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DEVELOPMENTS IN AUSTRALIAN AGRICULTURAL CAPITAL

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This paper provides an overview of the influences on the capital stock in Australian agriculture and of changes in the capital stock since the mid-1960s. Over this period, the ratio of prices received by farmers to prices paid declined by 2.8 per cent a year. Productivity improvements, however, allowed output to expand while capital and particularly labour usage per unit of output were reduced. Between 1970 and 1979, the cost of capital fell substantially relative to farm wage rates, and capital was substituted for labour. Since then, the cost of capital has risen relative to wages, and the substitution of capital for labour has slowed or even been reversed. Investment levels in 1985-86, while somewhat depressed, do not appear to have been out of line with recent experience.

Introduction

Investment behaviour in Australian agriculture has major implications for agricultural output and hence for exports. Although there has been considerable discussion of the behaviour of total Australian investment and capital, agricultural capital formation has received very little attention in recent years. This is despite the importance of agricultural exports in Australia's trade and the extensive literature on agricultural investment in earlier years (see, for example, Campbell 1958; Waugh 1977a,b; and Powell 1982).

Australian agriculture is highly capital intensive and the level of capital in use has a major impact on the productivity of other major farm inputs. Capital investment frequently embodies technological advances, raising the overall productivity of the sector. These benefits, however, need to be weighed up against the costs of employing capital in the sector, particularly given the large increases in real interest rates worldwide in recent years (Blanchard and Summers 1984).

In contrast with many other farm inputs, there is not a close link between purchases of capital inputs in any one period (investment) and the services provided by capital. The services provided by any particular category of farm capital depend on the stock of capital in use rather than on purchases in any one year. Only as the capital stock changes will output be affected. Thus, a knowledge of developments in the capital stock is likely to be useful in forecasting future output levels. The aim in this paper is to fill the apparent need for a discussion of such developments.

The concept of capital used in this paper includes all physical inputs yielding a flow of services over an extended period. Thus, land, livestock, machinery and structures are all included in the capital stock measures. It is assumed that the services provided by the capital stock are directly proportional to the quantity of capital in use. Hence, the measures of capital relate to the physical quantity of capital employed, measured using constant price estimates. Human capital inputs, while undoubtedly important, have not been directly considered because of the lack of data. A full discussion of the data used in this paper, including definitions and sources, is included in Appendix I.

In the next section of the paper, the principal influences on the demand for capital and investment behaviour are examined. Following this, the characteristics of the data examined in the paper are discussed and the behaviour of capital and investment in agriculture over the past twenty years is examined. Finally, some tentative conclusions arising from this examination are presented.

Influences on the Agricultural Capital Stock and Investment

The desired level of capital in any industry depends on the profitability of production in that industry, the nature of the technology employed, the cost of capital relative to other inputs, and the overall composition of output. Because changing the capital stock involves adjustment costs, the equilibrium level of capital stock will not be attained instantaneously. Thus, the stock of capital is likely to be continually adjusting toward its long run value. Some of the major influences on the desired capital stock and hence on investment are reviewed in this section.

Profitability and output

An initial indication of the profitability of agriculture is provided by the ratio of prices received to prices paid by farmers (farmers' terms of trade). Over the period 1966-67 to 1985-86, this measure has shown a downward trend of 2.8 per cent a year (see Figure 1). If Australian agriculture had not adjusted and improved its technology, a fall in output would have been inevitable. Only if productivity had increased at a similar or greater rate could profitability and output have been maintained. Clearly, there has been substantial adjustment; real agricultural output increased by 2.4 per cent a year despite the decline in relative prices faced by the sector. While remarkable, given the decline in farmers' terms of trade, this increase was less than the increase of 3.4 per cent a year in total real gross domestic product, and so agriculture's share of total GDP declined.

Increases in productivity are undoubtedly the major reason why agricultural output has been able to expand despite the unfavourable trend in relative prices. Probably the best known estimate of productivity in Australian agriculture is that provided by Lawrence and McKay (1980), who estimated that productivity increased by 2.9 per cent a year in the sheep industry over the period 1952-53 to 1976-77. Beck, Moir, Fraser and Paul (1985, p.9) provide an estimate of 2.7 per cent for the period 1952-53 to 1982-83. While these estimates are based on the Bureau's detailed survey information on inputs and outputs, they unfortunately do not cover the whole agricultural sector. It is likely that productivity growth would have been substantially greater in some industries, and possibly slower in others.

To obtain some indication of the rate of productivity growth in the sector as a whole, agricultural productivity growth was estimated using

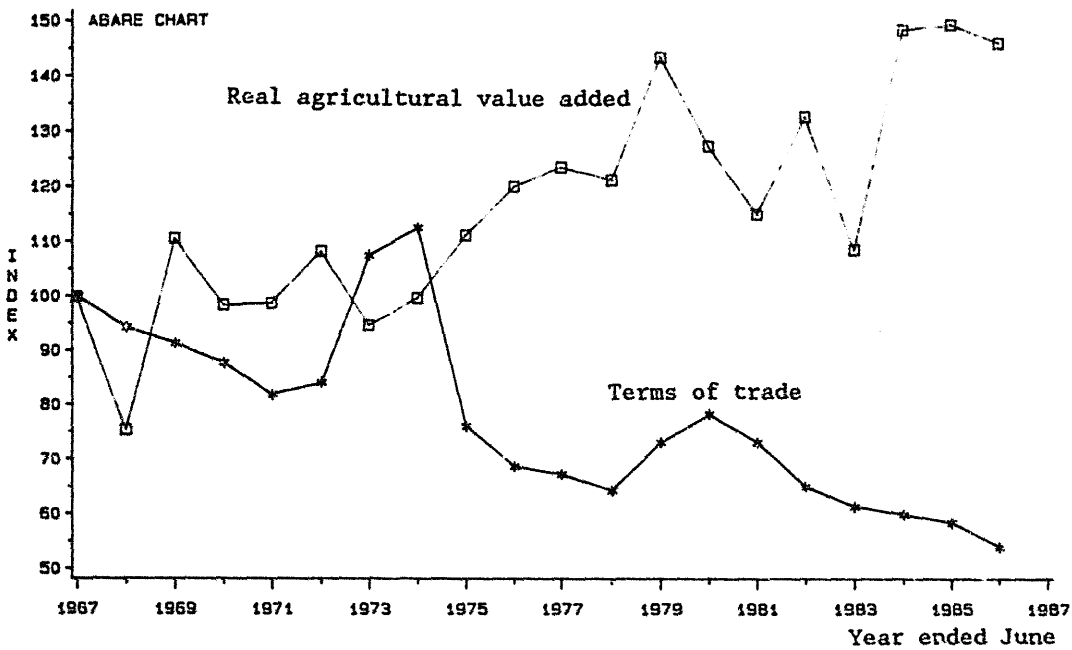

FIGURE 1 - Farmers' Terms of Trade and Agricultural Value Added

aggregate data on agricultural capital and labour inputs, and real value added. This method provided an estimate that could be compared with productivity growth in the economy as a whole.

