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A stochastic analysis of the impact of input parameters on profit of Australian pasture-based dairy farms under variable carbon price scenarios

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ABSTRACT

The imposition of a carbon tax in the economy will have indirect impacts on dairy farmers in Australia. Although there is a great deal of information available regarding mitigation strategies both in Australia and internationally, there seems to be a lack of research investigating the variable prices of carbon-based emissions on dairy farm operating profits in Australia. In this study, a stochastic analysis comparing the uncertainty in income in response to different prices on carbon-based emissions was conducted. The impact of variability in pasture consumption and variable prices of concentrates and hay on farm profitability was also investigated. The two different feeding systems examined were a ryegrass pasture-based system (RM) and a complementary forage-based system (CF). Imposing a carbon price ($20–$60) and not changing the systems reduced the farm operating profits by 28.4% and 25.6% in the RM and CF systems, respectively compared to a scenario where no carbon price was imposed. Different farming businesses will respond to variability in the rapidly changing operating environment such as fluctuations in pasture availability, price of purchased feeds and price of milk or carbon emissions differently. Further, in case there is a carbon price imposed for GHG emissions emanated from dairy farming systems, changing from pasture-based to more complex feeding systems incorporating home-grown double crops may reduce the reductions in farm operating profits. There is opportunity for future studies to focus on the impacts of different mitigation strategies and policy applications on farm operating profits.

1. Introduction

The dairy industry is the third largest rural industry and one of the most leading agricultural exporters in Australia, producing 9.2 billion L of milk in 2013 (Dairy Australia, 2013). In order to remain competitive in the changing economic environment, dairy farmers are required to adopt new technologies and alternative strategies such as new feeding systems. Alternative pasture-based systems supplemented with concentrates

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and conserved home-grown forages may have a high potential to overcome the limitations of pasture-only systems, thereby increasing the dry matter (DM) intake of cows (Bargo et al., 2003). However, the increased returns in a production system should be considered in relation to the variability in inputs, in other words, risk. For instance, pasture growth is dependent on rainfall that is unpredictable (Soder and Rotz, 2001). Similarly, variability in prices of milk and concentrates impacts on the operating profits to a large extent (Chapman et al., 2008). The deregulation in Australia in 2000 resulted in all market prices being set by world market rates with no customer support (Edwards, 2003), leading to the expansion efforts made by dairy farmers to remain competitive (i.e. increasing herd size and stocking rates (Doyle et al., 2000). As a result of the improved farm management practices after deregulation, the Australian dairy industry increased its outputs by 4.9% per year since 2000. However, the increased additional milk production in the dairy industry was a result of the increased use of purchased feeds instead of improved productivity, which contributed to 4.1% increase in use of total inputs per year (Dharma, 2011). Average dairy farm business profit was reported by Dharma et al. (2012) as approximately $106,000 per farm for year-round producers ($83,000 for seasonal producers), reflecting the use of 1.5 t of grains and other concentrates per cow per year. Although use of purchased feeds remains the main cost of production for most dairy farms, more recently this approach has been questioned. This has led to evaluation of the increased use of home-grown feeds in order to diminish the cost of milk production (Alford et al., 2009; Chapman et al., 2008, 2014).

There may be a perception among the dairy farmers tending to change their management (e.g. feeding systems) due to the recent policy obligations regarding greenhouse gas (GHG) emissions they produce (Hendy et al., 2006). Agriculture produced around 79 Mt CO_2-eq emissions which contributed to around 15% of total Australian GHG emissions in 2010 (DCCEE, 2012). Australia is required to reduce its national GHG emissions due to its commitment to the Kyoto Protocol (DCCEE, 2010a) even though agriculture is excluded from regulatory obligations at commencement. According to the current policy settings including the Clean Energy Future package and the Carbon Farming Initiative (CFI), agricultural emissions in Australia, of which the participation is through voluntary measures, are expected to reduce by 5% below 2000 levels by 2020 (DCCEE, 2012). The CFI, as the latest regulation published in 2010 (DCCEE, 2010b), encourages the development of mitigation and adaptation options for agricultural producers to benefit from domestic and international carbon markets. The imposition of a carbon tax in the economy will have indirect impacts on dairy farmers in Australia. These indirect impacts are expected to occur in the long run and include electricity, freight (and fuel included in freight and purchased by farmers) and aerial agricultural services. In the case that the prices of above-mentioned services increase due to a carbon policy, dairy farmers will have to pay higher prices for these services (Whittle et al., 2011). That is, under a carbon policy, internalising this externality will only be profitable for farmers if the carbon policy provides a mechanism to improve their profitability over and above the *status quo*.

The troublesome in predicting the future events lies in the terms 'variability' and 'uncertainty'. While variability is a function of the physical system and cannot be reduced by measurements, uncertainty relates to a lack of knowledge about the parameters that define the system and thus may be reduced by measurements (Vose, 2000). The evaluation of variable prices of carbon as well as other inputs such as milk and feed prices can be done by using a stochastic analysis. In order to define one option as a better bet than the alternative, the term 'stochastically dominate' is used (Malcolm et al., 2007). Monte Carlo Simulation is used to randomly sample the probability distributions of each input parameter in order to generate thousands of scenarios called iterations. Each probability distribution generated from a Monte Carlo Simulation forms the shape of the final distribution. It is a precise method as the level of precision depends on the number of iterations which can be easily increased (Vose, 2000). If farmers are risk-averse, strategies with relatively low variance of income (and sometimes even at the cost of some reduction in expected outcome) may be favoured by farmers over strategies with high variance of income in general (Pannell et al., 2000). Nevertheless, different farming businesses will respond to variability in the operating environment such as fluctuations in pasture availability, price of purchased feeds and price of milk differently (Armstrong et al., 2010).

Much international research has focused on the mitigation strategies from agriculture and dairy (Boadi et al., 2004; Bryant et al., 2007; Cottle et al., 2011; Ledgard et al., 2007; Pete et al., 2008; Place and Mitloehner, 2010; Smith et al., 2008; Waghorn and Clark, 2006). To date, there has been little research investigating the inclusion of agriculture in an emission trading scheme except for the work published in New Zealand under their policy implications (Kerr and Sweet, 2008). There are a few studies evaluating the effects of a static carbon price on farm management practices and values (Hendy and Kerr, 2005; Hendy et al., 2006; Lennox et al., 2008; Özkan et al., 2012). However, the impact of variable prices of carbon emissions on dairy farm operating profits in Australia has not been studied widely. In this paper, economic performances of two dairy systems in the face of changing prices of carbon emissions as well as the variable pasture consumption and prices of milk, and feed were evaluated using a stochastic analysis approach.

2. Materials and methods

The data used in this study were obtained from Project 3030 where two separate farmlets were developed for a non-irrigated ryegrass pasture-based system (RM) stocked at 2.25 cows/ha and a complementary forage-based system (CF) stocked at 2.9 cows/ha at Terang in south-west Victoria (DemoDairy, Terang: 38°14′ S, 142°54′ E) between 2005–2006 and 2009–2010 (Table 1). The last year of the Project 3030 required a transition of the RM and CF to the RMax (RM) and RMPlus (CF), where stocking rates of the systems were increased to 2.6 and 3,08 cows/ha effective milking area (EMA), respectively. In the last year of the CF system, 25% of the perennial pasture base was to be replaced each year and 25% of the EMA was to be renovated to annual ryegrass for grazing and silage followed by turnips for early summer