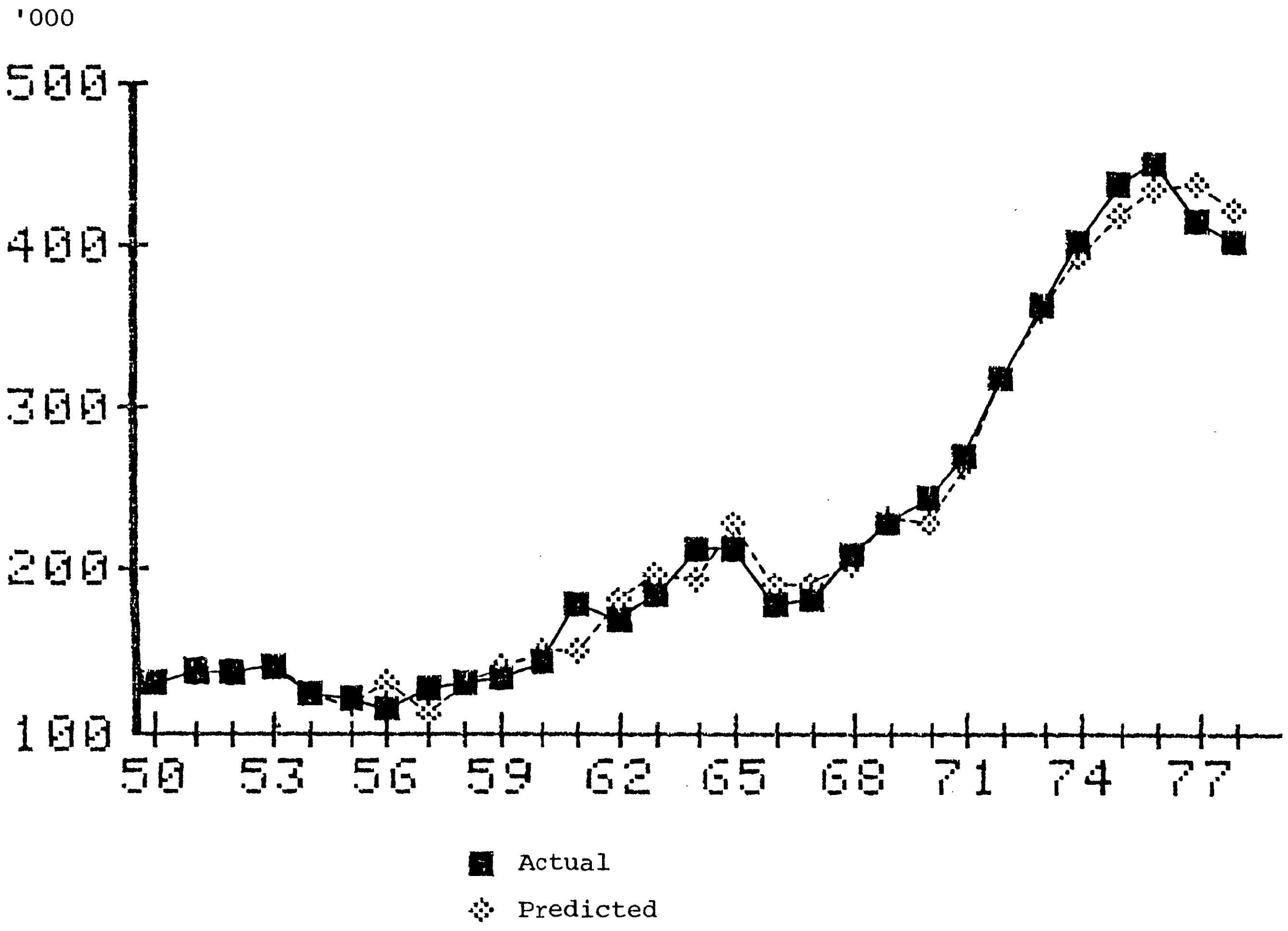

Figure 5.2 Number of Cows and Heifers in the Northern Tablelands Region.

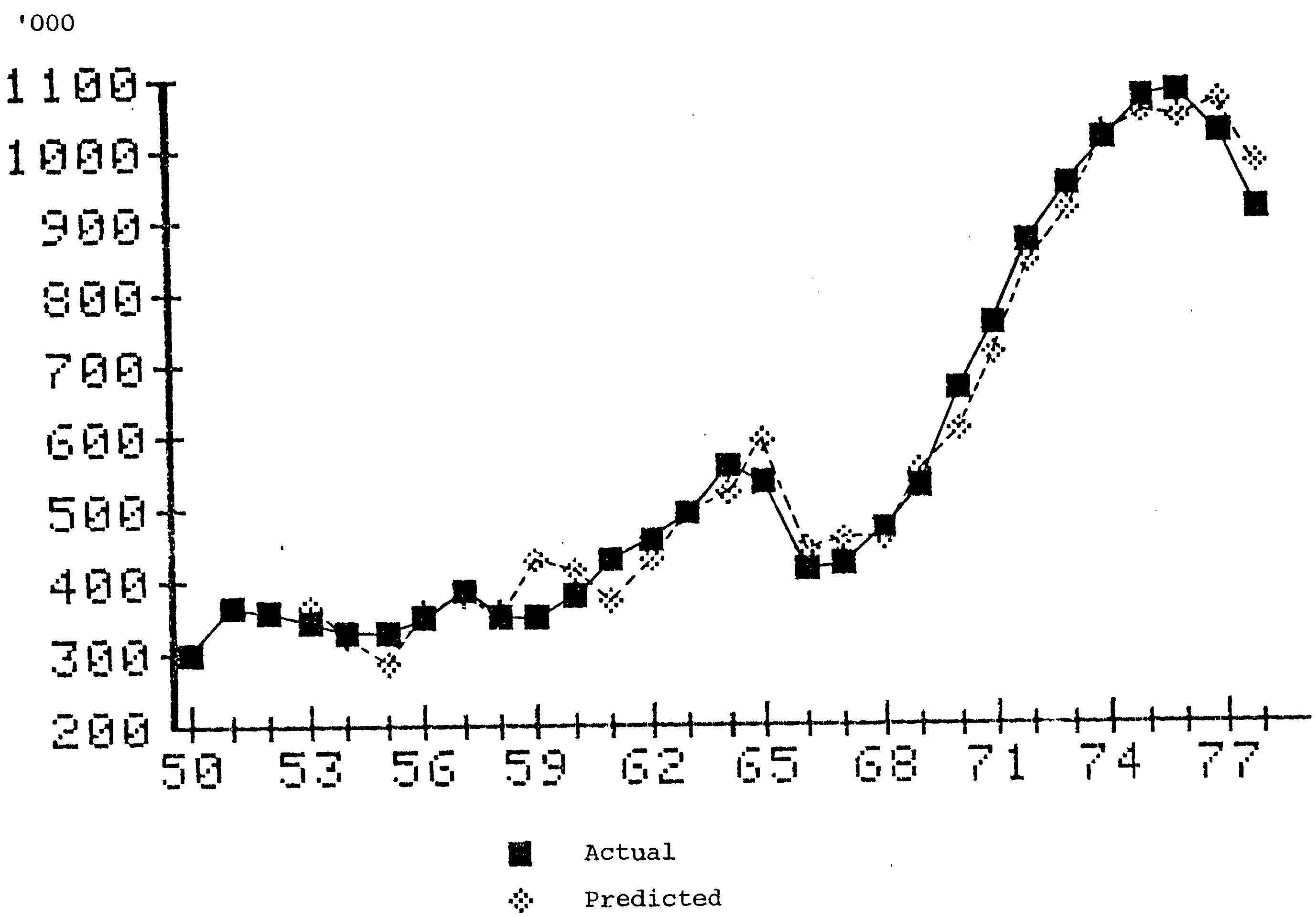

Figure 5.3 Number of Cows and Heifers in the Northern Slopes and Plains Region.