The procedure used involved decomposing total output growth into a component due to changes in the capital and labour inputs, and a residual associated with productivity growth. The rate of growth in real value added was first expressed (following BIE 1985, p.56) as

$$(1) \qquad \hat{Q} = \hat{TFP} + S_K\hat{K} + S_L\hat{L}$$

Where

$\hat{Q}$ = percentage change in real value added;

$\hat{TFP}$ = percentage change in total factor productivity;

S_K = the share of capital (including land) in value added; and

$\hat{K}$ = percentage change in the capital stock;

S_L = the share of labour in value added;

$\hat{L}$ = percentage change in labour use.

Estimates of $\hat{Q}$, $\hat{K}$ and $\hat{L}$ were first obtained by regressing the logarithms of the variables against time. Average shares of labour were then calculated using the employment and wage rate series discussed in Appendix I and capital shares calculated as a residual under the assumption of constant returns to scale. An estimate of $\hat{TFP}$ was then derived using equation (1). The resulting estimates are presented in Table 1.

The estimated rate of productivity growth for agriculture obtained using the simple methodology outlined above is strikingly similar to the estimates for the sheep industry obtained by Lawrence and McKay and by Beck et al., despite the marked differences in methodology. While we are not aware of comparable estimates of total factor productivity for the economy as a whole, the estimate of 1.12 per cent is broadly comparable with the labour-saving productivity growth rate of 1.4 per cent a year reported by Murphy,

TABLE 1

Results from the Estimation of Total Factor Productivity for Agriculture and the Economy as a Whole: 1965-66 to 1985-86

Sector	Output growth	Productivity growth	Capital share	Capital growth	Wage share	Labour growth
	%	%	%	%	%	%
Agriculture	2.43	2.76	0.49	0.29	0.51	-0.91
Economy	3.4	1.12	0.43	3.97	0.57	0.99

Note: All growth rates are expressed as percentage growth per year.

Bright, Brooker, Geeves and Taplin (1986). For the purposes of this study, a key point is that total factor productivity growth appears to have been much more rapid for agriculture than for the economy as a whole.

In addition to the measured gains from pure productivity changes, producers have been able to offset the measured decline in their terms of trade by taking advantage of the possibilities for substitution between inputs and for transformation between outputs in response to changes in relative prices. By taking advantage of productivity gains and of factor and output substitution possibilities, producers have been able to expand agricultural output despite a terms of trade decline roughly as rapid as the apparent increase in productivity.

The improvement in total factor productivity means that a smaller total quantity of inputs is needed to produce a given level of output. Frequently, however, technological change is biased toward saving one input more than others. One of the 'stylised facts' of economic growth in industrialised countries is that technological change tends to save labour more than capital (Burmeister 1980, p.46). For most economies, it appears that capital and investment per unit of output tend to remain roughly constant, while labour usage per unit declines. By contrast, it appears from recent research on Australian agricultural production (McKay, Lawrence and Vlastuin 1980, 1982; Martin 1982) that technological change in Australian agriculture reduces capital usage per unit of output, although by less than the reduction in labour usage.

Another important factor likely to affect the level of farm capital is the composition of farm output. In general, crop production is more capital intensive than livestock production, at least for the broadacre industries (McKay, et al. 1982, p.22). Thus, a shift from crop to livestock production could be expected to reduce the total demand for capital, particularly equipment.

<u>Relative input prices</u>

Another major influence on the desired level of the capital stock in agriculture, and hence investment, is the cost of using capital relative to the cost of other inputs. There is evidence that the demand for capital in Australia is reasonably price responsive (McKay et al. 1980, p.66), with a 1 per cent increase in the price of capital resulting in a reduction in the quantity employed of around 1 per cent. The cost of using capital has been calculated so that it can be compared with the cost of using labour and other inputs.

The cost of using a unit of capital depends primarily on the opportunity cost of capital and on the rate of depreciation of the capital stock. If there were no inflation and if taxation did not affect the user cost of capital, the user cost of a capital input valued at one dollar would equal the real rate of interest, r, plus the rate of depreciation, d, of the capital good. The private user cost of capital is, however, affected considerably by the combination of inflation and the taxation system. Inflation, on the one hand, makes capital more expensive to use by reducing the real value of the tax deductions provided by depreciation allowances since these deductions are based on historic cost accounting methods. On the other hand, the opportunity cost of holding capital tends to fall as the inflation rate increases whenever investment is financed through fixed interest borrowings, or farm firms invest their surplus funds in fixed interest securities. This is because the tax system is based on nominal interest rates, and treats the inflation component of interest rates as though it were real income instead of merely compensation for the decline in the value of the asset.

Given the importance of fixed interest borrowings compared with equity as a source of investment funds, and the importance of interest earnings as a source of off-farm income (Males, Poulter and Murtough 1987), the distortion resulting from the use of nominal rather than real interest rates in the tax system is likely to be more marked in agriculture than in other sectors. Special taxation measures such as investment allowances or accelerated depreciation allowances can also affect the private cost of employing capital.

Using the general approach suggested by Jorgensen (1963) and Feldstein, Green and Sheshinki (1978), the private user cost per dollar of capital in Australian agriculture over the period 1966-67 to 1985-86 has been estimated (see Appendix I) and is depicted for equipment and structures in Figure 2.

These estimates have several features of particular interest. First, the cost of using equipment was substantially higher than the cost of using structures. This difference reflects the higher rates of depreciation on equipment. Second, over the entire period the private cost of using capital was lower than the economic cost for both structures and equipment. This was largely a consequence of the tax deductibility (liability) of nominal interest costs (returns), which lowers the private cost of using physical capital. This feature of the taxation system is partly offset by the depreciation allowances, which are based on historic rather than replacement costs, and hence tend to underestimate the true cost of capital depreciation under conditions of inflation. The investment allowance which applied to depreciable plant and equipment ordered between January 1976 and June 1985 also reduced the private cost of capital (CCH Australia Limited 1987).

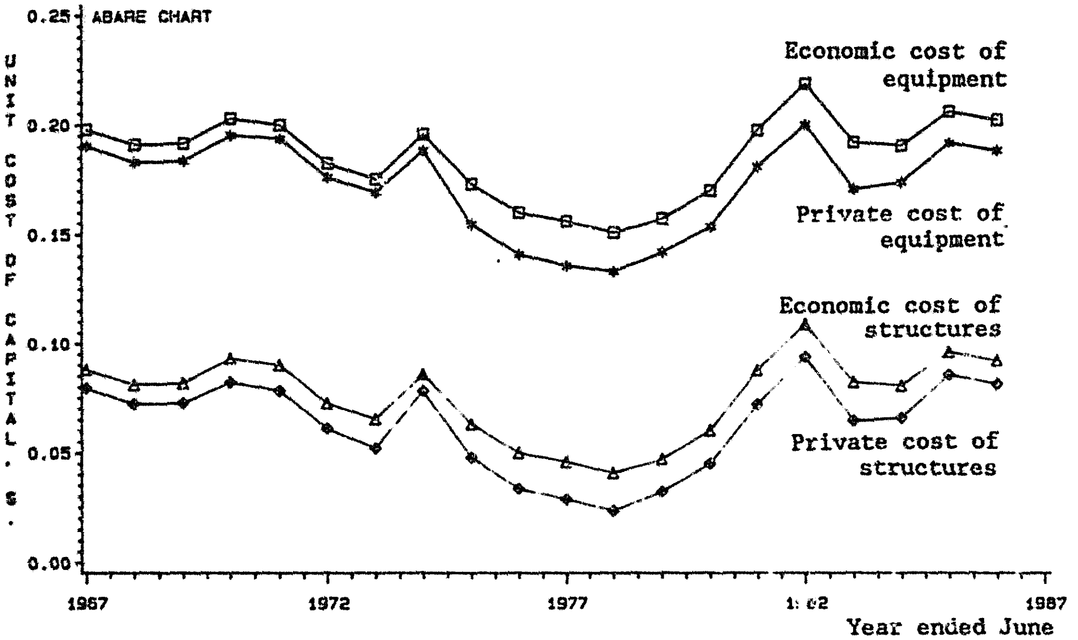

FIGURE 2 - User Cost Per Dollar of Capital: Economic and Private.

