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Effect of a Carbon Price on Farm Profitability on Rainfed Dairy Farms in South West Victoria: A First-Look

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Abstract

In this study, the possible impacts of different prices of carbon on farm profitability in two dairy farm businesses with different feeding systems operated over five years were analysed. The feeding systems were a ryegrass pasture-based system (RM) and a complementary forage-based system (CF). Data were obtained from a five year farmlet trial which was applied to a scaled up representative farm model. As a first look, a carbon charge was imposed on the systems as they currently operate to gauge the order of magnitude of a carbon charge on dairy systems if they were to continue to operate essentially the same system following the impost of a cost of carbon. The main finding of this study was that overall net present value (NPV) of five years of annual operating profit for each system, at five per cent discount rate, decreased when a price on carbon, as a direct cost, was included. Compared with the *status quo* situation where there was no effect of a price on carbon on farm operating profit, a price of \$15/t CO_2-eq on carbon reduced the net present value of five years of operating profit by about 6 per cent for the RM farm system and 5 per cent for the CF farm system (equivalent to \$70 000/farm and \$66 000/farm). A carbon price of \$25/t CO_2-eq reduced the overall net present value by about 10 per cent and 9 per cent in the RM and the CF systems respectively (equivalent to \$114 000/farm and \$110 000/farm).

Key words: dairy cow, pasture-based feeding system, carbon cost, operating profit

1. Introduction

The dairy industry in South West Victoria is based on rain-fed pasture as the majority of the feed base with supplementation using bought-in feeds such as concentrates, by-products, hay and, occasionally silage. For these systems to work well, calving is adjusted in accordance with pasture supply. Hence, calving in late winter means pasture growth in spring is well utilised and cows reach high milk yields before pasture quality and quantity decline in summer and autumn. In South West Victoria, almost half of the pasture production grazed by dairy cows is produced in spring (September to November). Pastures, in this region, grow between 9 and 14 t DM/ha per year. The production, depending on the seasonal conditions, slows in January and February (1-18 kg DM/ha per day) (Doyle *et al.* 2000; pp16-17).

Considerable supplementary feeding is needed when there is deficit in pasture supply (Doyle *et al.* 2000; pp26). Competitiveness of the dairy industry can be maintained by improving productivity through applying new technologies (Auldist *et al.* 2007; Borman *et al.* 2004; Nesseler 2002). Among the alternatives, applying new feeding strategies is one option (Doyle *et al.* 2000; pp26).

Whilst applying different feeding strategies is a key technology to pursue productivity and profitability improvements on Victorian dairy farms, the benefits and costs of changing systems are important questions. For instance, different feeding systems will contribute to climate change differently, producing different amounts of greenhouse gas (GHG) emissions. Global agricultural GHG emissions have increased by about 17 per cent from 1990 to 2005 (Smith *et al*. 2007). The Australian agricultural sector produced 87.4 Mt of CO_2-eq (16 per cent of net national) GHG emissions as methane (CH_4) and nitrous oxide (N_2O) in 2008 (DCCEE 2010a). Enteric fermentation contributed to the 63.6 per cent of the total sectoral emissions or 55.6 Mt CO_2-eq GHG emissions (DCCEE 2010a). The GHG emissions contributing towards the Global Warming Potential (GWP) of agricultural systems were CO_2, CH_4, and N_2O (De Boer 2003), however CO_2 emissions are viewed as sector neutral, reflecting capture in plant biomass balancing respiration. The GHG emissions from the livestock sector are sensitive to a number of factors, for instance national herd numbers and structure, nutritional and farm management factors. For instance, in New Zealand, the increased number of cows and the intensification in the agricultural sector have lead to increased amounts of GHG emissions per cow as well as total emissions, but emissions intensities (kg CO_2-eq/kg product) remain relatively constant or have declined. Increased use of fertilizer and energy required for irrigated systems were also other reasons for the high amount of GHG emissions produced (Lennox *et al.* 2008).

