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## A case study of changes in economic performance of an irrigated dairy farm in northern Victoria

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**Abstract.** Average total factor productivity measures for the dairy industry provide an insight into how the industry is performing as a whole, but reveal little about what may be happening on individual farms. A case study of an irrigated dairy farm in northern Victoria, over a 37-year period, found that total milk production and some measures of partial productivity increased substantially. The economic performance of this case study farm over the 37-year period is described and analysed. From records of income and expenses, operating profit, returns to capital, labour and management and total productivity measures were calculated. Between 1980 and 2000, the business achieved productivity gains at higher than the rate estimated for the whole industry. This performance was related to the timing and sequence of developments on the farm, with investment in land and infrastructure occurring prior to the 1990s, followed by a period of intensification involving increasing herd size and supplementary feed use.

**Keywords:** dairy farming systems, productivity, long-term case study, farm production measures

### Introduction

The operating environment of the Australian dairy industry places farm businesses under continual pressure to make productivity gains to remain profitable. Analyses from ABARE (2002) suggest total factor productivity (TFP) gains by dairy farm businesses over the past two decades from 1978-79, have been modest at about 1.8% p.a., with lower productivity gains on average in the second half of this period.

These estimates of low TFP on dairy farms could be attributable to factors such as a slowing rate of adjustment out of the industry during the 1990s, when relatively prosperous conditions prevailed; to increasing farm complexity with the use of new technology; or to expansion of farm area and increases in concentrate feeding that increased both inputs and outputs. As well, the use of less productive land, associated with farm expansion, and the time needed to develop skills for managing increasingly complex systems, result in periods of inefficiency (Melsen *et al.* 2006).

Watson (2004) stressed that individual farming systems employ unique timing and input mixes to produce output, and that TFP estimates of average productivity for the whole dairy industry have little to say about what is happening on individual farms. To make a detailed examination of production and resource use trends on an irrigated dairy farm, Melsen *et al.* (2006) conducted a case

study of a business over a 40-year period. Substantial increases in production, but also increases in input and resource use, were found. A number of partial productivity measures increased substantially, including:

- kg milk fat + protein/cow;
- kg milk fat + protein/ha milking area;
- kg milk fat + protein/ML irrigation water;
- estimated pasture consumed/ha milking area; and
- kg milk fat + protein/labour unit.

Partial productivity measures reveal little about whole farm (total factor) productivity. Melsen *et al.* (2006) concluded that their analysis of production and resource use changes needed to be accompanied by an analysis of farm economic performance to determine how the partial technical productivity changes contributed to TFP.

This paper describes the economic performance of an irrigated dairy farm over a 37 year period. The analysis builds on work completed by Melsen *et al.* (2006), which discussed the biophysical and infrastructure factors associated with changes in productivity on the same farm.

### Method

Several aspects of the approach will be discussed in this paper. Further details can be found in Moule *et al.* (2005).

### **Case study farm**

A case study approach was chosen as farm management decisions require consideration of the complex combination of human, production, environmental, economic, and financial components of the business (Makeham and Malcolm 1993). Case studies over a long timeframe enable an in-depth analysis of changes in economic performance.

In 1960, the total area of the case study farm was 28 ha. During the 1960s and 70s, 37 ha was purchased, with a further 59 ha purchased in the 1980s. Of the 124 ha on the home block, 104 ha was milking area. In 1996, a 200 ha outblock was purchased, which was subsequently used for dry stock, heifers, agistment and fodder conservation. Herd size increased from 90 Jersey cows in the mid-1960s to 513 Jersey X Holstein-Friesian cows in 2002-03. Herd size peaked at 538 cows in 2001-02. Milk production increased approximately 15 fold over the 40 years, from 200,000 L to 3.2 million L in 2001-02. Production declined to 2.8 million L during the drought in 2002-03. Milk fat production increased from 10,500 kg in the mid 1960s to 155,930 kg in 2001-02, while milk protein increased from 8,200 kg to 120,780 kg. Other developments on the farm included:

- the construction of a water reuse dam in 1980;
- the whole farm being laser-graded between 1978 and 1995; and
- the dairy being upgraded in 1972-73, 1977-78, 1986-87 and 1988-89. The start of grain feeding coincided with the installation of a rotary dairy in 1988-89.