Perhaps the most important feature of Figure 2 is the substantial variability in the costs of using capital. The period of very low real interest rates in the mid-1970s caused economic, and particularly private, unit user costs to fall substantially. From 1979 to 1982, however, these costs increased substantially, primarily because of rises in real interest rates. They have since remained well above the levels prevailing in the mid-1970s. At any given output level, the demand for capital is likely to depend on the unit user cost of capital relative to wage rates and the cost of other inputs.

The user cost of capital equipment and the wage rate for farm labour, both deflated by the price of farm inputs other than capital and labour, are plotted in Figure 3. Over the whole period under review, the real wage rate trended upward. However, since the peak in 1978-79, the real wage rate has generally been declining. The most notable feature of the real user cost of capital is the very steep decline in 1974-75 and the substantial increase since 1977-78. The relative cost of using capital and labour (the ratio of the user cost of capital to the wage rate) has also increased substantially since 1978-79, primarily because of the increase in the user cost of capital. This change is likely to have reduced the pressure to substitute capital for labour.

Implications for investment

The desired stock of capital is the fundamental determinant of investment behaviour. In contrast with other, more readily varied, inputs, the capital stock is not generally adjusted completely in a single period such as a year. The process of choosing or designing, installing and learning how to operate new capital involves costs which are not captured in the purchase price and which are likely to increase substantially if undertaken too rapidly. Given the need for time to make efficient investment decisions,

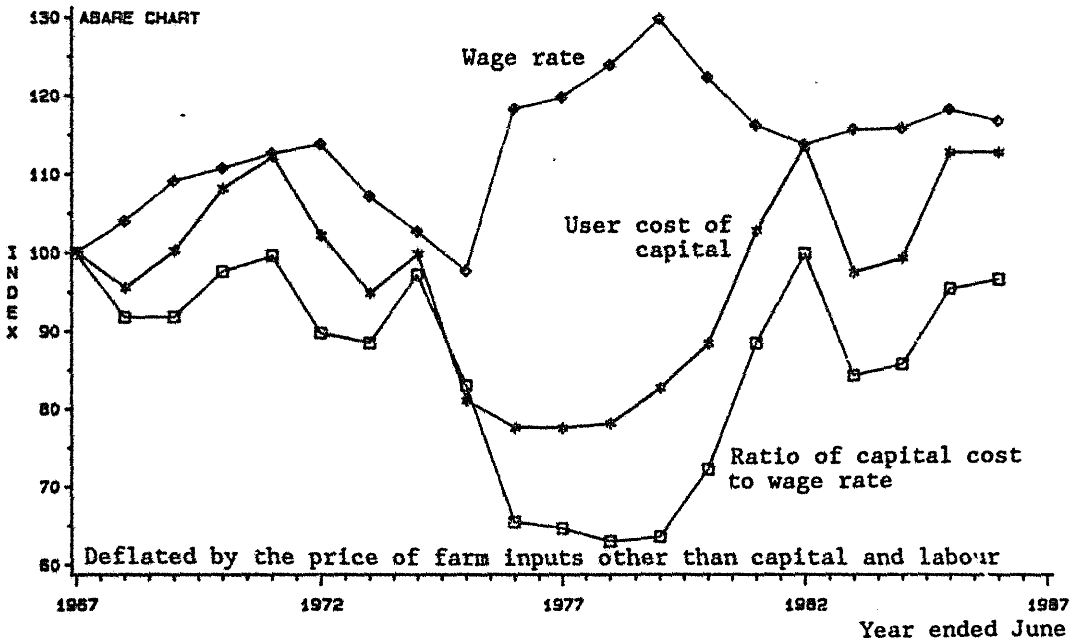

FIGURE 3 - The User Cost of Capital Equipment and the Wage Rate for Farm Labour.

investors are likely to adjust their capital stocks only part of the way toward their new target levels in any one period (Lucas 1967).[1]

The partial nature of adjustment does not mean that investment is stable over time. For example, if the capital stock is at its desired level of 100 units and it depreciates at 10 per cent a year, investment of 10 units a year will be needed to maintain the stock level. If the desired stock level is to be increased by 10 per cent and half of the increase is to occur in one year, investment in that year will need to be 15 units, 50 per cent above its previous level. Such 'flexible accelerator' models with partial adjustment of the capital stock to its desired long run level have been the main means of representing agricultural investment (see, for example, Fisher 1974; Waugh 1977b; Lewis et al. 1987).

Given the importance of internal financing in agriculture and given the high variability of rural incomes, which requires that large amounts must be saved in boom years if farm household consumption is to remain stable, Campbell (1958) suggested that the residual funds available to a household were likely to be an important influence on investment behaviour. While some studies (for example, Waugh 1977b) have found evidence that residual funds have a timing role in investment decisions, agricultural investment behaviour appears to be determined ultimately by the desired long run capital stock.

The Total Farm Capital Stock and Investment

Trends in the capital stock

The composition of total agricultural capital (at constant prices) and how it has changed can be seen from Figure 4. The total capital stock in agriculture is estimated to have grown at a trend rate of only 0.3 per cent a year over the period 1966-67 to 1985-86, compared with 3.9 per cent a year for the economy as a whole. Livestock capital has been more variable than the other capital components and the buildup of livestock inventories up to 1976, and their subsequent decline, was the principal cause of the corresponding peak in the total capital series. The fixed structures included in these ABS (1987a) data make up only a very small share of total capital. Although this component of capital is defined to include structures such as roads, dams and fences, this definition may be less comprehensive than that used by the ABARE in its sheep industry survey.

It is clear from Figure 5 that agriculture has been substantially more capital intensive than the economy as a whole. At the same time, the ratio of capital to trend output in agriculture has declined substantially over the period being examined - that is, the productivity of capital has risen. This suggests that technological advance in agriculture has reduced the amount of capital needed per unit of output.

In contrast with agriculture, the capital to output ratio for the economy as a whole has increased slightly, implying some decrease in the

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[1] This model, based on quadratic adjustment costs, leads to the so-called flexible accelerator model of investment behaviour. If adjustment costs are linear, an operator will adjust fully toward a desired capital stock in a single period. If adjustment costs increase more than proportionately with the rate of adjustment, the producer can minimise these costs by only partly moving toward the desired level of capital stock in a single period.

