Farms' environmental impact and economic performance: The case of an Amazonian beef farm

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1. Abstract

This work studies the environmental impacts and economic performances of an Amazonian traditional beef farm, using a production cost and profitability analysis (Matsunaga et al., 1976) and a Life Cycle Assessment Standards Model (ISO 14044, 2006). The results reveal that economic and environmental performances share the same kind of determinants – low productivity of animals and land – which are major problems in Brazilian extensive livestock farms. Better management practices and technical efficiency associated with an "ecological intensification" of the production system could be a "win-win" strategy (Porter, 1991; Porter and van der Linde, 1995) in order to improve both performances.

Key words: Environmental economics, performance, Amazonian beef farm, win-win strategy

2. Introduction

The new food sector's objective is to produce enough to feed 9.3 billion people in 2050. To address this problem it is necessary to improve food production by 70% (FAO 2009). Furthermore, it needs to deal with a context of natural resources depletion and societal demands to reduce environmental impacts. The animal production sector is commonly cited by its large environmental footprint (Steinfeld et al., 2006). Moreover, various studies show that livestock farming environmental impacts represents the majority animal products' emission footprint (Roy et al., 2009; Beauchemin et al., 2010; Peters et al. 2010; Kristensen et al., 2011; Thoma et al., 2013; Opio et al., 2013).

It is often argued that the firms' environmental and economic performances are opposed at cross purposes, in cases where technology, production processes and customer needs are fixed. In this win–lose standpoint, the environmental performance is associated with higher costs and less profit (Walley and Whitehead, 1994; Greer & Bruno, 1996). However, the Porter hypothesis (Porter, 1991; Porter and van der Linde, 1995) suggests that environmental and economic performance can be achieved together, in a "win-win" approach. Empirical contributions on the agricultural sector have received major attention (Carpentier and Ervin, 2002; van Passel et al., 2007; Thomassen et al., 2009).

Both reducing environmental impacts and improving economic gains have become a major challenge for farmers, agro-industries and policy-makers. In this context, this study aims to analyze how the internal structures of farms and their capacity to mobilize their resources are related with environmental impacts and economic performances. The objective is to study whether improvements in the environmental and economic performances of an Amazonian extensive beef farm may be achieved by a win-win strategy.

3. Data and methods

In order to test this hypothesis we have constructed a typical farm according to Plaxico & Tweeten (1963) method. It is a representative farm of local farms, in the most important Brazilian beef cattle region, in the Legal Amazonia (Mato-Grosso State). The economic and technical farm's data was collected during a focus group carried out in this region in 2012 by the CEPEA (Center for Advanced Studies on Applied Economics).

The farm's economic performance is measured by the farm production cost and profitability as in Matsunaga et al., (1976). This methodology is often used in CEPEA and (Barros et al., 2006; Abreu et al., 2012; Siqueira et al., 2013). The farm "operational effective costs (OEC)", or cash costs, take into account all expenditures around the year and used in the same period. OEC considers variable costs, taxes and syndical compulsory contribution. The "operational total costs (OTC)" is composed by COE added to depreciation and farmer labor remuneration. The farm total cost (TC) is the sum of OTC, return on capital of 6% per year (the minimal return of Brazilian bank savings) and the opportunity cost. The land opportunity cost regards the price to rent the land in this region. Van Passel et al. (2007) consider the uses of opportunity costs a key role to assess firm economic sustainability. Farm' returns is the income obtained by animals sold during the year of 2012.

The environmental performance is based on the on indicators derived from Life Cycle Assessment Standards Model (LCA) (ISO 14044, 2006). LCA is an evaluation method of environmental impacts of all processes in the life cycle of a production activity. The LCA is widely used to assess the environmental performance of livestock production at farm level (Thomassen et al., 2009; Basset-Mens et al., 2009; Beauchemin et al., 2010; Siqueira et al., 2013; Dick et al., 2014). LCA has four steps: goal and scope definition, inventory analysis, impact assessment and interpretation of results (ISO 14044, 2006).

