PRODUCTION AND SUPPLY RELATIONSHIPS IN THE NEW ZEALAND SHEEP AND BEEF INDUSTRIES

by

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THE AGRICULTURAL ECONOMICS RESEARCH UNIT
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PREFACE

This is a report of research undertaken in the Agricultural Economics Research Unit (A.E.R.U.) during the period 1975 to 1977 to investigate production and supply relationships in the New Zealand sheep and beef industries.

This research was undertaken as part of a co-ordinated approach by the New Zealand Meat and Wool Boards' Economic Service, Massey University, and the A.E.R.U. to develop a series of models that would be of assistance in forecasting future New Zealand output of meat and wool. It was the role of the A.E.R.U. project to concentrate on the development of econometric single equation models.

The A.E.R.U. has received financial support for this research, via the New Zealand Meat and Wool Boards' Economic Service, from both the New Zealand Meat Producers' Board and the New Zealand Wool Board. This support is gratefully acknowledged.

J. B. Dent
<u>Director</u>

INTRODUCTION

The objective of this study has been to investigate production and supply relationships in the New Zealand sheep and beef industries, using various formulations of a single equation model.

Chapter 1 provides an historical perspective of production changes in the sheep and beef industries between 1918 and 1975, while in Chapter 2 a number of previous New Zealand livestock production and supply studies are reviewed.

In Chapter 3 the adequacy and reliability of livestock production data published by the New Zealand Department of Statistics is discussed. An alternative data source is evaluated.

Chapter 4 discusses the specification of a new single equation model. The aim of the model is to explain annual changes in total livestock units on sheep and beef farms. The model is developed for the eight classes of farms as defined in the New Zealand Meat and Wool Boards' Economic Service Sheep and Beef Farm Survey. Results of estimating parameters for four different formulations of this single equation model are presented in Chapter 5.

In the concluding chapter the study is summarised, and the implications of the results that were obtained from the model are discussed.

CHAPTER 1

AN HISTORICAL PERSPECTIVE OF PRODUCTION IN THE NEW ZEALAND SHEEP AND BEEF INDUSTRIES

1.1 Sheep

Movements in aggregate sheep numbers in New Zealand for the period 1918 to 1975 are shown in Table 1. The table indicates that numbers increased over this 57 year period from 26.5 million to 55.3 million. The average annual rate of increase was approximately 1.2 per cent but the rate of change fluctuated widely. There were two periods (1918-22 and 1930-33) during which numbers declined more than 10 per cent, and one 10 year period when total sheep numbers remained almost constant (1938-1948). However, from 1948 to 1968 numbers increased every year and total numbers reached more than 60 million. After 1968 numbers declined again to reach 55.3 million in 1975.

The composition of the New Zealand flock changed from 49 per cent ewes and 14 per cent wethers in 1918, to 74 per cent ewes and 2 per cent wethers in 1975.

Production parameters are not available for all of this period. However, lambing percentage increased steadily from 80 per cent in 1919 to 100 per cent in 1961 but slowly declined thereafter. Between 1970 and 1975 it ranged from 91 to 95 per cent. Wool production per head increased from 5.20 kg in 1948/49 to 5.86 kg in 1965/66. Thereafter it declined to a low point of 5.03 kg in 1973/74.

1.2 Beef Cattle

Aggregate data on beef cattle are less comprehensive than for sheep, and prior to 1941 can only be estimated indirectly from statistics on total cattle and cows in milk.

Estimated changes in beef cattle numbers over the period 1918 to 1975 are shown in Table 2. This table shows that total beef cattle numbers increased from 1.8 million in 1918 to 6.5 million in 1975. The average annual rate of increase was 1.75 per cent but the annual rate fluctuated widely from -11.7 per cent to +11.8 per cent. Figures on meat production per head are not available for most of this period.

It is evident that movements in beef cattle numbers have not always occurred in parallel with movements in sheep numbers. Comparative movements for the period 1918-1975 are shown in Figure 1. Prior to 1966 the long term growth rates for sheep and beef cattle were very similar, although short term divergences did occur. However, between 1966 and 1975 the growth rate for cattle was sustained at a very high rate, whereas sheep numbers remained almost static.

1.3 Factors Influencing Changes in Production

It is notable that livestock numbers increased rapidly during the boom times of the 1920s, declined markedly during the subsequent depression and then increased again up until World War II. The next period of marked expansion began in 1948 and coincided with the introduction of aerial topdressing. This period of fast growth continued until the late 1960s. The lower rate after 1968 coincided with (but was not necessarily caused by) a prolonged period of generally difficult climatic conditions. In addition, for much of this seven year period farm costs rose at a faster rate than product prices.

A number of econometric models have been developed to investigate and quantify the factors influencing farm output. These include studies by Johnson (1955), Rowe (1956), Court (1967) and Rayner (1968), all of which are reviewed in Chapter 2. However, all of these models relate to time periods prior to 1968. The changes in sheep and beef cattle numbers that have occured since 1968 have

TABLE 1

Movements in Sheep Numbers on New Zealand Farms, 1918-1975

Year	Total Sheep at 30 June	Change in Numbers from the Preceding Year	Index (1918=100)
1918	26,538,302	-	100
1919	25,828,552	-709,750	97.33
1920	23,919,970	-1,908,582	90.13
1921	23,285,031	-634,939	87.74
1922	22,222,259	-1,062,772	83.73
1923	23,081,439	-859,180	86.97
1924	23,775,776	694,337	89.59
1925	24,547,955	772,179	92.50
1926	24,904,993	357,038	93.84
1927	25,649,016	-744,023	96.64
1928	27,133,810	1,484,794	102.24
1929	29,051,382	1,917,572	109.46
1930	30,841,287	1,789,905	116.21
1931	29,792,576	-1,048,711	112,26
1932	28,691,788	-1,100,788	108.11
1933	27,755,966	-935,822	104.58
1934	28,649,038	893,072	107.95
1935	29,076,754	427,716	109.56
1936	30,113,704	-1,037,000	113.47
1937	31,305,818	1,192,114	117.96
1938	32,378,774	1,072,956	122.00
1939	31,897,091	-481,683	120.19
1940	31,062,875	-834,216	117.04
1941	31,751,660	688,785	119.64
1942	No data available	-	-
1943	No data available	-	-
1944	33,200,298	-	125.10
1945	33,974,612	774,314	128.02
1946	No data available	-	-
1947	32,681,799	-	123.14
1948	32,483,138	-198,661	122.40
1949	32,844,918	361,780	123.76
1950	33,856,558	1,011,640	127.57
1951	34,785,386	928,828	131.07
1952	35,384,270	598,884	133.33
1953	36,192,935	808,665	136.37
1954	38,010,954	1,181,019	143.23
1955	39,117,300	1,063,346	147.39
1956	40,255,488	1,138,188	151.68
1957	42,382,008	2,126,520	159.70
1958	46,025,930	3,643,922	173.43
1959	46,876,222	850,292	176.64
1960	47,133,557	257,335	177.61
1961	48,462,310	1,328,753	182.61
1962	48,987,992	525,682	184.59
1963	50,190,284	1,202,292	189.12
1964	51,291,898	1,101,614	193.27
1965	53,747,753	2,455,855	202.53
1966	57,343,257	3,595,504	216.08
1967	60,029,277	2,686,020	226.20
1968	60,473,597	444,320	227.87
1969	59,937,425	-536,172	225.85
1970	60,276,111	338,686	227.13
1971	58,911,525	-1,364,586	221.99
1972	60,882,719	1,971,194	229.41
1973	56,683,811	4,198,908	213.59
1974	55,883,000	-800,811	210.57
1975	55,320,000	-563,000	208.45

Source: Derived from Ministry of Agriculture & Fisheries Data.

TABLE 2

Movements in Beef Cattle Numbers on New Zealand Farms 1918-1975

Year	Total Beef Cattle at June 30	Change in Numbers Since Preceding Year	Index (1918=100)
1918	1,810,252		100
1919	1,937,098	126,846	107.01
1920	1,914,472	-22,626	105.76
1921	1,803,893	-110,579	99.65
1922	1,823,623	19,730	100.74
1923	1,785,872	-37,751	98.65
1924	1,811,626	25,754	100.08
1925	1,702,720	-108,906	94.06
1926	1,680,325	-22,395	92.82
1927	1,485,412	-194,913	82.06
1928	1,409,676	-75,737	77.87
1929	1,508,984	99,308	83.36
1930	1,685,912	176,928	93.13
1931	1,831,227	145,315	101.16
1932	1,698,357	-132,870	93.82
1933	1,606,153	-92,204	88.73
1934	1,576,525	-29,628	87.09
1935	1,551,556	-24,969	85.71
1936	1,519,042	-32,514	83.91
1937	1,680,993	161,951	92.86
1938	1,860,420	179,427	102.77
1939	1,948,229	87,809	107.62
1940	1,923,221	-22,008	106.24
1941	1,906,468	-16,753	105.32
1942	1,969,768	63,300	108.81
1943	1,875,109	-94,659	103.58
1944	1,967,378	92,269	108.68
1945	2,072,511	105,133	114.49
1946	2,173,866	101,355	120.09
1947	2,047,990	125,870	113.13
1948	2,077,998	30,008	114.79
1949	2,041,408	-36,590	112.77
1950	2,088,305	46,897	115.36
1951	2,148,592	60,287	118.69
1952	2,282,069	133,477	126.06
1953	2,478,302	196,233	136.90
1954	2,634,454	156,152	145.53
1955	2,807,724	173,270	155.10
1956	No data available	-	-
1957	2,861,085	-	158.05
1958	2,915,339	54,254	161.05
1959	2,969,651	54,312	164.05
1960	3,019,162	49,511	166.78
1961	3,334,309	315,147	184.19
1962	3,462,362	128,053	191.26
1963	3,557,907	95,545	196.54
1964	3,567,678	9,861	197.09
1965	3,627,576	59,808	200.39
1966	3,856,099	228,523	213.01
1967	4,241,152	385,053	234.29
1968	4,549,143	307,991	251.30
1969	4,811,791	262,648	265.81
1970	5,048,048	236,257	278.86
1971	5,280,000	231,592	291.67
1972	5,414,000	134,000	299.01
1973	5,733,000	319,000	316.70
1974	6,142.000	409.000	339.29
1975	6,528,000	386.000	360.61