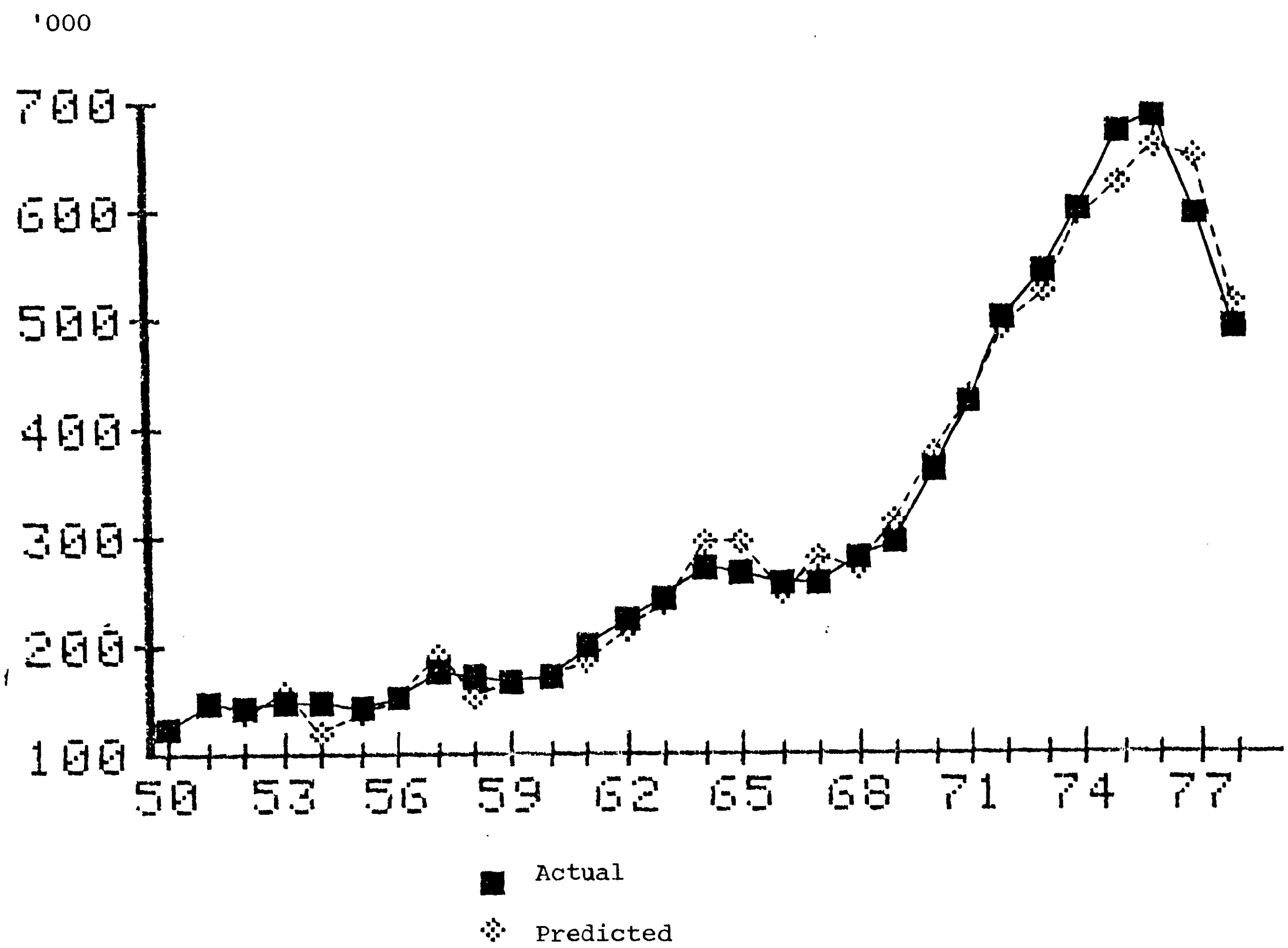

Figure 5.4 Number of Cows and Heifers in the Central and Southern Tablelands Region.

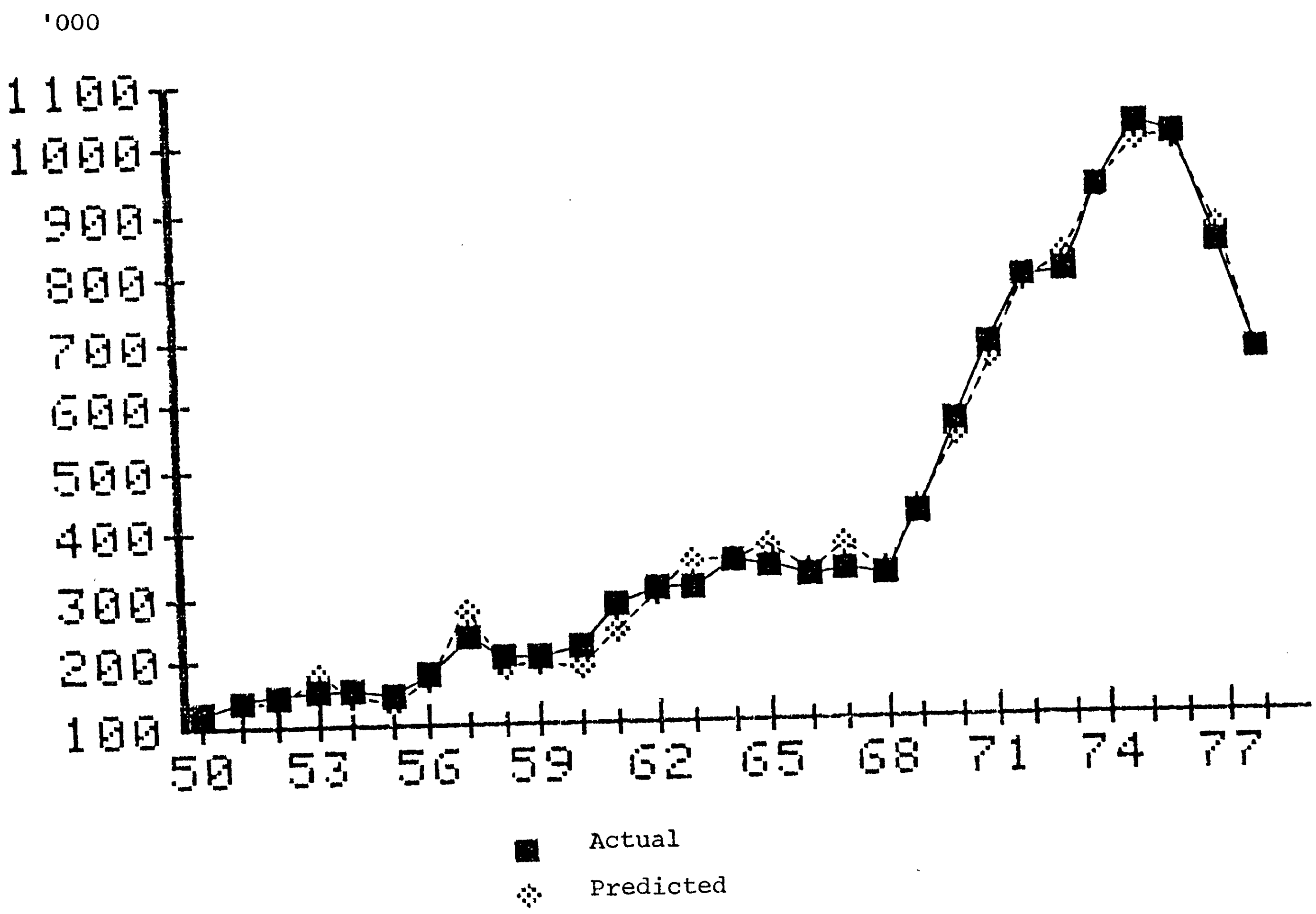

Figure 5.5 Number of Cows and Heifers in the Central and Southern Slopes Region.

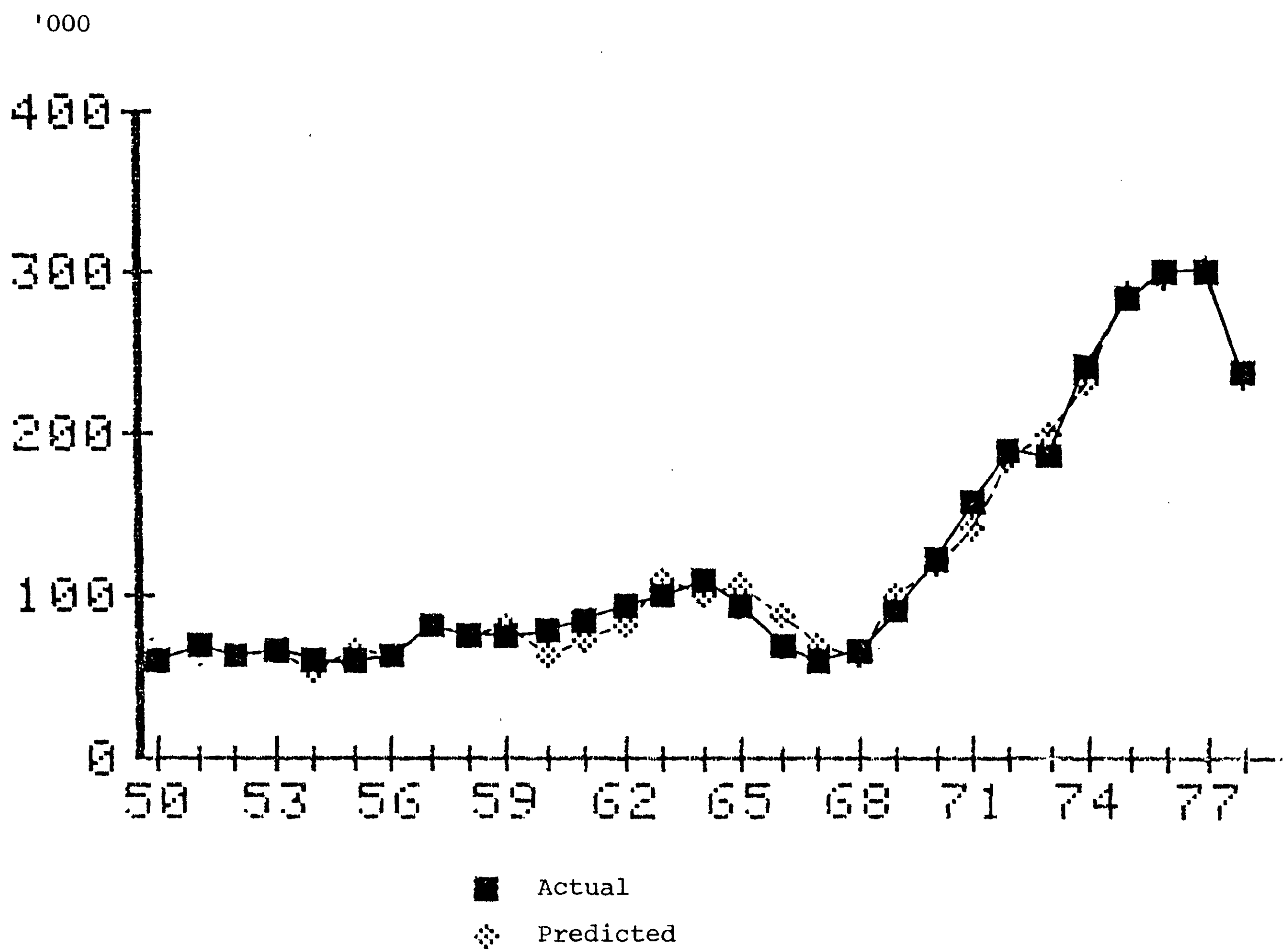

Figure 5.6 Number of Cows and Heifers in the Western Plains Region.