The aim is to analyze the greenhouse gas emissions (GHG), as a performance measure, per kg of animals sold living the farm. The scope of this study is a "cradle-to-farm gate". All emissions after the animals left the farm (post-gate) were not analyzed in this study. Land use change is taking into account. Animals' medicines, mineralized salt, grass seeds were excluded because of a lack of the LCA results references. Tractor, tools and buildings are all excluded of boundary studied because their impacts can be depreciated along the lifespan. These missed annual emissions are unlikely to change significantly the whole farm impacts results (Cederberg et al., 1998; Thomassen et al., 2009). Moreover, the farm has a low input system, in other words, a minimum of infrastructure and agricultural machinery.

In the second and the third step, we calculate all direct emissions (on farm) and the indirect emissions (outside of farm due to inputs' production and transportation). In order to evaluate direct GHG, we use the IPCC (2006) methodology Level 2. Using the Ecoinvent v2.0 2007 database (Nemecek and Kägi, 2007), we include the indirect emissions of fuel production transport and transportation until the farm. The total of GGE of the whole farm, displayed per kg CO_2 equivalents (kg CO_2 eq.), is divided by total kg of animals living the farm gate. In this way we obtain the impact of farm products showed in kg CO_2 eq./1 kg of live weight (LW) (Dollé et al., 2011; Dick et al., 2014). These results are considered as measures of farm's environmental performance.

Finally, we relate farm's economic and environmental impact with the farm's technical structure. Relating both technical and practices structures are important to find the sources of farm performances.. It is also important to identify a possibility of a farm win-win strategy.

4. Results

4.1. The typical farm's data

The farm livestock activity in this typical farm was established in the eighties year with the forest transformed to pasture. The mean annual temperature where the farm is located is 26 degrees Celsius. The total typical farm area is 1500 hectare (ha), 1000 ha of permanent grassland and 500 ha of permanents reserves of natural forest. This typical beef farm system is composed of cow-calf and fattening period. These animals are feeding mainly by grass and mineral salt. Grassland availability is seasonal. In a dry period the animals spend more energy than in the rainy season to feed.

The cow-calf animals eat 9321 tons of grass by year and the fattening animals' 3679 tons. The total digestible nutrients for the cows-calves were 61.49 % and 57.93% for fattening animals. This typical Amazonian beef farm is composed by 400 cows. These cows produce 149 females and 149 male calves per year. Each year 100 older cows are sold to the slaughterhouse with 360 kg, 100 heifers are used to replace theses cows, 41 are sold to other farms with 320 kg and the rest are lost or die of natural causes. 144 bulls are fattened and sold to a slaughterhouse with 490 kg per year. The total kg of animal sold per year is this typical farm is 120253 kg. A typical farm of Amazonia region has extensive uses of farm land, low input, simple technology and modest management (no rotating grazing, no genetic improvement, no stalls neither machines, no fertilizers). Therefore they have low productivity and technical indices (infertility, small daily weight gain, late age at first calving, others).

4.2. The economic performance of typical farm

The results suggest that the farm is profitable only in the short-run. The output is sufficient to pay the cash cost or OEC. But in the medium/long-run, the farm is not profitable. Thus, this farm is not economically efficient in a long run. Indeed, the total returns is too low to cover depreciation and opportunity cost. Farm's outcome it's enough to cover only 58.81 % of total costs. This is the typical situation of a majority of Brazilian beef farms.

Farm's costs are divided in different components of a farm system: livestock expenditures, labor, depreciation, capital investment and land opportunity cost. This analysis allows identifying two main critical issues: the land opportunity costs and livestock expenses represent together 68% of the costs (Table 1).

Table 1: Representativeness of different groups in the production cost

Groups	% of Total Cost
Livestock	31
Labor	5
Depreciation	12
Return on capital investment	15
Land opportunity cost	37

Source: Author based on CEPEA data.

