A study of labour use and efficiency for mixed sheep and crop agricultural systems of the Central Wheat Belt of Western Australia

by

Ian James Rose

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Certification

I certify that the substance of this thesis has not already been submitted for any degree and is not currently being submitted for any other degree.

I certify that help received in preparing this thesis and all sources used have been acknowledged.

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Ian James Rose   Date

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Abstract

Using as a study region the central wheatbelt of Western Australia, this thesis examines labour demand for sheep and cropping during an average production year in different farming systems under a range of scenarios of labour cost and availability. The impacts of these scenarios on farming system profits and enterprise selection are examined using the bio-economic farm model MIDAS (Model of an Integrated Dryland Agricultural System).

Labour requirements for sheep are found to be far greater than those for cropping. Additionally the labour requirements for sheep are found to be high in all production periods. By contrast cropping has infrequent peak labour requirements mostly at seeding and harvest. This means that the most profitable farm labour option is found to be employing casual labour to accommodate these periods of peak demand in cropping. The lesser relative profitability of the sheep enterprise makes employing a permanent worker the least profitable labour option. Employing casual labour during busy periods for cropping is more profitable but it is also associated with only small areas of perennial pastures being sown which has environmental implications.

The logistics of employing labour at only certain times of the year, compared to employing a full time worker, means that farmers need to pay more per week to employ these seasonal workers or do the extra work themselves. Additionally, outsourcing sheep management is only more profitable than other labour options if the efficiency of cropping is improved due to more of the farmer's time being freed for cropping activity.

This investigation of labour and the various options related to labour management highlight the importance of labour for Western Australian mixed sheep and crop farms. The thesis findings highlight the complexity of labour use and its interaction with land management and identify the need for further research into the efficient use of labour. The modelling results give credence to the view that time pressures on farmers and scarcity and affordability of specialist hired labour, when combined with the greater relative profitability of cropping, have encouraged many farmers in Western Australia to focus more on cropping than sheep production over the last couple of decades. Findings also give a rationale as to why many farmers have opted to run low input livestock systems.

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1. General Introduction

1.1. Farm labour in Western Australia: the current situation

Many broadacre farms in Western Australia (WA) experience problems in attracting and retaining farm labour. A survey of WA farmers (Rabobank 2007) reported that of the 69 percent of farmers who required additional labour over the previous 12 months, 14 percent said it was 'impossible' to find labour. A further 62 percent said they had experienced 'some difficulty' attracting adequate labour. To overcome this labour shortage, 41 percent of the survey participants said they had increased their own working hours.

There are a few reasons for these labour difficulties and resulting time pressures on farmers. Firstly, it can be difficult to attract workers into an industry like agriculture where employment prospects are shrinking. The increasing size of farms and use of labour-saving technologies have reduced employment in agriculture, causing a 9 percent decline in rural labour between 1996 and 2001 (Tonts 2005). Secondly, rural populations in many inland areas are stagnating or declining, further limiting employment prospects for other family members and lessening the social attractiveness of life in these rural regions. Thirdly, higher wages in metropolitan areas and in the resources sector (Barr *et al.* 2005 , Minerals and Energy Research Institute of Western Australia 2007) attract skilled labour away from agriculture (State Training Board 2007).

The difficulty of finding and retaining farm labour causes farmers' workloads to increase (Rabobank 2007) and leads farmers to desire simpler and easier lives (McGuckian 2006). In some medium and low rainfall zones farmers are focusing on cropping rather than animal production; as cropping relies on less labour input and furthermore, since the 1990s, cropping has often been the more profitable enterprise, underpinned by higher rates of productivity gain (Zhao *et al.* 2008 , Nossal and Sheng 2010). The higher rate of productivity has been attributed to labour-saving technologies, new herbicide technologies (Gill and Holmes 1997), improved crop varieties (Kokic *et al.* 2006) and large machinery that provides economies of size benefits (Liao and Martin 2009). In contrast, the profitability and innovation in sheep production has been less. This, in combination with the expense and difficulty of attracting labour into sheep husbandry has led some farmers to reduce sheep numbers and run low stocking rate, easy care flocks. Clear evidence of the switch of farm resources into cropping and away from sheep production is that in WA from 1990 to 2005 sheep numbers fell by over 40 percent, while the area sown to cereals increased by over 50 percent.

1.2. Reporting and modelling farm labour in Western Australia

Most surveys of WA farm businesses (BankWest 2007 , Planfarm and BankWest 2008 , Australian Bureau of Agriculture and Resource Economics 2010) and business models of farming (Kingwell and Pannell 1987, Gibson *et al.* 2008, de Voil *et al.* 2009) report labour use on farms fairly simplistically. For example, the (Australian Bureau of Agriculture and Resource Economics 2010) comment that:

> *Payments for owner manager and family labour may bear little relationship to the actual work input. An estimate of the labour input of the owner manager, partners and their families is calculated in work-weeks and a value is imputed at the relevant Federal Pastoral Industry Award rates.* (p.45)

In other surveys (Planfarm and BankWest 2008), hours or weeks actually worked by family members usually are not recorded but rather a range of assumptions are invoked about labour use, cost and availability.

Similarly, financial models of WA farm enterprises or whole farms (Department of Agriculture and Food Western Australia 2005, Gibson *et al*. 2008) typically fail to record the types, quantities and costs of labour employed in agricultural operations. Usually an aggregated per hectare or annual cost of labour is provided or assumptions are made about typical use of family and hired labour.

For example, the widely used whole farm model of Western Australian broadacre farming, known by its acronym MIDAS (Model of an Integrated Dryland Agricultural System) assumes there is sufficient family labour, supported by periods of hired casual and contract labour, to run a diverse range of possible farming systems, from cropping-only through to pasture-based sheep systems (O'Connell *et al.* 2006, Gibson *et al*. 2008, Kopke *et al.* 2008). However, models such as the MIDAS model (Kingwell and Pannell 1987, Kingwell 2002, Ewing *et al.* 2005, Flugge and Schilizzi 2005) inadequately capture the impacts of farmers being time-pressed. These models fail to portray any difficulties of securing skilled farm labour, particularly for sheep enterprises that require a high level of sheep husbandry skill. Hence, there is a need to improve farm models like MIDAS to ensure they better represent labour use, availability and expense, especially regarding sheep management.

Accordingly the primary objective of this dissertation is to investigate the impact of labour availability and cost on mixed farming systems in WA. The analysis will provide farmers and researchers with information about how farm labour affects whole farm profitability and farm management. Different options for employing labour will be investigated to identify the most efficient use of labour. This primary objective will be answered by:

1. Identifying the impact of labour on whole farm profit and land use
2. Investigating different labour options to identify the most profitable use of farm labour.

1.3. Thesis structure

The changing labour situation in the broadacre agricultural region of WA is discussed in Chapter 2, along with the impact and consequences of labour shortages on the current nature of farming systems. The nature and role of labour in these farming systems is also described. Chapter 3 describes the farm modelling approach subsequently used to examine the role of labour in broadacre farming systems in WA. Chapter 4 outlines the labour requirements of various farm operations and how these requirements and different sources of labour are represented in the farm model. Chapter 5 presents modelling results regarding the impact of limited labour and the efficiency of different labour options. The particular case of the outsourcing of sheep management is investigated in Chapter 6. A general discussion of the thesis's key findings is given in Chapter 7.

2. Labour and its Role in Broadacre Farming in Western Australia

There have been several changes in broadacre farming in Western Australia (WA) over the last 20 years which have contributed to decreased labour availability. This chapter will describe these changes and outline how labour supply has been affected.

2.1.1. Changing demographics in Western Australia's wheatbelt

The wheatbelt region of WA has experienced a rapid decline in population and a reduction in available farm labour. In WA over 75 percent of the State's population lives in the Perth metropolitan area, parts of which record among the highest rates of population growth in the State (ABS 2010). This growth is due to higher wages in metropolitan areas and in the resources sector that attracts fly-in-fly-out workers based in the Perth region (Garnaut *et al.* 2001, Barr *et al*. 2005). The dominance of agriculture in the broadacre region means there are limited employment opportunities in other areas outside of agriculture (Hogan *et al.* 1999, Kingwell and Pannell 2005). As a consequence, agriculture's share of employment has halved to 9 percent between 1960 and 2005 (Tonts 2005).

This decline in population means that many broadacre farms in WA experience problems in attracting and retaining farm labour, making cropping even more attractive due to its relatively lower labour requirement compared to sheep production. A survey of WA farmers (Rabobank 2007) reported that of the 69 percent of farmers who required additional labour over the previous 12 months, 14 percent said it was 'impossible to find labour'. A further 62 percent said they had experienced some difficulty attracting adequate labour. To overcome this labour shortage, 41 percent of the survey participants said they had increased their own working hours.

This increased work requirement has also been accompanied by a decrease in farm businesses and an increase in farm size. The number of farm businesses in the wheatbelt decreased by 33 percent in the central and southern wheatbelt and by 25 percent in the north and eastern wheatbelt between 1990 and 2008 (Figure 2 1). With this decrease in farm businesses, farm sizes have increased (Figure 2 2). This expansion of farm size has meant higher debt levels for farmers, particularly due to the high interest rates during the 1980s and 1990s (Australian Bureau of Agriculture and Resource Economics 2001).

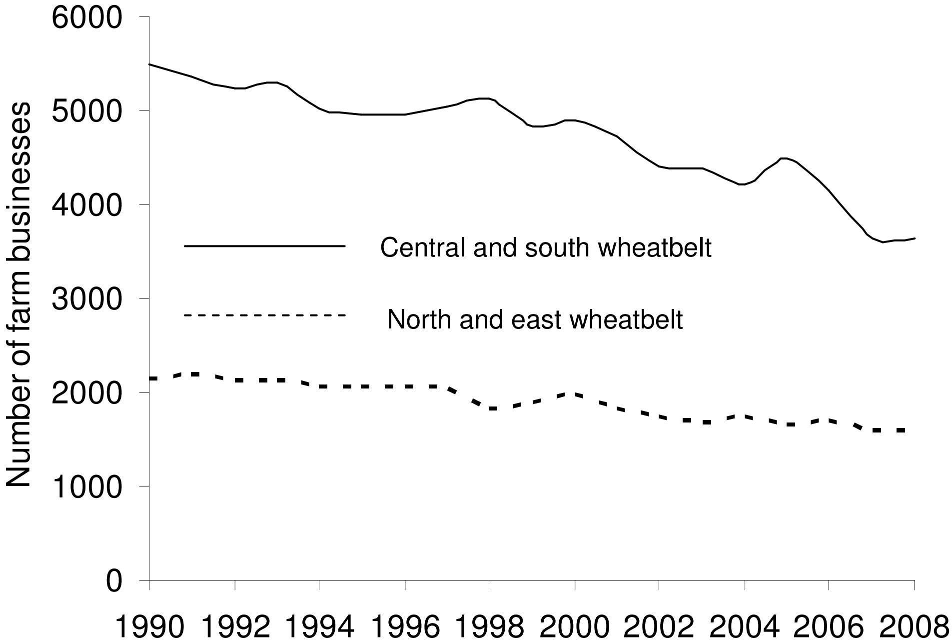

Figure 2.1 Number of broadacre farm businesses in the wheatbelt in WA: 1990 to 2008

(Source: based on ABARE farm survey data available on AgSurf.)

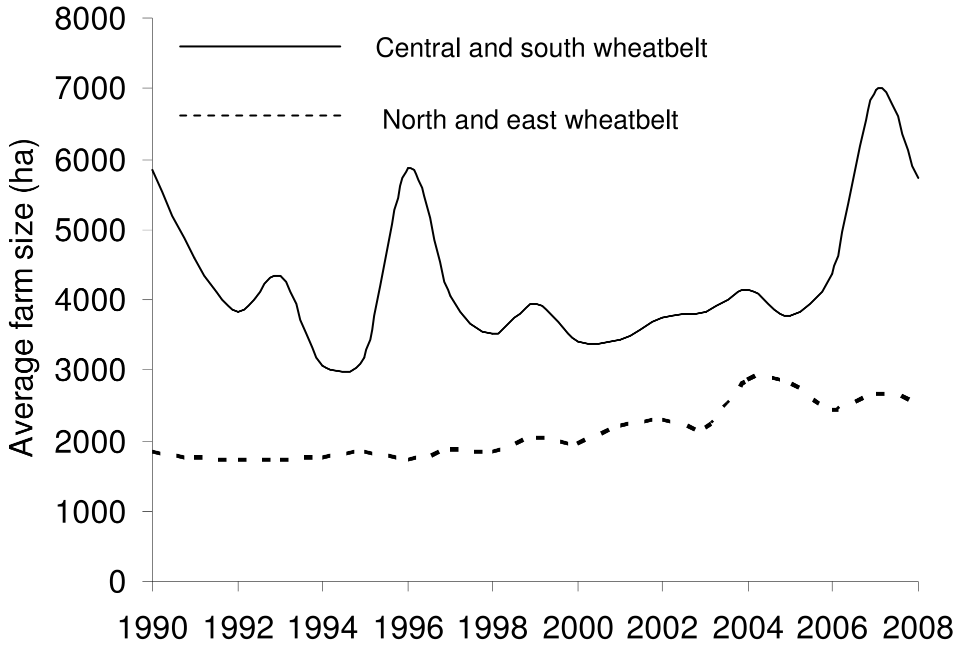

Figure 2.2 Size of broadacre farm businesses in the wheatbelt in WA: 1990 to 2008 (Source: based on ABARE farm survey data available on AgSurf.)