In light of the changes in GHG emissions, a number of initiatives and policies to mitigate or abate GHG emissions have been examined. For this purpose, Australia’s most up-to-date mitigation policy has been introduced in the Carbon Farming Initiative (CFI) (Nelson 2010). In the CFI, farmers and landholders are issued carbon credits provided that the participants manage and report their GHG emissions and allow other offset aggregators to their land for offset activities. In November 2010, DCC (2010) published the design (for consultation) of the CFI, which enables farmers as well as forest growers and landholders to benefit from domestic voluntary and international carbon markets. This new policy will require feasible abatement options to meet internationally consistent integrity standards. Some of the potential eligible abatement activities are listed as reforestation and revegetation, reduced CH_4 emissions from livestock, reduced fertiliser emissions, manure management, reduced emissions or increased sequestration in agricultural soils, avoidance of deforestation and reduced emissions from rice cultivation (DCC 2010).

Australia, as a signatory to the Kyoto Protocol, will be required to reduce its increased GHG emissions (ABARE 2009). To date, there has been little research investigating the inclusion of agriculture or forestry in an emissions trading scheme apart from work published in New Zealand under their policies (Kerr and Sweet 2008). Nevertheless, a policy focusing on carbon taxation may in the future impose a carbon price in agriculture just as in other sectors of the economy, so as to enable Australia to meet its Kyoto Protocol targets and to efficiently control its GHG emissions. Since the policy has not yet been implemented in Australia widely, there are concerns about how it will impact on dairy farm profitability if a price on carbon is implemented. Establishing a price on carbon firstly encourages possible reductions in emissions intensity of production; and secondly, aims at decreased consumption of more GHG-intensive products (Lennox *et al.* 2008).

Numerous studies have focused on evaluating the effects of a price on carbon (Lennox *et al.* 2008; Hendy *et al.* 2006; Hendy and Kerr 2005). A study to investigate the effects of a price on carbon was carried out in New Zealand’s food and fibre industries, using a price of NZ$25/t CO_2-eq by Lennox *et al.* (2008). Hendy *et al.* (2006) developed a model called LURNZv1 which was capable of calculating the emissions impacts of land use for CH_4, N_2O and CO_2. Its ultimate aim was to investigate the potential impacts of such policies as a charge to farmers in proportion to the amount of GHG emissions they produced in New Zealand. The impacts of a regulatory and a tradable emissions permits (TEPs) approach on farm income also were studied by Breen (2008). However, much of the work to date on the implementation of a policy in Australia has not been practical, but theoretical. The current study evaluates two different scenarios of price on carbon and their impacts on farm by using farm level system analysis.

When a price is placed on carbon emissions, Australian dairy farmers will seek mitigation strategies to reduce their GHG emissions. There has been a considerable amount of research on mitigation strategies to curtail GHG emissions in Europe, Australia and New Zealand. There are a great range of options that may result in reductions in agricultural GHG intensities, although the information about their practicability and costs is fairly limited. Some of the options that may help curtail emissions were listed in Lennox *et al.* (2008) as: 1) Increased efficiency in different intensive feeding and house systems and reduced substitution for other inputs with high GHG emissions, 2) Nitrification inhibitors in intensive grazing systems, 3) Land use changes between farm systems and between farming and forestry systems and 4) Native reforestation (by generating carbon credits).