Further details on the changes in production and farm infrastructure are in Melsen *et al.* (2005).

### **Data collection**

The information required to calculate annual operating profit was obtained from farm records and external sources. The farmer had a farm ledger that listed all income and expense items for the years from 1966-67 to 1976-77. The farmer also had tax returns for the business, dating from 1969-70 to the present, with only three years missing. The profit and loss statements in these tax returns were used to collate annual income and expenses over time. Tax related items not relevant to annual operating income and expenses were not included. The aim was to derive a realistic set of measures of management performance, rather than taxation measures of performance. These incomes and expenses were then collated to calculate total operating income and costs.

Gross income was the sum of income from milk, livestock trading, hay sales and agistment. Variable costs comprised shed costs, herd costs, feed costs, repairs and maintenance and milk levies, volume and cartage charges. Overhead costs were administration, employed labour, depreciation and operator labour and management costs.

Data on actual labour units working on the farm were obtained from Melsen *et al.* (2005a). The cost of owner/operator labour and management was defined as the amount that these services could earn elsewhere. The farm-manager labour unit, working a 50-60 hour week and managing 500 cows, was assumed to cost \$80,000 in 2002-03. A wage for a hired labour unit working 40 hours per week was assumed to be \$40,000 p.a. in 2002-03. The values for manager and labourer wages in 2002-03 were adjusted according to the changes that have occurred in the ABARE index of farm wages over time. Thus, in 1960, the equivalent wages were \$4,000 p.a. for a manager and \$2,000 for a labour unit.

### **Historical and current dollar terms**

To enable a valid comparison of income and costs between years and to account for inflation over time, all previous years' data were inflated to 2002-03 dollars. This was done by multiplying historical values by the Consumer Price Index (CPI) where the index was based on 1989-90 = 100 as calculated by the Australian Bureau of Statistics (2004).

### **Measures used**

#### Operating profit

Annual farm operating profit (before interest and tax) was the primary measure of economic performance. It was defined as:

Operating Profit = Gross Income – Variable Costs – Overhead Costs

#### Returns to capital, labour and management

Partial productivity measures can be estimated using the residual value method. With this approach, all factors except the one of interest, e.g. total capital, are rewarded out of the value of output produced. The reward to factors is based on market rates or opportunity cost. The remainder of the value of output produced is then attributed to the factor of interest. This measure is an indicator of the productivity of those inputs, collectively called capital in this case. Alternatively, all factors except operator labour and management can be rewarded at their market value or opportunity cost, and the residual is an estimate of the contribution to production of operator labour and management. These payments are not actual

payments, but estimates of contributions by factors to the value of production.

The return to capital and operator labour and management, and implied return to capital, with an imputed payment labour and management calculated at market rates, were estimated.

#### Total productivity measures

Estimating productivity values on an individual resource basis is not consistent with a whole systems view of a farm enterprise. From a systems perspective, the essence of farm production is that management is applied to a mixture of factors that interact with one another to produce output. From this perspective, the system should be assessed as a whole. This leads to the concept of total factor (or multi-factor) productivity, whereby productivity is assessed on a whole farm basis.

Total factor productivity is total output divided by total input, aggregated using monetary values based on market price or opportunity cost. A commonly used TFP measure is gross factor productivity, measured as total gross income/total costs.

This TFP index is indicative of the management that has been applied in the farm system. Over a number of years, the larger the TFP index, the better the performance of the farm's management. However, results that occur in a farm system are not the same as results that are planned, and hoped for, by management before the production occurs. Output is not fully under the control of the farm's management. Markets, climatic conditions, chance and other sources of risk all strongly influence actual outcomes.

The change in the total gross income to total costs ratio (GI:TC), considered in conjunction with the movement in the farmer's terms of trade, can be used to derive an estimate of change in farm TFP. The GI:TC ratio incorporates the changes that have occurred in the price of output produced and the cost of inputs used, including opportunity interest cost of capital invested. Combining the change in the GI:TC ratio with the change in farmers' terms of trade gives the *implied* change in TFP. For instance, suppose the GI:TC ratio remained constant over a run of years despite real prices received declining and real costs of inputs rising annually. The interpretation would be that productivity of inputs must have increased at a rate that offset the effects of the declining real terms of trade, thereby maintaining the real level of profit (the GI:TC ratio).

