Effect of a carbon price on farm profitability on rain-fed dairy farms in south-west Victoria: a first look

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Abstract. In this study, the possible impact of different prices of carbon on farm profitability in two dairy farm businesses with different feeding systems was analysed. The feeding systems evaluated were a ryegrass pasture-based system (RM) and a complementary forage-based system (CF). The carbon charge was imposed on the systems as they currently operate and without the farmers making strategic changes in response to the tax. The study is a first-look approach in order to gauge the order of magnitude of a carbon charge on dairy systems if they were to continue to operate essentially under the same system following the impost of a cost of carbon emissions, and to gauge the likely size of incentives to respond. The main finding of this study was that net present value (NPV) of operating profit for each system over the five years was reduced by a price on carbon. The carbon charge of \$15/t CO_2-eq reduced the present value of the operating profits over the five years of operation by around 7% and 6% in the RM and the CF systems respectively. The carbon charge of \$25/t CO_2-eq reduced the present value of the operating profits over the five years of operation by around 11% in the RM and 10% in the CF systems. Farmers continually face rising costs of production, and respond accordingly. A price on carbon emissions, if ever applied to agriculture, would invoke responses to further increase productivity and possibly to seek offsets if genuine opportunities occurred.

Keywords: dairy farm, feeding system, carbon cost, operating profit.

Introduction

The dairy industry in south-west Victoria is based on rain-fed pasture supplemented by concentrates, by-products, hay and, occasionally silage (Fulkerson and Doyle 2001). In south-west Victoria, almost half of the pasture production grazed by dairy cows is produced in spring (September to November) (Doyle et al. 2000). The desirable calving time is usually adjusted to 4–6 weeks before the spring pasture peak to meet the increasing cow requirements at that time (Thompson and Poppi 1990). Pastures, in this region, grow between 6 and 12 t DM/ha per year (Malcolm et al. 1996, p. 142). The production, depending on the seasonal conditions, slows in January and February. Therefore, considerable supplementary feeding may be required to increase the total dry matter intake (Bargo et al. 2003). However, managing feed costs is an important component of dairy-farm businesses and one of the keys to increased profitability. One way to maintain the competitiveness of the dairy industry is to apply new feeding strategies that can offer high nutrient content with low cost (Doyle et al. 2000).

Whilst applying different feeding strategies is a key technology to pursue productivity and profitability improvements on Victorian dairy farms, the choice of feeding strategy has implications for climate change because different feeding strategies result in different greenhouse gas (GHG) emissions. Thus, the complete benefits and costs of changing systems are important questions. For instance, global agricultural GHG emissions have increased by about 17% from 1990 to 2005 (Smith et al. 2007). The Australian agricultural sector produced 87.4 Mt of CO_2-eq (16% of net national) GHG emissions as methane (CH_4) and nitrous oxide (N_2O) in 2008. Enteric fermentation contributed to the 64% of the total sectoral emissions or 55.6 Mt CO_2-eq GHG emissions (DCCEE 2010a).

Australia, as a signatory to the Kyoto Protocol, is required to reduce its increased GHG emissions (ABARE 2009). Kyoto commitments only last to 2012 and Australia is on track to meet these obligations as the projected Kyoto Target for agricultural emissions is to reduce emissions by 86 Mt CO_2-eq (0.4%) below its 1990 level (87 Mt CO_2-eq) (DCCEE 2010b). Both major political parties have committed to reducing emissions by 5% on 2000 levels by 2020. This is a challenge given that emissions are projected to be 22% higher in 2020 under a business as usual scenario. The federal government has the further goal of reducing emissions by 80% on 2000 levels by 2050 (The Parliament of the Commonwealth of Australia 2011).

The policy approach for abating agricultural emissions in Australia has been reconsidered so that a carbon crediting scheme might be adopted instead of an emission trading scheme. For this purpose, the design of the Carbon Farming Initiative (CFI) was published for consultation in 2010 (DCCEE 2010c). The CFI is an Australian Government legislative scheme that provides farmers, forest growers and landholders with credits for reduced or avoided GHG emissions produced in agricultural sector, or sequestration through changes to soil and land management practices, or systems biology (DCCEE 2010c). 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 (DCCEE 2010c). The most plausible future scenario is that landholders may act as an offset provider to other sectors which would mean that they are paid to reduce their emissions rather than being taxed. The alternative incentives should have similar effects in respect to on-farm behaviour, but will have different impacts on operating profit. There is a range of input–output relationships over which the fundamental dairy systems that are analysed is likely to remain relatively unchanged. That is, whilst tactical changes will be made, strategic (medium term) changes will not be implemented.