Source: Derived from New Zealand Department of Statistics Data

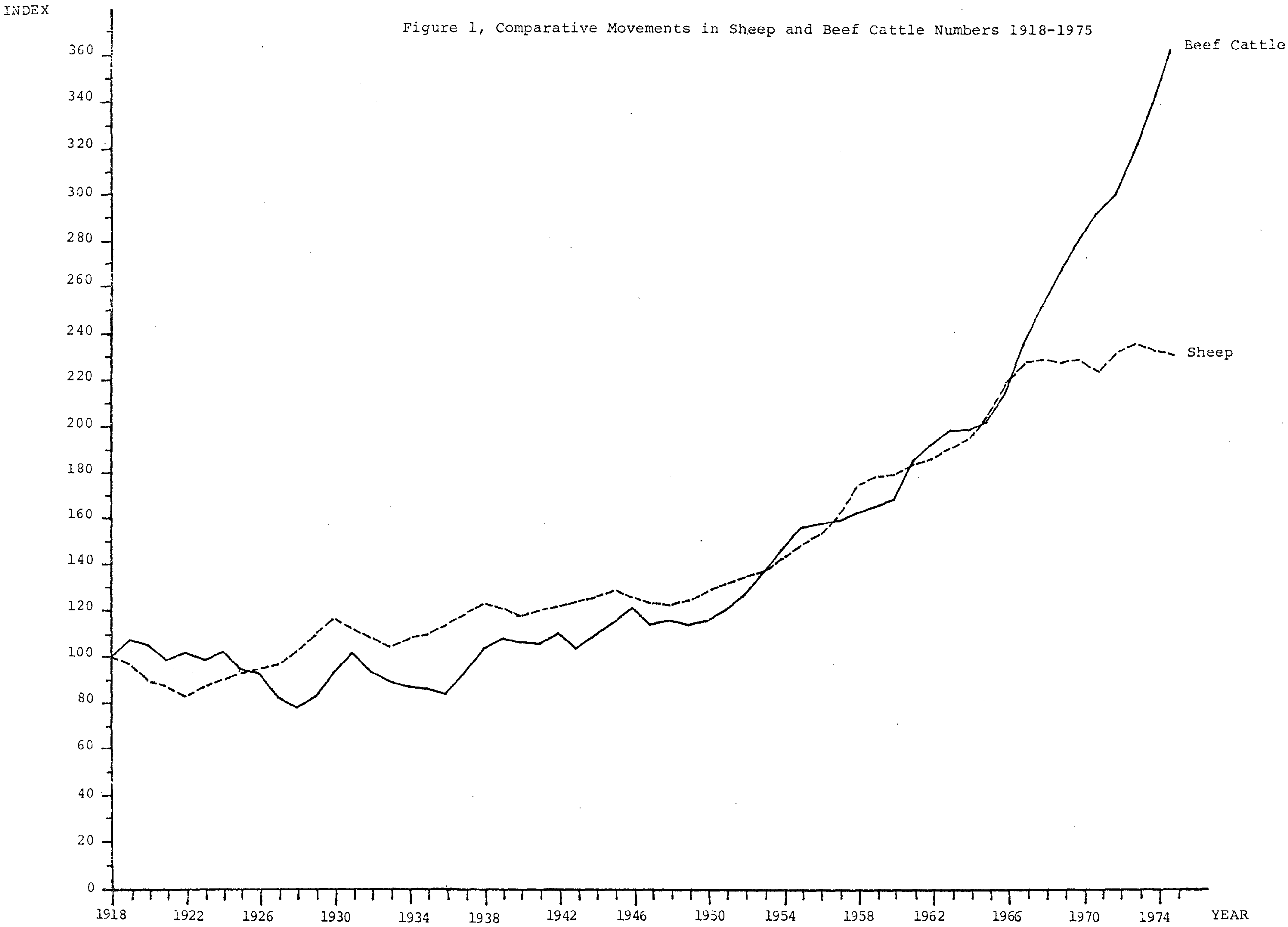

Figure 1, Comparative Movements in Sheep and Beef Cattle Numbers 1918-1975 not previously been subjected to econometric analysis, although there has been considerable discussion as to the reasons for the decline in sheep numbers that occurred after 1968.[1]

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[1] See Taylor (1974) and Report of the Farm Industry Incomes Advisory Committee (1975).

CHAPTER 2

A REVIEW OF PREVIOUS NEW ZEALAND PRODUCTION AND SUPPLY STUDIES

2.1 Introduction

In this chapter four of the major New Zealand production previous and supply studies are reviewed. The applicability of these models for analysis of the period up to 1975 is considered.

2.2 Johnson's Model of Aggregate Farm Production

Johnson (1955) analysed changes in aggregate agricultural output from 1928/29 to 1949/50 using a single equation model. The dependent variable was defined as "the total volume of New Zealand's farm production as computed by the Government Statistician".

For use as an explanatory variable Johnson constructed an index of climatic conditions. The index represented total rainfall for the months January to March for each year, as measured at Ruakura Animal Research Station near Hamilton.

A second explanatory variable was the area of hay and silage saved by New Zealand farmers in the preceding year. This hay and silage area affects the level of feeding during the intervening winter and Johnson suggested that it can be regarded as a measure of the lagged effect of climate.

First difference transformations of the logarithms were used to overcome serial correlation. The proportion of variance explained for the multiple regression was 0.46, with coefficients of both variables significant at the 5 per cent level.

Johnson also attempted to isolate a systematic price element in the production series. However this attempt was not successful and Johnson subsequently stated:

> "Our preliminary conclusion at this stage is that we have failed to isolate any real price influences in the farm production series. We have only a negative indication that the supply function of New Zealand agriculture is highly inelastic. In other words, not only is the supply of farm products independent of the current market situation, but it also tends to be independent even of previous market situations."

2.3 Rowe's Study of Economic Influences on Livestock Numbers

Rowe (1956) analysed economic influences on livestock numbers in New Zealand between 1920 and 1950, using a single equation model. The basic hypothesis of this study was that:

> "economic factors account for most of the observed variation in livestock numbers. The residual variation may be attributed to technological, climatic and other influences".

He hypothesised further that climatic factors

> "have relatively little influence on livestock numbers",

although he suggested they may have marked effects on per head production. Consequently, climatic factors were not incorporated into this model.

Initial selection of possible regressors was made using a 'general knowledge of farming practices', supplemented by 'graphical reconnaissance'. Appropriate lags were determined in the same way. The dependent variable and the independent economic variables were expressed in logarithmic form on account of the better fit obtained and the immediate identification of the beta coefficients with elasticities. The trend variable was calculated in non logarithmic form.

Results were presented for five different series of sheep and beef cattle numbers including lambs tailed, sheep shorn, beef cows, steers, and total beef cattle. For two of these series an alternative formulation of the model was also presented. The results are reprinted here in Table 3.

TABLE 3

Results of Rowe's Study of Economic Influences on Livestock Numbers

	Dependent Variable	Explanatory Variables	Lag in Years	R^2 (a)	Von Neu-mann Ratio	Beta Coeff-icients (b)	Standard Error (b)
1	Lambs tailed	Lamb to mutton price ratio	1	0.96	0.83	+0.34	0.06
		Time	-			+9.8	1.3
2	Sheep shorn	Lamb to wool price ratio	2	0.64	0.86	-0.24	0.06
		Lamb to mutton price ratio	2			+0.87	0.11
3	Sheep shorn	Mutton to wool price ratio	2	0.98	1.54	-0.19	0.01
		Time	-			+5.4	0.2
4	Beef cows	Beef price to dairy return ratio	4	0.96	1.13	+0.29	0.03
		Time	-			+8.3	0.4
5	Ratio of beef cows to sheep shorn	Beef to wool price ratio	4	0.81	1.77	+0.29	0.03
		Real Beef price	2			+0.22	0.04
6	Steers	Real beef price	4	0.77	1.42	+0.48	0.03
7	Total beef cattle	Beef price to dairy return ratio	4	0.90	1.21	+0.17	0.03
		Time	-			+5.0	0.4

(a) The R^2 figures were reported by Rowe in the form of the multiple correlation coefficient, R. For the sake of consistency throughout the present study, they have been converted here to R^2 values.

(b) The beta coefficients and their standard errors are reprinted here exactly as recorded by Rowe. Rowe pointed out that since all variables except trend were run in logarithmic form, the parameter estimates for the trend variables should be preceded by a number of zeros to the right of the decimal point. Rowe multiplied these trend terms by 1000 for ease of presentation.

Since lamb, wool and mutton are all complementary products derived from sheep, it is difficult to assess the long run economic implications of those equations where price ratios of these products are used as explanatory variables. In addition, in the four equations in which a trend term is incorporated, it is this trend term that provides the majority of the explanation. This would seem to contradict Rowe's original hypothesis that economic variables account for most of the observed variation, with the residual 'attributed to technological, climatic, and other influences'.

There are also some reservations concerning the statistical validity of Rowe's study. Rowe stated that:

> "Although several residuals are highly autocorrelated, in only one case are the estimates of parameters less than five times their respective errors, so that we may feel fairly confident of the significance of the estimates."

This suggests that Rowe has underestimated the effect of serial correlation and the consequent likelihood of spurious correlation. The inappropriateness of making conclusions from results such as this has been clearly shown by Granger and Newbold (1974).

In summary it is concluded that Rowe's study does not provide evidence for economic factors influencing sheep and beef numbers. Neither, however, does it provide evidence that these factors are unimportant.

2.4 Court's Study of Supply Responses of Sheep and Beef Farmers

Court (1967) estimated supply functions for lamb, mutton and beef using both the ordinary least squares method (OLS) and the method of two stage least squares (2SLS). He used a modified version of Nerlove's adaptive expectations model[2] to estimate short and long run price elasticities for these three products.

The price elasticities for lamb, mutton and beef obtained by Court are as follows:

	Short Run		Long Run	
	2SLS	OLS	2SLS	OLS
Lamb	0.09	0.05	2.00	2.00
Mutton	-0.25	-0.45	-0.73	-0.94
Beef	-0.54	-0.30	-1.00	0.16

The negative short run supply elasticities could be explained by farmers building up stock numbers when prices increase in the expectation of increased future income outweighing present income, but long run negative elasticities are harder to rationalise.[3] This suggests that there may be errors of either measurement or specification incorporated into the model.

Court also noted that:

> "An unfortunate aspect of the data used is that the series for lamb, mutton and beef show fairly strong trends over time which are due to reasons other than the income maximisation hypothesis and distributed lags upon which the model is based."

As Court pointed out, these trends show up in the Beta coefficients of the lagged supply variables and this results in overestimation of long run elasticities by unknown, but possibly very large amounts.

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[2] See Nerlove (1956) and Nerlove (1958).

[3] Negative long term elasticities were also found by Bergstrom (1955) in a similar study covering the period 1922 to 1938.

Court concluded that:

> "It is almost certain that definite economic influences on the supply of New Zealand meats exist and that these can be obtained from a model taking account of the decision making processes of the New Zealand farmer over time. That these influences cannot be determined very precisely seems to be characteristic of supply models in general."

2.5 Rayner's Model of the New Zealand Sheep Industry

Rayner (1968) developed a national sheep supply model in which sheep numbers were disaggregated into structural classes based on age and sex. Numbers in the main classes of sheep were analysed independently of each other. The explanatory variables used were a combined lamb price and wool price index lagged one year, and trend terms to account for technological change.

The equations were originally estimated using data for the years 1952 to 1964 and were then re-estimated by Rayner incorporating 1965 data. As part of the present study the equations were further updated to 1973.

Results for the two main classes of livestock, i.e. breeding ewes and ewe hoggets, are shown in Table 4. It is clear that the product prices index, although providing significant explanation for the first order differences over the period 1952 to 1964, performs poorly over the longer period.