One of the most important abatement options for agriculture is to reduce emissions from enteric fermentation in livestock to eventually reduce CH_4 emissions (Chapman *et al.* 2008c). Emissions of CH_4 are primarily driven by dry matter intake (DMI) (Kerr and Sweet 2008) and it has been suggested that emissions can be reduced by providing the dairy cows with high quality forage (perennial ryegrass or white clover reduced emissions per unit of production by up to 50 per cent (Chapman *et al.* 2008c), or appropriate fats (40 per cent reduction can be achieved by adding unsaturated fatty acids to ruminants, or dietary additives (use of antibiotics and tannin can reduce methane emissions by 25 per cent (Chapman *et al.* 2008c); and/or low structural carbohydrates. A further option is to reduce emissions from manure management. There are a number of factors affecting manure management, e.g. the amount of manure produced, temperature, moisture levels and type, and length of storage. Reducing the level of manure produced can only be achieved by providing highest digestibility feed and not feeding above the levels required. Reducing N_2O emissions from agricultural soils is another option. This can be achieved by applying improved management practices e.g. fertilizer application (the major cause resulting in high N_2O emissions from agricultural soils), manure application, soil disturbance and crop production. The rainfall and temperature also have impacts on N_2O emissions (ABARE 2009). N_2O emissions are caused either directly from agricultural soils and animal manure or urine in soils, or indirectly from the nitrogen that comes from fertiliser use. Applying the right amount of fertiliser at the best time will also control N_2O emissions (Kerr and Sweet 2008).

This paper examines the impacts of a variable price of carbon on the profitability of two different dairy systems, predominately a ryegrass pasture-based and a complementary forage-based feeding system managed in South West Victoria. The information used to develop the economic scenario is drawn from a five year farmlet study (Project 3030; Chapman *et al.* 2008a and b). In the next section, the data sources and the economic approach taken in this study to compare the systems are outlined.

2. Materials and Methods

Data source

The data used in this study were obtained from a dairy farmlet trial conducted from 2005 to 2009 at Terang, South West Victoria (DemoDairy, Terang: 38^{o}14′S, 142^{o}54′E). The trial was established on 28.5 ha of grassland comprising greater than 90 per cent perennial ryegrass (*Lolium perenne*), and was based on a modeling exercise described in Chapman *et al.* (2008a and b). The two different feeding systems compared were ryegrass max (RM), which consisted of pasture and pasture products; and complementary forages (CF), which provided extra feed by producing summer crop in summer and cereal silage in winter when the pasture availability was relatively lower. There were twenty paddocks which were each subdivided into two and allocated to the two farmlets on a ratio of 0.56:0.44 (RM: CF respectively) effective grazing area. Thirty-six Australian Friesian dairy cows were allocated to each farmlet, and were managed under rotational grazing. The parameters of milk production, milk composition, body weight and body condition score over the five lactation periods were recorded. The chemical compositions of feed were also obtained from Hill *et al.* (unpublished data), which include the estimates of metabolisable energy (ME), dry matter (DM), digestible organic matter (DOM), and crude protein (CP). Table 1 shows the farm characteristics compared to an average South West Victorian dairy farm.

Table 1. Farm characteristics of the dairy farms in South West Victoria and the research farm studied in South West Victoria.

Characteristics	**Dairy farms in South West Victoria**	**Research Farm (DemoDairy)**	
		RM	**CF**
Average milk production (L/cow)	6800*	6070	6820
Average milk production (kg MS/cow)	503	449	499
Average dairy area (ha)	124	16	12.4
Average herd size	366	36	36
Stocking rate (cows/ha)		2.25	2.9
The estimated pasture consumption (t DM/ha)	3-9	8.6 (Pasture plus pasture products)	8.8 (Pasture plus pasture products) PLUS 3.2 double crop)
Concentrate feed supplemented (t DM/ha)	0.8	1.18 (t DM/cow)	1.45 (t DM/cow)
% of feed consumed purchased	32	24	26

*Total MS is estimated as 7.4 per cent w/v

Source: Doyle *et al.* (2000); DPI (2009) and DPI (2010).

As can be seen from the table, the research farm in South West Victoria was a representative farm amongst the dairy farms in South West Victoria. Representative farms are used to generalize solutions. Anderson and Hardaker (1979) explained the representative farm approach as a method to analyse the general impact of the new technology on the whole farm. The average herd size on the farmlets was thirty-six cows. For analysis, a scaled up representative farm of two hundred eighty eight cows was formulated.