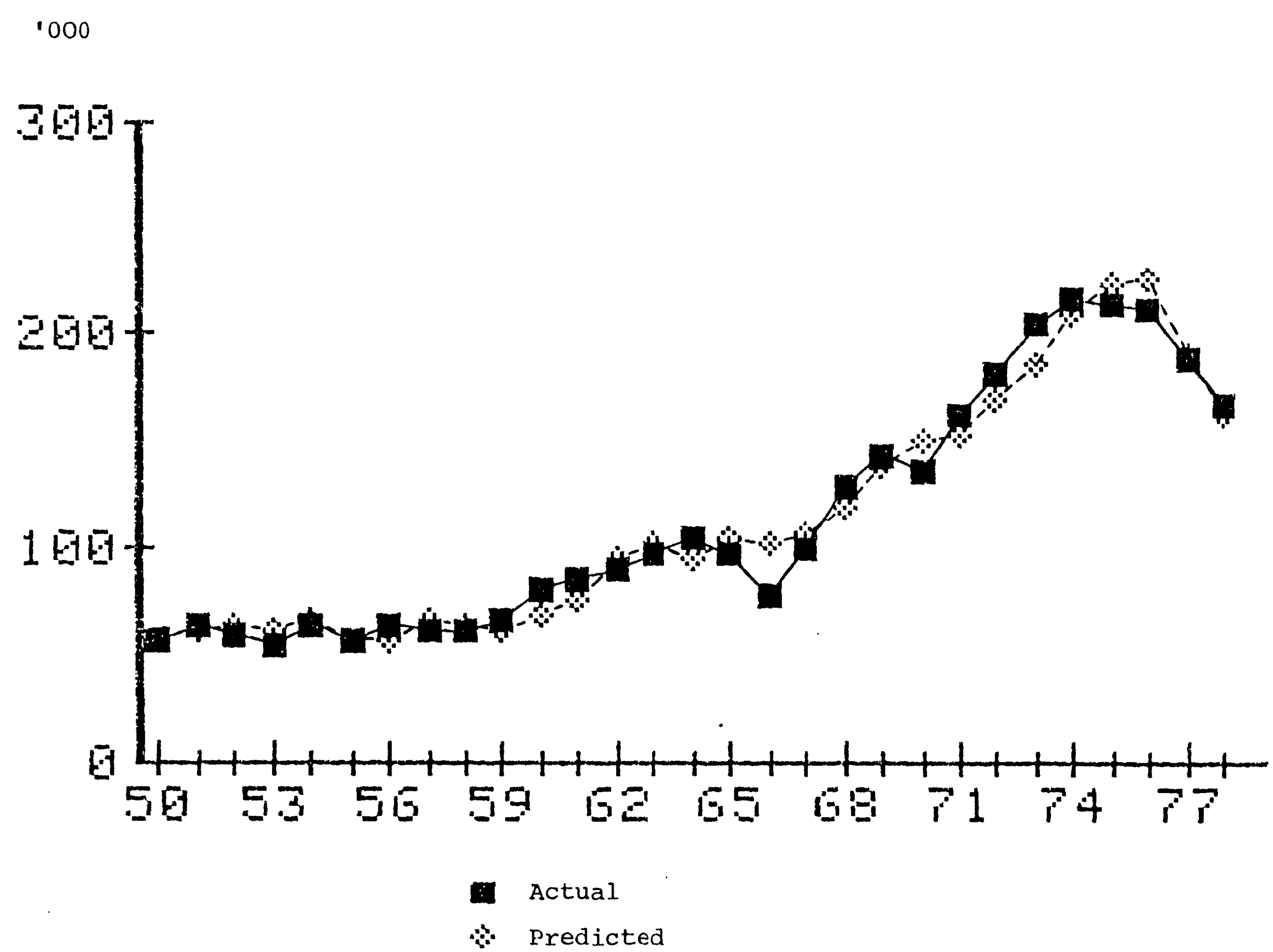

Figure 5.7 Number of Female Calves in the Coast Region.

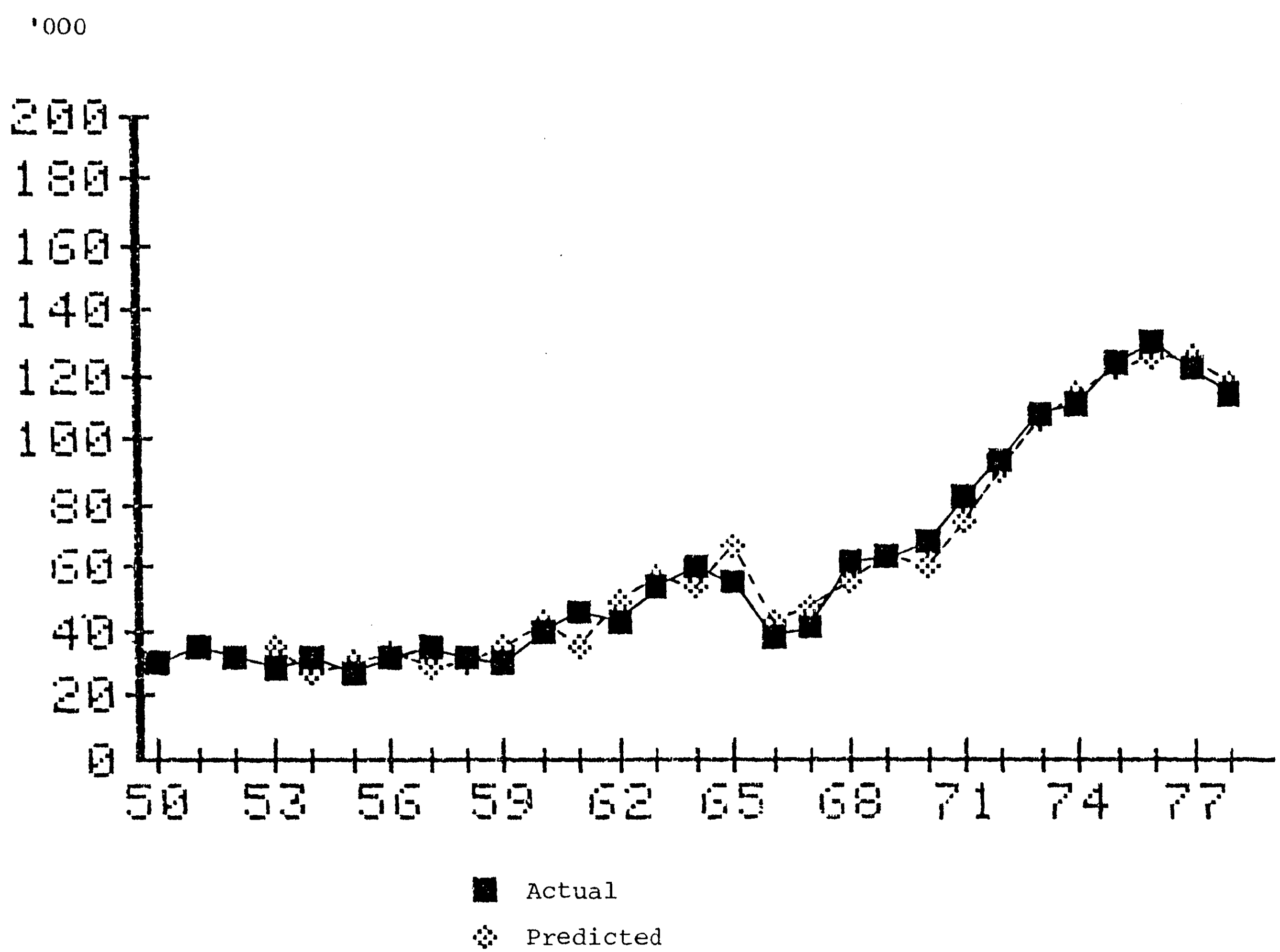

Figure 5.8 Number of Female Calves in the Northern Tablelands Region.

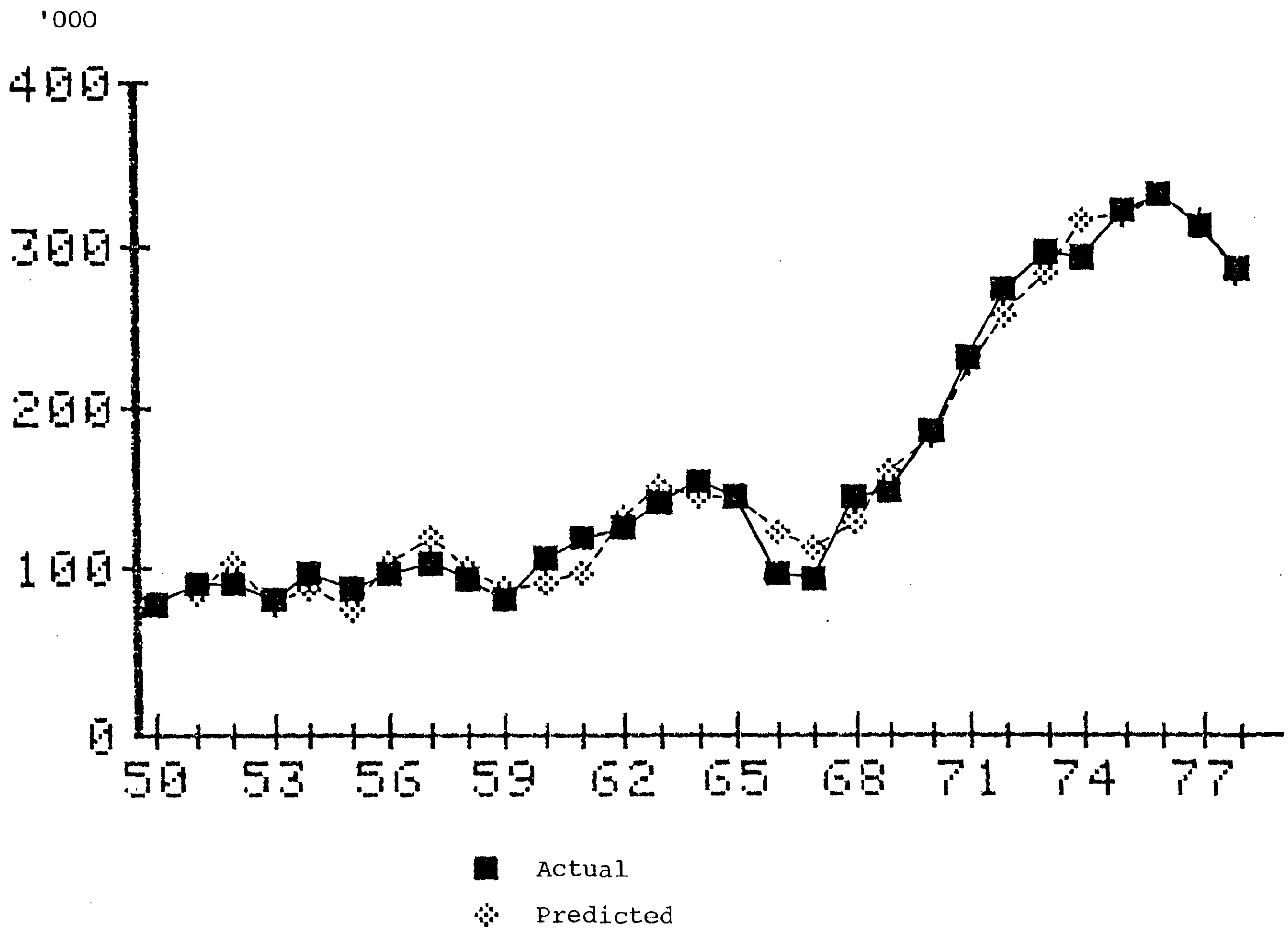

Figure 5.9 Number of Female Calves in the Northern Slopes and Plains Region.