TABLE 4

Sheep Supply Functions as per Rayner's Model

(a) Breeding Ewes
(Dependent Variable : Annual Change in Ewe Numbers)

	Observation Period		
	1952 to 1964 (Rayner)	1952 to 1965 (Rayner Update)	1952 to 1973 (Woodford and (Woods Update)
Product Prices Coefficient	21,641 (SE not available)	21,771 (SE not available)	8,460 (9,360)
Constant Term	-1,465,500	-1,393,400	-161,731
r^2	0.53**	0.34*	.04
Durbin Watson Statistic	2.69	1.81	1.14

(b) Ewe Hoggets
(Dependent Variable : Annual Changes in Ewe Hogget Numbers)

	Observation Period		
	1952 to 1964 (Rayner)	1952 to 1965 (Rayner Update)	1952 to 1973 (Woodford and Woods Update)
Product Prices Coefficient	11,019 (SE not available)	11,098 (SE not available)	5,832 (3,810)
Constant	-1,016,000	-975,000	-447,278
r^2	0.42**	0.27	0.11
Durbin Watson Statistic	1.87	1.58	2.14

* Significant at the 5% level

** Significant at the 1% level.

Note: Numbers in brackets indicate standard errors.

2.6 The Possibilities for a Revised Model

At this stage of the present project consideration was given as to whether any of the studies reviewed in this chapter provided a basis for a revised model capable of explaining the changes in sheep and beef cattle numbers for the period up until 1975.

In this respect, it is notable that the only model to take explicit account of climatic conditions is Johnson's and that there are no published studies relating changes in livestock numbers to climatic conditions. Therefore, if climatic conditions do influence farmers' decisions relating to short term expansion or contraction of livestock numbers, then none of these models is suitable for quantifying this relationship.

Similarly, in the three studies reviewed here which analysed livestock numbers, cattle were either omitted from the analysis or else analysed independently as a non-competitive class of livestock to sheep. Court (1967) stated:

> "This seems reasonable when considering the nature of New Zealand beef production, where beef cattle have in the past been used largely as agricultural implements to crush fern and second growth on rough country and to control pasture growth in the spring. Generally, sheep farmers have not expected to make much profit from beef."

However, since the mid 1960s it is evident that increases in the beef price schedule have made beef rearing economically competitive on many classes of land.[4] In addition, a structural change has taken place on many farms, and stocking rates have become sufficiently high that less cattle are needed for control of pasture quality. The result of this is that a transition from a complementary to a competitive relationship has occurred. This aspect will be referred to again in Chapters 3 and 4.

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[4] See Johnson (1970).

As a result of these problems it was considered that none of the published New Zealand production and supply models has either the structure or the specification to explain recent changes in livestock numbers. Indeed, all that can be said is that one study provides strong evidence of climatic influences affecting aggregate production. The influence of economic factors is not clear and there is doubt as to whether the long run supply elasticities for some New Zealand livestock products are positive or negative.

Consequently it was decided not to persist with further updating and revision of previously published models and that a new model would be developed.

CHAPTER 3

THE AVAILABILITY AND SELECTION OF LIVESTOCK DATA

3.1 Introduction

In this chapter the alternative sources of livestock data available as input for an econometric time series model are discussed. The limitations and advantages associated with the use of both the Department of Statistics and Ministry of Agriculture & Fisheries census figures and the Meat and Wool Boards' Economic Service annual survey of sheep and beef farms are considered. The standardisation procedures that are necessary before the Meat and Wool Boards' Economic Service data can be used in a time series model are discussed.

3.2 Aggregation Problems in Selecting Data

If different farm types respond differently to given economic conditions, then analysis of any aggregate model will tend to be confounded by such behaviour. In addition, different types of farms may experience different economic and physical conditions at any one point in time. This reasoning, together with dissatisfaction with the results obtained from previous studies of national aggregates implied that consideration should be given to using either a regional or farm type classification of data.

3.3 Alternative Sources of Data

Regional data on sheep numbers are published by the Ministry of Agriculture & Fisheries. Regional data on cattle numbers are published by the Department of Statistics.

A preliminary analysis of these data indicated considerable variations in short term trends within the same statistical area. For instance in the Wellington statistical area during 1972/73, sheep numbers in Horowhenua County declined 25 per cent while in Rangitikei County they declined 2.7 per cent. Similar examples could be quoted for other statistical areas for other years. This indicates that either large errors of measurement are occurring, or else there is great heterogeneity within regions. In addition, there is no price and income data collected on a regional basis for incorporation into regression models.

An alternative source of data on livestock numbers is the New Zealand Meat and Wool Boards' Economic Service annual survey of approximately 550 New Zealand sheep and beef farms. The objective of the survey is to provide a source of information on income and production trends within the industry and results are published in eight farming sub groups. The Meat and Wool Boards' Economic Service (henceforth referred to as the Economic Service) describes these farms as 'a random sample stratified by geographical regions and by sheep numbers'.[5]

The eight classes of farm are defined as follows:

1. HIGH COUNTRY, SOUTH ISLAND
   Extensive run country located at high altitude, carrying fine wool sheep, with wool as the main source of income. In Canterbury, Otago and Marlborough.

2. HILL COUNTRY, SOUTH ISLAND
   Mainly fine wool sheep with a carrying capacity of over two livestock units per hectare. Wool and sales of cast-for-age ewes are a major source of income. Mainly in Canterbury.

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[5] Further details concerning the survey frame and the sample are published in the Economic Service's annual publication "Sheep and Beef Farm Survey". Stock reconciliations for each class of farm are not printed in this publication, but they are available on request from the Economic Service.

3. HARD HILL COUNTRY, NORTH ISLAND
Mainly Romney sheep. Cattle provide up to one third of the revenue, the balance being derived from the sale of store sheep and lambs, plus wool income. Mainly on East and West Coasts and Central Plateau of North Island.

4. HILL COUNTRY, NORTH ISLAND
Easier hill country and smaller holdings than Class 3. A high proportion of sale stock is sold in forward store or fat condition. These farms are located throughout the North Island.

5. INTENSIVE FATTENING FARMS, NORTH ISLAND
High producing grassland farms. Replacement ewes often bought in. Mainly in South Auckland, West Coast North Island and Hawke's Bay.

6. FATTENING-BREEDING FARMS, SOUTH ISLAND
A more extensive type of fattening farm generally breeding its own replacements and frequently with some cash cropping. Mainly in Centerbury and Otago.

7. INTENSIVE FATTENING FARMS, SOUTH ISLAND
High producing grassland farms and with cash crop returns increasing in importance.
Mainly in Southland, South and West Otago.

8. MIXED CROPPING AND FATTENING FARMS, SOUTH ISLAND
Mainly in Canterbury with a high proportion of the income being derived from grain and small seeds.

It is clear that the Economic Service Farm classes are specifically grouped so as to maximise the homogeneity of salient production characteristics. However, most of the eight classes have a wide geographical spread and initially it seemed this might compound the problem of finding suitable climatic indices for incorporation into the model. There is, however, no evidence available on this point, and it was considered possible that exactly the opposite may also occur. For example, a hill country farm in Hawke's Bay may experience climatic conditions more similar to those on a Wairarapa hill farm than on a Hawke's Bay flatland farm.

3.4 Standardisation Requirements and Procedures

Inevitably, there is a small turnover each year of farms in the survey. This is caused by farm amalgamations, sales and purchases, and also by farmer deaths. In addition, as knowledge of the total farm population (i.e. the sample frame) has improved, some reselection has occurred to provide a more representative sample. The Economic Service states[6] that "the annual turnover of farms in the survey approximates that which takes place nationally".

As a result of the continuing turnover in surveyed farms, the numbers of livestock recorded as being carried at the end of a year (i.e. 30 June) are seldom identical with the numbers recorded as being on hand at the start of the following year (i.e. 1 July). To take an extreme example, on Class 1 farms, the closing sheep numbers at 30/6/74 averaged 8095 whereas the opening sheep numbers for the same class of farm in the following year (i.e. 1/7/74) averaged 6391. Accordingly, before the Economic Service livestock data can be used in a time series regression model, adjustment is necessary to link successive years of the survey so as to provide a continuous series of livestock numbers.

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[6] Anon (1976), p4.

Two possible standardisation procedures were considered. These were:

1. Standardisation of total sheep stock units and total cattle stock units and _pro rata_ adjustment of component livestock series.

2. Standardisation by individual age and sex groupings.

The details of both these procedures are described in Appendix A and the relative merits of each method are also discussed.

The method finally chosen was to standardise total sheep units and total cattle stock units and then adjust the component livestock series on a _pro rata_ basis. In summary, this standardisation procedure:

(a) Reconciles total livestock units at the end of each year with opening livestock units for the following years for both sheep and cattle.

(b) Uses recent information concerning the survey frame to reduce the influence of unrepresentativeness in the average size of the sample farms for early years of the survey.

However, the standardisation procedure does not attempt to separate out changes in stock slaughter policy, flock composition or herd composition which have occurred as a result of structural change in the industry, from these same changes caused by a change in the nature of the sample. These limitations are not considered important for a model based on aggregate sheep and aggregate cattle numbers. They could become of greater importance in a model incorporating biological relationships between different age classes of stock.

3.5 The Standardised Livestock Series

The annual percentage changes in total livestock units over the period 1964 to 1975 are shown for the eight classes of farm in Figures 2 and 3. The variability between classes in the same seasons is particularly notable. It is also notable, as shown in Table 5, that most of the increases in livestock units have occurred on the hill country farms.

3.6 Validation of the Standardised Livestock Series

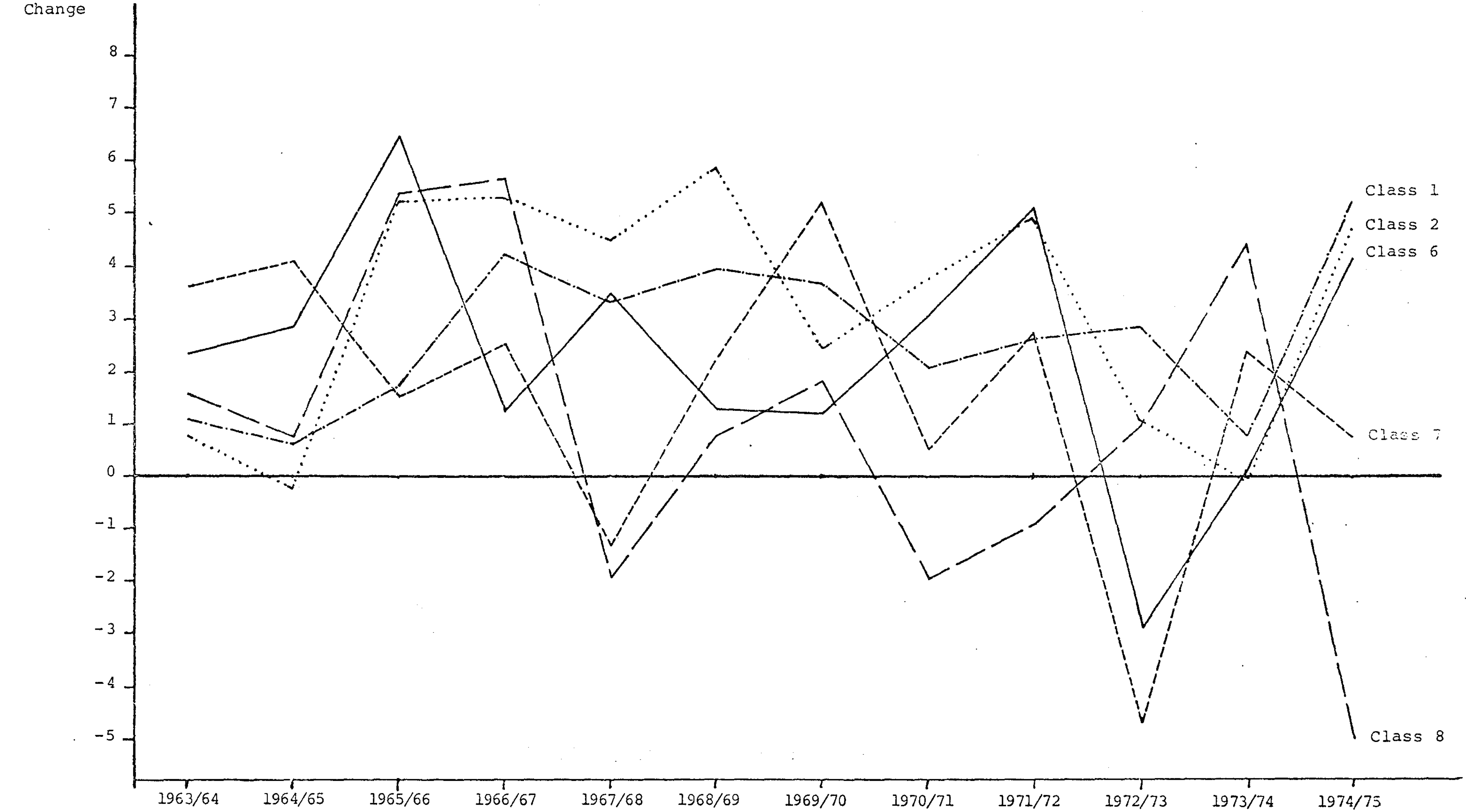
Unless the standardised survey data are validated against other livestock series, there must inevitably be reservations as to whether the trends therein are representative of the trends within the total industry. Accordingly, a number of tests and analyses were performed on both the standardised survey data and also the New Zealand Government census data. The detailed results of these analyses can be found in Appendix B.