If a price was placed on carbon emissions, Australian dairy farmers would seek mitigation strategies to reduce their GHG emissions. Some of the options that may help curtail emissions were listed in Lennox et al. (2008) as: (i) increased efficiency in different intensive feeding and house systems and reduced substitution for other inputs with high GHG emissions, (ii) nitrification inhibitors in intensive grazing systems, (iii) land use changes between farm systems and between farming and forestry systems, and (iv) native reforestation (by generating carbon credits). There is no doubt that fertiliser management plays an important role in reducing N_2O emissions from agricultural soils (Kerr and Sweet 2008).

A carbon price policy not applicable to the agricultural sector is about to be implemented in Australia. It is an interesting question as to how a price on carbon emissions applied to dairy farming would affect dairy farm profitability. In this study, two different scenarios of price on carbon and their impacts on farm are evaluated using farm system analysis. The two feeding systems examined are a predominately ryegrass pasture-based system (RM) and a complementary forage-based feeding system (CF).

In this paper, actual farm data from five years of a dairy farm trial were used. The trial was designed to compare the profitability of two alternative feeding systems. The farm feed system was adjusted tactically each year according to seasonal conditions, however decisions were made under the circumstance that there was no carbon tax to be considered. Hence, the first look: to see the magnitude of a carbon tax on emissions relative to annual operating profits of the two feeding systems. Knowing this magnitude indicates whether the alternative feeding systems have different implications for carbon emissions and carbon charges, and indicate the sort of incentive, if any, dairy farmers running these types of systems might have to change between systems as a result of a carbon tax. If the effect is significant on operating profit of the feeding systems, the analysis will also indicate whether strategic changes to the system will be likely to be needed.

In the next section, the data source and the approach taken in this study to compare the systems are outlined.

Materials and methods

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°14’S, 142°54’E). The trial was established on 28.5 ha of grassland comprising greater than 90% perennial ryegrass (*Lolium perenne*), and was based on a modelling 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 (Hill et al. 2012). Some of the characteristics of the two farmlets are described in Table 1.

The systems of the research farmlets were designed to be representative of the dairy farms in south-west Victoria (Doyle et al. (2000); DPI (2009) and DPI (2010)), and, for analysis, the farmlets were scaled up to be typical sized operations for the region. The average herd size on the farmlets was thirty-six cows. For analysis, a scaled up representative farm of 288 cows was formulated.

To estimate the global warming potential (GWP) of the two systems, CH_4 emissions from enteric fermentation and N_2O emissions from urine and faeces, as well as from fertiliser use were calculated according to Australian method published by DCCEE (2010d). These methods used to estimate the GHG emissions in Australia reflect country-specific information, revised IPCC guidelines for national GHG inventories (1997) and emission factors, and they are believed to represent international practice (DCCEE 2010d). Methane emissions are calculated from feed inputs while N_2O emissions are calculated from two sources namely N_2O emissions associated with animal (urine and faeces) and N_2O emissions associated with fertiliser application. The production and transport of raw material or inputs such as purchased feeds, fertiliser production processes, extraction of sources or packaging and transport of the output off-farm have not been considered. Also not considered is the emissions related to land use under constant management practices, capital goods such as buildings and machinery (Cederberg and Mattson 2000; Chen et al. 2005), on-farm milking and cooling; and retail-stage activities such as refrigeration and disposal of packaging.

Whole farm approach was used to evaluate the impact of carbon charge on farm operating profit. Farm operating profit was calculated as described in Malcolm et al. (2005; pp. 29–31):

Gross Income (milk, livestock trading, inventory change) – Variable Costs (herd, shed, feed) = Total Gross Margin (1)

Total Gross Margin – Fixed Costs (also known overhead costs including depreciation, operating allowance) = Operating Profit or EBIT (earnings before interest & tax) (2)

Operating Profit – Interest and Long Term Lease = Net Profit (Return on the owner’s capital) (also known net farm income) (3)

Feed costs are shown in Table 2, and milk prices in Table 3.

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). The annual discount rate used is 5% (Armstrong et al. 2010) nominal reflecting the opportunity cost of the current capital in the system. 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 preferred (Malcolm et al. 2005; pp. 138–141).

The carbon prices used are $15 and $25/t CO_2-eq carbon emissions. A reference case scenario is simulated (*status quo*) where no policy is introduced for a consistent comparison of different price inclusions. The currency used is Australian dollars. In the following section the results of the analysis are presented.

Results

Five years of data were analysed to evaluate the impact 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 over the five years of operation, reflecting higher milk yields produced in the CF system relative to that in the RM system (cumulative NPV of $1287000 versus $1171500 respectively).