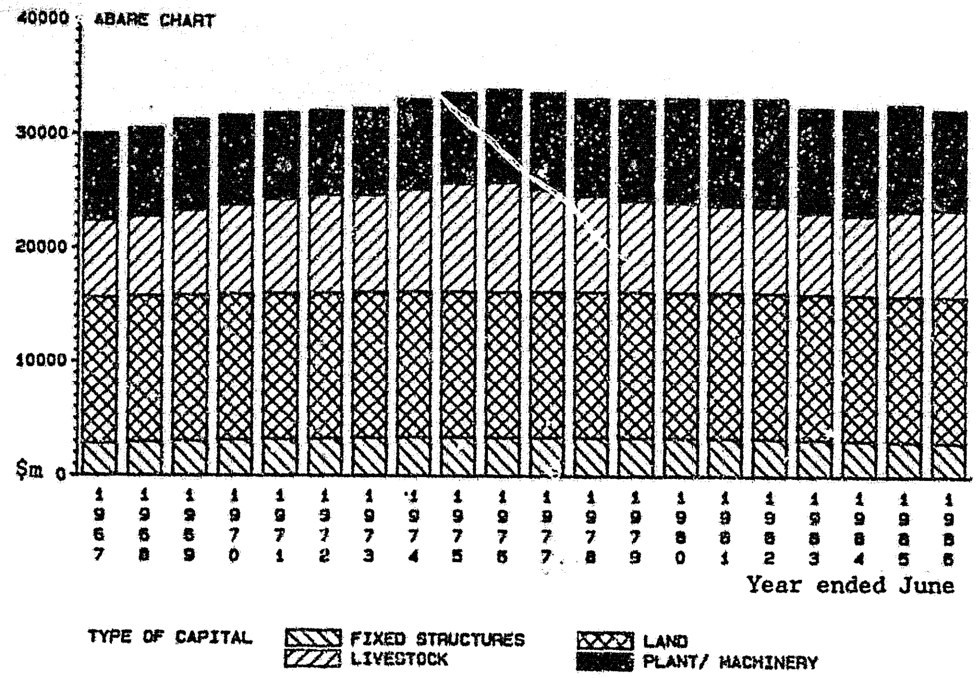

FIGURE 4 - Composition of Agricultural Capital.

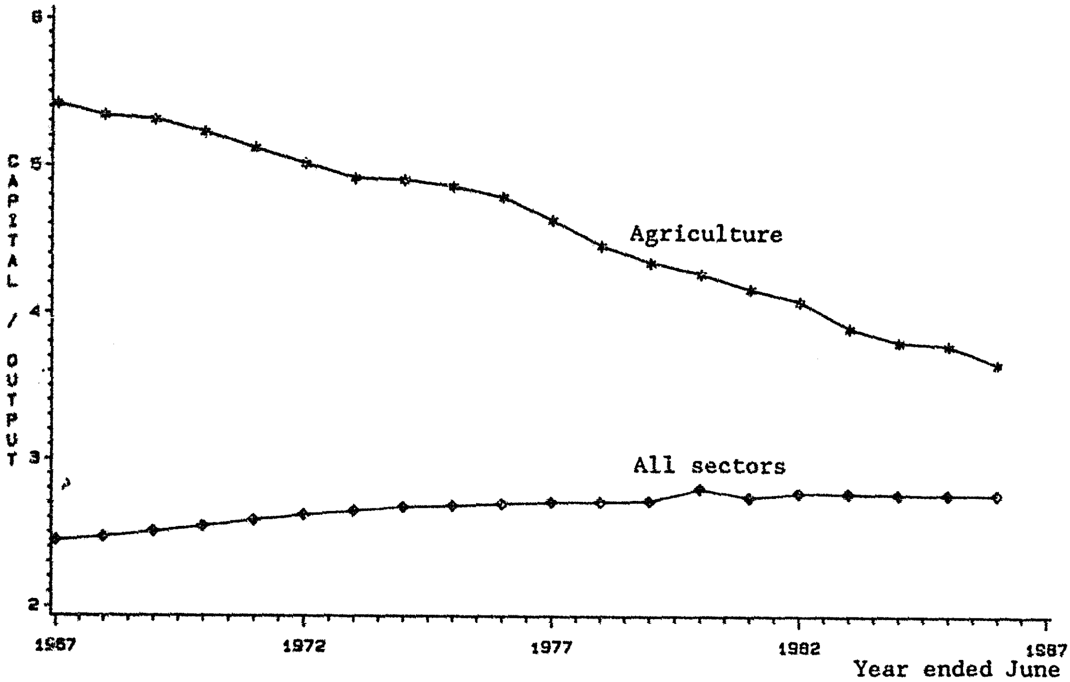

FIGURE 5 - Capital to Output Ratio in Agriculture and All Sectors.

productivity of capital in the economy, as noted by Carmichael and Dews (1986). The relatively high rate of productivity growth in Australian agriculture, together with the absence of a strong capital using bias, contributed to this quite marked difference from the rest of the economy.

Another key variable in understanding the trends of the capital stock is the relationship between capital and labour (see Figure 6). Over the period as a whole, the capital per unit of labour (worker) in agriculture increased. In the period up to 1977-78, when the user cost of capital was static or declining relative to the wage rate, capital per worker exhibited an upward trend. Since 1977-78, when the user cost of capital began to rise relative to the wage rate, capital per worker has been on a slight downward trend. In the economy as a whole, capital per worker rose until 1982-83, when it began to level off.

The relationship between output, productivity and inputs expressed in equation (1) can be rearranged to provide an indication of the effect of changes in capital per worker on the (partial) productivity of labour. Subtracting $\hat{L}$ from both sides of equation (1) results in:

$$(2) \qquad \hat{Q} - \hat{L} = \hat{TFP} + S_K\hat{K} + (S_L - 1)\hat{L}$$

Under constant returns to scale, factor returns exactly exhaust total output and hence $S_K + S_L = 1$. Assuming this condition holds, $(S_L - 1) = -S_K$ and the growth in labour productivity is given by:

$$(3) \qquad \hat{Q} - \hat{L} = \hat{TFP} + S_K(\hat{K} - \hat{L})$$

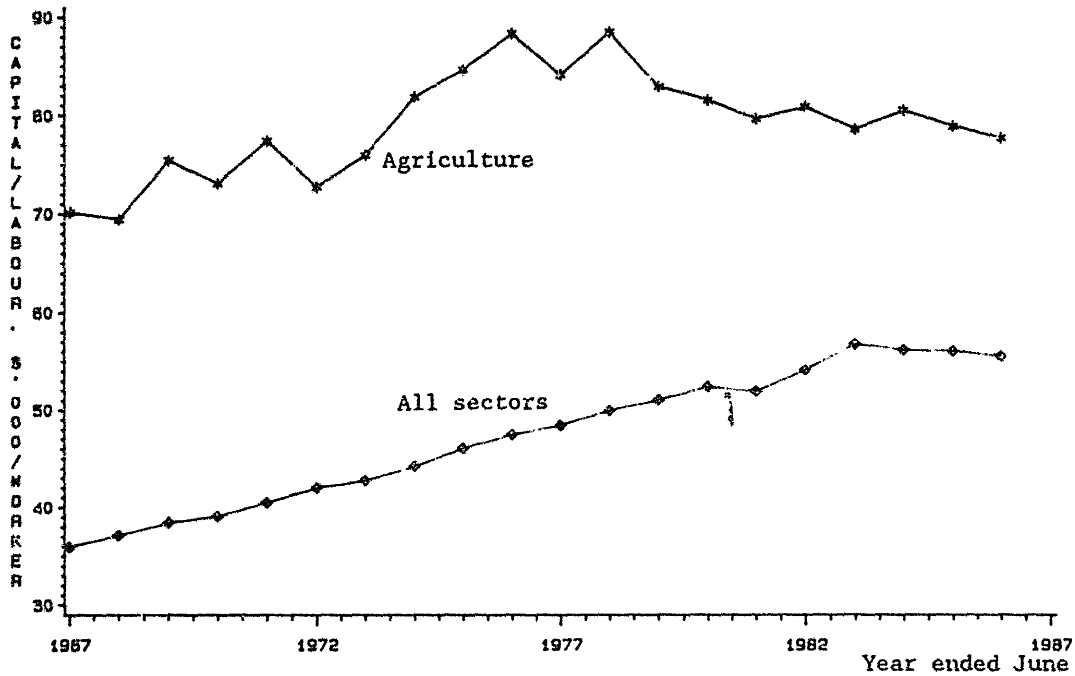

FIGURE 6 - Capital per Worker in Agriculture and All Sectors.

It is clear from equation (3) that the increase in capital per worker over the period as a whole would have increased the partial productivity of labour in agriculture. The corollary is that the decline in capital per worker since 1977-78 would have tended to reduce the productivity of labour, and hence increase labour input for any given output - although this effect would be very slight relative to the increase in total factor productivity over the period. The fall in capital per worker does, however, imply higher employment in agriculture than would otherwise be the case, presumably in response to the rise in the cost of capital relative to the wage rate.

Equation (1) can also be used to explore the causes of changes in the productivity of capital. Rearranging and replacing $(S_K - 1)$ with $-S_L$ gives:

$$(4) \qquad \hat{Q} - \hat{K} = \hat{TFP} - S_L(\hat{K} - \hat{L}).$$

This result highlights the fact that increases in capital per worker $(\hat{K} - \hat{L})$ tend to decrease the partial productivity of capital $(\hat{Q} - \hat{K})$. The change in the partial productivity of capital (fall in the capital to output ratio) observed in this study, despite the overall rise in capital per worker, highlights the importance of increases in total factor productivity in the sector.

Investment patterns

It is clear from Figure 7 that the ratio of investment to trend output has generally declined both for agriculture and for the economy as a whole. The investment to output ratio has been, on average, slightly lower for agriculture than for the economy as a whole. This is consistent with th slower growth rate in agricultural capital, the assumed zero rate of

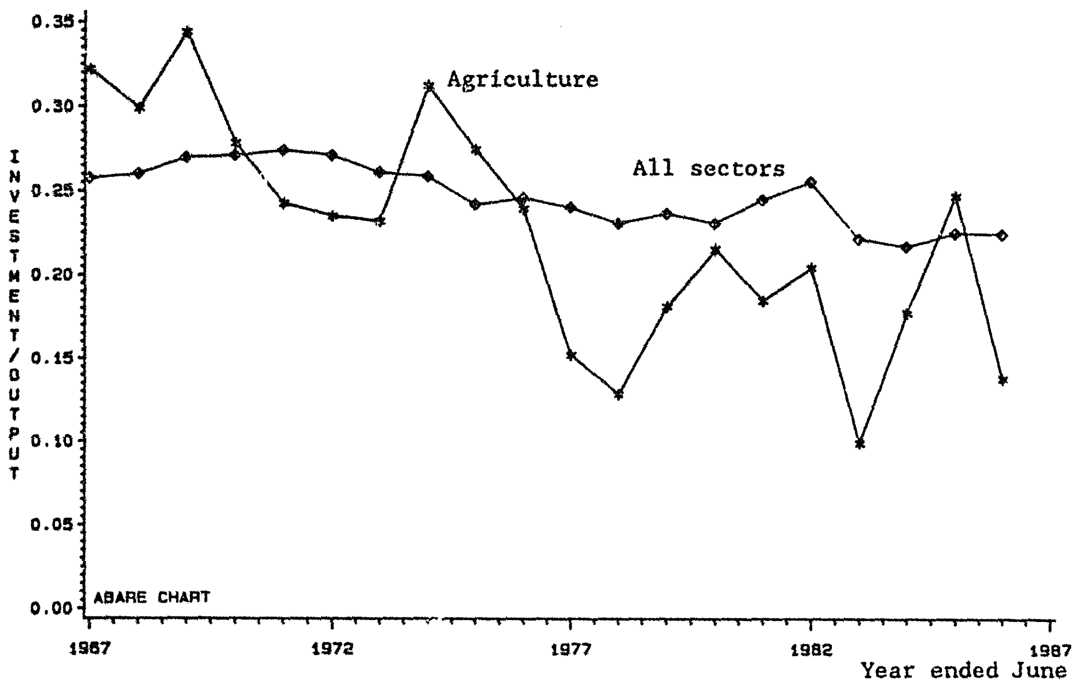

FIGURE 7 - Investment to Output Ratio in Agriculture and All Sectors

depreciation on land and livestock capital, and the nature of technological change in agriculture reviewed earlier in this paper (the quantity of capital needed per unit of output declining over time).

It is far easier to observe the fundamental trends resulting from changes to the desired capital stock by observing the capital stock itself than by examining investment behaviour. That this is so although the capital stock does not fully adjust to changes in its desired level is somewhat surprising. The marked year-to-year volatility in the agricultural investment series makes its interpretation relatively difficult in the absence of a detailed multivariate model.

Of particular interest in Figure 7 is the marked decline in the agricultural investment to output ratio in 1985-86. Likely contributing factors to this fall are the depressed conditions in the capital intensive cropping industries, and the high user cost of capital relative to both wages and the prices of other inputs. Although the investment ratio fell, it does not appear to be below the trend level associated with capital saving technological advance.

Capital in the Sheep Industry

Data

The ABARE's sheep industry survey results provide a wealth of information on the structure of production in the Australian broadacre industries, which account for a high proportion of total agricultural output.

The survey data have several conceptual advantages over the aggregate capital series already discussed. First, the quantity indexes are available in the form of Tornqvist indexes, which aggregate inputs and outputs taking into account the available substitution possibilities. Second, intermediate inputs can be identified separately and output is gross output rather than value added as is the case in the ABS national accounts data. Third, and most importantly, capital is based on a detailed inventory of total capital on each farm and is likely to be more comprehensive than the ABS measure. Fourth, the sheep industry survey data are available on a per farm basis and hence provide additional insights into changes in capital.

Some problems, however, do exist with the sheep industry survey data. Changes in survey methodology between 1975-76 and 1977-78 mean the data collected before and after this period are not exactly comparable. In general, the results after 1977-78 are generated from a larger survey sample using a more sophisticated method of capital valuation. In spite of these differences, the results appear to be broadly consistent over the period 1966-67 to 1985-86. Further, the agreement between the sheep survey data and the ABS aggregate data is, in most cases, good. It is important, however, that the sheep industry survey results are not considered in isolation, but viewed as complementary to the aggregate analysis.