The overall conclusions of these analyses are as follows:-

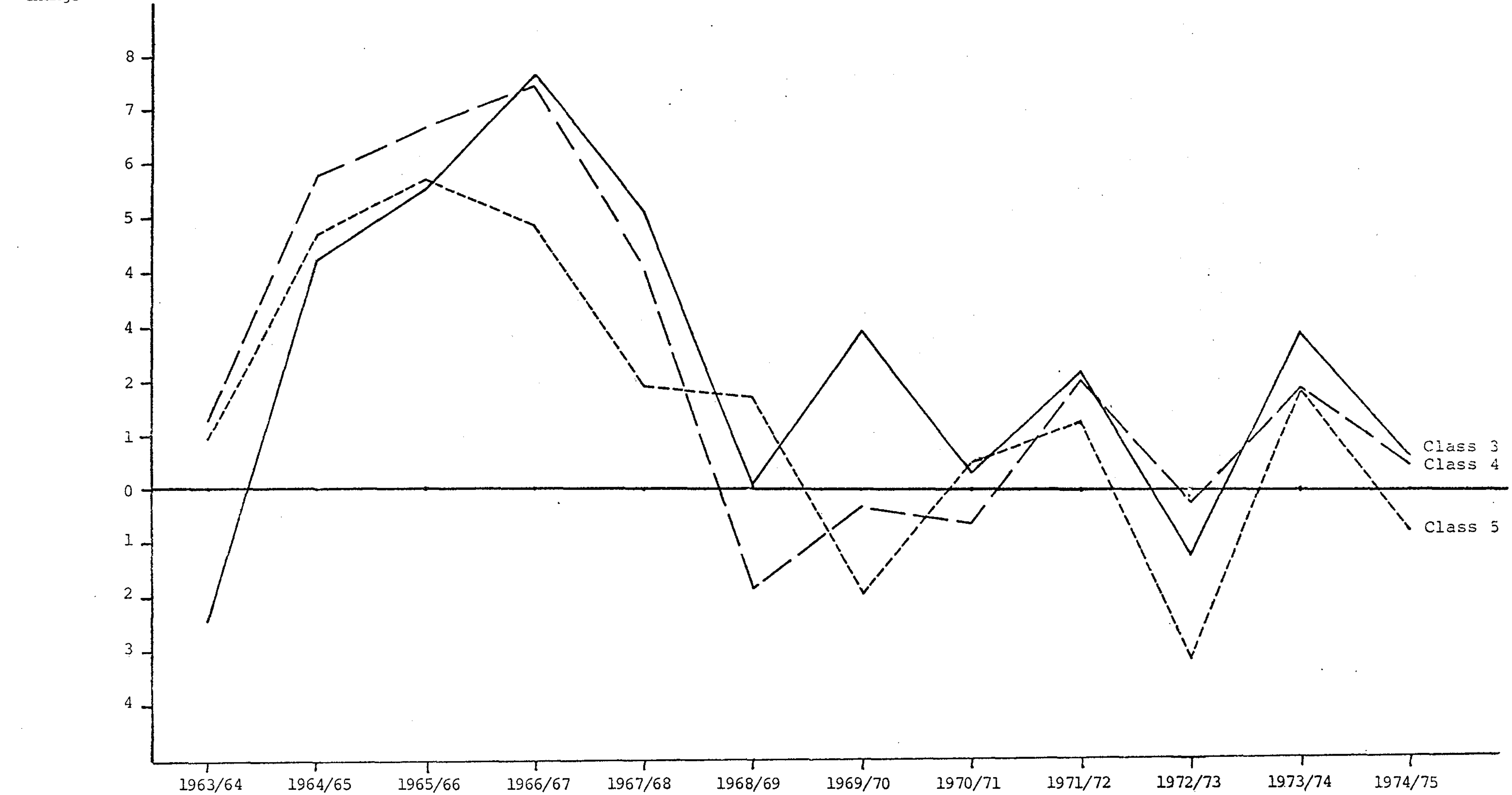
1. There is strong evidence that errors of measurement are incorporated into the government census livestock series. These are not of major importance in determining long term trends within the industry; since they are random they tend to cancel out. However, these errors are believed to be sufficiently large as to confound any econometric analysis based on annual changes in stock numbers as measured by these series.

2. The long term trends in the national aggregate of total sheep and beef cattle livestock units as measured by the standardised survey data correlate very closely with the trends as indicated by the government census data. There is, however, a tendency for increases in sheep numbers to be overestimated relative to the census data and increases in cattle to be underestimated by a compensating amount. It is believed that this

FIGURE 2 : Changes in Total Livestock Units on South Island Farms



<u>FIGURE 3</u> : Changes in Total Livestock Units on North Island Farms.



is a function of the survey frame definition.[7]

3. Comparison of national slaughtering statistics with the first order differences series for sheep, cattle and total livestock units, as indicated by both the census data and the standardised survey data, suggests that the standardised survey data is the better indicator of annual changes occurring within the industry.

TABLE 5

Percentage Changes in Livestock Units 1964-1975

Class of Farm	Total Percentage Increase Sheep	Cattle	Sheep plus Cattle
1. South Island High Country	18.9	193.7	35.5
2. South Island Hill Country	28.5	118.0	46.1
3. North Island Hard Hill Country	31.0	45.3	36.5
4. North Island Hill Country	20.1	50.2	29.3
5. North Island Intensive Fattening Farms	-4.1	94.5	18.1
6. South Island Fattening-Breeding Farms	20.0	116.3	29.9
7. South Island Intensive Fattening Farms	12.8	73.6	17.7
8. South Island Mixed Cropping and Fattening Farms	5.5	125.0	11.1

[7] For instance any farm substituting cattle for sheep to the extent that the sheep flock declined to less than 500 would automatically be excluded from the survey. In 1974/75 this minimum number of sheep was raised to 750.

CHAPTER 4

MODEL SPECIFICATION

4.1 Introduction

This chapter discusses the specification of a model that relates changes in the number of livestock units carried on farms to physical and economic factors. The model is developed for the eight classes of sheep and beef farms as defined by the Meat and Wool Boards' Economic Service.

4.2 Selection of Dependent Variable

The two components of total output of livestock products are numbers of livestock units and per head production. The major long term component of changes in output is considered to be changes in livestock units; it is also the component which farmers can change by direct decision. In this model annual changes in livestock units are used throughout as the dependent variable.

Total sheep numbers can be broken down into classes by age and sex. However, the numbers in each class are obviously in part interdependent, and all classes of sheep are competitive for the same feed on most types of farm. Similarly, it is clear that sheep and cattle compete for the same resources, at least at the margin, on most New Zealand farms. Therefore, an index of total livestock units, in which the numbers in each class of livestock are adjusted by their relative feed requirements, will be the best measure of total carrying capacity. The numbers of animals that farmers carry within each of these livestock classes will be a function of their respective resource requirements and of relative output prices.

4.3 Length of Data Series

Accurate livestock reconciliations are not available for years prior to 1964. In any case it is considered that earlier observations would relate to a period with rather different socio-economic and physical conditions, and one in which the relationship between sheep and beef cattle tended to be non competitive. The model was therefore developed using data for the period 1964 to 1975.

4.4 Responses to Climatic and Other Physical Factors

There are many New Zealand studies which have related annual fluctuations in agricultural output to inter-year variability of weather conditions.[8] However, there are no published studies concerning interactions between this weather variability and annual changes in stock numbers.

It is contended here that the critical period of the year which limits overall stocking rate on most New Zealand farms is the winter and early spring. Decisions (at least at the margin) as to the numbers to be carried over this period are usually made in the autumn and on most farms these will be based on:

1. Availability of feed - either *in situ* or conserved.
2. The present condition of stock.

In years when feed is short then more stock are culled and less stock bought. In years when there is a satisfactory supply of feed the converse occurs.

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[8] Some recent examples are Maunder (1974), Thompson and Taylor (1975) and Rich and Taylor (1977).

It is likely that any long term trends in overall livestock condition and feed conserved will be a function of technical progress, investment and management practices. However, Johnson (1955) found significant correlation ($r^2 = 0.32$) for the Waikato district between feed conserved and seasonal rainfall conditions in the period January to March, and there are obvious a priori reasons for expecting a similar relationship between rainfall and livestock condition. Consequently rainfall was included in the model as an independent variable.

Construction of rainfall indices posed considerable problems. Not only are most farm classes widely spread geographically, but most climatic stations tend to be situated near centres of population. Consequently there are some limitations, especially for hill country areas as to the applicability of the rainfall data used.

The method used was to group the survey farms in each class into geographical areas. The most appropriate climatic station for each area was then chosen and the rainfall weighted according to the proportion of farms within that area. Initially two separate rainfall indices were considered appropriate - one being for the three months October to December and the other for January to March. However, after graphical analysis and some preliminary regressions it was found that there was minimal loss of explanation if these were combined into one index for total rainfall over this six month period.

Clearly there are a number of physical factors other than rainfall that may cause annual variability in both the condition of livestock and the amount of feed conserved. Temperature, wind and sunlight are three climatic examples. Annual changes in the severity of pests and diseases are two further possibilities, although much of this variability may be a direct result of the climatic factors previously listed.

Unfortunately there are considerable problems incorporating many of these physical factors into an econometric model. Thus, the use of proxies must be considered.[9] Two such possibilities are:

(i) Wool weights per head.

(ii) Lambing percentage.