Furthermore, the management of these larger farms has become more complex as the availability of technology, crop choice, input selection, rotation options, marketing and information services has increased (Kingwell 2011). Therefore, farmers have been forced to become more selective in how they allocate their time.

Farm benchmarking suggests that the labour requirement for sheep is high compared to cropping (Holmes and Sackett 2009). Hence, when farm management labour is scarce, sheep management can place high demands on that labour. Moreover, because of the dominance of cropping in the wheatbelt over recent decades, many young farmers who have specialised in cropping, have limited experience, knowledge and skills for managing sheep (Dymond 2006). This means that some farmers, because of time pressures or limited knowledge, are managing low maintenance sheep systems.

2.1.2. Changes in broadacre agriculture

The main land use of the agricultural zone in WA is mixed crop and sheep production (Kingwell and Pannell 2005). The region's Mediterranean climate of mild wet winters and dry hot summers supports dryland cropping that is complemented by sheep. Sheep graze the crop residues over summer and autumn and aid in weed control (Ewing *et al*. 2005). However, in WA over the period 1990 to 2005 sheep numbers fell by over 40 percent while the area sown to cereals increased by over 50 percent.

Cropping has become the dominant land use mostly due to:

1. cropping being relatively more profitable than sheep production and
2. crop production becoming physically easier compared to sheep management that has remained labour intensive.

Managing larger farms with limited or less labour has meant many farmers have preferred cropping compared to sheep. Cropping has been supported through the introduction of more crop options such as lupins and canola, and better varieties such as wheat varieties with different flowering times that suit more environments (Beare *et al.* 1999, Zhao et al. 2008).

Cropping has become easier with the introduction of new herbicides (Gill and Holmes 1997) and new machinery technology such as direct drill (Kokic et al. 2006) and GPS-based controlled traffic systems (Fuschbichler and Kingwell 2010). Alternatively, sheep technology has remained relatively stagnant, and although the introduction of live sheep export created a new market option for farmers, the benefits of cropping often have outweighed those of sheep.

This swing towards cropping has created many challenges, however, including herbicide resistant weeds in crops, salinity and inefficient sheep enterprises.

2.1.3. Salinity

The change towards crop dominant farms means that farmers are running low input, low output livestock operations. Stocking rates are lower and the advantages of a mixture of livestock and cropping are not seen on crop dominant farms. Even though continuous cropping is the most profitable in the short term, long periods of cropping have negative impacts on soil health and soil nitrogen reserves (Reeves and Ewing 1993). The long term consequences of crop dominant agriculture have become clearer in recent years (Ewing *et al*. 2005). The most dramatic consequences are dryland salinity, herbicide resistance and a loss of potential income from livestock.

Many areas of southern Australia has experienced dryland salinity because native vegetation has been replaced with annual crops and pastures for agriculture (Hatton and Nulsen 1999). Annual crops have shorter root systems and a lower leaf area index which reduces evapotranspiration and water use from soil profiles, and increases drainage and runoff. Asseng *et al.* (2001) calculated drainage on deep sands under wheat to be 29 percent of annual rainfall in a high rainfall zone (461 mm/year average rainfall), 23 percent in a medium rainfall zone (386mm/year average rainfall), and 12 percent in a low rainfall zone (310 mm/year average rainfall). This increase in drainage makes water tables rise, whereas under native vegetation this was not the case. The rising of the water table brings salt that formerly resided in deep soil profiles into contact with plants' root zones. This salt makes the land saline and unsuitable for annual crops and pastures.

An estimated 4.3 million hectares (16%) of the south-west region of WA had a high potential of developing salinity from shallow watertables in 2000 (National Land and Water Resources Audit 2001). This was predicted to rise to 8.8 million hectares (33%) by 2050 (National Land and Water Resources Audit 2001). In the cropping regions of Australia salinity is predicted to cost A$29 million a year in foregone profits (Kingwell 2003).

To prevent the water table from rising, annual crops and pastures need to be replaced with perennial pastures that are similar to the original native vegetation (Cocks 2003). A number of studies have shown that deep rooted perennial plants, particularly lucerne, reduce the amount of groundwater more than annual crops and pastures (Latta *et al.* 2001, Bell *et al.* 2006, Latta and Lyons 2006). Including perennial plants into phase rotations reduces leakage by over 90% in regions with less than 380mm of annual rainfall, such as the wheatbelt in WA (Ward 2006). These pastures can delay the onset of salinity by as much as several decades (Ward 2006). Saltland pastures are also an option for slightly saline areas that are no longer suitable for annual crops and pastures. O'Connell *et al* (2006) found that saltland pastures planted on moderately saline environments increased profit and reduced recharge.

Despite the costs of salinity farmers are not planting saltland pastures at a rate that will significantly decrease salinity. Trewin (2002) reported that 60 percent of dryland farmers indicated time pressures on their management were a major limitation to their adoption of salinity management options. Doole *et al* (2009) found that when labour resources are limited on farms in the central wheatbelt of WA, farms have lower stocking rates and use less perennial pastures. Bennett *et al* (2004) found that another limitation to the adoption of lucerne was the establishment phase. If large areas of lucerne were planted in crop rotations then there was a short term decrease in the carrying capacity of the farm because of the reduction in overall pasture area (Bennett *et al*. 2004).

2.1.4. Herbicide resistance

Another problem with crop dominant farming is herbicide resistance. Herbicide resistance develops when overuse of herbicides causes intense selection pressure on weeds and facilitates the development of herbicide tolerance (Doole and Pannell 2008). Herbicide resistance continues to be a real problem in the wheatbelt region of WA, particularly in the crop dominant northern region. Llewellyn and Powles (2001) found that out of 264 randomly selected cropping fields in the wheatbelt of WA, 46 percent were resistance to diclofop-methy, 64 percent to chlorsulfuron and 37 percent were resistance to both herbicides. Only 28 percent of tested populations were classified as susceptible to both diclofop-methyl and chlorsulfuron, although all but one population were susceptible to clethodim. Walsh *et al* (2007) found that 54 percent of wild radish (*Raphanus raphanistrum*) were resistant to the herbicide chlorosulfuron and 60 percent were resistant to the herbicide 2,4-D.

Herbicide resistance can be managed without the use of sheep, using methods such as green manuring and spray topping (Gill and Holmes 1997, Walsh *et al*. 2007). However, livestock still remains the best long term solution to herbicide resistance (Monjardino *et al.* 2004).

2.1.5. Low input and low profit sheep enterprises

A third problem with crop dominant agriculture is the tendency for farmers to adopt low input, low output livestock enterprises. This includes set stocking systems with low stocking rates set for poor seasons (Doyle *et al*. 1993). This type of management means that pasture utilisation is low and much pasture is lost through decay from spring to autumn (Doyle *et al.* 1996). Given the strong relationship between stocking rate and profit (White and Morley 1977, White *et al.* 1980), there is potential on many farms to increase stocking rates and make more money from sheep.

However, the relationship between profit and stocking rate is not linear (White and Morley 1977, White *et al*. 1980). When stocking rate exceeds the optimum, farm profits decrease (White and Morley 1977, White *et al*. 1980) and soil health is compromised. This optimal stocking also varies depending on the season, particularly when available pasture fluctuates (White and Morley 1977, White *et al*. 1980). WA farming systems are characterised by such fluctuating levels of pasture biomass (Rossiter 1966). Increasing stocking rate then has risks causing farmers to adopt conservative stocking rates.

Controlled grazing and strip grazing can increase utilisation of spring pasture whilst increasing stocking rates (Thompson *et al.* 1994, Doyle *et al*. 1996). However, grazing to maintain feed on offer in spring requires frequent, at least weekly, assessments of pasture and adjustments in the area grazed (Doyle *et al*. 1996). Most farmers in southern Australia currently do not formally monitor feed on offer (Rose *et al.* 2005) which suggests that the extra work required for intensive grazing strategies is too much for farmers with time pressures. Doole *et al* (2009) found that when farm labour is limited, whole farm profit at optimal stocking rates decreases by A$10,000 for wool enterprises and A$20,000 for a prime lamb enterprise compared to when labour is not limited. Also, when labour is limited, more crop is grown because of its higher profitability and relatively lower labour requirements.

The reduction in available farm labour, combined with the trend towards cropping has caused many environmental and social problems in the wheatbelt region of Western Australia. This thesis aims to explore the importance of labour in influencing land use and farm profitability, and improve our understanding of how labour is likely to impact on agriculture in Western Australian agriculture in the future.

Chapter 3 will investigate how models have been used to investigate the issues in Chapter 2. The variety of models, their application and their limited power in investigating labour problems will be discussed.

3. Modelling of Broadacre Farming in Western Australia

Models and assessment tools that apply to broadacre farming in WA, and in many other agricultural regions, are varied. These models range from quick and simple calculation methods such as gross margins, break-even analysis and simple cash-flow budgeting (Makeham and Malcolm 1981, Makeham and Malcolm 1993) through to more complex decision support models that are more detailed and comprehensive in their description of the farm and its enterprises (Kingwell and Pannell 1987, Pannell 1997, Robertson *et al.* 2009). Although simple models and assessment tools like gross margin analysis have advantages of being fast and easy indicators of whether an enterprise can break even and by how much above its investment and production costs it will generate income (Herbert *et al.* 2005) often these techniques inadequately capture interactions between enterprises within a farming system (Obst 1986). Also where capital costs are an important component of a comparative analysis (Barnard and Nix 1979) often simple tools like gross margin analysis have limitations.

Cash flow budgeting is another approach for recording the expected receipts (cash in) against payments (cash out), associated with a particular investment or farm plan (Makeham and Malcolm 1993). Farmers can use discounted cash flow budgets or financial planning cash-flow budgets to assist them in their business management such as applying for loans (Scott *et al.* 2000) or comparing different investment options (Scott *et al*. 2000). In contrast to gross margin analysis, cash flow budgets are dynamic; therefore they are useful for monitoring the profitability of an enterprise through time.

Although a valuable tool in many situations, one of the disadvantages of cash flow budgets is that each time a change is made to the structure of the analysis, a new budget must be recalculated. Additionally, cash flow budgets do not consider opportunity costs of farm inputs when they are allocated between enterprises, and interactions between enterprises often are overlooked. Most importantly, cash flow budgeting is not an optimisation methodology. Construction of a cash-flow budget will not reveal if the budgeted strategy is the profit-maximising strategy (Libbin *et al.* 1994).

Whole-farm optimisation models can be useful (Beneke and Winterboer 1973, Kingwell and Pannell 1987) but tend to require much time and effort to construct and validate (Pannell 1996) and care is needed to build the desirable level of accuracy and complexity. Pannell *et al* (2000) for example argue that often there is over-investment in the treatment of risk in some production systems.

3.1. The MIDAS model

The principal advantage of optimisation models of farms is that a variety of alternative decisions can be jointly considered to determine an optimal plan and reveal plans of similar advantage (Beneke and Winterboer 1973). In linear programming (LP) models of farming systems, for example, the objective is to find the optimum set of activities that generates maximum profit or utility, subject to various constraints or restrictions (Barnard and Nix 1979). The fundamental components of a such a model are its objective function that needs to be maximised (or minimised); alternative activities that can be selected to achieve the objective; and with their selection being subject to various constraints such as resource limitations (Kingwell and Pannell 1987).

One example of the LP approach, as applied to economic investigations of broadacre farming issues in Western Australia is the MIDAS (Model of an Integrated Dryland Agricultural System) model of a representative broadacre farm. This model is a powerful analytical tool for assessing farming system impacts as it considers simultaneously the biological, financial, technical and managerial aspects of a broadacre farm business.

MIDAS represents a typical farming system and as a steady-state model assumes an average production year under average climatic conditions for the specified region.

There are several versions of MIDAS, which differ in system characteristics due to the particular nature of the region being considered. For example, the MIDAS-CWM version represents a farm of the medium rainfall region (350-400 mm) in the central wheatbelt of Western Australia (see Figure 3-1).