To enable comparison with the ABARE (ABARE 2004) estimates of average industry TFP, the TFP of the case study farm was

estimated for similar times. The time periods used to assess TFP for the case study farm were:

1982-83 to 2002-03;

1982-83 to 1992-93; and

1992-93 to 2002-03.

#### Life of business returns

The internal rate of return from the investment was estimated with all assets of the business being 'purchased' in 1966-67 in 2002-03 dollar values and 'sold' in 2002-03, and with annual operating profits earned over the life of the business expressed in 2002-03 dollar values.

### **Results and Discussion**

#### ***Income***

Milk income increased over time as a result of both increased production per cow and increased cow numbers (Figure 1). Total milk income adjusted to 2002-03 dollars remained relatively constant between 1966-67 to 1975-76, after which a steady increase occurred for a twelve-year period. After grain feeding commenced in 1988-89, milk income increased dramatically. The deviations from this trend after 1988-89 were because of variations in milk price (1995-96 a record high price; 1999-00 and 2002-03 low milk prices) and the drought in 2002-03 where cow numbers were reduced. Milk income reached a plateau in 1996-97. The farm also changed dairy company in the mid 1990s, initially capturing a higher milk price (~\$1/kg butterfat equivalent) for a number of years.

Income from livestock sales accounted for over 10% of income between 1968-69 and 1973-74 and was as high as 26% in 1971-72, when beef prices boomed. In contrast in the later period, the proportion of income from livestock sales averaged 4.4% p.a. of total income between 1978-79 and 2002-03, with a range of 1 to 9%.

#### ***Costs***

##### Variable costs

All variable costs in 2003 dollar terms increased over time. The changes in variable costs per cow are shown in Figure 2, with the increase for feed costs being greater than that of any of the other cost categories. Over the study period, annual feed costs comprised about 60% of farm variable costs, but this varied between 40 and 89%.

Feed costs per cow were relatively constant for 15 years from 1966-67 to 1981-82, after which they began to rise steadily. The drought of 1982-83 caused a spike in feed costs per cow, of \$864 in 2002-03 dollars. The 2002-03 drought also caused a spike in feed costs, with high prices for temporary

water (average of \$365/ML) and brought in feed costs (grain at over \$300/t).

Feed costs also rose in 1990-91, the year after the introduction of grain feeding. Throughout the 1990's feed costs tended to fluctuate, but the overall trend was for feed costs per cow to increase. The costs of fertiliser, fuel and oil, and irrigation expenses per cow were relatively constant over the study period, while brought in feed costs increased. Water costs per cow were constant, except in 2002-03.

Shed costs (\$/cow) were generally stable between 1966-67 and 1978-79, except for 1972-73 when the 8-a side herringbone shed was upgraded to a 12-a side double up dairy. Some of the capital costs were probably included as operating costs at this time. Shed costs for the farm then increased gradually until 1988-89, with sharp increases in costs at times when the dairy was upgraded (1977-78, 1986-87 and 1988-89, when the rotary dairy was constructed (Melson *et al.* 2006)). The gradual increase in total shed costs for the farm and shed costs per cow were predominantly associated with significant changes in power costs, with smaller increases in the cost of dairy expenses through the 1980s. Shed costs were more variable after 1988-89, possibly associated with differences between years in replacement costs for rubberware and liners.

Total herd costs and costs per cow in 2003 \$ terms were stable between 1966-67 and 1978-79, before increasing steadily through to 2002-03. The increases in costs were due largely to increased veterinary, freight and calf rearing costs.

Total, and per cow, repairs and maintenance costs increased over the study period, from approximately \$50/cow in the late 1960s to early 1980s, to almost \$100/cow in the late 1990s. The overall increase in repairs and maintenance costs reflect the increased herd size and the growing use of technology and equipment on the farm over time.