Consider first the use of wool weights per head. The Economic Service data on wool weight per head are already adjusted for wool on the sheep's back at the beginning and end of the year, and also for wool bought and sold on the sheep's back during the year. Consequently it would seem to be a satisfactory index of feed availability per livestock unit over the total growing season. Research by Rich & Taylor (1977) indicates that soil moisture conditions are the most important determinant of fluctuations in annual wool weights per head.

If we regard wool weights as being a proxy for physical factors affecting feed availability, then changes in opening numbers of livestock units between years t and t + 1, (i.e. changes in livestock units during the year t) can be expected to be positively correlated with wool weights in year t.

Research by Rich & Taylor (1977) has also shown that wool weights in year t are negatively correlated with livestock units carried at the start of year t.[10] Thus, it is possible that <u>changes</u> in livestock units between the start of years t and t + 1 are themselves a function of <u>total</u> livestock units at the start of year t. Accordingly, there is a possibility that the dependent variable is negatively autocorrelated. This possibility will be referred to again in Section 4.5.1.

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[9] A similar approach has been used in an Australian study by Dalton & Lee (1975).

[10] However it remains unclear as to how much of this explanation attributed to the livestock unit index is due to a linear trend in both the dependent and independent variables.

It is also possible that wool weights per head, as well as being a proxy for physical factors affecting availability, act as a direct determinant of livestock unit numbers. At the time when culling decisions are being made in the autumn farmers are already likely to be aware of any marked trends in wool production. If production is low and farmers are dissatisfied with either wool quality or per head production, then numbers may be reduced in an attempt to raise total output. Expressed slightly differently, wool weights per head may act as a direct indicator to the farmer as to whether he is "understocked" or "overstocked".

The use of lambing percentage as an alternative proxy was considered. However research has clearly shown that lambing percentage is affected by at least three distinct seasonal factors, i.e. weather at lambing, the weight of ewes at tupping and also the level of nutrition at tupping.[11] Owing to the complexity of those relationships it was decided not to persist in this study with the use of lambing percentage as a proxy for physical factors affecting feed availability.

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11 For a statistical analysis of the factors determining lambing percentage see Rich & Taylor (1977).

4.5 Economic Response Factors

It is possible to hypothesise a number of different responses to economic factors, all of which are rational given specific situations. While some of these responses are mutually exclusive, others can occur together.

Livestock number changes in response to economic factors may include:

1. A positive price expectations response where farmers alter livestock numbers in response to a change in the expected level of product prices.

2. An investment response which is a function of gross farm income in preceding years.

3. A short run income maximisation response where farmers sell more potential breeding stock when meat prices are high, in an attempt to "cash in" on the high prices while they are maintained.

4. A short run income supplementation response where liquidity considerations force farmers to sell additional livestock when product prices are low.

In the following sections these responses are considered in more detail.

4.5.1 Price Expectation Responses. These responses may be of two types:

(i) Substitution responses where output of one or more products is increased at the expense of output of some other products.

(ii) Intensification responses where there is a movement along the production curve until the new equilibrium point is reached where expected marginal revenue equals expected marginal cost.

In general, substitution responses can be expected to occur when two or more products compete for the same set of resources. The ratio in which farmers produce the products will be a function of relative expected prices, and in an open market situation these expected prices can be hypothesised as being a function of prices in preceding years. Such adaptive expectation models are well recorded in economic literature.[12]

The opportunities for New Zealand sheep and beef farmers to substitute other forms of production are in general very limited. There will be some substitution between sheep and cattle, but these relationships are by definition excluded from models such as these where the dependent variable is the total number of sheep and cattle livestock units.[13]

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[12] See Koyck (1954) & Nerlove (1956) for a theoretical exposition of the method.

[13] The only other substitution opportunities of potential importance on either a regional or national scale are dairying and cash cropping. With the possible exception of cash cropping activities on Classes 7 and 8 there is no evidence to suggest that such substitution has been important during the period of this study. However, to the extent that such substitution does occur then we might hypothesise a relationship where changes in livestock units of sheep and cattle are a function of prices for sheep and cattle products relative to prices for the competing products.

If intensification responses occur then it is apparent that, in contrast to substitution responses, changes in the level of output will be a function of changes in the real value of the product price variables; price ratios will not be relevant.

Unfortunately these responses are further complicated by the need for additional investment in livestock, and also possibly other resources, before any intensification can occur. Thus, although the desired response will stem from expected prices, the actual response may be constrained by the availability of cash for investment.

As mentioned previously the usual method of handling expectation responses is via distributed lags. It can be shown that if (1) the long run supply interval is greater than one year, and

(2) farmers estimate future prices based on present and previous prices, then the actual response in year t will be a function of the response in year t - 1, the response in year t - 2, and the <u>change</u> in prices between years t and t - 1.[14]

i.e. $\Delta S_t = fn(\Delta S_{t-1}, \Delta S_{t-2}, \Delta P_t)$

where ΔS_t is the change in livestock units in year t

ΔS_{t-1} is the change in livestock units in year t - 1

ΔS_{t-2} is the change in livestock units in year t - 2

ΔP_t is the change in product prices between year t and year t - 1.[15]

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[14] See Nerlove (1958) and Watts (1958). The equations derived by these authors are for the total level of activity (be it stock or crop) rather than annual changes in that activity. However the principles of the derivation remain the same.

[15] Since the culling decisions are made towards the end of the year product prices for that year (i.e. year t) will already be known.

Unfortunately this method demands some sacrifice in degrees of freedom. For the present study, where the number of years of data was limited, this was of particular importance. Therefore a preliminary model was specified to test whether price expectation responses should be included in the main model.

There were problems in choosing an appropriate price variable, since average product prices over the whole season were not available in all years. This problem was particularly serious on those farm classes where sale of store livestock is important. Accordingly, for the present study the most appropriate variable was considered to be deflated gross income per livestock unit as recorded in the accounts of the survey farms. This variable provides a measure of output prices as actually experienced on these survey farms. The data will be biased by seasonal variations in the volume of farm output per livestock unit and this bias theoretically requires correction. However these variations are believed to be quite minor in comparison to price fluctuations (see, for example, Chudleigh and Filan (1976)). By deflating gross income by the Economic Service's input prices index, and dividing by total livestock numbers, the major trends have been removed from the data.

The regression results obtained from the preliminary model were disappointing for all farm classes, with no relationship being found between changes in livestock units and deflated gross incomes per livestock unit. Simplification of the model formulation, with the two year lagged dependent variable omitted, failed to improve the results.

In Table 6 the simple correlation coefficient between the dependent variable and its lagged value is shown for each class of farm. The fact that none of the coefficients is significant indicates not only that there are no statistically significant distributed lag responses to price expectation effects, but also that there are unlikely to be significant distributed lag responses to other factors. Recall, however, that there was the possibility of negative autocorrelation of the dependent variable (Section 4.4). It is possible that the two different types of response are cancelling each other out.

On account of the disappointing results obtained from the preliminary regressions it was decided not to continue with the modelling of price expectation responses.

TABLE 6

Correlation Coefficients between Annual Changes in Livestock Units and Annual Changes in Livestock Units Lagged One Year for the Eight Classes of Farm

Class of Farm	Simple Correlation Coefficient, r
1	.02
2	.11
3	.15
4	.43
5	.35
6	-.19
7	-.27
8	-.08

4.5.2 Investment Responses. It was hypothesised that there is an investment relationship linking real gross farm income per livestock unit to subsequent changes in livestock numbers.[16] Such a relationship may be considered as comprising several components.

1. Livestock Units = fn (Farm Investment)
2. Farm Investment = fn (Cash Farm Expenditure)
3. Cash Farm Expenditure = fn (Gross Farm Income)

The relationship between livestock units and investment is undoubtedly a complex one owing to different types of investment operating with different lags. For example, investment in fertiliser may increase pasture productivity in less than three months, whereas investment in irrigation, especially if pasture renewal is required, may not give a response for two or three years. Consequently, if the investment resource mix varies between years then this will tend to confound any attempt at delineating a link between this investment and any subsequent livestock increases.

The relationship between investment and cash farm expenditure is not immediately obvious. However, many of the items included in farm expenditure, such as fertiliser, fencing and contract expenses, can have an investment component. It therefore seems reasonable to regard fluctuations in annual expenditure as being, at least in part, an indicator of fluctuations in levels of investment.

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16 Note that this investment response is hypothesised as being a function of total real gross farm income per livestock unit. The price expectations response discussed in the preceding section was hypothesised as being a function of annual changes in real gross farm income per livestock unit.

Consequently, although not all farm investment is recorded as farm expenditure in farm accounts, farm expenditure is often used as a proxy for farm investment.[17]

It seems reasonable to assume that fluctuations in cash farm expenditure are a function of fluctuations in gross farm income. In addition, on account of the progressive marginal tax structure in New Zealand, most of this expenditure can be expected to occur in the same year as the income is received. To test this postulate a regression of farm cash expenditure on gross farm income in the same year was carried out for each of the eight farm classes. Prior to the regressions being performed the major trends in both sets of data were removed by deflating by a farm costs index and dividing by the number of livestock units carried. The results, which refer to the period 1964 to 1974, are shown in Table 7. It is clear from these results that there is a close link between farm expenditure and gross farm incomes.[18]

It is clear from the above discussion that although we can expect carrying capacity to be linked to real gross farm income per livestock unit by an investment response, there are a number of factors which complicate the quantification of such a relationship.

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[17] For an example see Taylor (1976).

[18] It could be argued that this income is itself a function of expenditure in the current year. However, since the major component of income variation is product prices rather than output volume, it seems reasonable to accept the direction of causation as initially hypothesised. Nevertheless, the possibility of some simultaneous equation bias being present cannot be excluded.

TABLE 7

The Relationship between Gross Income and Cash Farm Expenditure on Sheep and Beef Farms

(Dependent Variable : Cash Farm Expenditure)

Period : 1964 to 1974

Farm Class	Beta Coefficient	Constant Term	R^2	F Statistic
1	0.37 (0.06)	11675	0.80	34.07**
2	0.21 (0.08)	10645	0.44	6.23*
3	0.22 (0.12)	11154	0.29	3.29
4	0.19 (0.05)	7580	0.64	14.43**
5	0.26 (0.04)	5243	0.81	35.1**
6	0.30 (0.07)	7027	0.68	16.83**
7	0.30 (0.04)	5006	0.87	55.57**
8	0.36 (0.08)	6299	0.67	16.37**

* Significant at the 5% level

** Significant at the 1% level

Note: Numbers in brackets indicate standard errors.

The fact that different types of investment have different lags indicated that a distributed lag relationship would be appropriate. However, owing to the failure in Section 4.5.1 to establish a relationship between the dependent variable and its lagged value, and also on account of the limited number of degrees of freedom available, a simplified formulation was used where

$$\Delta S_t = fn(I_{t-1})$$

where ΔS_t = change in livestock units during the year t

and I_{t-1} = gross income lagged one year.

It is emphasised that the relationship modelled here is not the total investment relationship. Rather, it is an attempt to measure that part of farm investment that varies between years and that is dependent on farm incomes. Since the dependent variable is annual changes in livestock units rather than the absolute number of livestock units, any linear trend that investment exerts on the absolute number of livestock units will be measured by the regression constant.[19] In addition, to the extent that for some types of investment farmers may not adjust their livestock numbers until there is visual evidence of the effects of this investment on pasture productivity, then any investment response may be in part measured by the wool weight proxy for seasonal conditions.