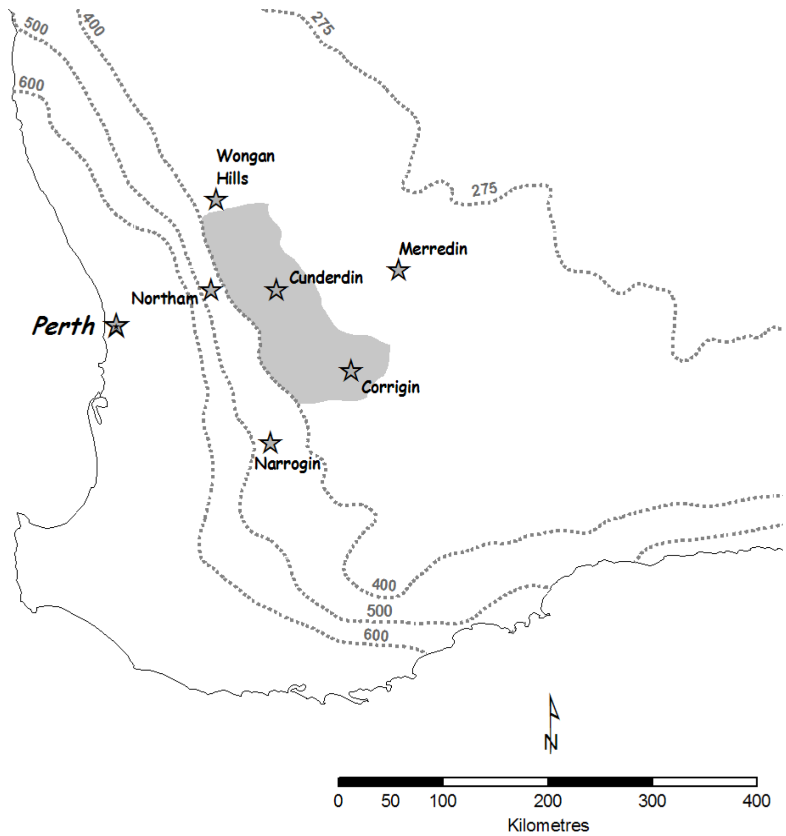

Figure 3.1 Map of the region represented by the central wheatbelt MIDAS model (shaded). Rainfall isohyets (mm) are represented with dashed lines.

Source: (Gibson *et al*. 2008))

MIDAS was originally developed in the mid-1980s for the eastern wheatbelt region of Western Australia (Kingwell and Pannell 1987), but subsequent versions have been developed for other regions, including the central wheatbelt region. The MIDAS model used in this thesis is the MIDAS-CWM model, hereafter referred to as MIDAS. It describes a 2000 hectare broadacre farm that typifies the central wheatbelt region of WA.

The several hundred farming activities in MIDAS include alternative rotations on each of eight soil classes (S1-S8) (see table 3.1), crop sowing opportunities, livestock options, yield penalties for delays to sowing, cash flow recording, and machinery specifics and overhead expenditures.

Table 3-1 Land management units (LMU) in the MIDAS model.

LMU	Name	Dominant soil type	Area (ha)
S1	Poor sands	Deep pale sand	140
S2	Average sandplain	Deep yellow sand	210
S3	Good sandplain	Yellow gradational loamy sand	350
S4	Shallow duplex soil	Sandy loam over clay	210
S5	Medium heavy	Rocky red/brown loamy sand/sandy loam; Brownish grey granitic loamy sand	200
S6	Heavy valley floors	Red/brown sandy loam over clay; Red and grey clay valley floor	200
S7	Sandy surfaced valley	Deep sandy surfaced valley; shallow sandy-surfaced valley floor	300
S8	Deep duplex soils	Loamy sand over clay	390

Constraints include resource restrictions such as availability of land, labour and capital. Several studies describe this MIDAS model and other variants in detail (Morrison *et al.*

1986, Kingwell and Pannell 1987, Pannell 1996, Abadi Ghadim and Pannell 1998, Bathgate *et al.* 2009).

One of the major strengths of MIDAS is its ability to address a range of whole-farm issues (Pannell 1996). However, as with any model, MIDAS has both advantages and limitations. Pannell (1996) identifies the most important of MIDAS's strengths as being capable of jointly taking into account biological and economic considerations, and to consider a range of whole-farm issues. But this characteristic of the model also generally limits its use to researchers and consultants due to its complexity and depth. One of the common criticisms of LP models is that they do not allow for production and price risk (Beneke and Winterboer 1973, Pannell 1996). To partially offset this, users of MIDAS usually conduct sensitivity analyses to test the robustness of findings (Pannell 1996).

3.2. Sensitivity analysis

The nature of agricultural activities can be highly uncertain, volatile and uncontrollable (Knight and Malcolm 2007). Hence, sensitivity analysis can be a useful technique to explore how the profitability of an activity or innovation may be affected by a range of changes to various parameters or variables (Merrifield 1997). Although LP models may give a single optimal solution, a decision maker also needs to know how far parameters can change before the optimal solution changes. In addition, decision makers need to be convinced that the model is a credible and reliable source of information before acting on its results, including sensitivity analysis results.

A sensitivity analysis is an investigation of the responsiveness of conclusions to changes or error in parameters and assumptions (Pannell 1997). Variables that affect model output (e.g. prices, costs, yields) can be altered in sensitivity analysis to gauge their impact on model output (Abadi Ghadim and Pannell 1998).

3.3. Applications of MIDAS

The MIDAS model has been applied to a diverse range of issues from evaluating new technologies, analysing supply elasticity of farm commodities and trade-offs between economic and environmental objectives (Abadi Ghadim and Pannell 1998). Further examples include analyses in weed management, benefits of nitrogen fertilisers, salinity and land degradation, lambing percentages, perennial cereals, deep ripping practices, comparisons of pasture, cropping and livestock enterprises and the effects of climate change (Pannell and Falconer 1988, Abadi Ghadim *et al.* 1991, Abadi Ghadim and Pannell 1991, Morrison and Young 1991, Schilizzi and Pannell 2001, Bathgate and Pannell 2002, Petersen *et al.* 2003, Ewing *et al*. 2005, Lefroy *et al.* 2005, Flugge and Abadi Ghadim 2006, O'Connell *et al*. 2006, Revell *et al.* 2007, Byrne *et al.* 2008)

Unfortunately, only one application of MIDAS published thus far is directly relevant to this thesis. Doole *et al.* (2009) used farm benchmarking information to estimate the amount of labour required to manage one dry sheep equivalent and to grow one ha of crop over a whole year. Labour was then included as a constraint for the whole year. Doole *et al.* (2009) concluded that sheep enterprises on central wheatbelt farms are less profitable when farm labour is limited. Additionally, the use of perennial pastures also decreased when labour was limited as lower stocking rates reduced the requirement for and viability of perennial pastures. These results reflect the current enterprise mix of central wheatbelt farms which are dominated by crop.

This technique employed by Doole *et. al.* (2009) provided a quick analysis of the effects of labour on land use but did not consider the seasonal nature of use of labour for crop and sheep production.

In reality there are times of the year such as seeding and harvest that have a high demand on labour and different enterprises, particularly crop and sheep, can compete for labour at such times. Therefore, Doole *et al.* (2009) may have underestimated the impact of labour on the profitability of sheep.

The strength of MIDAS is that its detailed activity-based structure facilitates a more detailed analysis of labour use. Provided information is available on the time requirements for various farm activities, then use of available labour can be specified in MIDAS. For example, the 69 crop rotation options available in MIDAS have an associated set of activities and labour requirements. Hence an optimal solution will reveal not only which rotations are part of a profit-maximising plan but also the associated pattern of labour use across the farm year.

MIDAS includes a detailed representation of sheep biology with different sheep types, including sheep bred to Merino and cross bred rams and different options for selling wethers as lambs or as older wethers. The different labour requirements for these different systems can be specified in MIDAS, provided relevant data on labour are available.

3.4. Limitations of MIDAS

Although MIDAS can determine the optimum strategy for a farming system, it does not determine dynamic aspects of optimality. For example, how a particular farm manager might implement the transition from their current position to the ‘optimum’ state is not determined by the model (Abadi Ghadim and Pannell 1999). Neither does the model account for impacts of sequences of different seasonal conditions nor sequences of commodity prices and input costs. Furthermore, it assumes the driver of farm management is profit maximisation. Although other aspects of farm management such as animal welfare, leisure preferences and sound soil management practices are built into the model, nonetheless the overarching decision objective is to maximise profit.

Chapter 4 will describe how, for this thesis, labour was incorporated into MIDAS and how the sensitivity analysis for labour was structured.

4. Incorporation of Labour in MIDAS

4.1. Introduction

Although farm labour is a key component in broadacre agricultural production systems, as outlined in the General Introduction to this thesis, most farm modelling involves a fairly simplistic treatment of labour (e.g. Doole *et al*. 2009). Most surveys of WA farm businesses (BankWest 2007, Planfarm and BankWest 2008, Australian Bureau of Agriculture and Resource Economics 2010) and business models of farming (de Voil *et al*. 2009) fairly simplistically report labour use on farms. The Australian Bureau of Agriculture and Resource Economics (2010) admits that the payments it invokes for the owner manager's labour mostly will "bear little relationship to the actual work input". (p. 45).

In farm surveys (Planfarm and BankWest 2008) hours or weeks actually worked by family members usually are not recorded but rather a range of assumptions are invoked about labour use, cost and availability. Similarly, financial models of WA farm enterprises or whole farms (Department of Agriculture and Food Western Australia 2005 , Gibson *et al*. 2008) typically fail to record the types, quantities and costs of labour employed in agricultural operations. Usually an aggregated per hectare or annual cost of labour is provided or assumptions are made about typical use of family and hired labour.

In MIDAS several assumptions about labour availability and use are invoked. Contract labour is used for mulesing and shearing. Casual labour over several weeks is employed for seeding and harvest and for supplementary feeding of sheep. In addition, family labour is used for all other farm tasks. This pool of labour is assumed sufficient and capable to run a diverse range of possible farming systems, from cropping-only through to pasture-dominant, cross-bred prime lamb sheep systems (Gibson *et al*. 2008).

However, a potential weakness of the MIDAS model is its failure to adequately capture the impacts of farmers being time-pressed and the difficulties of securing skilled farm labour, particularly for sheep enterprises that require a high level of sheep husbandry skill. For example, MIDAS studies of sheep systems that produce prime lambs and that draw upon lucerne and saltland pastures (Bathgate and Pannell 2002, O'Connell *et al*. 2006) assume that labour supply for sheep management is not limiting. However, farm surveys (Trewin 2002, Rabobank 2007) indicate that farmers are time-pressed and experience difficulties in employing skilled farm workers. Hence, there is a need to represent more accurately the availability, expense and use of farm labour in the MIDAS model, especially regarding sheep management.

4.2. Revision of the representation of labour in MIDAS

The most recent version of MIDAS was changed to include labour requirements during the year. Three steps were used to include labour in MIDAS as recommended by Hazell and Norton (1986):

1. Allocate the time required to do each management activity on the farm in each month.
2. Specify the time available to do each management activity in each month by defining the total number of hours provided by the farm owner.
3. Provide for the opportunity to hire casual labour or hire a unit of permanent labour. This adds labour costs in the objective function of the model and increases the hours available for each management activity in each month.

Extra periods were included in addition to each month for four seeding periods, A, B, C and D. These periods represent four intervals during seeding to capture the importance of timeliness of sowing crop as crops sown later incur yield penalties. There is also a limitation in the amount of days that lupins and canola can be harvested and also the time available to harvest the cereal crops is limited.

Table 4.1 lists the length of each period and the activities that require labour in each period. All assumptions about time requirements and time of the year for each task were made in consultation with four farmers from the wheatbelt region of Western Australia. This involved farm visits and telephone interviews to quantify the time requirements of each farmer. Because of the level of detail and volume of information required about the timing of farm activities and labour requirements, it was not feasible nor practical to use a large sample of farmers. The very small sample of farms was selected on the basis of their willingness and ability to provide accurate and detailed information, whilst being representative of typical farms in either the central wheatbelt or typical of the labour management practices of key farm enterprises. The data in the following tables regarding each activity are the average of responses among the small sample of farmers.

Table 4-1 Amount of days available and the main activities in each time period.