Economic Approach to the study

The carbon charge was imposed on the dairy systems as they currently operate in a 'first-look' approach to gauge the order of magnitude of a carbon charge on dairy systems if they were to continue to operate essentially the same system following the impost of a cost of carbon. Hence, only relatively modest carbon prices e.g. \$15/t CO_2-eq and \$25/t CO_2-eq, were investigated. More significant carbon prices would cause substantial overhaul and revision of farm plans and of ways of doing business.

The study uses a whole farm approach to evaluate the impacts of a change in one particular part of the farm on other parts of the business. Whole farm models of dairy systems can represent adequately the internal cycling of materials and their constituents. They also can predict the effects of change in the farm business by representing the exchange of materials and nutrients coming in and out between the farming system and its environment (Schils *et al.* 2007). Although there are some models that are able to simulate dairy farms, most of them lack the ability to evaluate farm economics (Schils *et al.* 2007).

Malcolm *et al.* (1995; p.8) explained the importance of having the whole of a farm business problem considered, not necessarily in great detail, rather than focusing extensively on a small part of a problem when some equally important parts of the problem were entirely neglected. They termed the farm management economic approach ‘the whole farm approach’, emphasizing the substantial importance of considering all the elements which potentially have a role in identifying and solving a particular problem studied. Within the whole farm approach, one of the economic concepts commonly used as an analytical tool is operating profit. Operating profits was calculated as following as described in Malcolm *et al.* (2005; pp30):

> *Gross Income (milk, livestock trading, inventory change) – Variable Costs (herd, shed, feed) = Total Gross Margin*
>
> *Total Gross Margin – Fixed Costs (also known overhead costs including depreciation, operating allowance) = Operating Profit or EBIT (earnings before interest & tax)*
>
> *Operating Profit – Interest and Long Term Lease = Net Profit (Return on the owner’s capital) (also known net farm income)*

Gross income is milk receipts plus stock trading profit or loss. The sum of price per kg of milk butterfat multiplied by the amount of total milk fat (kg) produced and the price associated with milk protein multiplied by the amount of total protein (kg) produced gives gross milk income. A volume charge is deducted from gross milk income. Feed costs are shown in Table 2.

Table 2. Feed costs

	years				
	2005-2006	**2006-2007**	**2007-2008**	**2008-2009**	**2009-2010**
Feed costs ($/t)					
Home grown feed cost					
Pasture	150	150	200	150	150
Pasture silage	160	160	250	160	160
Purchased concentrates	200	250	350	200	200
Purchased forage fed					
Hay	150	150	250	150	150
Silage	180	180	250	180	180
CO_2 cost ($/t CO_2-eq)	15 and 25	15 and 25	15 and 25	15 and 25	15 and 25

Table 3 provides information on the variable milk prices used in this study.

Table 3. Variable milk prices applied

	2005-2006	**2006-2007**	**2007-2008**	**2008-2009**	**2009-2010**
Butterfat ($/kg)	2.67	2.55	4.06	n/a	n/a
Protein ($/kg)	6.46	6.34	10.15	n/a	n/a
Average milk price ($/L)	0.35	0.36	0.57	0.38	0.32
Volume charge ($/L)	0.028	0.028	0.026	n/a	n/a
Production incentive for Butterfat ($/kg)	0.07	0.07	0.07	0.07	0.07
Productivity incentive for protein ($/kg)	0.175	0.175	0.175	0.175	0.175

Source: Warrnambool cheese and butter Factory Company Holdings Limited

The prices of fat and protein for years 2005, 2006 and 2007 were derived from the base price, step ups, seasonal and productivity incentives. For 2009, 2010, district average cents per litre was used: this encapsulated the sum of the effects of base price plus step-ups and incentives.