With regard to the impact of change on carbon price, a price of $15 per tonne of CO_2-eq emissions reduced the mean operating profits of the two systems over the five years from $272000 in the RM and $297000 in the CF to $254000 in the RM and $279000 in the CF systems. This equates to 7% and 6% reduction in the mean operating profits of the RM and the CF systems over the five years of experimental trial respectively. The reduction in the operating profit was higher if the price imposed on carbon was $25 (11% and 10% for the RM and the CF systems respectively). Amongst the five years of the experimental trial, change in operating profit as a result of imposition of a carbon price was the highest in 2005–2006 when $15 reduced the operating profit by 12% and $25 reduced the operating profit by 20% in the RM system. In the CF system, the greatest response in the operating profit towards a carbon price was observed in 2009–2010 when operating profit was reduced by 9% ($15 scenario) and 16% ($25 scenario).

Operating profits of the two systems under different price scenarios are presented in Figure 1a and b.

An obvious finding of this study was that overall net present value (NPV) at 5% discount rate of operating profit for each system over the five years decreased when a price on carbon was included. Using a discount rate of 5%, NPVs of the systems, without charges, were the highest in a no carbon price scenario ($1171000 versus $1287000 in the RM and the CF systems respectively). Including $15/t CO_2-eq reduced the NPV by $80000/farm and $79000/farm in the RM and the CF systems respectively (7% and 6%). This reduction was higher in a higher carbon price scenario ($25/t CO_2-eq) and was observed as $133000/farm and $131000/farm in the RM and the CF systems respectively (11% and 10% reduction relative to a no price on carbon scenario).

Discussion

In this study, the impact of a price on carbon on farm profitability was 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 because the use of summer crops followed by winter cereal silage enabled more cows to be milked. 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 7% and 6% respectively. The carbon charge of $25/tonne reduced the present value of the operating profits over the five years of operation by 11% and 10% in the RM and the CF systems respectively.

These results are comparable to other similar studies. Lennox et al. (2008) in New Zealand found that a NZ$25 price on carbon would increase the annual costs for dairy farmers by 5.9%. Hendy et al. (2006) indicated that a high carbon charge (NZ$50/t CO_2-eq) may reduce the dairy farmers' revenues by 11%. Hendy and Kerr (2005) reported that a tax of 25NZ$/t CO_2-eq has the potential to reduce the revenue of dairy farmers by 7%. Sin et al. (2005) reported a loss of NZ$15000 in profit out of average farm net trading profits of NZ$49000 in 2002–03 and NZ$85,000 in 2003–04 in a scenario where NZ$25/t CO_2-eq was implemented for an average dairy farm in New Zealand. These results are comparable to the effects of a carbon tax on Victorian dairy farmers investigated in this study. Any difference between different studies on the impact of a carbon charge on farm operating profit may be attributed to the management of the farm practices in the two studies. However, it is important to note that the current analysis considered neither indirect emissions such as fertiliser production nor emissions from other pollutants. Only the emissions of CH_4 from enteric fermentation, and N_2O from animals and fertiliser were considered. The study was restricted to agricultural GHG emissions in the south-eastern part of Australia and excludes emission leakage in other parts of the region.

The price scenarios for carbon used in this paper were experimental and although the current policy (CFI) published by DCCEE (2010c) focuses on issuing carbon credits instead of a carbon tax, this study applies a price on carbon. 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, and to gauge the likely size of incentives to respond. Hence, only relatively modest carbon prices of $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. Note that the carbon tax scheme to commence in 2012 has a starting price of $23/t CO_2-eq (Australian Government The Treasury 2011).

This study uses a whole farm approach to evaluate the impacts of change in one particular part of the farm on other parts of the business. This is because the introduction of more complex feeding systems to achieve higher milk yields per cow may impact negatively on profit, labour efficiency, pasture management and utilisation (García and Fulkerson 2005). A whole-farm analysis, which allows for an understanding of complex interactions, offers the opportunity to evaluate the consequences of change in feedbase or feed utilisation components of farm systems on other parts of the farm business especially on returns and risk (Doyle et al. 2010). It considers all the elements which potentially have a role in identifying and solving a particular problem studied (Malcolm et al. 2005, p. 8). Therefore, 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).

There are a growing number of farm studies that estimate GHG emissions from farm systems. It is not well-recognised 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 while to reduce GHG emissions *per head* suggests a *higher* stocking rate. Technical estimates of GHG emissions from systems are no basis for policy decisions, neither on farm nor 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 the attempts to deal with them.