#### Overhead costs

Total farm overhead costs increased slowly, but steadily, corresponding to increased labour (employed and owner-operator) and management charges, plus additional administrative costs and increased depreciation following periodic new capital investment. The main items that contributed to the increase in administration costs, particularly from the early 1990s onwards, were increased shire rates and insurance costs. Overhead costs per cow fluctuated between \$600 and \$1,000 (in 2002-03 dollars) and did not change substantially on a per cow basis as herd size increased. This reflects the reality that overhead costs are

fixed only in the short term, and in the medium or long term, all costs are variable as farmers change the size of their operation by investment in fixed assets and labour and thus increase total overhead costs.

#### Average variable, overhead and total costs and economies of size

Until now, the analysis of costs has been based on accounting costs for the purposes of estimating operating profit and return to capital. In economic analysis, estimates are also made of average total cost per unit of output as an indicator of the existence of economies of size. Economies of size are defined as being the situation where average total cost per unit of output declines as the size of the business increases. However, for this purpose, total cost and average total cost must include the opportunity cost of capital. Typically, much of the effect of reducing average total cost per unit of output is achieved by increasing output without increasing overhead or fixed costs, including opportunity cost of capital, in the same proportion. This reduces average overhead cost per unit of output.

In this case study, average variable cost per kg of milk protein and fat produced increased from around \$2 to \$3 in the late 1960s to \$3 to \$4 in the early 2000s (Figure 3). In contrast, average overhead cost (including opportunity cost of capital) per kg of milk protein and fat produced decreased, from around \$5 in 1967 to \$1.70 in 2003, as a result of spreading overhead costs (including opportunity costs of capital) over more output.

The dilution of overhead costs was associated with increases in the output per unit of cow and land capital, and was not achieved by simply milking more cows or buying more land. While the opportunity cost of cow capital increased in proportion to the number of cows as herd size increased, this cost was diluted by increasing output per cow over time.

#### **Operating profit**

The analyses indicate little or no operating profit for this farm prior to 1992-93 (Figure 4), after allowing for owner-operator's labour and management and fully employed family labour, based on market rates<sup>1</sup>. This

<sup>1</sup> The situation that prevailed – typical for many farms in the 1960 and 1970s, at least – was that the sons would work on the farm with the father (owner), on a fairly *ad hoc* and informal remuneration basis and the family would take out drawings for living. If an outbreak of good times occurred, land would be bought, often in the names of the sons in lieu of wages foregone in the past.

illustrates that this farm business needed to expand and intensify (and develop the infrastructure and skills to accommodate the intensification) over time to remain viable as terms of trade declined. The farm had good annual operating profits over the last decade except when milk prices were low in 1999-2000 and during the drought in 2002-03. Milk prices were good in 2000-01 and 2001-02 and it appears the operating loss in 1999-00 is probably understated, reflecting a lower than expected profit in 2000-01. This was achieved by deferring expenditure, for example on fertiliser inputs. Note that labour is valued at the market rate, being the prevailing award conditions, using the quantity of labour required to operate the farm system at the time. More typically, a family farm often has access to some family labour that has low opportunity cost, and is thus low cost to the business, ie. some labour is used because it is free.

Following a change, it takes some time before farm businesses perform at potential. The years with reasonable operating profits occurred four years after the introduction of supplementary feeding, eight years after expansion of the milking area and four years after the rotary dairy was installed. This illustrates in part the lag time between implementing development options and adopting technology and increased farm profit. Some of the partial productivity measures reported by Melsen *et al.* (2006) also declined for short periods after implementing development options.

The estimated pasture consumption also increased (to between 12 and 14 t DM/ha) around the time when reasonable operating profits were achieved, after having averaged 8-9 t DM/ha for several years previously (Melsen *et al.* 2006). The order in which these development events were implemented may also have had an important impact on the period of higher operating profits. The general order of the key development events was:

- expand milking area,
- develop irrigation layout and improve pastures and increase cow numbers,
- build rotary dairy, and
- introduce concentrate feeding and increase cow numbers further to exploit the potential of the land and dairy.

If the development events had occurred in a different order, it is likely that the higher operating profits may not have been achieved when they were.