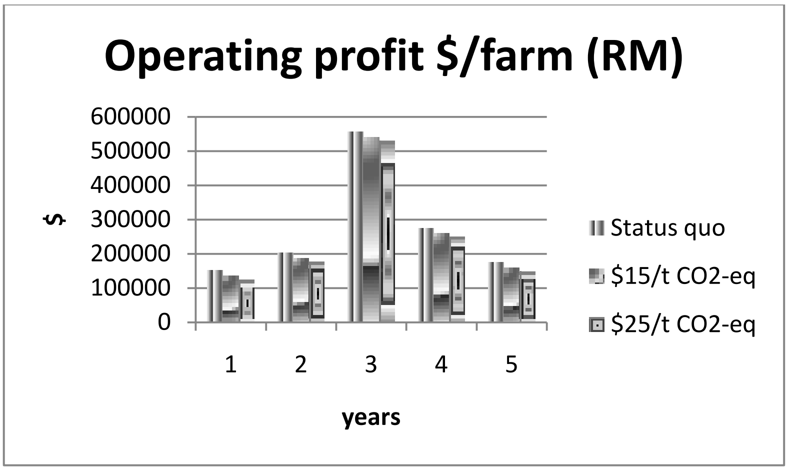
The effect of a carbon charge on operating profit is assessed in several ways. First, the effect each year on the five years of annual operating profits of the two systems is assessed. Second, the overall effect over the five years is assessed. This is done by calculating the present value (PV) of the stream of five years of operating profits, with and without an annual carbon charge. Net present value (NPV) means adjusting the future benefits and costs of an investment to their equivalent values at present by using an opportunity cost rate (discount rate). Opportunity cost is described as the earnings from alternative investments. A positive NPV after discounting means the investment being analysed better performs than its opportunity cost. When making a decision among alternatives, the option offering a higher NPV is chosen (Malcolm *et al.* 2005; pp138-141). The discount rate used was 5 per cent nominal. This paper did not consider the whole life cycle of production of concentrate feed or fertilizer. It set its boundaries within the farm gate, therefore did not include transportation of feed or the future of the ultimate farm products (milk and meat) e.g. transportation of the product, packaging, consumption or recycling.

The price scenarios for carbon used in this paper were experimental and although the current policy (CFI) published by DCC (2010) focuses on issuing carbon credits instead of a carbon tax, this study applies a price on carbon, and is a basis to evaluate the new obligations of a policy as they come into practice. The proposed carbon prices for this analysis were \$15 and \$25t CO_2-eq. The relative weight of carbon to CO_2 is 0.2727, with the result that the carbon content and CO_2 emissions are directly proportional (a carbon tax of \$100/t C equals to a \$27.27 tax on per t CO_2-eq) (Cornwell and Creedy 1996). A reference case scenario was simulated (status quo) where no policy was introduced to be able to consistently compare different price inclusions. The currency used was Australian dollars. In the following section the results of the analysis are presented.

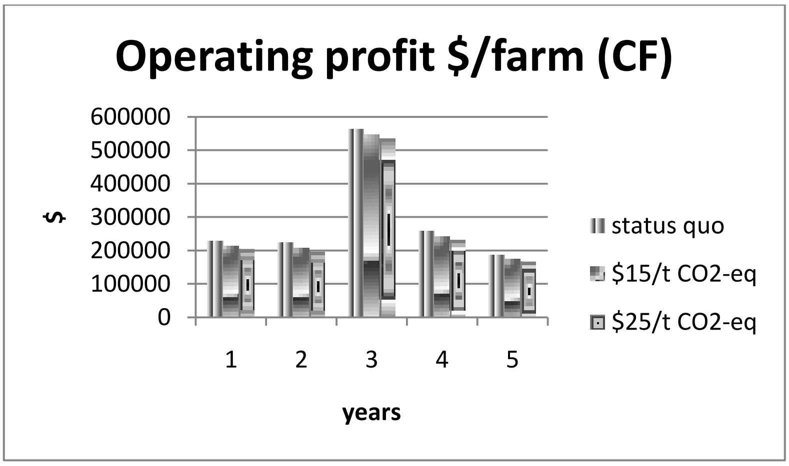
3. Results

Five years of data were analysed to evaluate the impacts of a carbon price on farm operating profit. The results were compared with a status quo where there was no price influence on carbon and the farm profit. The CF system produced a higher operating profit/farm than the