Findings

While the series on capital in the agricultural sector showed very little increase over the period, capital per farm in the sheep industry increased by an average of 1.5 per cent a year. It seems that land use has become more extensive. This has been one means of raising productivity, as total employment has declined. It probably reflects changes in relative

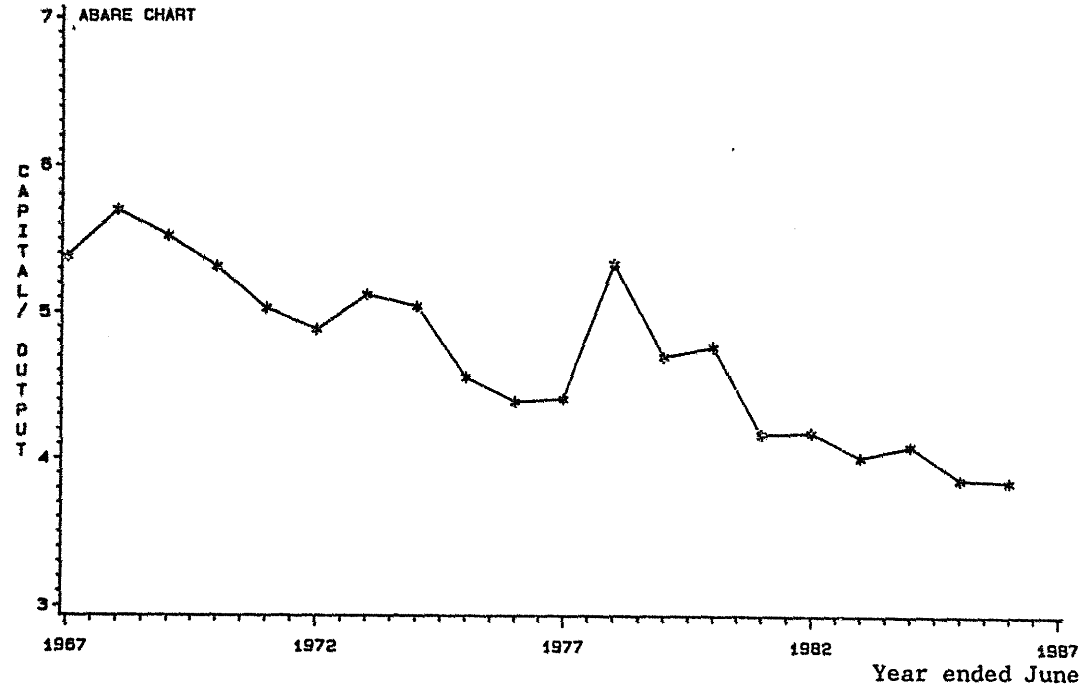

FIGURE 9 - Capital to Output Ratio in the Sheep Industry.

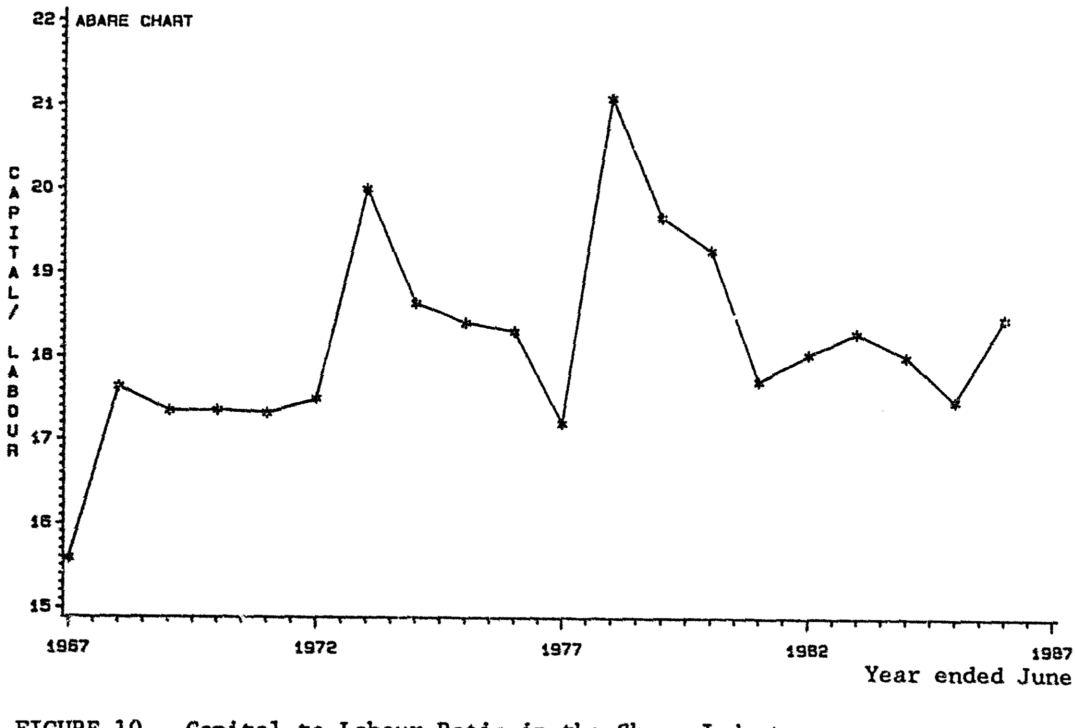

FIGURE 10 - Capital to Labour Ratio in the Sheep Industry.

The most obvious feature of the sheep industry investment to trend output ratio is its volatility around a relatively flat trend (see Figure 11). Since 1978-79, however, the ratio has been on a downward trend, corresponding to when the growth rate of the capital stock appears to have fallen.

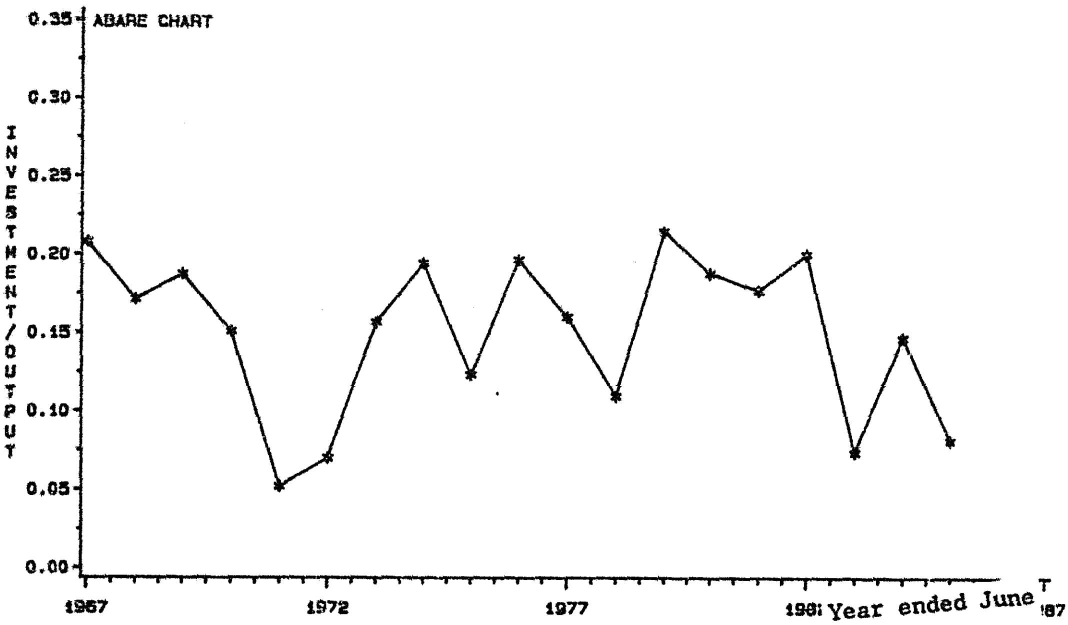

FIGURE 11 - Investment to Output Ratio in the Sheep Industry.