### **Returns to capital, labour and management**

Farm returns can be expressed as a 'grand total' return to everything - capital and operator's labour and management - as shown in Figure 5. Alternatively, owner's labour and management can be fully rewarded and the return to capital treated as a residual return i.e. what is left over to reward capital (Figure 6).

Average annual return to total capital (operating profit/total capital) varied around zero (mean of -0.004%) The overall fluctuation of percentage of return to total capital from 1966 to the late 1980s may be observed in Figure 6. Average operating profit after allowing for all accounting costs, including labour, at market rates was - \$17,000 during this time. From the late 1980s to 2002-03, average annual return to total capital was 3% (\$65,000 average operating profit).

### **Total productivity measures**

The ratio of total gross income to total costs (including opportunity cost of capital at 4% real p.a.) for the case study farm for the period 1966-67 to 2002-03 is shown in Figure 7. This performance was achieved after the ratio of prices received to prices paid changed as follows:

- 1982-83 to 2002-03 terms of trade declined at 1.1% p.a.

ABARE (2004) estimates of average productivity growth in the dairy industry were as follows:

- 1982-83 to 2002-03 TFP grew at 1.7% p.a.

If the real GI:TC ratio for the farm is taken to be around 0.8 in the early 1980s and around 1.0 in early 2000s, then the compound annual real rate of growth in the GI:TC ratio in the interim was approximately 1.1% p.a. Taking out the terms of trade effects yields a change in TFP from the early 1980s to early 2000s of 1.1% plus 1.1%, or 2.2% p.a. This compares with the ABARE (2004) estimate for the average of the industry for the same period of 1.7%. Put another way, if the measured GI:TC for the case study farm had been unchanged over the period, the productivity gains would be equal to the declining terms of trade because productivity gains must have offset the deterioration in the terms of trade to enable the GI:TC ratio to be maintained at a constant level.

If the measured GI:TC ratio for the farm for 1982/83 was 0.8, and 1.1 in 1992-93, then the compound rate of growth in the measured GI:TC ratio in the interim was approximately 3.2% p.a. The decline in the terms of trade over this period was 0.9% p.a.

Thus, the total change in TFP from the early 1980s to early 1990s was 3.2% plus 0.9%, equalling 4.1% p.a. This compares with the ABARE (ABARE 2004) estimate for the average of the industry for the same period of 3.2%.

Repeating these calculations for the periods 1982/83 to 1992/93 and 1992/93 to the early 2000s, revealed changes in TFP of 4.1% and 2.0% respectively. These results from the case-study compare with industry averages of 3.1% and 1.2% in the two periods.

The case study farm achieved productivity gains at 2.2% p.a. compared with the 1.7% p.a. estimated by ABARE (ABARE 2004) for the industry average over the whole of the period studied. The case study farm achieved higher than industry average productivity gains in the 1980s, and higher than industry average in the 1990s. This result seems largely related to the timing of the development events. Investment in land and infrastructure occurred mainly prior to the 1990s and was followed by intensification (increased cow numbers and concentrate feeding) during the 1990s.

#### **Life of business returns**

The Internal Rate of Return (IRR) is the average annual return on the capital invested in the business over the whole life of the business. In this case study, the IRR from the investment was estimated with all assets of the business being 'purchased' in 1966-67 and 'sold' in 2002-03, with annual operating profits earned over the life of the business, all in constant (2002-03) dollar values. Calculated in this way, the internal rate of return of this investment was 3.1%.

#### **Overall business performance**

On the basis of buying this farm business in 1966 and selling it in 2003, and receiving all the net benefits in between, the capital invested in this business managed to earn, on average, approximately 3% return per year. Productivity increased at 2.2% p.a., which was sufficient to offset (in the early decades) and more than offset (in more recent years) the real decline in dairying terms of trade that occurred over the same time. The case study farm achieved more than industry average productivity gains in the 1980s (4.1% v. 3.1%) and in the 1990s (2.0% v. 1.2%).

The performance of the business in terms of profitability increased markedly in the 1980s and 1990s. This result was linked to several factors.