Conclusions

This study compared possible impact of including dairy farming in a carbon pricing scheme. In particular, the effects of a tax on carbon emissions on the profits of dairy farmers *in the situation where the farmers do not make strategic changes to the system in response to the carbon tax*. With both feeding systems and no change in the system, a \$25/ t CO_2-eq price on carbon reduced the 5 year cumulative annual farm operating profits by around 10–11% per annum, with marginally more effect on the RM feed system than on the CF feed system. Like all potential cost increases, such a potential change in costs would be incentive to increase productivity such as increasing size of the system to reduce average fixed costs per unit of output or possibility getting involved in an appropriate offset scheme.

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Appendix

Table 1. Characteristics of the two farmlet studies. (Numbers in parentheses reflect the change in systems in 2009–2010)

Characteristic	RM	CF
milk production (L/cow/year)	7622	7950
milk production (kg MS/cow/year)	581	598
average dairy area (ha)	16 (13.8)	12.4 (11.6)
average herd size	36	36
stocking rate	2.25 (2.6)	2.9 (3.08)
home-grown feed (pasture + pasture silage) consumption (t DM/ha)	8	8.1+3.2 (double crop)
concentrate feed consumption (t DM/cow/year)	1.6	1.8
% of feed consumed as concentrates	25	27

Table 2. Feed costs across the five years of the experimental trial

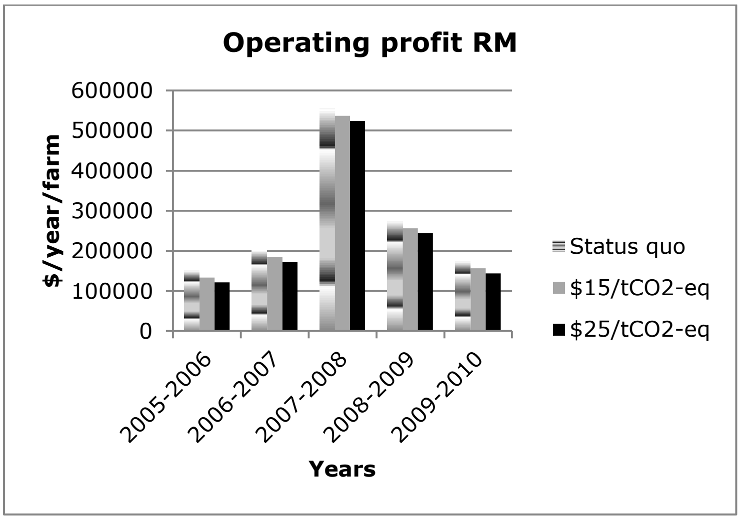
Feed types ($/t)	05	06	07	08	09
pasture	150	150	200	150	150
pasture silage	160	160	250	160	160
concentrates	200	250	350	200	200
purchased hay	150	150	250	150	150
purchased silage	180	180	250	180	180

Table 3. Milk prices used over the five years of experimental trial

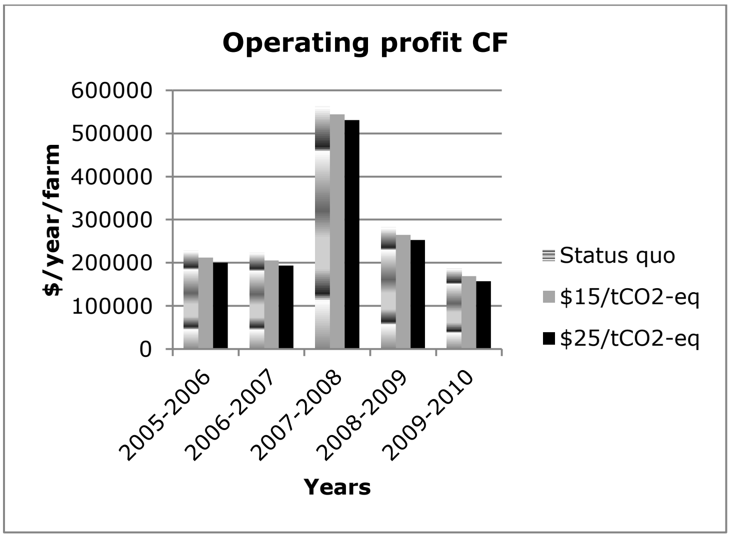
	05	06	07	08	09
butterfat ($/kg)	2.67	2.55	4.06	n/a	n/a
protein ($/kg)	6.46	6.34	10.15	n/a	n/a
milk price ($/L)	0.35	0.36	0.57	0.38	0.32
butterfat incentive ($/kg)	0.07	0.07	0.07	0.07	0.07
protein incentive ($/kg)	0.175	0.175	0.175	0.175	0.175

Source: Warrnambool Cheese and Butter Factory Company Holdings Limited.

Figure 1. Operating profits ($/farm) for different prices of CO_2-eq emissions



(a)



(b)