Overall, the pattern of investment behaviour in the sheep industry data appears to be broadly consistent with that revealed for agriculture as a whole by the ABS data, despite the differences in methodology and coverage between the two data sets. (The investment measure used in Figure 11 includes net purchases of machinery and structures, but excludes investment in land and changes in livestock inventories.)

Summary and Conclusions

Some of the key determinants of agricultural investment and capital stock have been examined in this paper to assess their implications for the capital stock over the past twenty years. Aggregate data for agriculture as a whole were examined together with more detailed data drawn from the Bureau's continuing surveys of the Australian sheep industry. From previous research, it was expected that productivity gains resulting from technological advances would be a major influence on investment and capital, and this is confirmed in this analysis. Productivity gains have allowed agricultural output to expand despite declining terms of trade and have very substantially reduced the amount of labour and capital inputs required per unit of output.

The total stock of capital in agriculture grew slightly over the period as a whole, although it appears to have levelled out or even declined slightly since the mid-1970s. By contrast, at the individual sheep farm level, the capital stock generally increased over the period. From the available data, it appears that total investment fell in 1985-86, although such a fall is not inconsistent with the past volatile behaviour of the investment series around its trend.

Throughout the period considered, the capital to output ratio in agriculture fell, implying a steady increase in the partial productivity of capital in the sector. By contrast, the productivity of capital appears to have declined slightly in the economy as a whole.

Over the past twenty years, capital per worker in agriculture has risen substantially, augmenting the effect of increases in total factor productivity on the productivity of labour in the sector. However, since 1977-78, capital per worker has tended to decline, presumably in response to the sharp rise in the user cost of capital in agriculture relative to wage costs. This substantially preceded the downturn in this capital-labour relationship for the economy as a whole. The effects of the slight fall in capital per unit of labour in agriculture on labour productivity are likely to be small relative to the increase brought about by the rise in total factor productivity.

The results of this examination clearly highlight the importance of innovation and productivity improvement as a long run influence on output and the capital stock in agriculture. The very marked changes in the relative prices of capital and labour over the period considered also appear to have had a noticeable effect on the extent to which capital or labour is employed and hence on the capital-labour relationship. Given the volatility of the investment series, it is difficult to infer much about the influences on recent investment behaviour, although the estimated levels of investment in 1985-86 do not appear to be extreme outliers.

APPENDIX I

Construction of the Input and Output Data Series

Two main sources of data were used in the examination of investment and capital stocks. The first was data on aggregate capital stocks published by the ABS (1987a). The second was farm level data collected from the ABARE's surveys of the Australian sheep industry. The aggregate data provide a basis for comparison with behaviour in the economy as a whole, but allow very little examination of the composition of the capital stock. The sheep industry data complement the aggregate capital data, providing a good deal more information about the composition of capital.

In this paper emphasis has been placed on capital stock calculated as a physical quantity. There are conceptual problems which make the measurement of aggregate capital stocks a potentially difficult exercise. While a full discussion of the theoretical considerations is beyond the scope of this paper, some discussion of the concepts of capital and capital values used in this paper is needed.

In this paper, capital is defined to include all those non-labour inputs which yield a flow of services over time. The measures used thus include machinery and equipment, fixed structures, livestock and land. The valuation of any given stock of capital involves discounting its future returns and, hence, depends on the interest rate. This dependence has given rise to heated debate in the theoretical literature (see Baumol 1977 for a discussion) as to whether capital can be treated as a single factor. In practice, however, such aggregation appears to be extremely useful. Further, any aggregation problems are likely to be much less serious for an individual sector where the real interest rate can be viewed as exogenous.

Aggregate data series

The data on aggregate capital stocks and investment, output and employment for agriculture and the economy as a whole were obtained from the ABS (1986; 1987a,c,d). The data described as agriculture in the paper are more correctly termed agriculture, forestry, fishing and hunting - that is, Division A of the Australian Standard Industrial Classification (ASIC) (ABS 1987b). Division A data have been used to represent agriculture because some series are available only at this level and comparable data are required throughout. It is a reasonable representation because of the dominance of agriculture in this ASIC category.

For the economy as a whole, the ABS (1987a) capital stock data are reasonably representative. However, for agriculture, the omission of capital held as land and livestock are serious omissions. An estimate of the value of unimproved land at 1979-80 prices was obtained by assuming a constant physical area of land employed in agriculture and indexing Powell's (1982) final estimate of land value forward to 1979-80, based on movements in land prices from the ABARE's Australian Sheep Industry Survey. An estimated value of livestock at 1979-80 prices was constructed by applying the average per head values from the ABARE's Australian Agricultural and Grazing Industries Survey for 1979-80 to the annual inventories of sheep and cattle. Price data at 1979-80 prices (ABS 1987a) were used to measure stocks of and investment in equipment and non-dwelling construction for agriculture and for the economy as a whole.

Ideally, capital stock data would be weighted by the service flow provided by each category of capital to obtain a measure of the capital input. However, the service flow is unobservable and will equal the observable user cost only when the capital stock is in equilibrium. A measure based on unweighted capital stock data, such as that applied here, provides a reasonable approximation of changes in the capital stock as long as the composition of the capital stock does not change too greatly.

Output estimates, at 1979-80 prices, for agriculture and for the economy as a whole were obtained from the national accounts (ABS 1987c). These are, of course, measures of value added by primary factors, rather than of gross output.

The labour series were based on hours worked rather than persons employed (ABS 1986, 1987d), thus taking into account changes in hours worked per week. The wage rate series was derived from the ABARE's index of prices paid for hired labour.

Sheep industry data

The sheep industry survey data provide an indication of investment behaviour at the farm level. The quantity variables used are implicit Tornquist indexes which, when aggregated, take into account the flexibility inherent in the production technology. Beck et al. (1985) and Lawrence and McKay (1980) discuss in detail the sampling methods and eligibility criteria as well as the procedures used to calculate the Tornquist indexes used in this study.

APPENDIX II

Estimating the User Cost of Capital in Australian Agriculture

In the absence of inflation and taxation, the cost of employing a unit of capital would equal $P_K(r + d)$, where P_K is the purchase price of the unit of capital, d is the rate of depreciation and r is the interest rate, indicating the return available in alternative investments or the cost of borrowing funds.

Once the realistic complications of inflation and the income tax system are introduced, however, the user cost of capital to individual producers becomes more difficult to calculate. Following the general approach outlined by Jorgensen (1963), however, a user cost of capital can be calculated taking these factors into account. The approach used in this paper is outlined in this appendix.