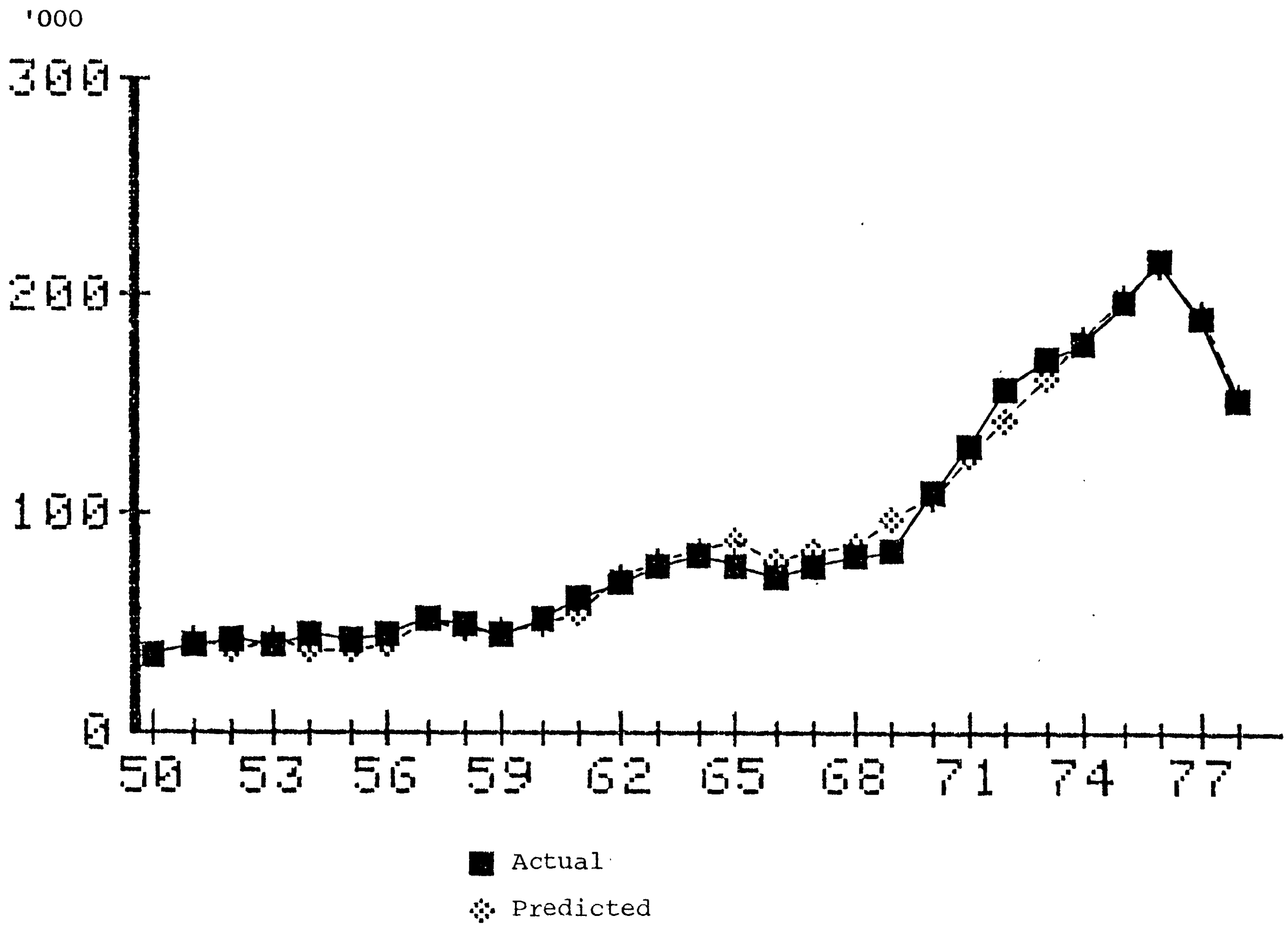

Figure 5.10 Number of Female Calves in the Central and Southern Tablelands Region.

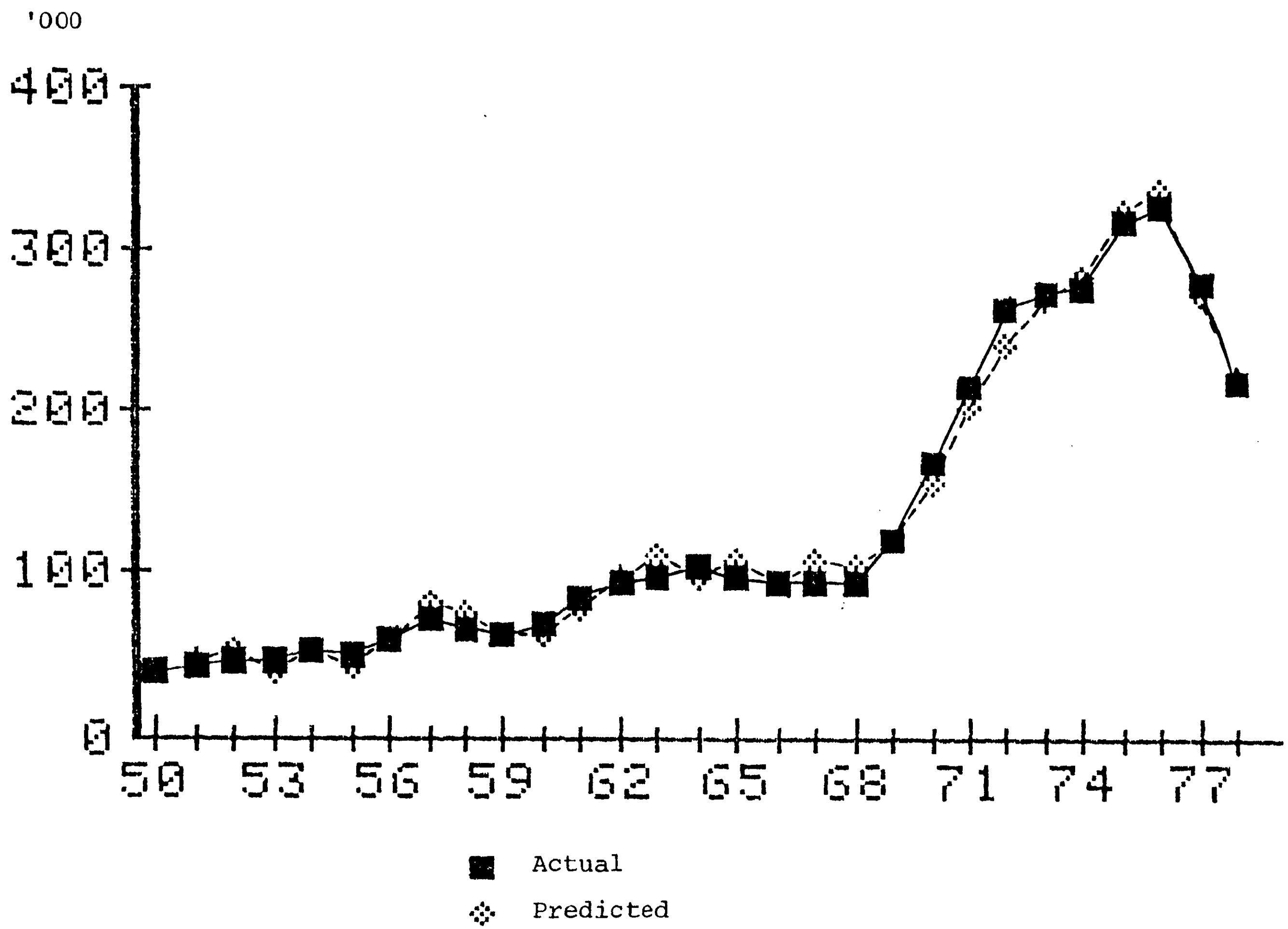

Figure 5.11 Number of Female Calves in the Central and Southern Slopes Region .