RM system as expected. This was reflected by the higher stocking rate applied in the CF system. With regard to the impact of change on carbon price, in 2005, a price of \$15 reduced the operating profit by about 11 per cent and 6 per cent in RM and CF systems respectively. The higher the price on carbon, the lower the operating profit generated. Annual operating profit reduced from \$152 051/farm in a non-carbon price scenario to \$135 432/farm when a price of \$15/t CO_2-eq was applied in the RM system in 2005. This reduction was higher in CF system and was observed as \$213 725/farm when a price of \$15/t CO_2-eq was applied compared to a *status quo* situation where no price for carbon was imposed (\$228 348/farm). Operating profits under different price scenarios were presented in Figure 1a and b.



a) RM system



b) CF system

Figure 1a and b. Operating profit $/farm for different prices for carbon. Notation on X axes is 1 – 5 where 1 = 2005 and 5 = 2009. The status quo in the figure demonstrates the corresponding operating profit figures for the reference case where there was no price included as part of the analysis. Correspondingly, Table 4 shows the effect of carbon on farm operating profit over the five years.

Table 4. Operating profits of the farmlets ($/farm) and (%) change from status quo under different carbon price scenarios ($/t CO_2-eq).

	Status quo		Rye Grass Max (RM)		Complementary Forage (CF)	
years	RM	CF	$15/t CO2-eq	$25/t CO2-eq	$15/t CO2-eq	$25/t CO2-eq
2005-06	152051	228348	135432 (-10.9%)	124352 (-18.2%)	213725 (-6.4%)	203977 (-10.7%)
2006-07	202753	224145	187204 (-7.7%)	176837 (-12.8%)	207767 (-7.3%)	196848 (-12.2%)
2007-08	555862	563903	539899 (-2.9%)	529257 (-4.8%)	546641 (-3.1%)	535134 (-5.1%)
2008-09	274777	258035	259532 (-5.5%)	249369 (-9.2%)	242326 (-6.1%)	231853 (-10.1%)
2009-10	174262	186621	158568 (-9.0%)	148104 (-15.0%)	174762 (-6.4%)	166856 (-10.6%)
Net present value ($)*	1171488	1266409	1102927 (-5.9%)	1057219 (-9.8%)	1200501 (-5.2%)	1156561 (-8.7%)

*****Discount rate: 5 per cent

Using a discount rate 5 per cent, NPVs of the systems were the highest in a no carbon scenario. Including $15/t CO_2-eq reduced the NPV by $69 000/farm and $66 000/farm in the RM and the CF systems respectively (6 per cent and 5 per cent). This reduction was higher in a higher carbon price scenario ($25/t CO_2-eq) and was observed as $114 000/farm and $110 000/farm in the RM and the CF systems respectively (10 per cent and 9 per cent).

4. Discussion

In this study, the impacts of a price on carbon on farm profitability were analysed with five years of farmlet data. This study used a whole farm model, considering different types of feeding systems. The operating profit was higher in the CF system compared to the RM system due to the use of summer crops followed by winter cereal silage enabling a higher stocking rate. The carbon charge of $15/tonne reduced the present value of the operating profits of the RM and the CF systems over the five years of operation by 6 per cent and 5 per cent respectively. The carbon charge of $25/tonne reduced the present value of the operating profits over the five years of operation by 10 per cent and 9 per cent in the RM and the CF systems respectively.

Including price on carbon in agriculture was also studied by Lennox *et al.* (2008) in New Zealand. They found that a 25 NZ$ price on carbon would influence sectors of ruminants most, increasing the cost for dairy farmers by 5.9 per cent, which was considered as a substantial trade barrier for New Zealand products especially to EU and the USA. Similarly, Hendy *et al.* (2006) investigated the impacts of a high carbon cost of NZ$50/t CO_2-eq, using a microeconometric climate model with fixed per-ha emission factors. They found that high carbon charge (NZ$50/t CO_2-eq) would reduce the dairy farmers' revenues by 11 per cent for the commitment period of 2003-2012 (equals to NZ$48 693 profit reduction on an average between 2000 and 2005). Hendy *et al.* (2006) simulating the effect of an agricultural land-use emissions charge and a reward for native forest and scrub regeneration concluded that a charge on farmers' emission that would be based only on land-use may not be an effective method to reduce GHG emissions.