First, the timing and sequence of the development events was important. Investment in land, development of the

irrigation layout, and infrastructure, such as the rotary dairy, occurred mainly prior to the 1990s and was followed by intensification (increased cow numbers and concentrate feeding) during the 1990s. However, there was a lag between these developments being undertaken and improvement occurring in farm operating profit. The manager believed that all aspects of the system came together in the early 1990s with not only increased cow numbers, but also improved cow condition and increased per cow production through better feeding, underpinned by investments in land, irrigation, pasture and milk harvesting. Improved pasture utilisation was instrumental.

Second, the use of tax returns in the analysis may mean that some component of capital investment undertaken has been included in annual operating costs, something that is not unusual in farm businesses. This means operating profit prior to the 1990s is likely to be understated in some years.

Third, in the mid-1990s, the farm shifted from one dairy company to another and captured a higher price, initially about \$1/kg butterfat equivalent, for a number of years.

Fourth, after 1993-94, management goals changed from a focus on investment back into the business to using some of profit in other ways.

Melsen *et al.* (2006) reported declines in some partial technical productivity measures on this case study farm immediately after implementation of development options. It might be expected that a lag in improvements in operating profit might also occur after the implementation of development options, as profit integrates all aspects of the farm business.

#### **Conclusions**

The overall effect of expansion and intensification of this case study farm was to dilute overhead costs (including opportunity cost of capital) per kilogram of milk protein and fat produced, and maintain an annual average of 3% return on capital after these changes were made. Spreading of overhead costs (including opportunity costs) over greater output was the means of overcoming the effects of declining terms of trade and improving return to total capital from the late 1980s onwards. It was the combination of expansion of land, development of and improvement of pastures, increasing cow numbers, intensification of feeding, and improvements in a range of technical efficiency (partial productivity) measures (Melsen *et al.* 2005; 2006) that led to the increase in protein and fat produced, and to increased income and operating profit.

Some overhead costs, particularly management and labour costs, increased as herd size increased. The increased milk production per cow (as a result of more concentrate feeding and higher pasture consumption), combined with the increased cow numbers, led to more total milk solids and income in relation to the total of variable and overhead costs (financial and opportunity cost), or, put another way, less variable and overhead costs per kg of milk protein and fat produced. This gave lower average total cost per kg of protein and fat.

As intensification proceeded and cow numbers increased, extra milk production per cow was the source of extra profit. More precisely, extra profit came from:

- the extra margin over extra variable cost per extra litre, and
- the reduced average overhead cost per unit of output.

Increasing cow numbers alone would not have achieved the results that were achieved. The key was increasing cow numbers and increasing output per cow.

Such a deduction is only possible after the whole of the system – economic, financial and technical – is analysed. This illustrates the importance of economic, financial and technical measures of farm performance in judging the performance of a dairy enterprise.

### Acknowledgments

We sincerely thank the case study farm family for their time, co-operation and willingness to share their farm data. We appreciate the direction and support provided by the project steering committee and our colleagues. Emily Moule and Monique Melsen provided valuable inputs to data collection and collation. Funding was provided by the Department of Primary Industries, Victoria; Dairy Australia via Murray Dairy; and the University of Melbourne.

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Figure 1. Total farm milk income ( $\square$ ) and milk income per cow (.) in 2002-03 adjusted dollars for an irrigated dairy farm in northern Victoria

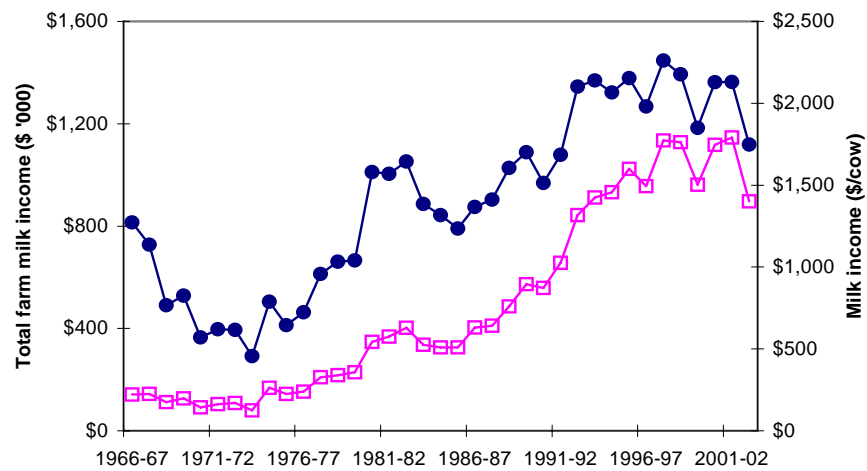


Figure 2. Variable costs in 2002-03 adjusted dollars for an irrigated dairy farm in northern Victoria