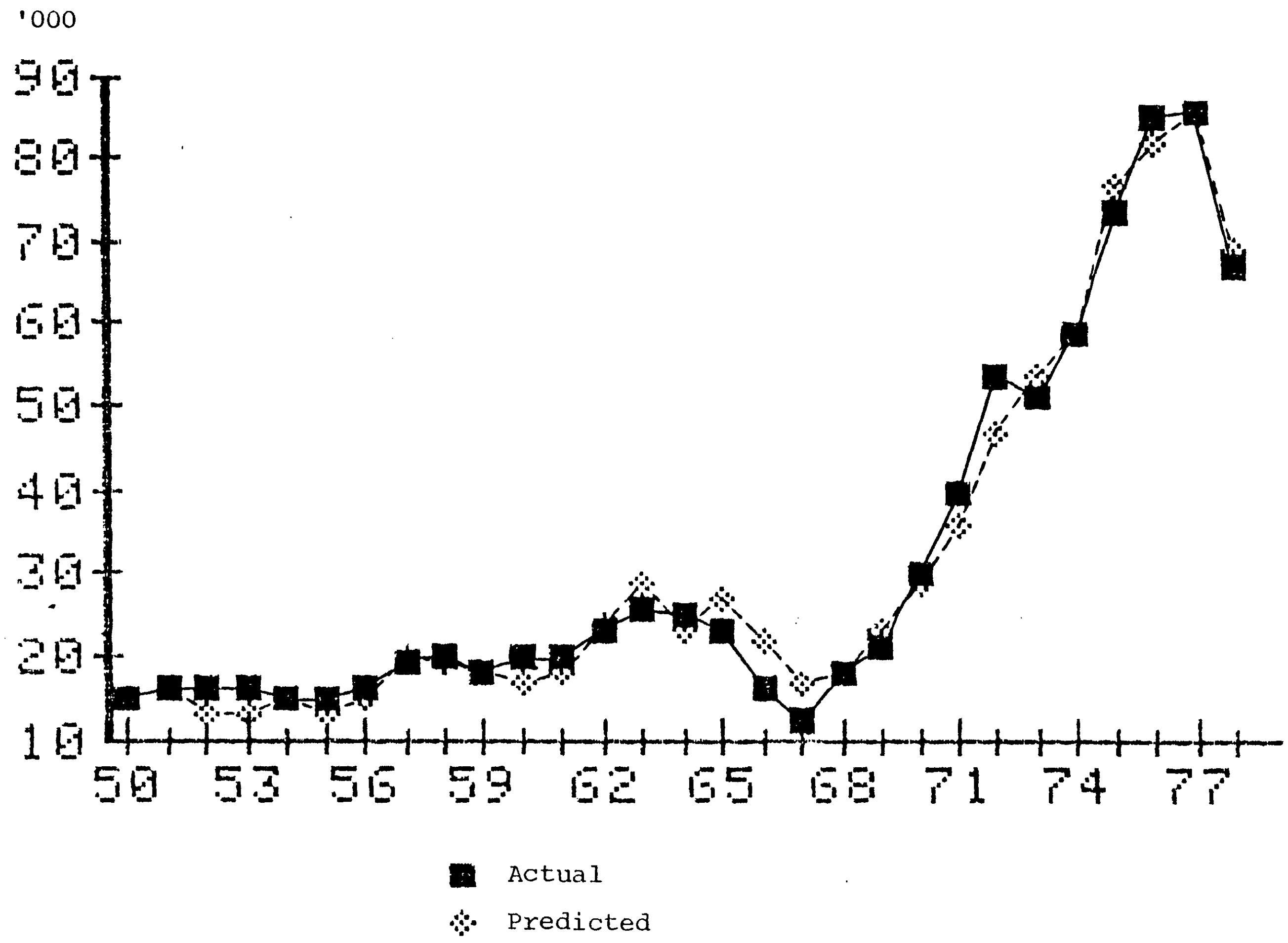

Figure 5.12 Number of Female Calves in the Western Plains Region.

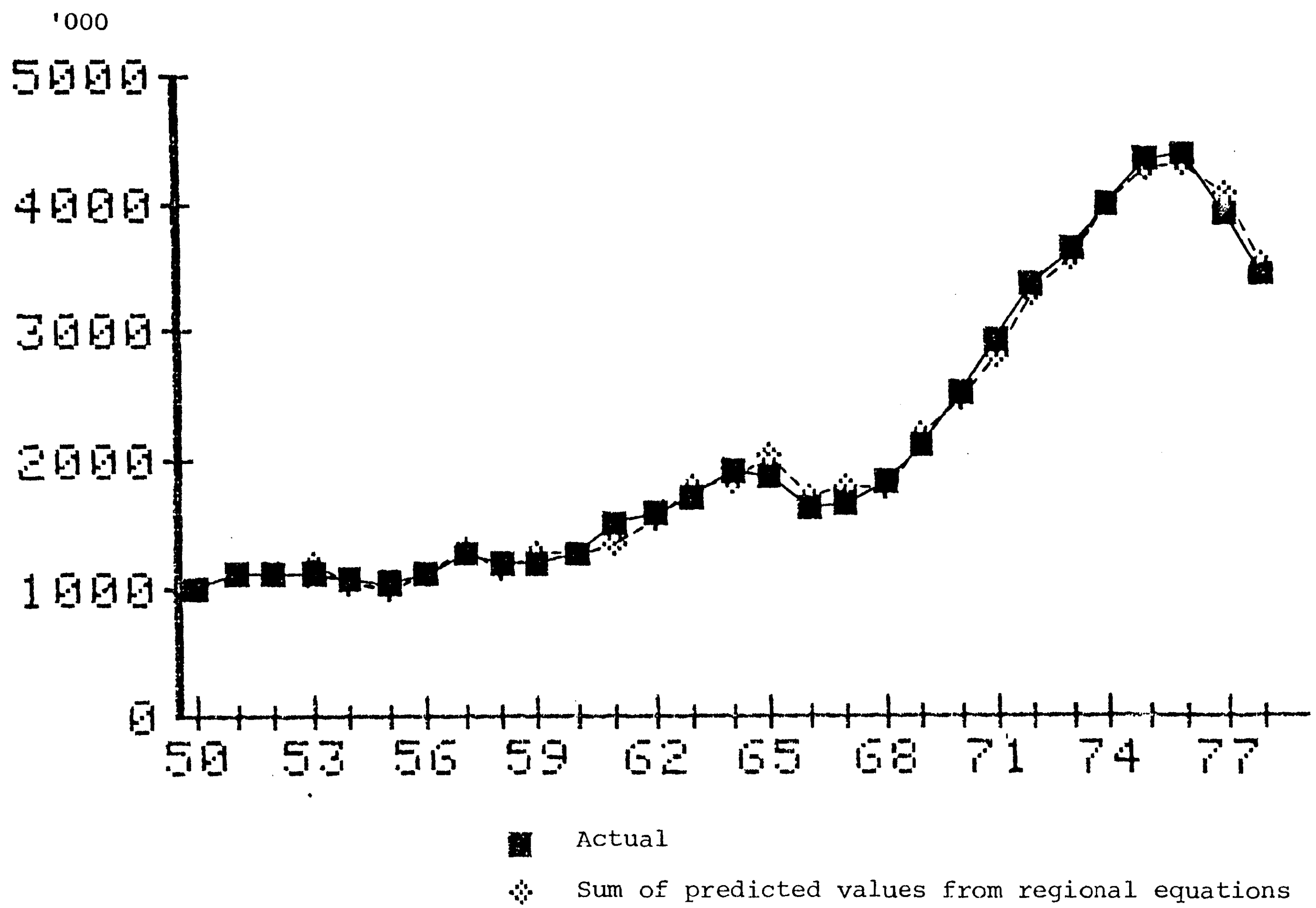

Figure 5.13 Number of Cows and Heifers in New South Wales - Regional Equations.

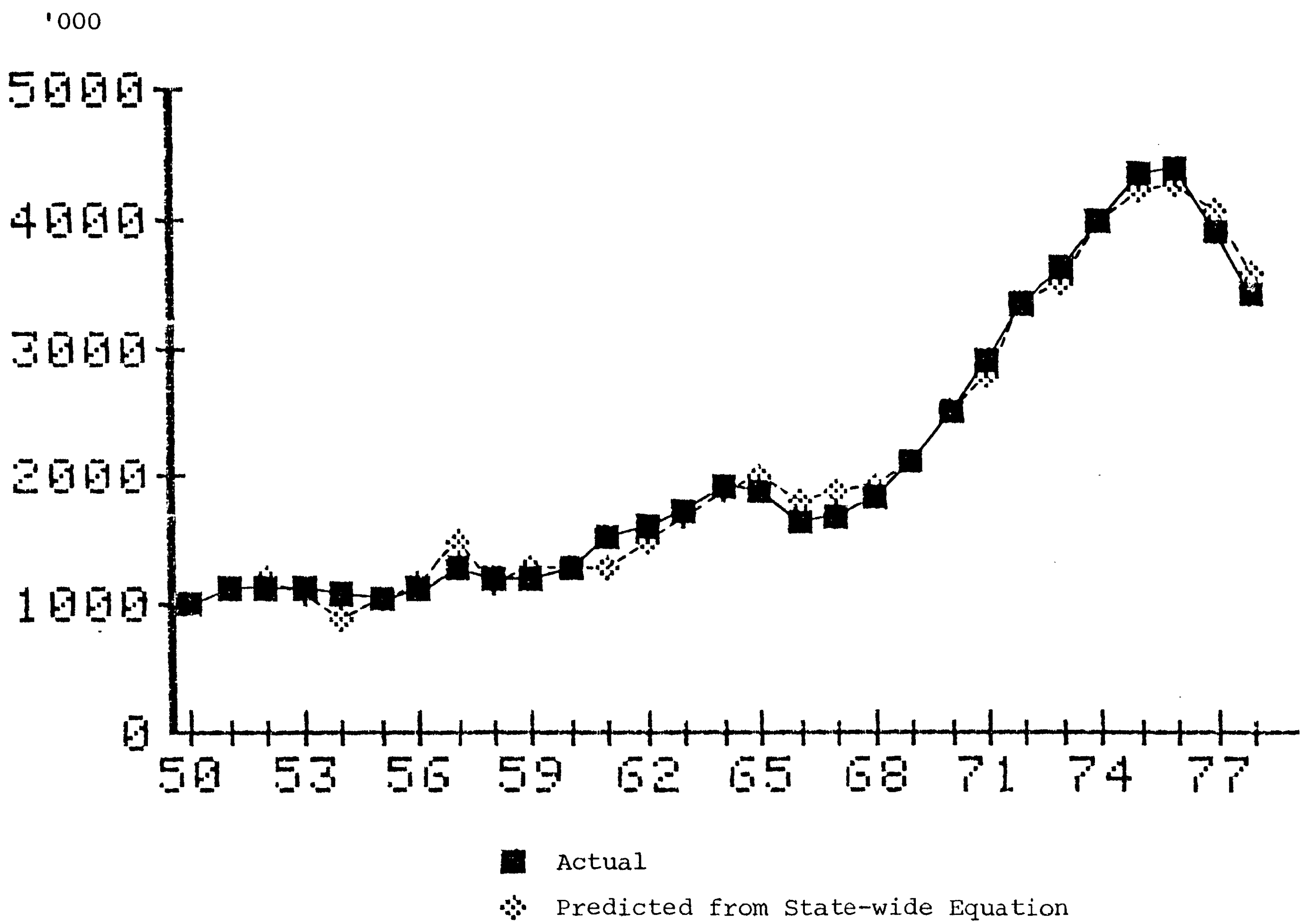

Figure 5.14 Number of Cows and Heifers in New South Wales - State-wide Equation.