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[19] However, this is not the only factor determining the size of the constant, which can be regarded as a "catch all" for all constant factors be they physical, economic, or a combination of the two (e.g. where technological advances require investment if they are to be implemented).

4.5.3 Short Run Economic Responses. In the short run situation a different set of response patterns to economic factors may occur than for the long run situation. For instance, if the prices for all meat products (lamb, mutton and beef) are high, then farmers may decide to "cash in" on the higher prices while they last. However, if these prices are believed part of a longer term trend then farmers may retain stock in the belief that the additional revenue in future years will more than compensate for reduced income in the short term. The final relationship will depend on the nature of the relationship between actual prices and expected prices, and also on farmers' rates of time preference.[20] If prices are high for only some classes of meat then a short run effect on aggregate numbers is less likely, but a substitution effect between classes of livestock could occur.

Yet another possibility is that liquidity problems may force farmers to sell additional stock when product prices are low. However, within the New Zealand context it seems unlikely that a significant proportion of farmers have been in such a situation during the time period that is being considered. Therefore, if a short run response does exist, it is most likely to be due to 'cashing in' on high prices, and withholding stock when prices are low.

Given this situation, the appropriate explanatory variable will be meat prices rather than all product prices. In addition, it will be meat prices in the current year that are of relevance.

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[20] The hypothesis here is that farmers are acting as managers whose aim is to maximise the discounted net present value of their livestock assets. For a more detailed exposition of this hypothesis refer to Jarvis (1974).

For similar reasons to those that applied for the price expectation responses considered in Section 4.5.1, the most satisfactory available variable for meat prices is the gross income in the meat accounts of the survey farms. Prior to incorporation in the present study this variable has been deflated by the Economic Service's input price index, and divided by total livestock units.

CHAPTER 5

RESULTS OF REGRESSION ANALYSES

Results of four different formulations of the single equation model are shown for each of the eight farm classes in Tables 8 - 15.

In the first regression in each table, the independent variable is rainfall in millimetres for the six months October to March. Recall that this six month period was chosen following preliminary analyses in which this index was compared with two separate three month rainfall indices as alternative explanatory variables (Section 4.4).

The second regression in each table adds two economic variables. The first of these was added to test the hypothesis that changes in livestock numbers are positively related, via an investment response, to gross income per livestock unit in the preceding year. The second economic variable was added to test the hypothesis that farmers react to high meat prices in the current year by selling additional livestock to 'cash in' while these prices are maintained.

In the third and fourth regressions the rainfall variable has been replaced with wool weights per head as a proxy for physical factors affecting feed availability per stock unit.

TABLE 8

Regressions for Class 1
South Island High Country

(Dependent Variable : Annual Changes in Livestock Units per Farm)

Period : 1964/65 to 1974/75

Independent Variables	Regression Coefficients Equation 1	Equation 2	Equation 3	Equation 4
Six Month Rainfall Index (mm)	-0.202 (0.525)	-0.602 (0.790)		
Wool weights per head (kg)			501.2** (95.8)	527.1** (101.6)
Gross Incomes per Livestock Unit Lagged One Year		1.9 (39.9)		-4.3 (16.8)
Meat Prices in the Current Year		-108.4 (140.7)		83.7 (50.1)
Constant	222.5	458.3	-1899	-2284
R^2	.02	0.10	.75	.82
F Statistic	0.15	0.25	27.4**	10.87**
Durbin Watson Statistic	1.70	1.54	1.42	1.96

* Significant at the 5% level

** Significant at the 1% level

Note: Numbers in brackets indicate standard errors.

TABLE 9

Regressions for Class 2
South Island Hill Country

(Dependent Variable : Annual Changes in Livestock Units per Farm)

Period : 1964/65 to 1974/75

Independent Variables	Regression Coefficients Equation 1	Equation 2	Equation 3	Equation 4
Six Month Rainfall Index (mm)	-0.001 (0.558)	-0.542 (0.428)		
Wool weight per head (kg)			219.6** (40.8)	149** (40.8)
Gross Income per Livestock Unit Lagged One Year		-57.1* (22.6)		-32.9 (16.7)
Meat Prices in the Current Year		-160.7** (44.6)		-74.2* (28.4)
Constant	152.6	1148	-905	-153
R^2	0.00	0.73	0.76	0.89
F Statistic	0.0	6.50*	28.9**	18.66**
Durbin Watson Statistic	1.85	2.14	1.72	1.57

* Significant at the 5% level

** Significant at the 1% level

Note: Numbers in brackets indicate standard errors.

TABLE 10

Regressions for Class 3
North Island Hard Hill Country

(Dependent Variable : Annual Changes in Livestock Units per Farm)

Period : 1964/65 to 1974/75

Independent Variables	Regression Coefficients Equation 1	Equation 2	Equation 3	Equation 4
Six Month Rainfall Index (mm)	0.283 (0.410)	-0.033 (0.575)		
Wool weights per head (kg)			308.1** (81.8)	293.2 (83.9)
Gross Income per Livestock Unit Lagged One Year		22.2 (46.3)		21.9 (27.7)
Meat Prices in the Current Year		-67.5 (96.3)		-45.2 (45.1)
Constant	-9.9	190.8	-1428	-1331
R^2	.05	.15	.61	0.69
F Statistic	0.5	.42	14.2**	5.2
Durbin Watson Statistic	1.44	1.38	2.35	2.13

* Significant at the 5% level

** Significant at the 1% level

Note: Numbers in brackets indicate standard errors.

TABLE 11

Regressions for Class 4
North Island Hill Country

(Dependent Variable : Annual Changes in Livestock Units per Farm)

Period : 1964/65 to 1974/75

Independent Variables	Regression Coefficients Equation 1	Equation 2	Equation 3	Equation 4
Six Month Rainfall Index (mm)	0.484 (0.247)	0.549 (0.304)		
Wool weights per head (kg)			282.2** (78.9)	286.4** (66.4)
Gross Income per Livestock Unit Lagged One Year		32.8 (25.7)		28.1 (16.2)
Meat Prices in the Current Year		13.5 (53.9)		-47.6 (28.3)
Constant	-174.8	-436.9	-1469	-1495
R^2	0.30	0.43	0.58	.77
F Statistic	3.84	1.78	12.79**	7.94*
Durbin Watson Statistic	1.50	1.56	1.93	1.85

* Significant at the 5% level

** Significant at the 1% level

Note: Numbers in brackets indicate standard errors

TABLE 12

Regressions for Class 5
North Island Intensive Fattening Farms

(Dependent Variable : Annual Changes in Livestock Units per Farm)

Period : 1964/65 to 1975/75

Independent Variables	Regression Coefficients Equation 1	Equation 2	Equation 3	Equation 4
Six Month Rainfall Index (mm)	0.387** (0.089)	0.408 (0.103)		
Wool weights per head (kg)			124.2* (53.8)	111.1 (53.4)
Gross Income per Livestock Unit Lagged One Year		15.4 (9.9)		17.1 (14.0)
Meat Prices in the Current Year		9.0 (20)		-26.1 (24.1)
Constant	-152.7	-301.6	-637.2	-578.5
R^2	0.68	0.77	0.37	0.53
F Statistic	18.9**	7.77*	5.33*	2.71
Durbin Watson Statistic	2.23	2.03	2.83	2.60

* Significant at the 5% level

** Significant at the 1% level

Note: Numbers in brackets indicate standard errors.

TABLE 13

Regressions for Class 6
South Island Fattening Breeding Farms

(Dependent Variable : Annual Changes in Livestock Units per Farm)

Period : 1964/65 to 1974/75

Independent Variables	Regression Coefficients Equation 1	Equation 2	Equation 3	Equation 4
Six Month Rainfall Index (mm)	0.468 (0.312)	0.141 (0.334)		
Wool weights per head (kg)			86.5* (35.5)	56.9 (33.8)
Gross Income per Livestock Unit Lagged One Year		3.47 (15.0)		6.2 (11.8)
Meat Prices in the Current Year		-69.5* (32.8)		-58.1* (26.7)
Constant	-143.0	230	-409.1	-79.6
R^2	0.20	0.51	0.40	0.65
F Statistic	2.24	2.47	5.92*	4.26*
Durbin Watson Statistic	2.18	1.95	3.1	2.59

* Significant at the 5% level

** Significant at the 1% level

Note: Numbers in brackets indicate standard errors.

TABLE 14

Regressions for Class 7
South Island Intensive Fattening Farms

(Dependent Variable : Annual Changes in Livestock Units per Farm)

Period : 1964/65 to 1974/75

Independent Variables	Regression Coefficients Equation 1	Equation 2	Equation 3	Equation 4
Six Month Rainfall Index (mm)	0.456* (0.167)	0.450 (0.222)		
Wool weights per head (kg)			73.6 (36.1)	75.7 (53.4)
Gross Income per Livestock Unit Lagged One Year		7.3 (10.6)		9.0 (11.9)
Meat Prices in the Current Year		-12.7 (294)		-32.2 (367)
Constant	-168.11	-222.0	-424.5	-498.3
R^2	0.45	.49	0.32	0.37
F Statistic	7.43*	2.22	4.16	1.36
Durbin Watson Statistic	2.75	2.64	2.84	2.72

* Significant at the 5% level

** Significant at the 1% level

Note: Numbers in brackets indicate standard errors.

TABLE 15

Regressions for Class 8
South Island Mixed Cropping & Fattening Farms

(Dependent Variable : Annual Changes in Livestock Units per Farm)

Period 1964/65 to 1974/75

Independent Variables	Regression Coefficients Equation 1	Equation 2	Equation 3	Equation 4
Six Month Rainfall Index (mm)	-0.029 (0.155)	-0.107 (0.160)		
Wool weights per head (kg)			62.0* (23.6)	48.5 (25.8)
Gross Income per Livestock Unit Lagged One Year		2.3 (9.6)		1.1 (7.2)
Meat Prices in the Current Year		40.3 (19.7)		24.5 (17.7)
Constant	22.7	-141.8	-313	-355.0
R^2	0.00	.38	.43	.56
F Statistic	0.04	1.41	6.92*	2.97
Durbin Watson Statistic	1.70	1.44	2.36	2.06

* Significant at the 5% level

** Significant at the 1% level

<u>Note</u>: Numbers in brackets indicate standard errors.

All equations were tested for multicollinearity. For the economic variables, the correlation coefficient, r, between the two variables was less than 0.3 in all cases. However, for Classes 1, 2 and 6 the correlation between wool weights per head and meat prices were 0.56, -0.45 and -0.41 respectively. Consequently there is some instability of the Beta coefficients between equations 3 and 4 for these classes of farm. However, this instability is not sufficient to be of serious concern at this stage of model development.

All equations were also tested for serial correlation. The Durbin Watson statistics shown in Tables 8 - 15 show that there is no strong evidence for the presence of serial correlation, but for several equations the statistic does lie within the region of uncertainty.[21]

The overall conclusion drawn from these serial correlation and multicollinearily tests is that, with only minor reservations, confidence can be held in the statistical measures of significance used in evaluating these equations.