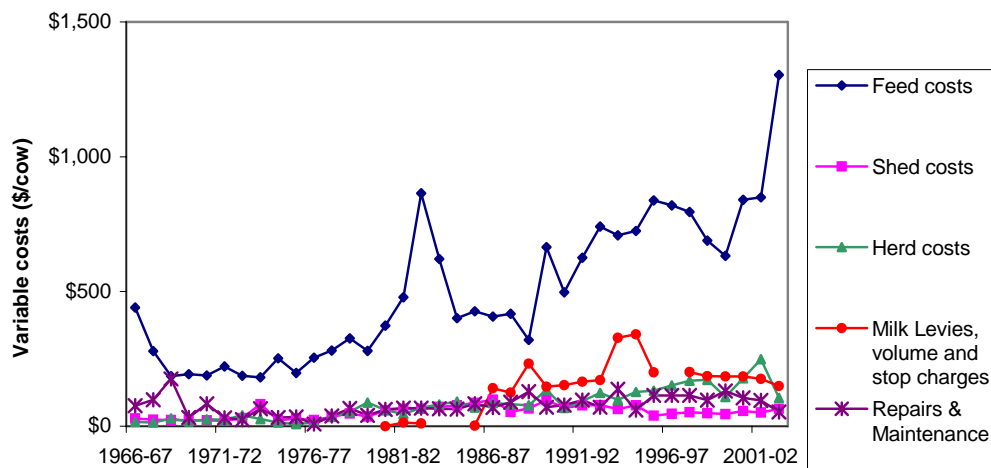


Figure 3. Variable (.), overhead ( $\square$ ) and total costs ( $\Delta$ ) per kg protein + fat, in 2002-03 adjusted dollars for an irrigated dairy farm in northern Victoria

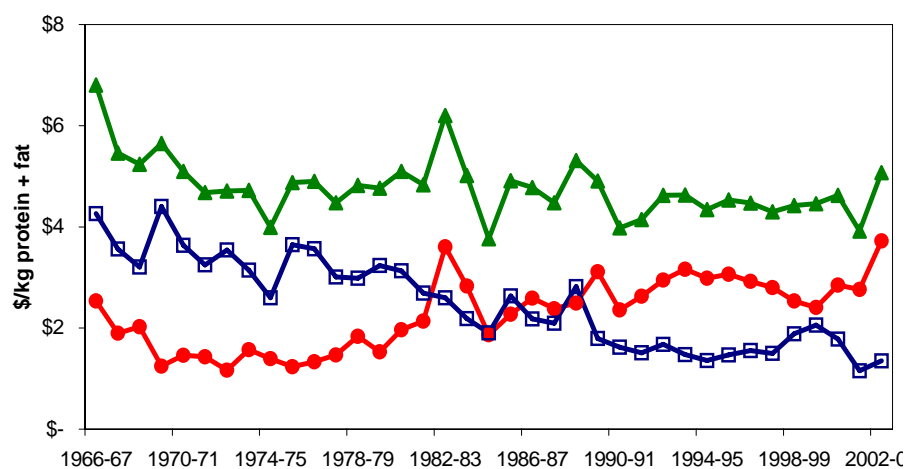


Figure 4. Annual operating profit, in 2002-03 dollars, for an irrigated dairy farm in northern Victoria.