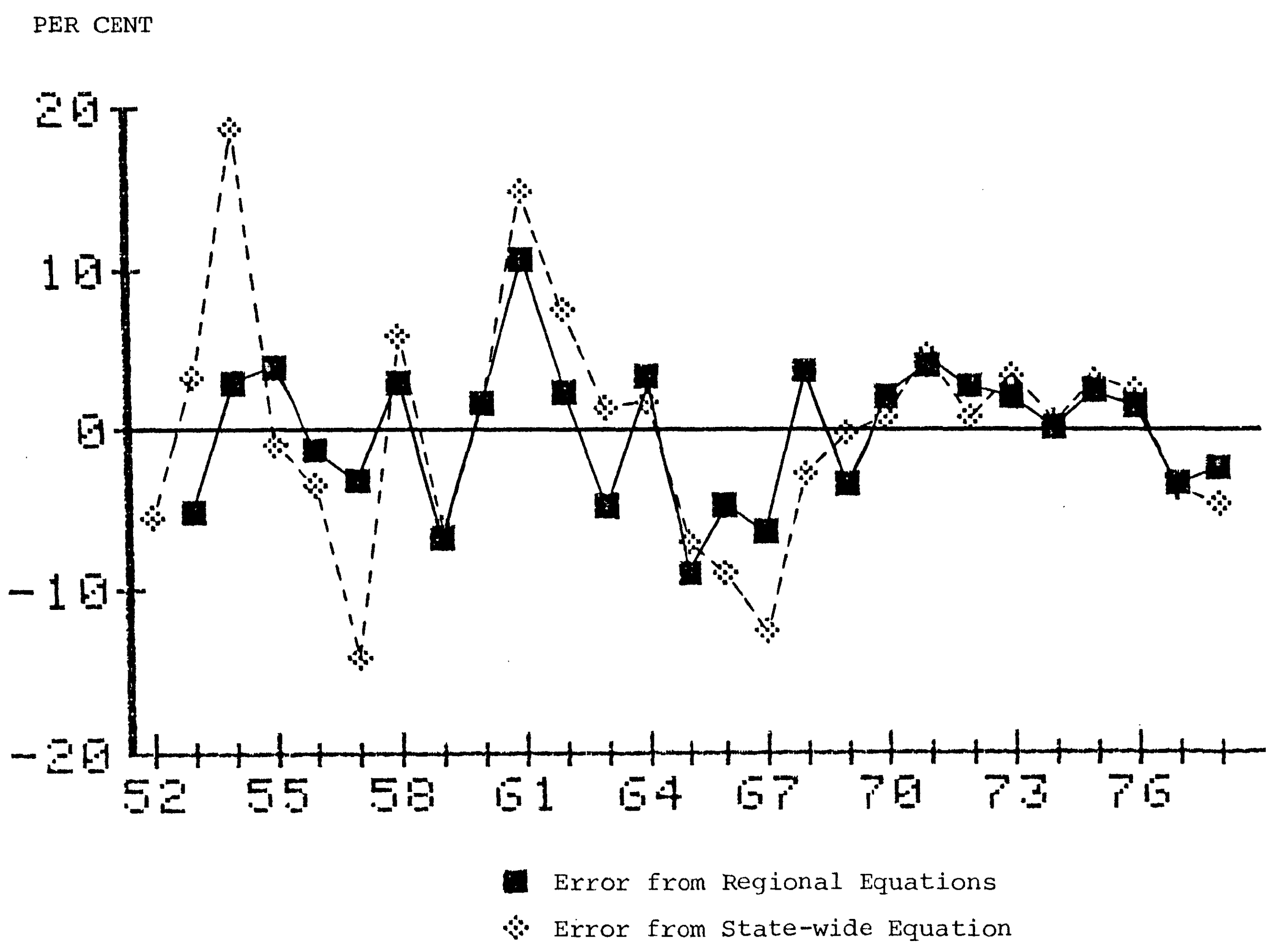

Figure 5.15 Errors as a Per Cent of Actual Number of Cows and Heifers in New South Wales.

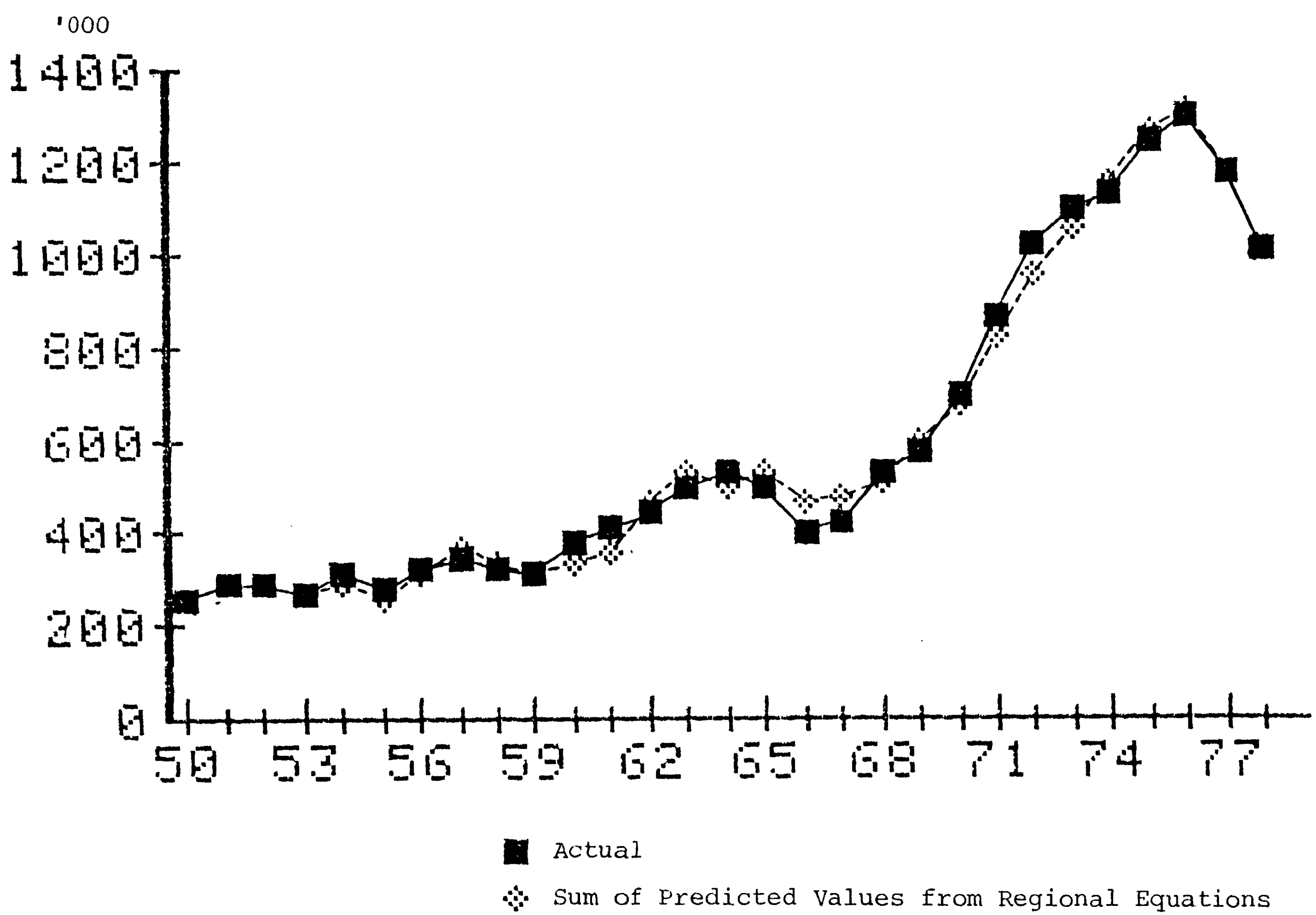

Figure 5.16 Number of Female Calves in New South Wales - Regional Equations.