It is apparent from Tables 8 - 15 that wool weights per head are positively correlated with annual changes in livestock units. Livestock units have tended to increase at the end of a season when wool weights were high and either decrease or else increase at a lower rate following a season when wool weights were low. On hill country classes of farm (i.e. Classes 1 to 4) this wool weight variable is significant at the 1 per cent level and it explains an average of

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[21] Since the dependent variable is the series of first order differences of livestock units rather than the series of absolute numbers of livestock units carried in each year, the likelihood of high levels of serial correlation has been considerably reduced.

68 per cent of the variation in the dependent variable. On the other four classes it is significant at the 5 per cent level in three instances and just fails at this level of significance for Class 7.[22] It succeeds in explaining approximately 40 per cent of the variation for these four classes.

The rainfall index is a much less powerful indicator of changes in livestock units than is wool weights per head. For Class 5 the rainfall index explains 68 per cent of the variation in the dependent variable (significant at the 1 per cent level) and for Class 7 it explains 45 per cent of the variation (significant at the 5 per cent level), but for the other classes of farm the relationship is either weak or non existent. The equations were subsequently rerun in logarithmic form to minimise the effect of extreme rainfall values, but no improvement was gained.

The two most likely reasons for the disappointing results with the rainfall index are:

1. Rainfall variability is not the major determinant of annual fluctuations in feed availability.
2. The rainfall indices used here are not representative of actual rainfall on the sample farms.

No conclusions as to the relative importance of these two factors are made here. However, it is considered that these indices are as representative as is possible with the present distribution of climatic stations. In this respect it is notable that the two classes

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[22] In these regression analyses two-tailed tests have been used. However, in cases such as this, where a negative relationship would be rejected as irrational, it can be argued that a one-tailed test is more appropriate. If a one-tailed test had been used then this relationship would have been classified as significant.

of farm for which statistically significant relationships were found are both intensive fattening classes and that these farms are in general situated closer to climatic stations than the more extensive farms.

It is possible that improved correlations would be measured if the rainfall index was reformulated as a soil moisture index.

The relationships between livestock unit changes and economic factors as measured in these models are in general quite weak. There is evidence (significant at the 5 per cent level) for Classes 2 and 6 that farmers sell additional stock when current prices are high, but on the other six classes of farm no significant relationship was found. There was no significant relationship found between changes in livestock units and gross income per livestock unit in the previous year for any of the eight farm classes.

A number of reasons for the poor performance of the economic variables can be suggested. Three are listed below.

1. The economic indicators used in this model are not representative of the economic conditions that farmers face.

2. Economic factors are not a major determinant of annual changes in total livestock numbers.

3. The model has been inadequately specified for the purpose of delineating the economic relationships that do exist.

The first of these three alternatives has already been discussed in Chapter 4. There it was pointed out that although there are some problems associated with the use of the data, these data appear to provide a satisfactory measure of economic conditions as actually experienced on the survey farms.

The second alternative, that of economic factors not being a major determinant of annual changes in total livestock units, is certainly a possibility that requires serious consideration. Such a conclusion would be in line with the results from this model, yet would not contradict the hypothesis that economic factors are a major determinant of the ratio of sheep to cattle that are carried. However, the validity of making such a conclusion rests upon the assumption that the model as specified is adequate for the purpose of delineating any economic relationships that do exist.

In this respect it has already been pointed out in Chapter 4 that the complexity and possible variation in the lags by which responses in production are related to investment expenditure, do complicate the measurement of any such relationships. In addition, it was pointed out that the model formulation used in this study was a simplification of the hypothesised real situation. Clearly some further work on this aspect of the model is called for before any definite conclusions can be drawn.

Considering the overall results for each class of farm, it is notable that the best results have in general been obtained for the hill country farms. On these farms the opportunities for diversification into other enterprises apart from sheep and cattle are very limited. In contrast to this situation, cash cropping has always been of major significance on Class 8 farms, and for Classes 6 and 7 it is evident from the survey accounts that it has been a factor of varying significance. It is obvious that variations in cropping area will have a major effect on the number of stock carried, and this should therefore be allowed for in any model. There are, however, major problems associated with lack of data, and the incorporation of cropping activities into the model is a major study in itself. Suffice to say that higher levels of explanation for Classes 6, 7 and 8 could reasonably be expected if such adaptations were made.

CHAPTER 6

SUMMARY AND CONCLUSIONS

This study has been concerned with the development of an econometric model capable of explaining the annual changes in total livestock units that are carried on New Zealand sheep and beef farms.

Although there have been a number of previous econometric studies of New Zealand livestock production, none of these has analysed the effect of annual variations in climatic and other physical factors on the <u>numbers</u> of livestock carried. In addition there have been no studies of livestock numbers that have considered sheep and cattle as enterprises that are competing for the same set of input resources. For these reasons it was considered that none of the previous studies provided a suitable framework for analysing the changes in the industry that have occurred in the decade up to 1975.

The development of a new econometric model was seriously affected by a lack of suitable data. A number of tests were conducted on the national livestock series as published by the New Zealand Department of Statistics. These tests indicated a number of inconsistencies in these data that appear to be sufficiently serious as to confound any econometric analysis of annual changes in the numbers of livestock as measured by these series.

Analyses indicated that, for the period 1964 to 1975, data obtained by the New Zealand Meat and Wool Boards' Economic Service during the course of their Sheep and Beef Farm Survey are the best available source of information on changes in livestock numbers. However, before these data could be incorporated into an econometric model a standardisation procedure had to be devised so as to link successive years of the survey.

Analysis of the survey data indicated that in any one year there have been considerable variations between farm classes, both in the extent and direction of changes in livestock units. This indicated that the model should, at least initially, be disaggregated according to these farm classes.

It was hypothesised that changes in total livestock units were a function of both physical and economic factors. For physical factors the major source of variation between years was expected to be climatic. Two alternative indices were therefore constructed, one being a rainfall index, and the other a proxy for physical factors as measured by the weight of wool produced per sheep.

The regression analyses showed that livestock units have tended to increase at the end of a season when per head wool weights were high and either decline or increase at a lower rate following a season when these wool weights were low. This relationship was found to be statistically significant on seven of the eight classes of farm. On the remaining class of farm the relationship just failed to pass a test of significance at the 5 per cent level. On average over the eight classes of farm more than half the variation in the dependent variable was explained by this wool weights variable.

The rainfall index was less successful than the wool weights variable in explaining the changes in livestock units, with a statistically significant relationship being found on only two classes of farm.

It was initially hypothesised that three distinct economic relationships might exist. They were:

1. a product price expectations effect;
2. an investment effect;
3. short run income adjustment responses to changes in product prices.

However no statistical evidence was found for the presence of either price expectation or investment responses. There was some evidence, statistically significant on two classes of farm, that additional livestock are sold when meat prices are high as farmers try to 'cash in' while prices are maintained.

Considerable care is needed in the interpretation of these results. For instance, these results indicate that during the period 1964 to 1975, annual fluctuations in the level of investment have not been a major cause of annual fluctuations in the numbers of livestock units carried on sheep and beef farms. However they do not indicate that investment is unimportant in determining the carrying capacity of sheep and beef farms. Similarly, although the evidence indicates that fluctuations in product prices have not had a major effect on annual changes in total livestock units carried during this 11 year period, this does not mean that product prices do not determine the ratio of sheep livestock units to cattle livestock units that are carried.

It is considered that a number of refinements could be made to the model which would improve the levels of explanation in the measured equations. Incorporation of cash cropping activities for Classes 6, 7 and 8 is one such example. Respecification of the investment relationship may also give improved results. The construction of a soil moisture index to replace the rainfall index is a third possibility. However, problems associated with the lack of suitable data may limit the overall improvement that is possible.

In summary, the major finding of this study is that annual variations in feed availability as measured by wool production per sheep, influence farmers' decisions as to the numbers of livestock that are carried in the following year. This relationship can be measured quantitatively and during the period 1964 to 1975 it appears to be the most important cause of annual fluctuations in the numbers of livestock units carried on sheep and beef farms. This finding, not only provides an explanation for the generally disappointing results that have been obtained in those previous New Zealand supply studies that have only investigated economic factors, but also provides a basis for ongoing work in the study of production and supply relationships in the New Zealand sheep and beef industries.

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APPENDIX A

ALTERNATIVE STANDARDISATION PROCEDURES FOR ECONOMIC SERVICE LIVESTOCK SERIES

(a) Standardisation of Total Sheep Livestock Units and Total Beef Livestock Units and pro rata Adjustment of Component Livestock Series.

With this method, numbers of sheep livestock units at the end of year t - 1 are adjusted up or down by a factor so as to equal sheep livestock units at the start of the following year. Livestock units at the start of year t - 1 are then adjusted by the same factor. Assuming that there are t years of observations, this procedure is repeated each year, working backwards from year t until year 1 is reached. The result is that the changes as measured in each year are spliced together so as to give a continuous series.

An example is as follows:

Assume there are t years of observations

Let the unadjusted opening livestock units in year t	$= m$
Let the unadjusted closing livestock units in year t-1	$= n$
Let the unadjusted opening livestock units in year t-1	$= p$
Let the unadjusted closing livestock units in year t-2	$= q$
Let the unadjusted opening livestock units in year t-2	$= r$

Then the adjusted opening livestock units in year t	$= m$
Then the adjusted closing livestock units in year t-1	$= m$
Then the adjusted opening livestock units in year t-1	$= p.\frac{m}{n}$
Then the adjusted closing livestock units in year t-2	$= p.\frac{m}{n}$
Then the adjusted opening livestock units in year t-2	$= r.\frac{pm}{nq}$

This sheep livestock unit series has a number of component parts (e.g. ewes, wethers, hoggets, etc.). Each of these components is adjusted by the same ratio as used for total sheep livestock units. Thus, for the above example, if the opening ewe numbers in year t-2 were s, then the adjusted numbers would be $s.\frac{p.m}{n.q}$.

This procedure is repeated for cattle using total cattle livestock units to determine the appropriate adjustment factors.

(b) Standardisation by Age and Sex Groupings.

This method is more sophisticated and requires the breaking down of sheep and cattle livestock units into their age groupings. Closing numbers in year t-1 in each of these livestock classes are adjusted to attain consistency with opening livestock numbers in the following year, in a similar way as for the previous method. These same adjustment factors are then applied to opening livestock numbers in year t-1 for the biologically related classes in which these same animals were at the earlier date.

For example, consider the following livestock relationship for year t-1:

Opening Stock of Yearling Steers	+	Purchases of 18 month Steers	-	Sales of 18 month Steers	-	Deaths	→	Closing Stock of 2 Year Steers

If the closing livestock in year t-1 for 2 year steers has been adjusted by factor x so as to reconcile with opening 2 year steers in year t, then the opening stock of 1 year steers in year t-1 would be adjusted by the same factor. Extending the standardisation to purchase and sale livestock, then purchases and sales of 18 month steers would also be adjusted by this factor.

(c) A Comparison of the Two Methods

With both methods of adjustment the major aim of the standardisation is achieved, i.e. livestock units at the end of each year are consistent with opening livestock for the following year. In addition, both methods, by working backwards from the most recent data, make use of the improved knowledge in recent years of the sampling frame.