Inflation generally increases interest rates, with the nominal interest rate ultimately incorporating a premium equal to the expected rate of inflation. Thus, the nominal interest rate, i, may be written:

$$\text{(A.1)} \quad i \simeq r + p^e$$

where p^e is the expected rate of inflation over the period considered.

With tax averaging, the income tax system in effect imposes a tax on profits in agriculture, with the rate paid by individual producers depending on their average incomes. If all input costs are allowed as a deduction against income, income, Y, can be expressed as:

$$\text{(A.2)} \quad Y = (1-t) [py - W_1x_1 - \ldots - W_nx_n - P_K(r + d) K]$$

where

t = the tax rate applied to an individual farmer;
p = the price of output;
y = the level of output;

$W_1, \ldots, W_n$ = costs of inputs other than capital (for example, labour materials);

$x_1, \ldots, x_n$ = the levels of these inputs; and

K = capital.

If the economic costs of all inputs were fully tax deductible, the net price paid for each input would simply be $(1-t)w_i$. The tax system would have no effect on relative prices, since the $(1-t)$ term would cancel out in forming the relative price ratios. Thus, the tax system would be neutral and not affect input or output levels.

If the tax system does not allow some costs to be fully tax deductible, or provides incentives for the use of some inputs, it does affect production incentives. Taking these effects into account has been a major feature of much of the investment literature since Jorgensen developed the user cost of capital.

Three features of the Australian tax system are likely to have a major effect on the user cost of capital: the taxation of nominal interest; the use of historic cost measures for depreciation; and investment allowances (Pagan and Gray 1983). The effect of each of these features is considered as a basis for the user cost measure presented in this paper.

Since the sale of equity (shares) is rare in agriculture, in contrast with manufacturing, most agricultural investment is financed either from internal funds or through debt financing. The nominal cost of borrowing funds is (1-t)i, or $(1-t)(r + p^e)$. When allowance is made for the reduction in the value of the debt over time, the real cost of borrowing is $(1-t)(r + p^e) - p^e$, or $(1-t)r - tp^e$. Thus, the cost of borrowing is reduced by the tax deductibility of the inflationary component of nominal interest. Farm households that are net lenders outside the farm sector tend to derive most of their investment income from interest (Males, Poulter and Murtough 1987). In this situation, the opportunity cost of funds employed in agriculture is reduced in the same way by the taxation of nominal interest. Thus, whether farmers are net borrowers, or net lenders, the tax system, in the presence of inflation, reduces the opportunity cost of capital employed in agriculture.

Depreciation allowances for taxation purposes are based on historic cost. Under inflation, the value of these allowances declines relative to the economic cost of depreciation. This raises the cost of using capital.

Over most of the period 1966-67 to 1985-86, investment allowances were available for most forms of capital investments. To assess the impact of these one-off allowances on the annual cost of using capital, their value must be converted to an annual basis using an annuity. This approach was used in this paper and the assumed asset life was twenty years.

The user cost of capital measures presented in this study incorporate each of these factors. Combining the two terms discussed above and dividing the resulting measure by (1-t) to allow it to be compared with the pre-tax prices of output and of other inputs, results in the following measure of the user cost of capital, u:

$$u = \frac{P_k \{d[1-t(DA/d)] + (1-t)(i-p^e)\}}{(1-t)} - \frac{P_k.IA.r.t.}{(1-t)\ \{1-[1/(1+r)^{20}]\}}$$

where

DA = the depreciation allowance for taxation purposes;

IA = the rate of investment allowance or capital expenditure allowance (Department of Primary Industry 1979). (All other terms are as previously defined).

The rate of interest used was a five year rate on finance company debentures (Norton and Kennedy 1986), which provides an indication of available off-farm returns and is probably in line with costs of secured borrowings. Interestingly, this rate was generally 1-2 percentage points above the Treasury bond rate in the pre-deregulation period. This is shown in Figure 12. Since around 1980, however, the gap between this series and the Treasury bond rate has declined considerably. The expected inflation rate, p^e, used to calculate the real interest rate was generated by

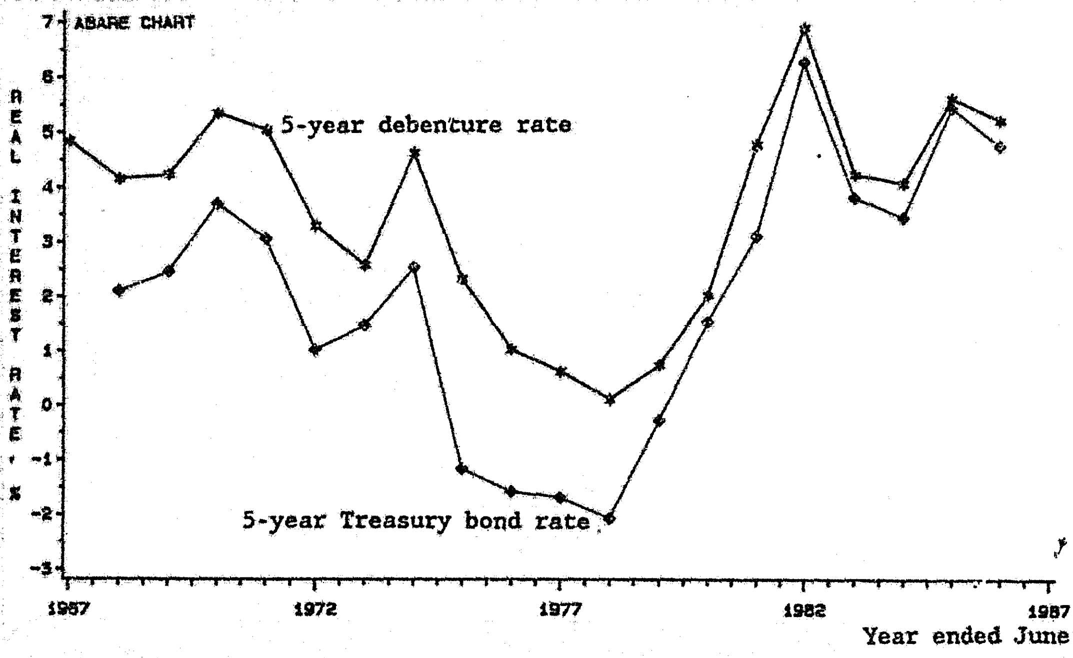

FIGURE 12 - Real Interest Rates on Five Year Bonds

exponentially smoothing annual changes in the consumer price index using an adjustment coefficient of 0.3.

The average income tax rate used was the rate paid by PAYE taxpayers, calculated using the PAYE tax payments less refunds for wages, salaries and supplements (ABS 1985). Given the tax averaging provisions, the relevant rate is the marginal rate applying to farmers' averaged incomes, adjusted for the reduction in real incomes resulting from the use of nominal incomes from earlier years. The average PAYE rate is likely to be a reasonable proxy for this series. It does exhibit a marked upward trend over the period which is likely to have affected investment behaviour to some degree.

The value of DA was the actual historic cost of depreciation allowed for taxation purposes (Australian Bureau of Statistics, personal communication, July 1987) while estimates of economic depreciation, d, were obtained from ABS (1987a).

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