Time period	Start date	Length (days)	Cropping	Sheep
January	1 Jan	31		Take rams out of ewes Feed sheep
February	1 Feb	28		
March	1 Mar	31	Prepare cropping machinery	Vaccinate ewes Crutching Ewes and hoggets drenched Feed sheep
April	1 Apr	30	Prepare cropping machinery Spray to remove lucerne	Feed sheep
May	1 May	7	Spray herbicides for seeding in period A	Finish feeding sheep
Seeding period A	8 May	9	Seeding and spray herbicides for seeding period B and C	
Seeding period B	17 May	5.	Seeding and spray herbicide for seeding period D	
Seeding period C	22 May	5	Seeding	Lambing starts
Seeding period D	27 May	5	Seeding	Lambing
June	1 Jun	30	Spray herbicides for sowing lucerne Sow lucerne	
July	1 Jul	31	Spray herbicides	Mark merino lambs and crossbred lambs
August	1 Aug	31	Spray lucerne in establishment year	Wean crossbred lambs and merino lambs
September	1 Sep	30	Spray for pest and diseases and late herbicides	Shearing Weigh crossbred lambs
October	1 Oct	31	Swath canola Prepare crop machinery	Ewes and hoggets drenched
Harvest lupins and canola	1 Nov	10	Harvest canola and lupins	
Harvest cereals	11 Nov	40	Harvest rest of cereals	
December	21 Dec	11		Class and selenium bullet ewe hoggets Put rams into ewes Start feeding sheep

4.2.1. Time required for sheep management

The time requirements for sheep include activities for each sheep (see Table 4.2 and Table 4.3) and activities for each mob of sheep. In addition to the time requirements in Table 4.2, five hours are required to organise and supervise contractors for shearing, crutching and marking.

All other sheep tasks are done on a mob basis. The maximum number of sheep in each mob and the time required for mustering each mob of sheep for each of the jobs is listed in Table 4.4.

Table 4-2 Time required for each activity (sheep/hour).

Sheep class	Drench	Jet	Shear[1]	Crutch[2]	Vaccinate	Draft ewes	Class Ewe hoggets	Selenium pellet
Hoggets	280	300	150	280	250		300	200
Ewes	280	300	140	250	250	500		
Wethers	280	300	120	220				
Merino lambs	300	400	170	320	300			
Xbred[3] lambs	300	400	180	320	300			

[1] Five shearers used during shearing. [2] Three crutchers used during crutching. [1,2] The farmer musters sheep whilst the sheep are being shorn and crutched. [3] Crossbred lambs

Table 4-3 Time required for additional activities for lambs (lambs/hour).

Sheep class	Mark	Wean	Weigh	Feedlot
Merino lambs	100	500	300	1000
Crossbred lambs	150	500	300	1000

To put rams into each mob of ewes takes 1 hour per mob. Rams are drafted from ewe mobs at a rate of 500 ewes per hour.

Table 4-4 Maximum number of sheep in each mob and time required to muster each mob.

Sheep class	Maximum number of sheep in each mob	Time required to muster each mob (hours/mob)
Ewes	700	1.75
Ewes and lambs		2.75
Wethers	700	1.75
Hoggets	1000	1.75
Merino lambs	1000	2.00
Crossbred lambs	1000.	2.00

Each mob of sheep is monitored once a week and this takes half an hour. During lambing each mob of ewes is monitored five days a week for half an hour. All sheep are supplementary fed between 6th December and 24th May, three times a week. The time required to supplementary feed depends on the amount of grain fed and the number of mobs (Table 4.5). The time required driving to and from the silo to the paddock is 30 minutes. The time required to put each tonne of grain in the 100 bushel feed cart and feed the grain once it is in the paddock is listed in Table 4.5.

Table 4-5 Time required for filling and emptying the feed trailer.

Filling and emptying feed trailer	Hours per 1000 bushels
Filling feed trailer	1
Emptying feed trainer	2

Before they are sold lambs are weighed up to four times, depending on the type of lamb (Table 4.6). This is because not all lambs will reach the sale weight at the same time. Each weighing is at 2 week intervals and the number sold at each weighing depends on the type of lamb.

Table 4-6 Percentage of lambs sold at each weighing

Lamb class	First weigh (%)	Second weigh (%)	Third weigh (%)	Fourth weigh (%)
XB lambs carryover	70	25	5	0
Merino prime lamb	55	25	20	0
Merino lamb sold 5 months	50	25	15	10

Table 4-7 Weeks required to feedlot lambs before they make the target weight for each lamb class in each month.

Month	Merino prime	Merino (5 months)	Crossbred
January	6	6	4
February	6	6	4
March	6	6	4
April	6	6	4
May	4	4	2
June	2	2	0
July	0	0	0
August	0	0	0
September	0	0	0
October	3	3	1
November	6	6	4
December	6	6	4

The total time required for feedlotting lambs in each period is the time required to feed and manage each lamb per day (Table 4.3) multiplied by the days in the feedlot (Table 4.7). Additional to this requirement, 0.5 hour per day is needed for running and maintaining the feedlot regardless of how many lambs are in the feedlot.

The time required for organising and supervising contactors for shearing, crutching and marking is listed in Table 4.8. This time is taken in the period of the activity (e.g. the 10 hours required to supervise shearers is in September).

Table 4-8 Time required for supervising contractors for shearing, crutching and marking.

Activity	Time required for supervision (hours)
Shearing	10
Crutching	8
Marking	8

If ewes graze lucerne then the time required to move the sheep on and off the lucerne is 1 hour per mob per period of grazing. The time required to monitor the lucerne in each period of grazing is 15 minutes per 100 ha of lucerne.

The time required for sowing and spraying pastures and lucerne is included in the cropping section because these activities use the cropping machinery.

4.2.2. Time required for cropping

The time required for sowing and harvesting is in Table 4.9 and Table 4.10. Spraying of all herbicides is at a work rate of 24.4 ha/hour. For every crop type sown, 3 hours are required to clean and modify machinery during seeding period A and after early harvest of lupins or canola. Additionally 16 hours are required in April to prepare seeding machinery and 16 hours in October to prepare machinery for swathing and harvest.

Table 4-9 Time required to sow one ha of crop for each sowing method. This is the total time including working up and sowing.

Sowing method	Sowing rate (ha/hour)
Direct drill	5.9

Work and seed	3.9
Work and seed plus tickle	3.9
Tickle	2.9

Table 4-10 Time required to harvest crops (ha/hour).

Crop	Harvest rate (ha/hour)
Cereals	7.0
Lupins	6.4
Canola	4.8
Field peas, faba beans and chick peas	4.6

4.2.3. Labour scenarios

To investigate the relationship between optimum land allocation and labour demand and supply, a number of labour scenarios were examined. The labour scenarios were:

1. No additional limitations on farm labour – the standard MIDAS model (i.e. excluding the revised treatment of labour)
2. Farmer labour only – no options to employ extra labour
3. Permanent labour – one permanent labourer is employed for the whole year.
4. Casual labour seeding and harvest – casual labour is available during seeding and harvest only.
5. Two sets of casual labour during seeding and harvest (i.e. double the labour availability in option 4)

The amount of time available to work in each period depends on the hours that each worker works each day (see Table 4.11). The cost of each labour source includes superannuation. The farmer and the permanent worker have four weeks off each year for holidays during December, January and July. All labour sources have Christmas, New Year's day and Easter as holidays and these days are not included in their annual 4 weeks holiday. The farmer is also assumed to spend 24 hours in each quarter for office work such as tax.

Table 4-11 Time available to work each day.

	Hours available to work each			
Labour source	Weekday	Weekend	Seeding[1]	Harvest[1]
Farmer	8	4	10	10
Permanent	8	0	10	10
Casual labour	0	0	10	10

[1] All labour sources are assumed to work on weekends during seeding and harvest

The default cost of permanent and casual labour is A$30/hour. The recommended cost of labour is A$27.50/hour (Department of Agriculture and Food WA 2008). To investigate the impact of a change in the cost of labour, a price sensitivity on the cost of labour in Table 4.12 was conducted.

Table 4-12 Range of per hour costs of permanent and casual labour.

Labour type	**Cost per hour (A$/hour)**
Permanent	20, 25, 30, 35
Casual	20, 40, 60, 80, 100

Additionally, the profitability of each labour scenario was tested at low, medium and high grain prices and at low, medium and high sheep and wool prices (Table 4.13 and Table 4.14).

Table 4-13 Gross price (A$/t) for each grain type in each grain price scenario.

Price scenario	Wheat	Barley	Oat	Lupin	Canola	Field peas	Faba bean	Chick peas
Low	256	256	192	224	544	328	384	480
Medium	320	320	240	280	680	410	480	600
High	384	384	288	336	816	492	576	720

Table 4-14 Price for wool and sheep in each sheep price scenario

Price scenario	Wool (A$/kg clean)	Shipper wether (A$/hd)	Lamb (A$/kg) Dressed weight	Cast for age ewe ($/hd) saleyard price
Low	6.9	56	3.32	40
Medium	8.6	70	4.15	50
High	10.4	84	4.98	60

4.2.4. Farm size

As farm size increases there is extra time required to manage the extra land area. To investigate how farm size impacts on labour requirements and use, farm size was increased from 2000 ha to 3000 ha, and the ramifications for use of casual labour during seeding and harvest were examined. When the farm size was increased to 3,000 ha, the shire rates were increased by 50 percent.

As farm size increases it is reasonable to assume an increase in the size of cropping machinery. Three sizes of machinery were tested to see how this impacts on whole farm profit (Table 4.15). Additionally different hours allowed for seeding each day were tested at the standard 14 hours, then 19 hours and 24 hours. A paddock efficiency of 60 percent was still assumed for each of these scenarios.

Table 4-15 Width of farm machinery for each machinery scenario

Machinery scenario	Seeder width (m)	Harvester width (m)	Sprayer width (m)
Standard	12.0	9.1	25.0
Medium	14.0	12.2	30.5
Large	15.8	13.7	36.6

After the addition of labour the number of column activities in MIDAS increased from 1800 to 3200 and the number of row activities increased from 830 to 1550. This relates to an increase in the matrix from 48,000 to 63,000 elements. The file size increased from 30 MB to 53 MB.

With these inclusions of labour in MIDAS the importance of labour on land use and profit could be assessed for a representative farm in the central wheatbelt region. Chapter 5 describes the farming system and profitability impacts of the more detailed and accurate treatment of labour under the range of sensitivity analyses described in this chapter.

5. Modelling Results for Farm Labour

5.1. Type of labour

Labour constraints impact on farm profit, particularly when low percentages of the farm are sown to crop (Figure 5.1). The most profitable use of farm labour is casual labour during seeding and harvest. The labour option of the farmer-only is the least profitable whilst permanent labour is more profitable than farmer-only labour as the proportion of the farm sown to crop increases. This is because as the area of crop increases, it is important to have enough labour to sow and harvest without penalties. This means that the model prefers paying extra for permanent labour for the whole year to benefit using the optimal crop rotations.

When the model has the option to employ one set of casual labour compared to two sets, there is almost no difference in profit (Figure 5.2). This is because of a combination between low annual cost for annual labour and one extra set of casual labour being enough to complete all the required tasks during seeding and harvest.

Permanent labour is more sensitive to changes in cost (Figure 5.3) compared to casual labour (Figure 5.4). This is because more labour is used in total during the year for permanent labour compared to casual labour. A cost of casual labour of A$100 per hour does not have a high impact on profit. However, if the cost of labour for a permanent employee increases by A$5 per hour then whole farm profit decreases by over A$13,000 (Figure 5 3). Also while changes in costs of both permanent and casual labour affect profitability, they do not change the optimal proportion of the farm sown to crop.

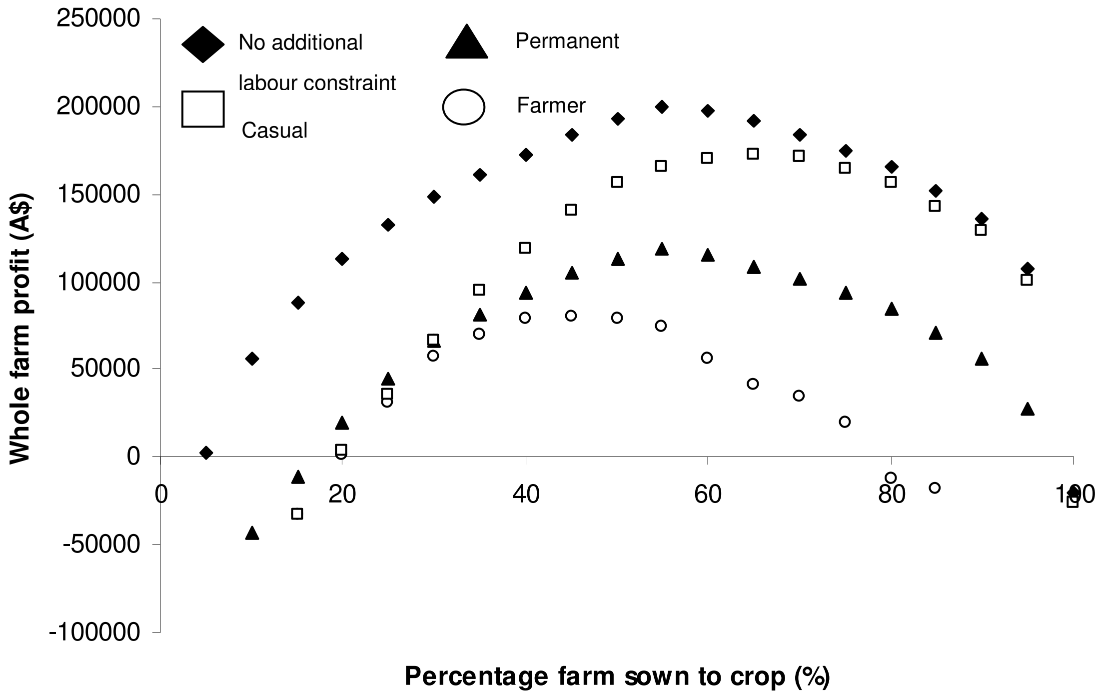

Figure 5.1 Whole farm profit as a function of crop area for each labour type. These types of labour are no labour constraint[1], casual labour during seeding and harvest, permanent labour employed for a whole year and the farmer-only.