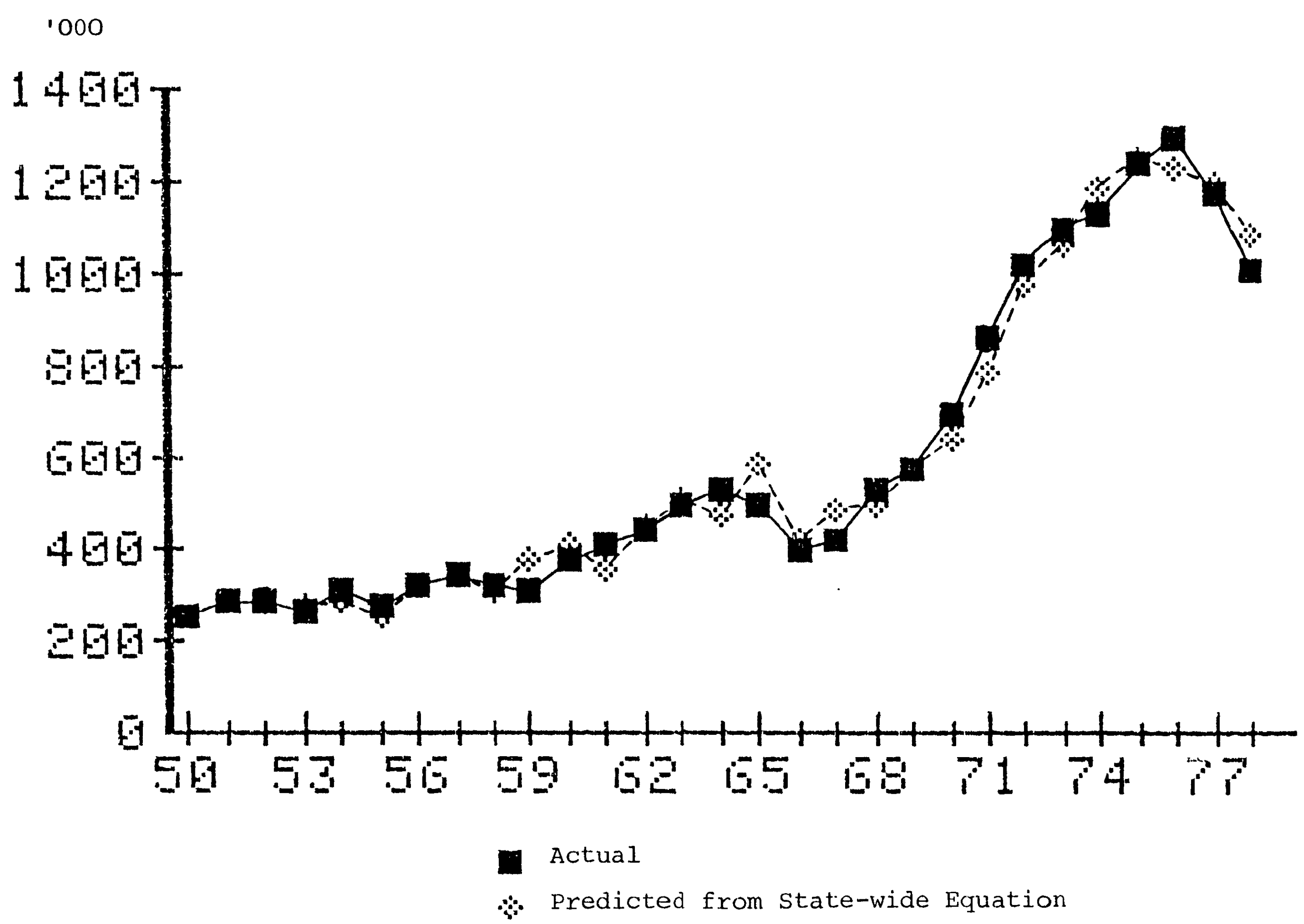

Figure 5.17 Number of Female Calves in New South Wales - State-wide Equation.

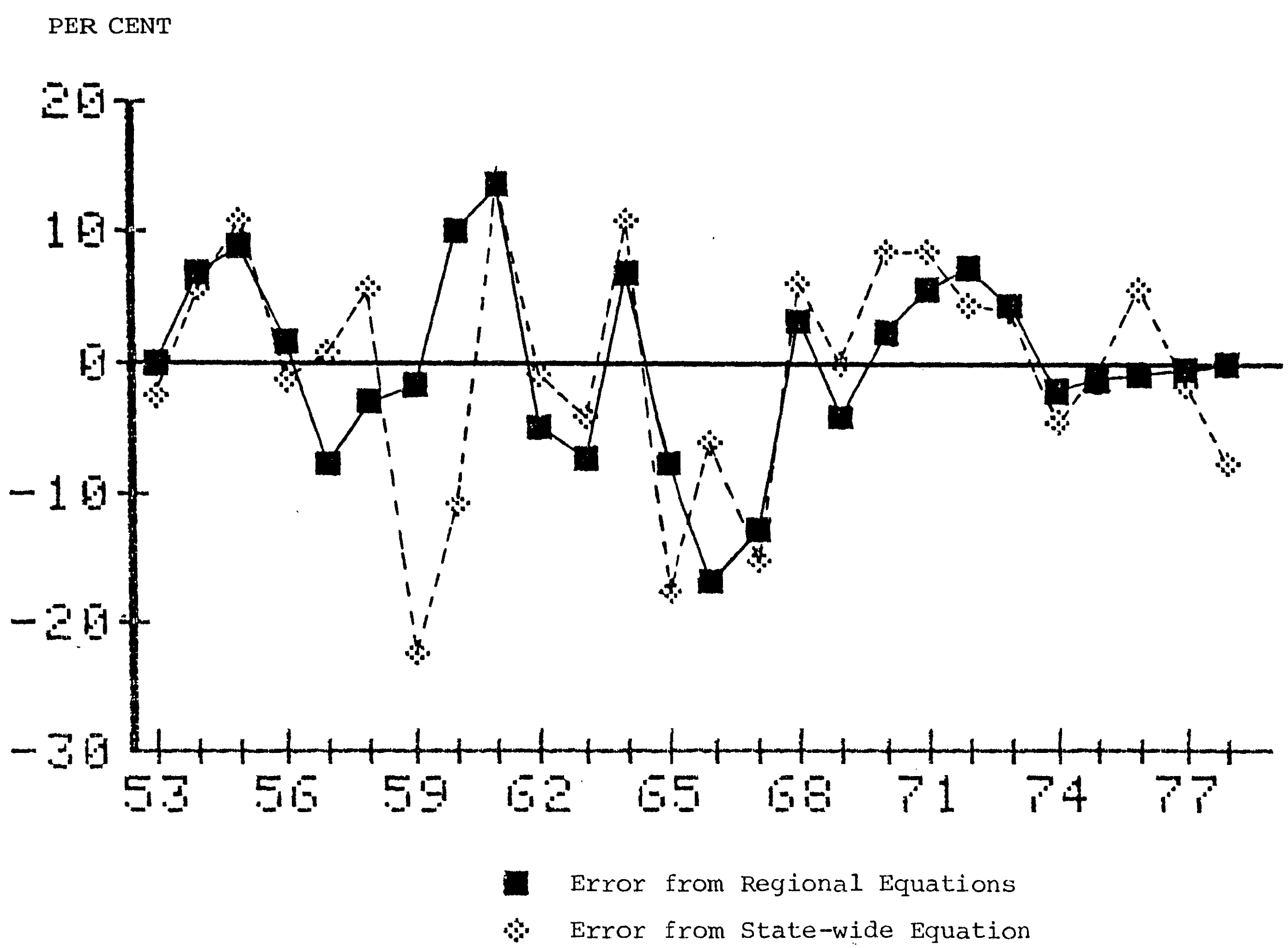

Figure 5.18 Errors as a Per Cent of Actual Number of Female Calves in New South Wales.

Plots of the actual and predicted values from the aggregative model approach and the State-wide equation for female calves are presented in Figures 5.16 and 5.17, respectively. The forecast errors from each approach expressed as a percentage of the actual values of female calf inventory in the State are plotted in Figure 5.18. Again, more than half of the forecast errors obtained using the aggregative model approach are smaller in percentage terms than the corresponding forecast errors from the State-wide equation. Two turning point errors are generated by the aggregation of the predictions from the regional equations; whilst the State-wide equation results in five of these errors.

The approach adopted in this study was to disaggregate New South Wales into six relatively homogenous regions for the purpose of analysing the annual inventories of beef cows and heifers and female calves. Based on the evaluation of the parameter estimates and the predictive performance of the estimated equations in section 5.2 and this section, respectively, it appears that this approach provides more acceptable results than State level equations.

5.4 Estimated Elasticities

To facilitate comparisons between the various estimated equations reported in the previous section, elasticities of the inventories of female beef cattle were calculated. For the purposes of this study, the elasticity measures the percentage change in the annual numbers of a given category of cattle associated with a one per cent change in annual expected prices of beef cattle. The series of expected prices for each region were calculated using the estimated values of θ and s presented in Tables 5.1 and 5.2

Estimated elasticities of response of female beef cattle inventories in the various regions of New South Wales are presented in Table 5.5 The estimates are calculated at the means of the beef price and inventories variables. The results suggest that the elasticity of cow and heifer inventory response is most elastic in the Central and Southern Tablelands region. Changes in the price of beef are associated with similar percentage changes in the numbers of cows and heifers in the Northern Slopes and Plains, and Central and Southern Slopes regions. There are relatively inelastic responses in the Coast region, in particular, and the Western Plains region.

Table 5.5 Elasticities of Inventory Response of Cows and Heifers and Female Calves in the Regions of New South Wales[a]

Regions	Elasticities	
	Cow and Heifer Inventory	Female Calf Inventory
Coast	0.26	0.43
Northern Tablelands	1.36	1.38
Northern Slopes and Plains	1.52	0.91
Central and Southern Tablelands	1.87	0.61
Central and Southern Slopes	1.54	0.42
Western Plains	0.82	0.74

a. Calculated at the means of the variables.

The estimated elasticities indicate that the numbers of cows and heifers are relatively elastic to changes in beef price in those regions of New South Wales where no single enterprise is dominant. However, in the beef cattle producing areas of the Coast region where major alternative enterprises are lacking, and the Western region where wool production is the dominant enterprise, the inventory elasticities have estimated values less than unity.

The estimated elasticities of the female calf inventories in all regions except the Northern Tablelands are less than unity. It is perhaps appropriate to ignore the estimate for the Northern Tablelands given that it appears to be an outlier.[13] Response is most elastic in the Northern Slopes and Plains region, followed by the Western Plains region, then the Central and Southern Tablelands region. The Coast and Central and Southern Slopes regions are the most inelastic in terms of the response of the numbers

13. The female calf inventory equation for the Northern Tablelands was estimated with a delay in the price lag of three periods compared to one period in the other regions. This result does not conform to prior expectations and may bias the elasticity estimate given the additional length of time for adjustment to occur.

female calves to changes in beef price. These results indicate that changes in beef prices lead to a less than proportional change in calf numbers within one year. This is reasonable given that it is highly unlikely that a pregnant cow will be slaughtered, and that other categories of beef cattle are likely to be slaughtered before cow and calf units during periods of herd liquidation. During periods of herd rebuilding in response to increases in price, changes in the numbers of calves is restricted by the numbers of breeding cows.

Estimated elasticities for female cattle inventories at the State level are reported in Table 5.6. Two estimates are presented for each category of female cattle. The first value is calculated in the same manner as the estimated elasticities of inventories in the regions. The second value is the weighted average of the regional elasticity estimates. For each category of cattle and region, the weight is given by

$$Z_{c,i} = \frac{1}{n} \sum_{t=1}^{n} \left(I_{c,i,t} / \sum_{i=1}^{6} I_{c,i,t}\right)$$

where $Z_{c,i}$ = weight for category c in region i;

$I_{c,i,t}$ = inventory of cattle in category c in region i in year t;

n = number of observations.