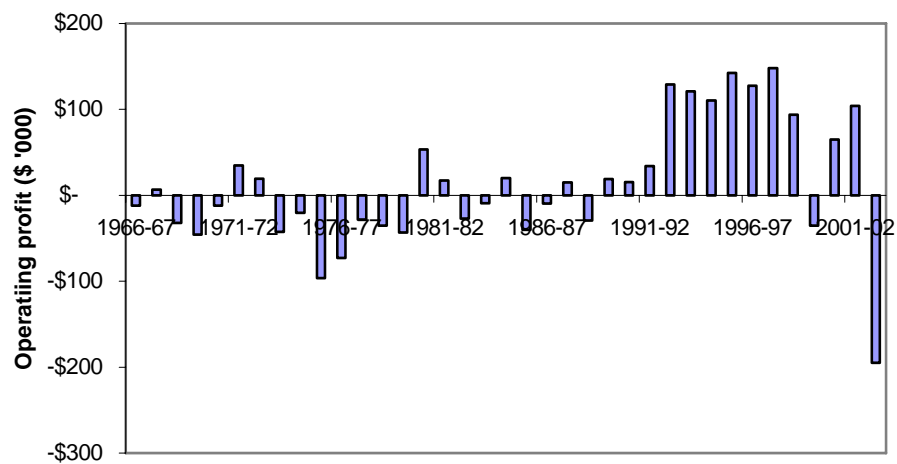


Figure 5. Return to capital and operator labour and management, in 2002-03 adjusted dollars.

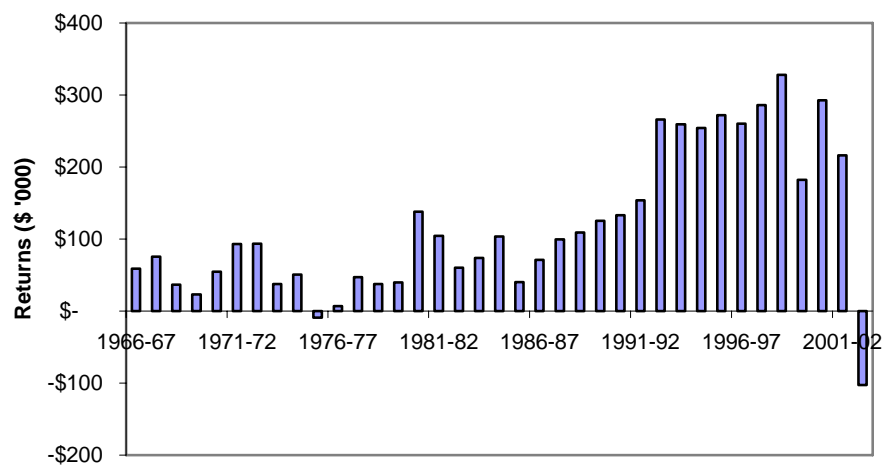


Figure 6. Implied return to total capital, before tax, with labour and management fully paid.

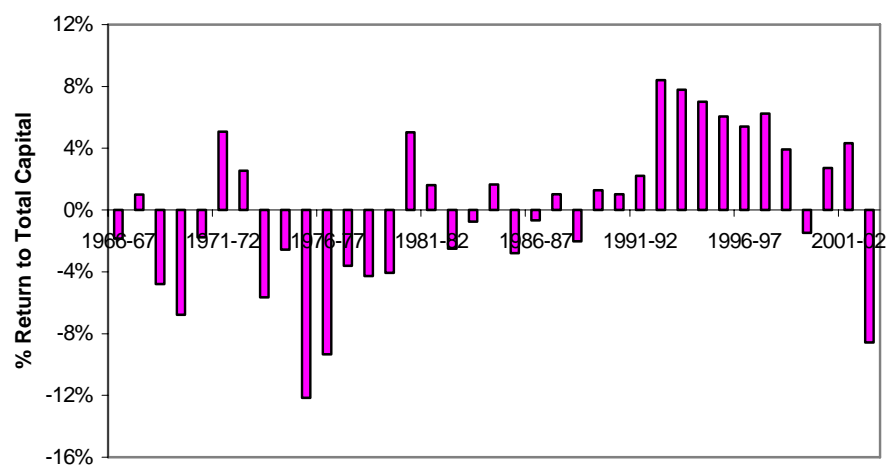


Figure 7. Ratio of gross income (GI) to total costs (TC).