[1] Note the "No additional labour constraint" is the standard MIDAS model that excludes the revised detailed treatment of labour.

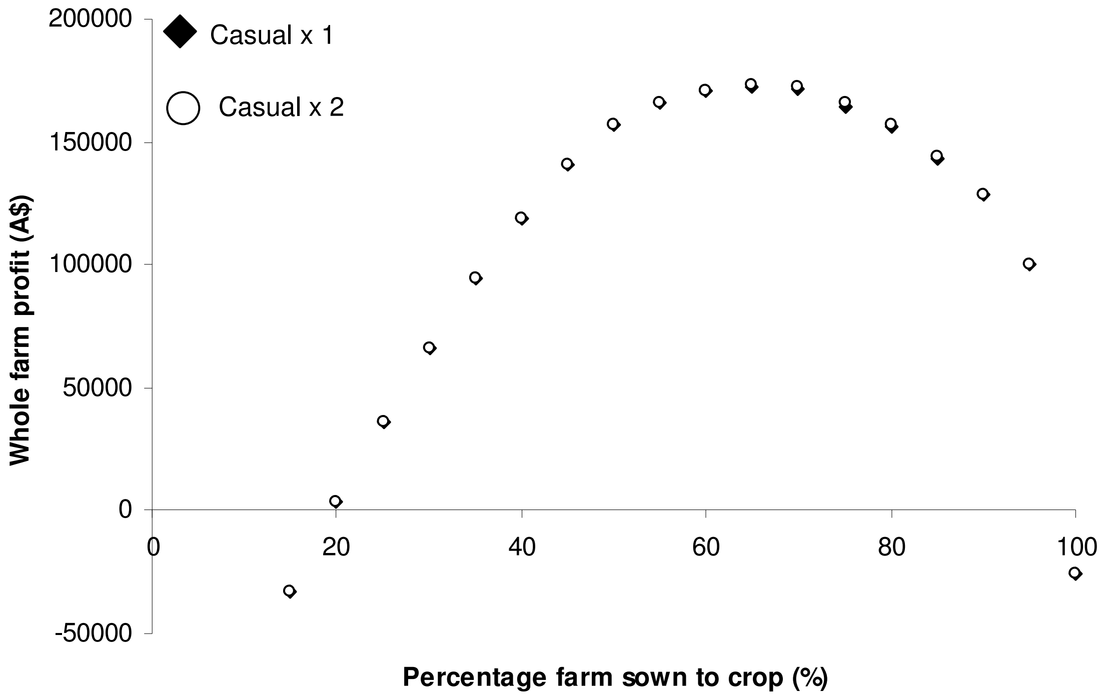

Figure 5.2 Whole farm profit as a function of crop area comparing casual labour during seeding and harvest with two lots of casual labour during seeding and harvest. Casual x 1 is mostly hidden by casual x 2.

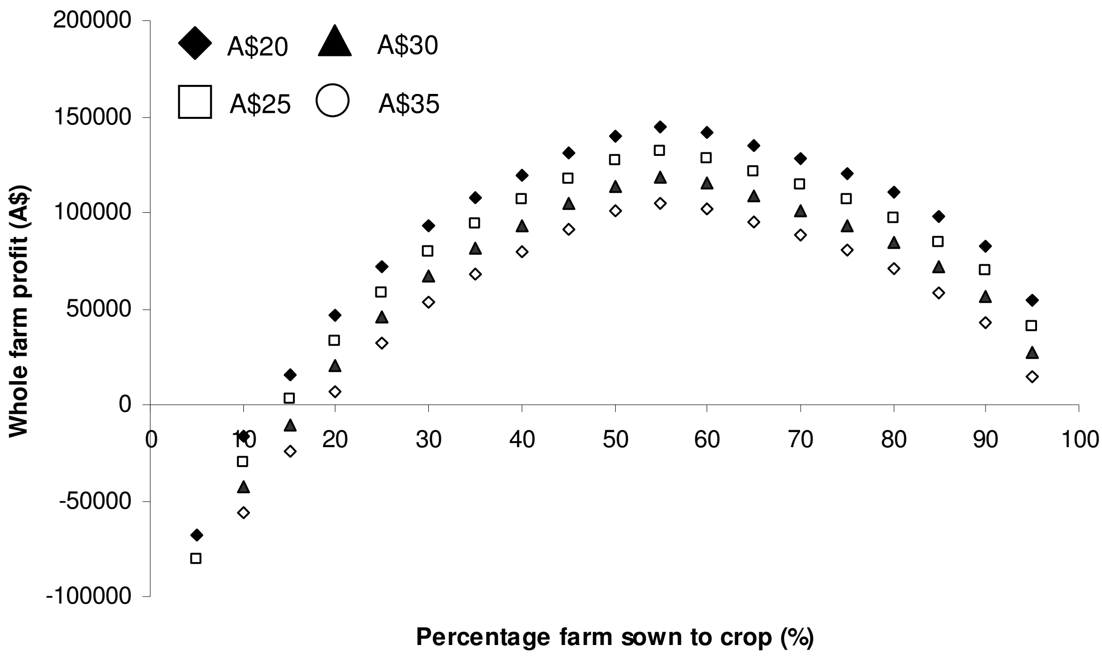

Figure 5.3 Whole farm profit as a function of crop area for different costs of permanent labour.

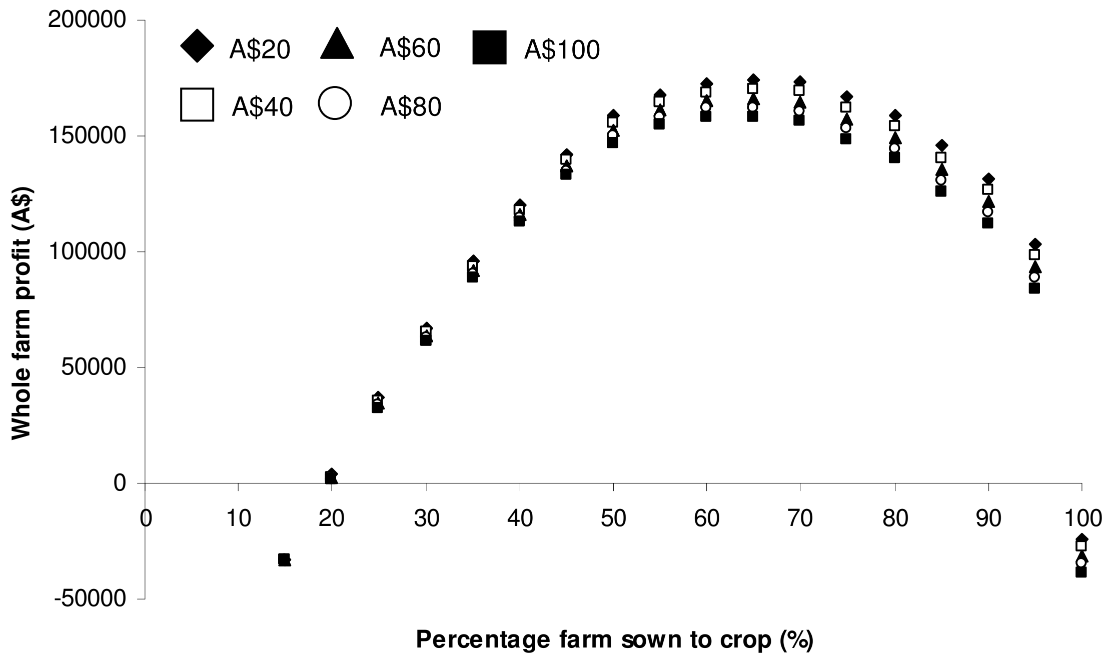

Figure 5.4 Whole farm profit as a function of crop area for different hourly costs of casual labour during seeding and harvest.

All of the labour scenarios are significantly less profitable than not having any labour restrictions (Table 5.1). Casual labour is always the most profitable option for use of labour. At low percentages of the farm area in crop and when sheep prices are high, then permanent labour is almost as profitable as casual labour. This is because more time is available during the year to run a higher stocking rate compared to casual labour when extra time is only available during seeding and harvest.

The stocking rates for the farmer-only option are significantly lower than the potential expected when there is no labour restriction. The stocking rate increases quite significantly, even when casual labour is employed during seeding and harvest. This suggests that, for the representative farm in MIDAS, cropping generally is preferred over sheep and sheep become preferred only when there are extra labour resources available during seeding and harvest.

The area sown to lucerne is also highest for permanent labour. This is because lower stocking rates are selected when casual labour is employed, which avoids or reduces the need for lucerne. This is complemented by the higher crop area with casual labour which means that there is more feed available from crop residues during summer when lucerne is mostly used.

Table 5-1 Key model output for each labour scenario for different grain, sheep and wool prices. The cost of labour is A$30 per hour for permanent and casual labour.

	Labour type	Standard	Low crop Low sheep	Low crop High sheep	High crop Low sheep	High crop High sheep
Whole farm profit (A$)	No labour	200,000	32,000	213,000	297,000	376,000
	Farmer	80,000	-41,000	65,000	131,000	209,000
	Permanent	119,000	-48,000	121,000	217,000	291,000
	Casual	174,000	17,000	142,000	291,000	346,000
Area crop (ha)	No labour	1,120	1,050	770	1,740	1,240
	Farmer	890	670	660	1,440	980
	Permanent	1,110	1,050	810	1,740	1,230
	Casual	1,360	1,090	1,170	1,740	1,470
Stocking rate (dse/wgha)	No labour	8.7	7.4	10.1	2.9	10.3
	Farmer	4.4	5.3	5.4	0	5.3
	Permanent	8.7	7.4	8.6	2.9	10
	Casual	8.0	6.3	8.3	3.0	7.8
Lucerne (ha)	No labour	291	268	608	27	297
	Farmer	0	0	0	0	0
	Permanent	292	267	438	27	292
	Casual	153	59	22	17	154

Table 5.1 (Cont'd)

	Labour type	Standard	Low crop Low sheep	Low crop High sheep	High crop Low sheep	High crop High sheep
Time crop (hours/ha)	No labour	0.85	0.84	0.84	0.93	0.87
	Farmer	0.85	0.88	0.88	0.85	0.83
	Permanent	0.85	0.84	0.90	0.93	0.87
	Casual	0.85	0.87	0.85	0.92	0.88
Time sheep (hours/ha)	No labour	2.05	1.83	2.53	1.58	2.53
	Farmer	0.71	0.71	0.70	0.00	0.75
	Permanent	2.07	1.83	2.03	1.69	2.34
	Casual	1.77	1.13	1.34	1.50	1.87
Labour cost (A$)	No labour	0	0	0	0	0
	Farmer	0	0	0	0	0
	Permanent	77,300	77,300	77,300	77,300	77,300
	Casual	5,500	3,700	4,400	5,500	5,500

The time required for crop is mostly less than that for sheep, unless the stocking rate of sheep is extremely low when only farmer labour is used (Table 5.1). The time required for sheep varies depending on the stocking rate and the amount of lucerne grown which represents the extra time required for establishing and managing sheep on and off lucerne.

The cost of labour is always high for permanent labour as the farmer must pay the employee for the whole year. Alternatively the total cost for casual labour is always low as the amount of time worked by casual employees is generally low.

When farm size increases to 3000 ha, it is still not more profitable to employ an extra set of labour during seeding and harvest (Figure 5-5). This is unless 24 hour sowing is possible in which case the extra employment of casual labour is profitable (Figure 5-6). Increasing machinery size when farm size is 3000 ha, increases profit more than increasing the hours of seeding between 60-80% of the farm area being in crop (Figure 5-7 and Figure 5-8). At higher than 80% of the farm being in crop, increases in profit are greater from increasing the hours of seeding rather than from increasing machinery size.

As farm size increases, with larger machinery and more hours available for seeding, the optimum proportion of the farm area in crop also increases suggesting that as farm size increases, farms will become more crop dominant.

Figure 5-5 Whole farm profit as a function of crop area comparing casual labour during seeding and harvest with two lots of casual labour during seeding and harvest. Farm size is 3000 ha and 14 hours per day is allowed for sowing.