The weighted average elasticity for the State for category c ($ENSW_c$) is

$$ENSW_c = \sum_{i=1}^{6} Z_{c,i} \; E_{c,i}$$

where $E_{c,i}$ = estimated elasticity of the inventory of cattle in category c in region i.

Table 5.6 Elasticities of Inventory Response of Cows and Heifers and Female Calves in New South Wales

Method of Calculation	Elasticities: Cow and Heifer Inventory	Elasticities: Female Calf Inventory
State Equations[a]	2.62	1.23
Regional Equations[b]	1.25	0.71

a. Calculated at the means of the variables. Coefficient estimate on the beef price risk variable in Table 5.3 used in the calculation.

b. Calculated as weighted average of estimated elasticities reported in Table 5.5

The estimates of the elasticity of cow and heifer inventory response using the two alternative methods of calculation are quite different. The State level equation provides a higher estimate than the aggregative model approach. The preferred estimate is that derived from the aggregative model for reasons discussed in sections 5.2 and 5.3. Given that the estimated equation for female calf inventory at the State level is not entirely satisfactory, it is perhaps inappropriate to draw conclusions about the resultant estimated elasticity of inventory response. Examination of the results of the aggregative model approach suggests that the inventory elasticity is higher for adult females than for female calves. This result is reasonable given the nature of the cattle cycle during the observation period in this study. Cattle numbers trended upwards during the period 1950 to 1978. Given that an increase in the number of calves depends on an increase in the number of breeding cows and heifers, the production period for calves, therefore, can be regarded as being longer. Short-run elasticity tends to be lower for a commodity which has a longer production period than some other commodity (e.g. Tomek and Robinson, pp. 64-65).

Chapter 6

SUMMARY AND CONCLUSION

6.1 Summary

This thesis is concerned with an analysis of female beef cattle inventory response in the regions of New South Wales. Separate equations are estimated for (i) cows and heifers and (ii) female calves in each of six relatively homogeneous agricultural regions in the State. Equations for both categories of female cattle inventory in the State as a whole were also estimated. The estimated equations for cows and heifers are based on a general equation in which the end of year numbers are expressed as a function of the lagged total numbers of female beef cattle, expected prices and price risks of beef and alternative commodities, seasonal conditions and areas of improved pasture. The expected price and risk variables are specified by imposing geometrically declining weights on past observations on the respective variables. Similar equations are estimated for the closing inventories of female calves except that the lagged (i.e. opening) total numbers of female beef cattle variables are replaced by variables which only account for the opening numbers of cows and heifers.

The reported results indicate that the empirical estimation of the general equation to explain variations in cow and heifer inventory does not provide statistically significant values of all coefficients in the individual regional equations. For example, and of particular interest, are the relationships between regional inventories and the risk variables.

Risk (or variance) in beef prices is significantly and negatively related to annual inventories of cows and heifers in the Northern Tablelands, Northern Slopes and Plains, and Coast regions. A suggested reason for the results is that beef production in these regions is oriented towards breeding activities. These regions produce cattle which may be fattened locally, but are often turned off in store condition for fattening in other regions, commonly in central and southern New South Wales and Victoria. Since the demand for store cattle is mainly derived in other regions and is likely to be responsive to changes in beef prices, risks are imposed upon beef breeding enterprises in the northern and coastal regions.

In the Slopes and Plains regions of the State, risks in prices of alternative commodities influence annual numbers of cows and heifers. The results indicate that changes in farmers' subjective evaluations of the variances of wool and wheat prices have a significant impact on breeding cattle numbers in the so-called Wheat-Sheep and Pastoral Zones, but are insignificant in the High Rainfall Zone.[14]

The results obtained from the estimation of the female calf inventory equations are not as satisfactory overall as the estimated equations explaining cow and heifer inventory response. Firstly, some unexpected signs were obtained on coefficient estimates associated with the beef price risk variables in the equations for the Northern Slopes and Plains region and the Western Plains region. Secondly, in the equation for the Northern Tablelands region there is an estimated delay of three years before the commencement of the declining geometric lag scheme assumed to be appropriate in this study. A delay of only one year was expected and was indeed obtained in the other equations explaining annual female calf numbers.

Notwithstanding these deficiencies in the female calf equations, the remaining statistically significant results that are reported conform to expectations. Again, the relationships between regional inventories and the risk variables are of particular interest. There is a positive relationship between annual female calf inventory and annual beef price risk in the Northern Slopes and Plains region and the Western Plains region. A comparison between these results and the estimated elasticities of inventory response of female calves suggests that the numbers of female calves in the Northern Slopes and Plains and Western Plains regions are significantly responsive to changes in the distribution of beef cattle prices. Furthermore, the responses to changes in the mean price are more elastic than in the other regions.

Equations of similar specification were estimated for cow and heifer and female calf inventories in the State as a whole. Estimated elasticities of inventory response derived from these equations were compared with elasticities calculated from the regional equations. These latter measures are weighted averages of the estimated elasticities of inventory in the six regions. In the cases of both cows and heifers and female calves, the State level equations provide higher inventory elasticities than the aggregative model approach. The

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14. See, for example, Longmire et al. (1979) and Davidson (1967) for descriptions of these zones.

aggregate elasticities calculated from the regional equations are preferred because the parameter estimates and the predictive performance of this approach are more acceptable than for the State level equations.

6.2 Some Implications

Implications arising from the results relate to suggestions for assistance to sections of the beef industry in New South Wales, market information and the level of aggregation. For example, the imposition of herd size quotas as a possible means of stabilizing beef prices or returns may not achieve the implicit aim of controlling the level of beef supply without first effecting the impossible - namely controlling inventory response to seasonal conditions in all regions except the Coast and Northern Tablelands. In regard to the distribution of beef cattle processing facilities beyond the farm gate (such as abattoirs), future expansion or maintenance of these services should be considered in the light of farmers' subjective evaluations of future prices and risks associated with the production of beef cattle and alternative commodities such as wool and wheat as these have an impact on future numbers of slaughter cattle.

In the absence of figures on regional female slaughterings, the results for inventory response suggest that the significance and magnitude of factors affecting beef supply are not uniform throughout New South Wales. Furthermore, a change in cow and heifer inventory in one region may lead to changes in the other regions and even, perhaps, changes in beef supply. Thus, the monitoring of inventory changes in that region may provide 'early-warning' signals in market information activities.

The difference in the estimated elasticities of inventory response for cows and heifers in New South Wales calculated using the regional level estimates and the estimate from the State-wide equation, respectively, indicates that the aggregate (i.e. State-wide equation) approach may bias the elasticity estimate upwards. The estimate from the State-wide equation is higher than all of the individual regional estimates of inventory elasticity. Among the estimated elasticities at the regional level, the values are higher in those regions where no single enterprise is dominant. Lack of dominance of any one enterprise is likely to be more pronounced at the State level than at the regional level. This may explain the high estimate of inventory elasticity calculated from the results of the estimation of the State-wide equation.

6.3 Suggested Future Research

There is scope for further research to analyse the response to changing risks in other categories of beef cattle inventory such as steers and bullocks. Indeed, it may be possible to extend the number of categories of beef cattle beyond those surveyed by the Australian Bureau of Statistics. For example, Jarvis (1974) estimated the numbers of animals in various categories of cattle using data on herd stocks in two different years, slaughterings and natural deaths. Other demographic modelling techniques may also be of use in generating disaggregated statistics on components of the cattle herd. Disaggregated data on the inventory of cattle may allow the study of the effects of age distribution of the herd upon inventory response and beef supply response.

Research to evaluate alternative specifications of the expected prices and risk variables is needed to more adequately assess the usefulness of Just's adaptive risk model in the study of supply response in beef cattle and other livestock industries. In the meantime, the geometric lag distribution which was shown to have theoretical justification by Just, generally provided satisfactory and useful empirical results in this study. Furthermore, the reported model could be modified by the inclusion of geometric weightings of past covariances of prices (e.g. Just 1974a, 1974b, 1976). Testing of hypotheses concerning diversification into alternative farm activities could then be undertaken as well.

The method adopted in this study requires the assumption that prices and risk in the current and more recent past periods do not have a significant effect on current inventory levels. A more realistic but perhaps complicating approach would be to impose some weighting scheme, other than zero weights, on these observations. In other words, additional variables could be included which are some weightings (including geometric weightings) of these nearby prices. Alternatively, the imposition of some weighting scheme other than the geometric distribution on past prices may overcome the current deficiency in the study; and at the same time save degrees of freedom for estimation and hypothesis testing purposes.

The use of lagged values of total female cattle numbers in the cow and heifer inventory equations, and cow and heifer numbers in the female calf inventory equations, corresponds to the more traditional partial adjustment model. This <u>ad hoc</u> approach to the incorporation of the biological constraints and perhaps costs preventing the attainment of desired changes in inventory may be replaced by a set of identities which define the beef cattle life cycle. The problem may then be solved using dynamic programming techniques (e.g. Nerlove 1979).

This study has been concerned with changes in annual inventories in the female beef cattle herd. However, problems often arise in forecasting and policy analyses which are better modelled using quarterly data. Whilst quarterly statistics on livestock inventories are not collected in Australia, it may still be preferable to generate quarterly estimates for inclusion in, for example, aggregate econometric models rather than ignore these important variables completely. For example, Griffith and Vere (1981) obtained quarterly numbers of ewes by linearly interpolating between annual figures. There is a need to consider the response of quarterly inventories of various classes of beef cattle to changes in risk in order to add to knowledge about the structure of the beef industry.

Variations in the climatic environment causes fluctuations in the inventory of livestock. Farmers' subjective evaluations of the uncertainty surrounding climatic conditions in the future were assumed to be constant in this study. Indeed, this assumption may be heroic. The hypothesis that farmers perceive and respond to changes in climatic uncertainty in the livestock sector is worthy of future research.