Hendy and Kerr (2005) also studied the cost of a tax of 25NZ$/t CO_2-eq; this eventually reduced the revenue of dairy farmers by 7 per cent. Our study showed that a direct cost of $25/t CO_2-eq reduced the farmers' revenues by 10 per cent and 9 per cent in the RM and the CF systems respectively. Sin *et al.* (2005) reported a loss of NZ$15 000 in profit out of average farm net trading profits of NZ$48 739 in 2002-03 and NZ$85 029 in 2003-04 in a scenario of NZ$25/t CO_2-eq was implemented for the average dairy farm in New Zealand.

This value was similar to what was found in this study. The current analysis considered neither indirect emissions e.g. fertilizer production nor emissions from other pollutants e.g. SO_2. The study was restricted to agricultural GHG emissions in South Eastern part of Australia and excludes emission leakage in other parts of the region. In addition, the production of biofuel or biogas was not included.

Implementing a charge to farmers for the amount of GHG emissions they emit is likely to result in reduced area in livestock (especially in dairy), reduced stocking rates and changes in farm management to reduce emissions per animal (Hendy *et al.* 2006). Kerr and Sweet (2008) reported a 0.5 per cent loss in dairy land as a result of a NZ$15/t CO_2-eq price included (low price impact). A proposed charge may furthermore have indirect effects on other parties e.g. workers on the farm and on other communities across the whole economy (Sin *et al.* 2005). Moreover, such consequences of a policy may include reducing/converting the emitting land to forestry and/or moving land from dairy to sheep/beef or conversely depending on the prices on the proposed change area e.g. dairy, sheep or beef (Hendy *et al.* 2006).

There is opportunity for future studies to focus on the impacts of different mitigation strategies and policy applications on farm operating profit. For instance, Breen (2008)'s study focused on a comparison of a regulatory and a TEPs (tradable emissions permits) approach in terms of their impact on farm income, based on a farm-level linear programming model in Ireland. They compared no constraint and 20 per cent reduction in emissions, and measured the farm income against these changes. They suggest that GHG emissions can be reduced at a lower cost if permit trading is allowed to Irish farmers, which will eventually generate higher average gross margin.

There are a growing number of farm studies that are estimating GHG emissions from farm systems. It is not well-recognized that this information is a necessary but not a sufficient condition to judge impacts of GHG emissions and their control. Estimates of GHG emissions, often expressed per head or per hectare, are measures of technical efficiency; and partial measures too. They are not measures of economic efficiency. Economic efficiency measures require estimates of profit from whole systems. Indeed, using technical ratios can lead to logically opposite conclusions. For example, to reduce GHG emissions *per hectare* suggests a *lower* stocking rate; to reduce GHG emissions *per head* suggests a *higher* stocking rate. Technical estimates of GHG emissions from systems are no basis for policy decisions, either on farm or beyond farm. It is only when this technical information about GHG emissions from farm systems is incorporated into effects on farm profit that conclusions can be drawn about the GHG emissions and attempts to deal with them.

5. Conclusions

At some point, including Australian agriculture within the scope of a policy that puts a price carbon will undoubtedly subject farmers to major challenges. This study has compared, from a carbon price point of view, possible impacts of this inclusion on dairy farm profitability with two different feeding systems. In both cases a price on carbon reduced the farm net income. In order for a proposed policy to function properly, current monitoring technologies should be improved to enable further research on policy. Systematic inquiry into the extent to which a proposed policy and a price associated with carbon might reduce the GHG emissions can provide an important direction for future studies as well as future modeling practices.

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