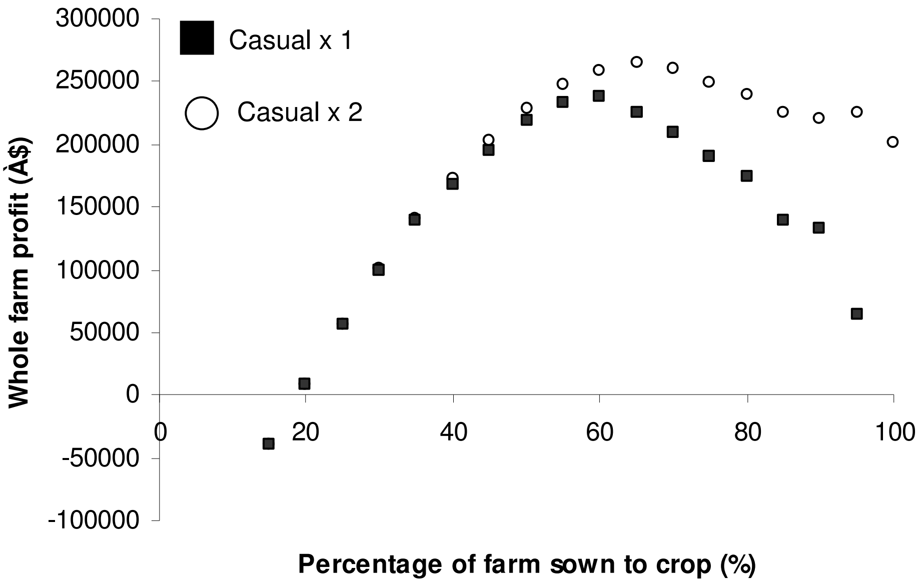

Figure 5-6 Whole farm profit as a function of crop area comparing casual labour during seeding and harvest with two lots of casual labour during seeding and harvest. Farm size is 3000 ha and 24 hours per day is allowed for sowing.

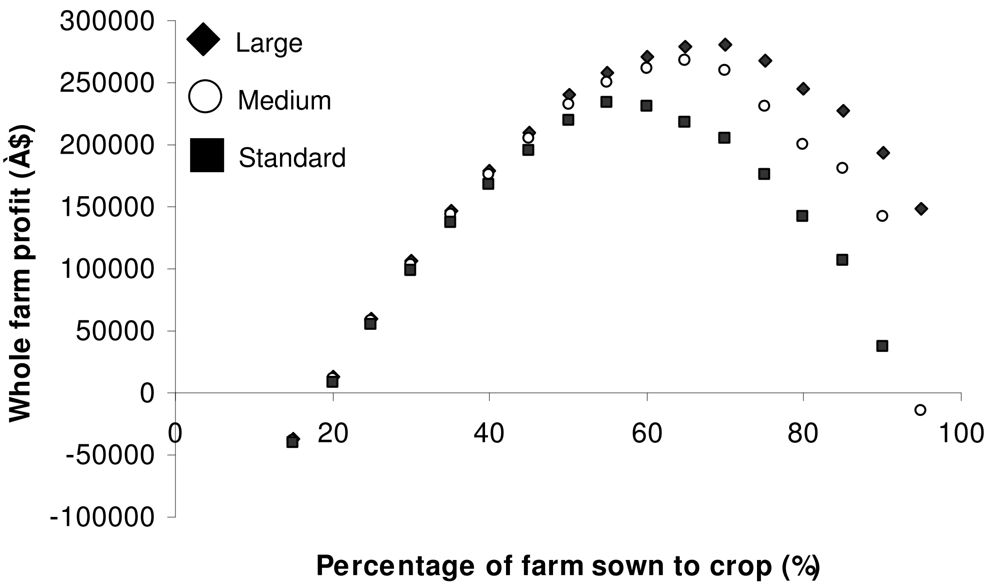

Figure 5-7 Whole farm profit as a function of crop area given 3 different sizes of machinery for a farm size of 3000 ha.

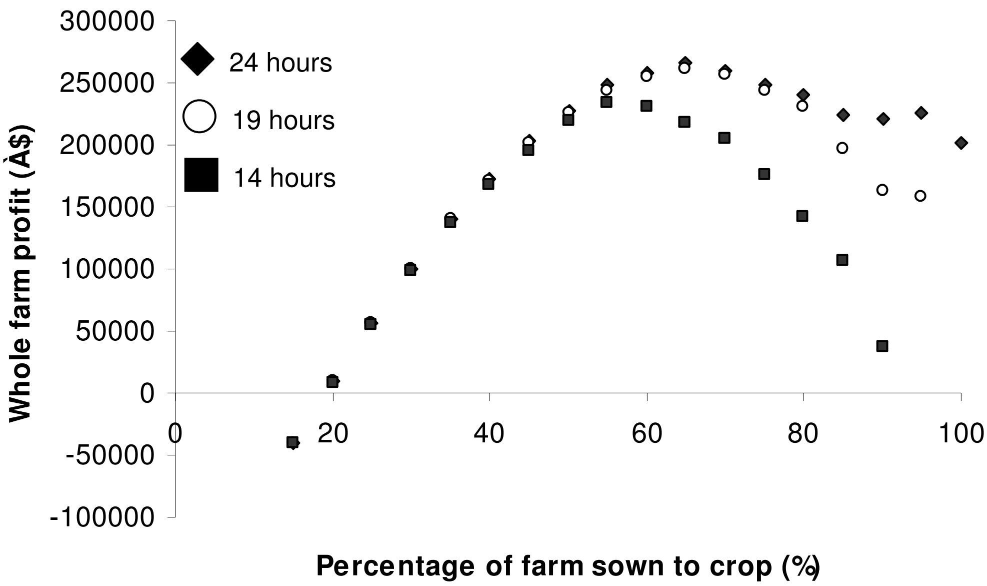

Figure 5-8 Whole farm profit as a function of crop area. Three different daily work schedules for crop sowing are given. Farm size is 3000 ha.

5.2. Discussion

The most profitable use of labour is casual labour during seeding and harvest. This enables the farmer to sow crops without penalties for late sowing whilst also maintaining high stocking rates. The large difference in stocking rates between the labour options of farmer-only and casual labour during seeding and harvest suggest that there is a conflict in the amount of time required for sheep feeding and crop sowing during seeding. Because there is no direct cost of labour for the farmer, MIDAS uses all of the farmer's extra time for sheep during the year.

The use of casual labour during seeding and harvest means that profitable farms are those that are crop dominant. This trend is exaggerated as farm size increases. These results support the currently observed crop dominant nature of broadacre farm businesses in WA. Farmers in these areas are often prepared to outsource cropping tasks. Production stages in farming, particularly in cropping, tend to be short, infrequent, and require a few distinct tasks, thus facilitating use of casual labour; especially as machinery technology facilitates use of unskilled and semi-skilled labour (Allen and Lueck 1998). Hence, employing casual labour for cropping activities is the most profitable use of labour

However, the logistics of employing labour for short periods of the year can be difficult. Moreover, because most farmers require labour for seeding and harvest at the same time of the year, this can make finding adequate casual labour problematic. However, the short periods of required labour mean that farmers are able to offer high prices to secure labour during these periods with little impact on their whole farm profit.

By contrast, employing a permanent labour source is not profitable due to the high cost. The highest return on investment in labour is for cropping because of its low labour demand per hectare, compared to sheep. As the permanent labour source needs to be employed for a full year’s work, the farmer is effectively forced to find tasks to keep the employee occupied. This is reflected in the high areas of lucerne being selected as part of the permanent labour scenario. The MIDAS model employs the extra labour, for which there is an excess in most periods, in profitable, yet labour-intensive activities such as managing sheep in and out of lucerne stands.

These results support those of Doole *et al.* (2009) who also found that labour restrictions support crop dominant agriculture as, in general, crop production has a lesser labour requirement than sheep production. Doole *et al.* (2009) also found that limited labour availability reduced the amount of lucerne selected by the MIDAS model as reduced stocking rates and increased crop residues decreased the requirements for extra feed during summer.

5.3. Conclusion

The management of sheep requires more work than cropping, and sheep production is generally less profitable than cropping. Therefore the most profitable use of labour is during periods when the farmer does not have enough time to properly grow and manage crops. The priority for farmers in the wheatbelt is therefore securing reliable casual labour for cropping.

The implications of employing such casual labour is the outcome of low input sheep management with little use of perennial pastures, highlighting the low adoption rate of perennial pastures on many WA farms. The greater labour requirements for sheep management suggests that WA farms would benefit from improved efficiency of livestock management, otherwise many broadacre farmers will persist with low input, low stocking rate sheep systems.

One way to make sheep easier to manage is by breeding sheep to be easier to manage. For example, sheep can be bred to be resistance to worms and less susceptible to fly strike. These sheep would need less drenching, monitoring and crutching and therefore a lower labour requirement.

If the profitability and labour efficiency of sheep production could be improved then many innovations, such as perennial pastures, would become more attractive to farmers and problems with the cost and availability of labour would be less constraining on farm performance. The particular case of outsourcing sheep management to a professional sheep manager is investigated in Chapter 6. Key findings and conclusions are given in Chapter 7.

6. Outsourcing Sheep Management

6.1. Introduction

As outlined in Chapter 5, the high labour requirements for sheep production compared to crop production, combined with the relatively higher profit of cropping, means that farmers are running sheep enterprises with low inputs and low stocking rates. This is because on mixed sheep and crop farms as the two enterprises compete for labour.

One solution is for farmers to employ someone else to manage their sheep. Recently in Australia private companies have offered farmers the opportunity to outsource their sheep business (e.g. Sheep Australia Pty Ltd). The structure of these businesses varies but the general concept is that farmers are paid for either their pasture area or for the amount of sheep managed by the sheep outsourcing company. The uptake of this outsourcing option by farmers, however, has been low as it is a novel business concept for farmers in Western Australia and there has been no research into the viability of this type of outsourcing for farmers. There is therefore a need to explore the viability of outsourcing for both the farmer and the sheep outsourcing firm.

Outsourcing is a tool used by many businesses (Ono and Stango 2005). Outsourcing is when firms or businesses choose to get other firms to supply goods and services instead of producing them themselves (Ono and Stango 2005). Firms mostly outsource goods or services when another business is able to produce a good or service at a lower cost. This reason for outsourcing, along with other reasons, can be listed as:

I. The cost of producing product (make or buy decision),
II. the size of the firm and the capacity of the firm to produce the product itself,
III. the complexity of the product,

IV. education or knowledge required to make the product,
V. diversity of products within the firm (firms with higher diversity would consider outsourcing so they can become more specialised),
VI. control and ownership (separating control can be risky) and
VII. the transaction costs (cost of setting up and maintaining contracts) of outsourcing (Ono and Stango 2005).

Outsourcing also allows a firm to become more specialised and efficient in their tasks (Merino and Rodriguez 2007).

The biggest disincentive to outsourcing is the need to create a contract that is beneficial to both firms (Masten 1984, Ono and Stango 2005, Geis 2007). A contract may require transaction costs for its design, negotiation and enforcement. Ono and Stango (2005) suggest that as outsourcing agreements become more complex it becomes harder to write a fair contract and there is more scope for opportunistic behaviour. Such behaviour is where one firm takes advantage of the other and this can occur when the contract is not clear on a specific issue.

This opportunistic behaviour means that outsourcing agreements need to consider an exit strategy in case one party (e.g. the farmer) to the contract decides to cut the contract short (Geis 2007). Masten (1984) suggests that if the product being outsourced is complex then a contract will make the agreement inflexible. This inflexibility means that contracts will tend to be of shorter term which may not entice the procurement firm into an outsourcing agreement.

These disincentives are reflected in the fact that outsourcing is not common in agriculture in Australia with 99% of family farms being family-owned and operated (Productivity Commission 2005). The low use of outsourcing in agriculture is attributed to the production stages in farming being short, infrequent, and requiring few distinct tasks. These characteristics limit the benefits of specialisation and make wage labour hard to monitor (Allen and Lueck 1998). Additionally transaction costs required to establish outsourcing agreements have discouraged the use of outsourcing in agricultural sectors (Allen and Lueck 1998). Therefore most farms have remained small family run businesses (Allen and Lueck 1998).

The use of outsourcing in agriculture tends to be limited to specific tasks within an enterprise. Small household-operated citrus farms in Spain outsource pruning and picking tasks to large co-operatives (Picazo-Tadeo and Reig-Martinez 2006). This outsourcing removes transaction costs between the farmer and workers and increases technical efficiency (Picazo-Tadeo and Reig-Martinez 2006). These farmers need to work off farm to supplement their income during periods that are less busy (Picazo-Tadeo and Reig-Martinez 2006).

Dairy farmers in the United States of America outsource heifer growing to custom heifer growers (Wolf 2003). This outsourcing of heifer growing reduces feed costs whilst providing more space for milking cows (Wolf 2003). It also reduces the labour demand, allowing farmers to focus on their dairy enterprise (Wolf 2003). The disincentives for using outsourcing are firstly the costs associated with paying the custom heifer grower who are paid on a per day basis; secondly loss of management control and thirdly costs associated with biosecurity risks (Wolf 2003).