The second method has the additional attribute that livestock numbers are standardised for each age grouping as well as in aggregate. It also takes account of changes in the relative importance of different livestock classes which have occurred owing to changes in the survey sample. For example, if the Economic Service Class 3 data for the early years has been influenced by over representation of Central North Island farms with large wether flocks, then the effects of this over representation will be removed from the standardised data.

There are also, however, certain problems associated with this second method. For example, a decline between closing 2 year steers in year t-1 and opening 2 year steers in year t may indicate a change in stock slaughter policy caused by a change in the sample (i.e. more stock slaughtered at 18 months rather than 2 years plus). Alternatively, it may be a change in policy as regards the type of stock carried (i.e. less weaner steers at the start of the period). Unless these questions can be answered then the correct adjustment to the number of 1 year steers at the opening of the previous year cannot be determined. Analysis of the data indicated that the standardised figures varied significantly depending on which hypothesis was accepted.

For the present study it was decided that the risks of incorporating bias into the aggregate livestock unit totals outweighed the potential advantages associated with this second method.

Accordingly, the method of standardisation finally adopted was to adjust total sheep livestock units and total cattle livestock units for each class of farm, and then adjust the component series on a *pro rata* basis.

APPENDIX B

VALIDATION OF THE STANDARDISED LIVESTOCK DATA

This appendix describes a number of tests performed on the standardised livestock data series. These series have been derived from data collected as part of the Meat and Wool Boards' Economic Service Sheep and Beef Farm Survey. The procedures used in standardising these data have been described in Appendix A.

The aim of the tests that are reported here is to investigate whether the changes in livestock numbers as measured by these standardised data series are representative of the changes that have occurred within the total industry.

The first step in this validation process was to aggregate the eight classes of farm to form an 'all classes average farm', using weights provided by the Economic Service.

In Table 16 total livestock units on this 'all classes average farm' are compared with livestock unit estimates derived from Department of Statistics and Ministry of Agriculture & Fisheries data.[23] It is evident that there is close correlation between the two series, and both indicate a very similar total rate of increase. The two series have a correlation coefficient r = 0.996.

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[23] Sheep numbers are collected as at 30 June by the Ministry of Agriculture & Fisheries. Cattle numbers are collected as at 31 January by the Department of Statistics. Since 1971 the Department of Statistics has also collected cattle statistics as at 30 June.

TABLE 16

Comparison of Data Series for Total Livestock Units of Sheep and Beef Cattle from 1964 to 1975

(Index : 1964 = 100)

Year	Standardised Economic Service Data	Department of Statistics & Ministry of Agriculture & Fisheries Data
1964	100	100
1965	106	104
1966	112	110
1967	118	116
1968	122	121
1969	123	122
1970	124	124
1971	125	124
1972	129	129
1973	127	125
1974	129	127
1975	130	129

Dividing these total livestock units into their sheep and cattle components produces series as shown in Tables 17 and 18. The correlation coefficient for cattle numbers as reported by the two series is r = 0.988, and for sheep r = 0.908.

It is apparent that the survey estimates of long term historical increases in sheep numbers are considerably greater than those recorded in the national totals of the census. However, cattle increases are underestimated and in the aggregate these balance out. This suggests that the survey by its definition may result in substitution rates of cattle for sheep being underestimated, and on a priori grounds this is considered reasonable.[24]

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24 For instance, as reported in the main text of this report, any farm substituting cattle for sheep to the extent that the number of sheep declines to less than 500 is subsequently excluded from the survey. In addition, as from 1974/75 year the minimum number of sheep was raised to 750. Thus, the survey sample is biased towards sheep producing farms at the expense of cattle.

TABLE 17

Comparison of Data Series for Sheep

Livestock Units from 1964 to 1975

(Index : 1964 = 100)

Year	Standardised Economic Service Data	Ministry of Agriculture & Fisheries Data
1964	100	100
1965	107	105
1966	114	111
1967	119	117
1968	121	118
1969	122	118
1970	124	118
1971	124	116
1972	124	120
1973	120	111
1974	119	110
1975	119	109

TABLE 18

Comparison of Data Series for Cattle Livestock Units from 1964 to 1975

(Index : 1964 = 100)

Year	Standardised Economic Service Data	Department of Statistics Data
1964	100	100
1965	103	101
1966	108	108
1967	117	119
1968	124	127
1969	125	134
1970	125	140
1971	132	146
1972	147	153
1973	153	163
1974	164	174
1975	172	184

Validation of First Order Differences

Correlation coefficients for the first order differences for these same series are as follows:

Total livestock units, r = 0.70

Sheep livestock units, r = 0.89

Cattle livestock units, r = 0.45.

These results indicate that for sheep the short term fluctuations about the long term trend are only moderately closely correlated with the fluctuations measured in the national statistics. For beef cattle (and consequently total livestock units) the correlation is very disappointing.

This situation suggests that there may be considerable errors of measurement either in the Sheep and Beef Farm Survey or in the Department of Statistics series. However, on a priori grounds it seems unlikely that such errors would occur in the Sheep and Beef Farm Survey data, which are collected by field officers who have access to all relevant livestock invoices etc. A more likely hypothesis is that measurement errors arise in the Department of Statistics data which are collected by mail. Although the response rate to this mail questionnaire is considered to be over 99 per cent, this is only achieved by threat of litigation and the reliability of some replies is questionable.

To test this a priori reasoning it seemed desirable to compare both sets of data with a third set of livestock data. This question is now considered separately for sheep and then beef cattle.

(a) Sheep

Stock sold by any one farmer is either purchased by other farmers or slaughtered. Provided that the Sheep and Beef Farm Survey is representative and the class weightings are correct then annual fluctuations in net sales for the 'all classes farm' should provide an indicator of fluctuations in national slaughtering tallies. The two series are not expected to be identical owing to the survey frame encompassing by definition only an estimated 94 per cent of total sheep within New Zealand. However, a high correlation could reasonably be expected.

The national annual sheep slaughtering statistics collected from all export and local slaughter houses and published as at 30 September were extracted from the Ministry of Agriculture and Fisheries Annual Reports. These figures were then adjusted to 30 June using the series published in the "Monthly Abstract of Statistics". The correlation coefficient between this national series and the survey series for the 11 year period 1964/65 to 1974/75 was $r = 0.987$. The correlation for the first order differences was only slightly lower at $r = 0.965$.

Regression of the national slaughtering series against this survey data resulted in an equation:

$$y = 22465x - 974,247 \qquad R^2 = 0.974$$

where

y = National slaughtering tally

x = Net sales on the 'average farm'.

It is noted that the coefficient for x varies from the estimated number of farms in the survey by less than 5 per cent.

The conclusion drawn from these analyses of net sales on the all classes average farm and the national slaughtering tallies is that the net sales are an excellent indicator not only of long term trends in New Zealand annual slaughterings, but also of short term (i.e. one year) fluctuations about this trend. This situation would not occur if the Sheep and Beef Farm Survey incorporated large measurement errors.

For comparison of the Ministry of Agriculture & Fisheries sheep series with the national slaughtering statistics a somewhat different procedure is required:

For any one year there is a simple relationship between opening stock and births on the one hand and slaughterings, deaths and closing stock on the other.

i.e. Opening stock + birth - slaughterings - deaths = closing stock.[25]

If observations for all these variables except for death rates are available, then it is possible to construct an implied death rate series. For the 11 year period in question this death rate series was found to have the following characteristics:

Mean	= 7.22% (S.E. = 0.55%)
Standard Deviation	= 1.83%
Range	= 2.71% - 9.82%

However, the actual death rate series for the 550 farms in the Sheep and Beef Farm Survey has characteristics as follows:

Mean	= 7.04% (S.E. = 0.14%)
Standard Deviation	= 0.47%
Range	= 6.2% - 7.93%

The correlation coefficient between these two series is only 0.45 and this is not significant at the 5 per cent level. It is certainly anomalous that a series constructed from data pertaining to all New Zealand sheep farms should exhibit a much greater variance than a series constructed from only 550 farms.

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[25] Since purchases and sales of breeding and store stock cancel each other out, they can be ignored.

It is notable that the extreme values for this implied death rate series are for 1972 and 1973. The 1972 sheep census coincided with a sheep retention scheme whereby farmers were paid a Government subsidy for every sheep carried. The implication is that the financial incentive resulted in the national sheep census results being biased upwards by approximately 4.5 per cent over what the true figures actually were. The extremely high implied death rate in 1973 (and an abnormally high rate in 1974 as well) appear to be "book adjustments" as farmers wrote down their stock numbers again. Removing the 1972 and 1973 data from this series results in a reduced series with the following characteristics:

Mean	= 7.44%	(S.E. = 0.29%)
Standard Deviation	= 0.86%	
Range	= 6.12% - 9.25%	

Although the variance has been considerably reduced, it is still much higher than for the survey series.

A parallel test for stock one year and older produced similar results.[26] In this case the relationship becomes:

Opening stock of hoggets and adult sheep -
Slaughterings of hoggets and adult sheep -
Deaths of hoggets and adult sheep
= Closing stock of adult sheep.

The implied annual death rate series has characteristics:

Mean	= 5.33%	(S.E. = 0.36%)
Standard Deviation	= 1.20%	
Range	= 2.4% - 7.4%	

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26 The advantage of this test is that it removes the possibility of any source of error from the lambing series.

This compares with the death rate series for the survey farms which has characteristics:

Mean	= 4.74% (S.E. = 0.99%)
Standard Deviation	= 0.29%
Range	= 4.3% - 5.1%

As with the previous test, removal of the 1972 and 1973 data from the national series removes the two extreme values, but the variance is still much higher than for the survey series. This reduced series has the following characteristics:

Mean	= 5.43% (S.E. = 0.14%)
Standard Deviation	= 0.43%
Range	= 4.7% - 6.2%

Accordingly, the overall conclusion of these analyses of implied death rates is that random errors of measurement are probably incorporated into the "Sheep Returns" series and that these errors are of considerable importance.

(b) Cattle

Cattle slaughtering statistics are not divided into animals of beef and dairy origin. Accordingly no implied death rate series can be constructed. For similar reasons comparison of total cattle slaughterings with net cattle sales on the all classes average sheep and beef farm would serve no useful purpose. However, in the following paragraphs it will be shown by other means that there are problems associated with the Department of Statistics cattle series as published in "Agricultural Statistics and Monthly Abstract of Statistics".

Prior to 1971 the annual cattle census was taken at 31 January. This is a particularly unfortunate date for a census as it is in the middle of the killing season. Industrial stoppages or abnormal climatic conditions could markedly affect the proportion of seasonal slaughtering occurring before this date.

Since 1971 there have been two annual censuses of cattle numbers, one being at 31 January and the other at 30 June. Over the period 1971 to 1974 the January figures indicate an increase in beef cow numbers of 36.5 per cent whereas the June figures indicate an increase of 22.1 per cent. For beef cattle the January figures indicate an increase of 16.3 per cent, whereas the June figures indicate an increase of 30.0 per cent. The difference in magnitude between the January and June figures, both of which refer to the same set of farms, cannot be explained.

Consequently, there is no reliable alternative source of data on beef cattle numbers with which to compare the standardised Sheep and Beef Farm Survey data. Although it seems reasonable to assume that any random errors of measurement in this standardised survey data will be no larger than for the equivalent sheep data, it is not possible to make any conclusions as to the presence or absence of additive bias.

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