Belgium farmers are increasingly outsourcing administration tasks (Vernimmen *et al.* 2000). Outsourcing of these tasks has become popular due to increasing volume of legislation that governs farm output, environmental impacts and the welfare of livestock (Vernimmen *et al*. 2000). Farmers are more willing to outsource administrative tasks when the legislation increases in complexity or the as uncertainty about a positive outcome increases, if the farmers do tasks themselves (Vernimmen *et al*. 2000).

These examples of outsourcing in agriculture involve the outsourcing of distinct tasks within an enterprise. This type of outsourcing is common within cropping and sheep enterprises in the central wheatbelt of Western Australia. It is common for farmers to outsource hay cutting, hay baling, swathing and harvesting, mostly because of the large investment required in machinery. Farmers also outsource sheep tasks such as shearing, crutching and lamb marking, due to the large labour requirement for these tasks. An area that has not been covered by the literature is the outsourcing of an entire enterprise.

If a farmer were to outsource their sheep enterprise to a sheep manager then it would potentially allow the farmer to specialise on cropping which is often the more profitable enterprise. Farmers could potentially be more effective and efficient in their use of time for their principal enterprise. For example, the farmer would be able to spend more time staying up to date with the latest information on cropping and could spend more time marketing their grain. The farmer would also have reduced supervision costs as they would not have to organise and supervise sheep contractors and labour. The farmer could become a crop specialist whilst the farm would retain the commercial advantages of a diversified mixed enterprise farm.

Additionally, a specialist sheep manager would use rotational grazing, condition scoring and supplementary feed to boost stocking rate, increase lambing percentages and turn-off. Erosion risk would lessen by greater monitoring of stock and feed condition to facilitate more rapid de-stocking. Greater profits from better managed sheep enterprises would boost land values and improve a farmer's ability to borrow and finance other activity, including improved natural resource management (e.g. pest and weed management). Farm surveys indicate that farmers' investment in natural resource management is positively correlated with the profitability of their farm (Hodges and Goesch 2006). So if outsourcing could be shown to generate higher farm profits then farmers would be more likely to additionally invest in natural resource management.

An outsourcing agreement needs to be attractive to both the farmer and sheep manager. With the shortage of labour and opportunity for work in the central wheatbelt region, the outsourcing agreement must provide enough money to entice sheep managers back into the market. The benefits of outsourcing for both the farmer and the sheep manager need to be of significant value for both parties to enter into an agreement that in practice could be complicated. In this chapter the viability of a sheep outsourcing agreement for both the farmer and sheep manager is explored.

6.2. Methods

The version of MIDAS used in Chapter 5 was modified to create two models. The first model optimised the crop income for the farmer and the second model optimised the sheep income for the sheep manager. The model for the farmer had all sheep activities removed and the farmer received income from crop and from each hectare of lucerne and pasture. All of the labour to establish, spray and fertilise pasture and lucerne was the responsibility of the farmer. The farmer also had the option to employ one set of casual labour during seeding and harvest.

By contrast, the model used for the sheep manager had all crop activities removed. Additionally shire rates, licensing costs, professional service fees, bank charges, household costs and education costs were removed. The professional sheep manager paid the farmer for every hectare of lucerne and pasture they used.

The farmer model was run first to identify the rotations that a farmer would use to generate the most crop income. Then the model was constrained at different levels of crop and for different levels of income received by the farmer for outsourcing each hectare of pasture. The areas of crop used and prices received for pasture land offered up for outsourcing are listed in Table 6-1.

Table 6-1 Scenarios investigated for the farmer model used in the farmer and sheep manager meta analysis

Description	Parameter values
Area sown to crop for farmer model (ha)	1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000
Price received per hectare of pasture and lucerne area outsourced (A$)	40, 80, 120,160, 200
Improved efficiency of labour use (%)	0, 5, 10

One benefit of outsourcing is that the farmer and the sheep manager are more able to specialise in their tasks and therefore should be more efficient. Accordingly, increased levels of efficiency were also tested (Table 6-1). For example, a 10 percent increase in efficiency means that for a 3 tonne wheat crop, the farmer can grow an extra 300kg of wheat for the same labour input. The rotations from each of the scenarios with the farmer model were then used in the sheep manager model to optimise profit for sheep managed on the pasture, lucerne and stubbles.

As the sheep specialist manages sheep on small proportions of the farm area in crop dominant farms there is opportunity for the manager to co-ordinate work on several farms. A simple estimate of the additional income that could be earned by spreading sheep management across a number of farms could be obtained by first identifying how much spare time the sheep manager had in every period and then multiplying the MIDAS whole farm profit (i.e. one farm) by the excess hours available. Explaining further, if the sheep manager only used a maximum of 50 percent of their available time in each period then the income of the sheep manager could be twice as large if they were able to manage two properties at the same time. In some subsequent analyses reported in this chapter, it is assumed that the sheep manager does act to become fully occupied and so takes on sheep management on additional farms to increase his or her income.

Another aspect of outsourcing is also investigated in this chapter. This is payments to farmers by the sheep manager to grow lucerne in order to raise the productivity of the sheep enterprise. To identify how much a sheep manager would need to pay the farmer to grow lucerne, a comparison of price paid for pasture and lucerne was used. The price paid for pasture area stayed at A$40 per hectare of pasture and the price paid per hectare of lucerne was set at either A$40, A$80 or A$120.

6.3. Results

The farmer makes as much money as they would without outsourcing, if they are paid A$200 per hectare for pasture (Figure 6.1). At prices below this the farmer makes more profit from avoiding any use of sheep management outsourcing. However, with the rotations used by the farmer at these prices it is not profitable for the sheep manager (Figure 6.2).

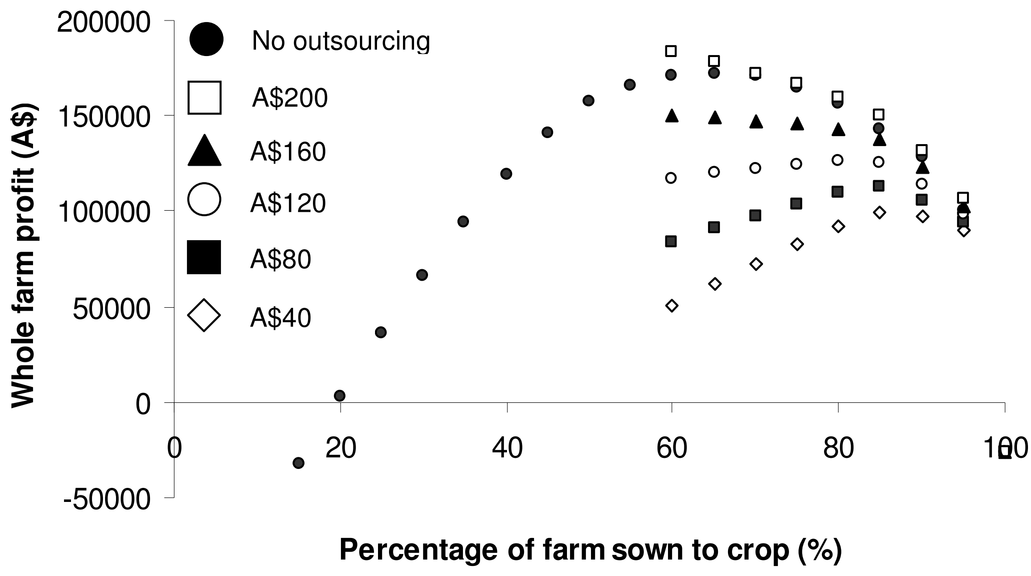

Figure 6.1 Whole farm profit as a function of crop area when different lease payments for pasture land apply.

Figure 6.2 Whole farm profit as a function of crop area for the farmer receiving different prices per hectare for outsourced pasture and lucerne areas; and profit of the sheep manager paying different prices per hectare of pasture and lucerne area they lease. The sheep manager's profit is calculated across as many farms as required to ensure their time is fully utilised.

The profit for the sheep manager decreases as the area sown to crop increases. This is because the soil types available for growing pasture and lucerne decline in quality as the area of crop increases. In other words, as the farming system becomes increasingly crop dominant less pasture is grown on the fertile clay soils, thereby restricting the quantity of feed on offer on which to graze sheep. Pasture continues to be grown on the most infertile soils that remain unsuited for cropping. However, pastures grown on these poor soils typically do not support high stocking rates and therefore are less attractive to a sheep manager.

It is more profitable to outsource sheep management if labour efficiency improves by 5%, when more than 80% of the farm is sown to crop (Figure 6.3), even when only receiving A$80 per hectare of pasture and lucerne. It is more profitable to outsource when efficiency is improved by 10% when more than 60% of the farm is sown to crop.

The profits earned by the sheep manager are also reasonable when they are 5% and 10% more efficient and when between 60% and 75% of the farm is sown to crop (Figure 6.4). When the area of crop is more than 75% of the farm area, then the profit earned by the sheep manager becomes less favourable as the remaining pasture is grown on inferior soils and therefore it supports fewer sheep.

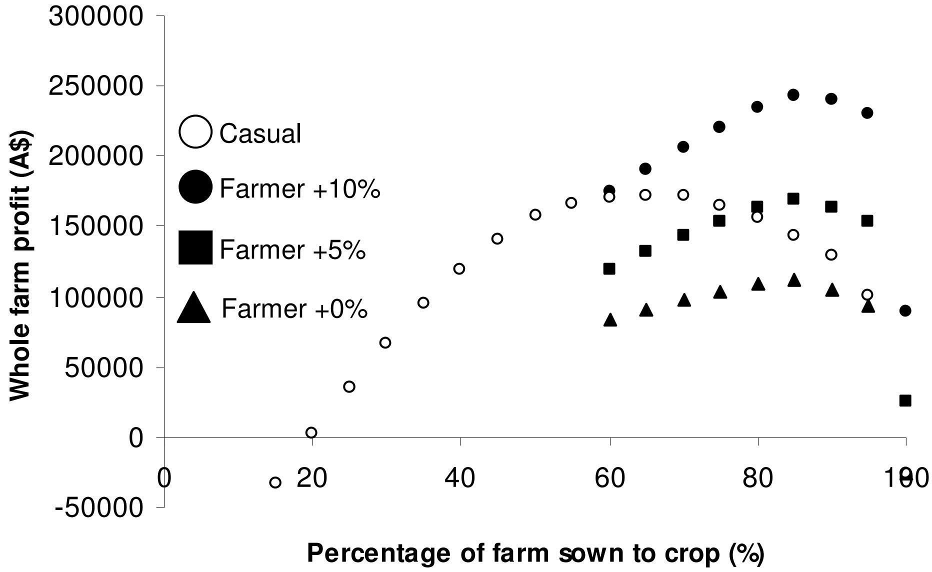

Figure 6.3 Whole farm profit as a function of crop area for the farmer receiving A$80 per hectare of pasture and lucerne at different levels of labour efficiency compared to no outsourcing and employing one set of casual labour during seeding and harvest.

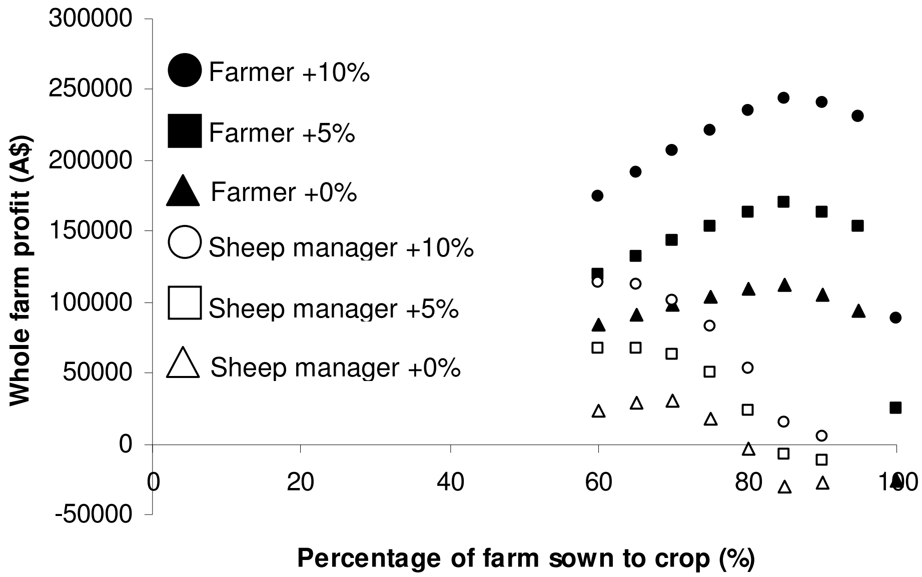

Figure 6.4 Whole farm profit as a function of crop area for the farmer receiving A$80 per hectare of pasture and lucerne at different levels of labour efficiency; and the profit for the professional sheep manager paying A$80 per hectare for pasture and lucerne at different levels of labour efficiency.

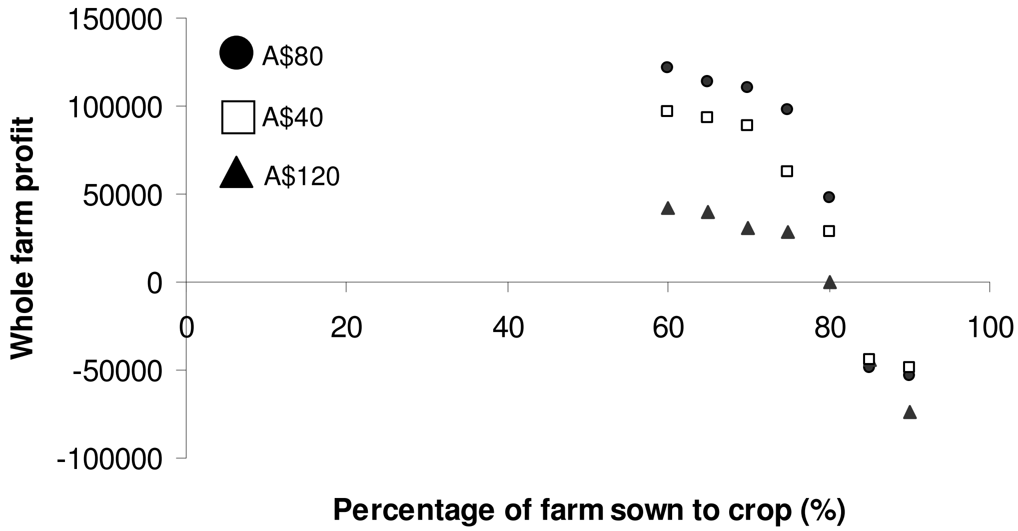

Figure 6.5 Profit as a function of crop area for a sheep manager paying A$40 per hectare for pasture area and paying different prices per hectare for lucerne.

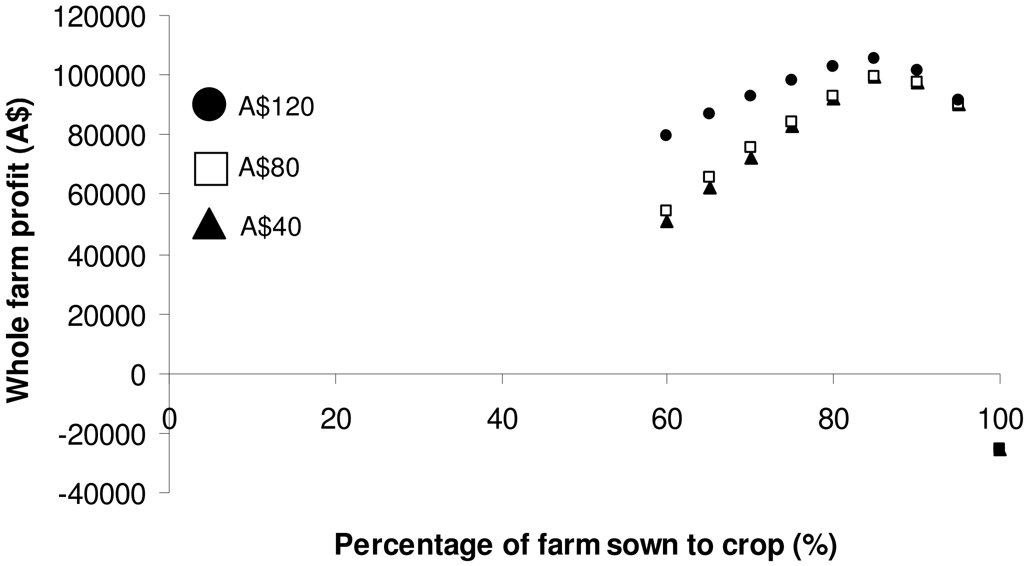

Figure 6.6 Whole farm profit as a function of crop for the farmer receiving A$40 a hectare for pasture area and different prices for each hectare of lucerne.

The professional sheep manager makes a little more money by paying the farmer A$80 more to use rotations that include lucerne but the sheep manager makes less money if they pay A$120 per hectare for the growing of lucerne (Figure 6.5). There is not a large increase in profit for the farmer (Figure 6.6) with these payments because in MIDAS this means that the farmer needs to change to rotations that include lucerne whilst they are not getting any of the benefits of increased sheep carrying capacity, other than the set lease payment.

Profitability per hectare is higher when the sheep manager pays more for lucerne. The higher labour costs per hectare, due to the higher stocking rate, means that the professional sheep manager can manage less hectares. The model does not include any costs associated with having to manage several farms at the same time. In reality there is a travel cost of fuel, vehicle depreciation and time associated with moving between farms.

Table 6-2 Difference in the sheep production system when the sheep manager pays more to the farmer for lucerne, when 60% of the farm is sown to crop.

	A$40 per hectare payment for lucerne	A$80 per hectare payment for lucerne
Stocking rate (dse/ha)	5.6	9.5
Lucerne (ha)	0	312
Profit (A$/ha)	47.1	82.4
Labour (hours/ha)	0.65	1.01
Labour (hours/dse)	0.18	0.16

6.4. Discussion

The preceding analysis indicated that outsourcing sheep management was not profitable compared to many other labour use scenarios, particularly if the farming system is crop dominant. Outsourcing is only likely to be attractive to the farmer who wishes or needs to work far fewer hours for a relatively small decrease in income. The income from outsourcing pasture areas is low risk and so highly risk averse farmers seeking stable incomes may prefer to enter into outsourcing agreements that provide annual lease receipts. However, this aspect of the risk-averse preferences of farmers has not been explored as the modelling framework used assumes risk neutrality.

Outsourcing sheep management only becomes profitable when accompanied by a substantial lift in the efficiency of growing crops. Whether farmers are able to increase the efficiency of their cropping by 10% is hard to predict and depends on how inefficient they are currently at growing crops. As cropping generally is the core business of most broadacre farms, one would expect their efficiency is currently reasonably high.

For farmers who choose to outsource, the opportunities to earn off farm income is limited due to the dominance of agriculture in the inland rural regions of Western Australia (Kingwell and Pannell 2005). But given that the farmer would only need to be on the farm for short periods of the year, it allows opportunities for the farmer to seek employment or investment opportunities in other regions. It may also allow the farm family to live off-farm and for the farmer to commute to the farm. In particular situations this may be socially beneficial for the family. For example, the social vibrancy of large rural towns, with their education and health facilities, may be an attractive base from which to commute.

The profitability of outsourcing for the sheep management firm seems often less attractive as there is a conflict over the soil types preferred for use by the farmer and the sheep manager. If the farmer grows more crop then this limits the opportunity for the sheep manager to have access to the better soil types and reduces potential stocking rates. The amount of money paid to the farmer may therefore need to depend on the quality of the soil and the pastures grown. A better payment system would be a payment for every sheep managed on the property. Therefore the sheep manager is not paying for land with low carrying capacity and so outsourcing agreements can be made more attractive to the sheep management company.

As a mixed crop and sheep enterprise is complex the outsourcing contract is likely to also be quite complex. There are issues associated with the condition of animals and land. If sheep are brought onto a farmer's property from elsewhere, there are potentially serious farm biosecurity issues. There are also risks associated with running crop and livestock independently. Often livestock are required to control weeds at certain stages of crop production. The complex nature of sheep enterprises and the length of a sheep's reproductive cycle also requires use of a long term contract or lease. A long term lease of land which is only suitable for grazing is essential to provide sheep managers with a pay-back interval sufficient to allow planting of stands of perennials, saltland pastures and fodder shrubs. If short term leases are only available then the likelihood of the perennial pasture establishment is much reduced, lessening the opportunity to boost stocking rates through use of perennials.

Although the farm modelling results suggest outsourcing is likely to be economically unattractive and practically difficult to implement, nonetheless not all current farming systems are closely similar to the profit-maximising farming system represented by the MIDAS model. Some farms in the wheatbelt utilise very low input and low profit sheep systems due to the high labour requirements of sheep, risk aversion and the farmers being unprepared to commit the time and effort required to find and retain appropriate labour for sheep management. For these farmers, the income from outsourcing sheep management does not need to be high for them to benefit from not doing the work themselves. Additionally, this extra income has little risk attached to it and no labour requirement by the farmer which means that the issues associated with writing a favourable contract would be less than might otherwise be thought to be the case, based on the farm modelling findings.

The main issue is how viable is outsourcing for the sheep management firm which needs to provide labour for sheep in areas where labour is not available and where furthermore, the business may generate relatively low returns. One possible outcome would be for the sheep management company to also manage a low input sheep system such as running wethers. This type of system might be possible if the sheep management company also managed sheep or farms in higher rainfall areas where they ran a breeding flock and could use outsourcing as a way to agist sheep during certain periods of the year. These scenarios are difficult to model given the current modelling tools and require further investigation. However, these scenarios do demonstrate the possible flexibility of outsourcing and the types of agreements that could be developed.

This research may suggest that sheep outsourcing is not a viable option, but given the complexity of outsourcing and the plethora of outsourcing options, a number of issues remain to be investigated. This study used an optimisation model which generates farm plans and resource use similar but not identical to what is observed in practice. Often the practical reality is that farmers are less efficient at managing their sheep, especially on crop dominant farms, than the outputs of a profit-maximising model, underpinned by knowledge certainty, would suggest. Additionally, some farmers can have strong preferences towards crop management and relegate the importance of sheep management. Outsourcing may be attractive to such farmers who make little profit from sheep but would like to retain the benefits of having sheep to complement their cropping.

This human component of decision making, and the diversity of farm management, makes it important for further research such as focus groups or choice modelling to understand the preferences of farmers. It is important to understand why farmers, and which farmers, would or would not like to use sheep outsourcing and if there is a role for outsourcing.

Given the importance of sheep in parts of the wheatbelt region, sheep outsourcing may have a niche role as a viable business option in some circumstances. Providing understanding of what those exact circumstances are is a rich area for further research.

This will be discussed further in Chapter 7 which discusses the outcomes of this chapter and Chapter 5.

7. General Discussion

This study has shown that labour scarcity and its affordability effect farm profit on mixed sheep and crop farms in WA, mostly due to the high labour demands associated with sheep production compared to crop production, and the relative profitability of these enterprises. The priority for farmers in the wheatbelt is found to be securing reliable casual labour for cropping.

The high labour demands for sheep, and the cost of hired labour are likely to have contributed to farms becoming more crop dominant. Farm modelling results indicate that highest farm profits are achieved when between 60% to 80% of the farm area is devoted to crop and only casual labour for cropping is employed. An implication of employing such casual labour is that sheep management becomes a low-input enterprise with little use of perennial pastures. This finding helps explain why the adoption rate for perennial pastures on many WA farms is so low.

Another implication of this study's findings is that it is financially preferable for farmers to invest in securing casual labour for seeding and harvest than the alternative of investing in more expensive, labour-saving, larger work-rate machinery. However, for many farmers, securing seasonal labour remains a practical difficulty, particularly when all farmers are competing for this labour at the same time. Anecdotally, farmers have sought to lessen this problem by employing backpackers or retired farmers who still want to earn extra cash whilst remaining in touch with life on a farm.

A strategic research implication of this study's findings is that sheep production must become less demanding of labour, including management labour. Farmers will benefit from having sheep that are easier to husband and manage. Sheep that are more resistant to fly strike and worms and that require less supplementary feeding will be highly desired. The design and location of shearing sheds, sheep yards and fencing to lessen the demands on labour and increase labour efficiency will be increasingly important if labour scarcity remains problematic. There is a need to include labour as a constraint when considering breeding objectives for sheep.

If the profitability and labour efficiency of sheep production could be improved then many innovations, such as perennial pastures, would become more attractive to farmers and problems with the cost and availability of labour would be less constraining on farm performance.

For farmers that are not interested in working with sheep anymore, then outsourcing sheep management would be worth considering. Outsourcing is an attractive solution for these farmers where it provides low risk income whilst encouraging efficient sheep management practices. This may lead to an increased use of perennial pastures, further benefiting cropping enterprises. Although this study had mixed results for the usefulness of outsourcing, further research is required to investigate the associated complex of possible business and contract structures.

The overall theme of this thesis is that labour vitally affects farm profitability and is an important issue for Australian agriculture. The tendency towards crop dominant agriculture and its lesser requirement for labour, when combined with increases in farm size, only increases the likely continued migration of people out of the wheatbelt. For sheep production to remain a profitable component of mixed enterprise broadacre farming requires action from the sheep industry and its supporters to make sheep management easier and more efficient.

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