4.3. The environmental performance of typical farm

Regarding to greenhouse gas emissions (GHG) the farm produced 1805290 kg CO_2 eq. Dividing this value by the total weight of leave animals leaving the farm gate in one year, 120253 kg, we obtain 15.0124 kg CO_2 eq./ 1 kg LW. Assuming a carcass yield of 52%, the farm produced 28.87 kg of CO_2 equivalents/ kg carcass at the farm gate in one year. This value is convergent with Cederberg et al., (2009) (28.2 kg). It is also in the value range (18.32 and 45.05 kg) found by Dick et al., (2014) for the Brazilian beef farms. The farm has no land use changes emissions. IPCC (2006) assumes a 20-year transition period following conversion over which all carbon losses are accounted for. The forestland conversion to pastureland happened 30 years ago. Moreover, little change in soil carbon is expected following the conversion of forests to grasslands (Houghton and Goodale, 2004).

Almost 100% of the farm emissions come from the internal activities (direct emissions). Only 0.035 kg CO_2 eq./1 kg LW is derived from indirect emissions i.e. due to production and transportation of inputs. Breaking the farm's direct GHG emission we found that animal enteric fermentation accounts for a larger share of farm GHG impacts (83%) (Figure 1).

Animal excreta accounts for 16% and combustion of fossil fuels (oil) represents only 1% of total GHG emissions. Therefore the two environmental critical issues to the farm performance are enteric fermentation and animal excreta.

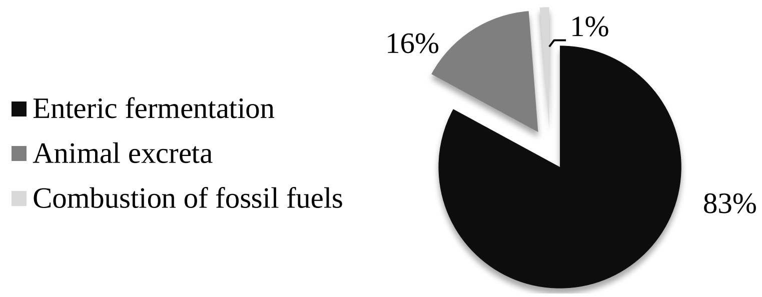

Figure 1: Share of direct greenhouses gas emissions of the typical farm's sources

Source: Author.

5. Discussion

The most important issues in the lack of profitability in the medium/long-run are the land opportunity cost and the livestock expenditures (Table 1). For the environmental emissions the main results reveal issues related to enteric fermentation and animal excreta (Figure 2). Furthermore, economic and environmental performances share the same kind of determinants – the low productivity of the animals and the land – that are major problems in Brazilian low input and extensive livestock farms. The low quality and quantity of food available associated with bad herd technical indices (high death rates, low pregnancy rates, low weight gain per day, low inputs) are the main determinants of farm low overall performance and productivity.

Thus, our results corroborate assertions from Reinhard et al., (2002); van Passel et al., (2007); Thomassen et al., (2009): farms' economic and environmental performances are not contradictory, in other words, win-win strategies can improve both performance. As these studies we also suggest that high animal productivity and efficient use of feed per kg product are important to provide farms economic and environmental performance. Better management practices and technical efficiency associated with an "ecological intensification" of the production system could help to improve both performances. This result agree with Bartl et al., (2011); Cederberg et al., (2009) and Dick et al., (2014) on the possibility of GHG reduction through productive increments, through both pasture management improvement and productive herd indices.

6. Conclusion

The results, for the Amazonian typical beef farm studied, reveal that the economic and environmental issues are not necessarily opposed. Otherwise, economic and environmental performances share the same kind of determinants – the low productivity of the animals and the land. Therefore, our results confirm our main hypothesis for this case study, that improvements in environmental and economic performances of a Brazilian extensive beef farm can be related by a win-win perspective. This study intended to contribute to a greater understanding of sustainability challenges of an Amazonian beef production system. Improving the number of typical farms studied and considering other environmental impacts on the performance's measures are key element to go further in this analysis. A challenging topic for the future is the consideration of positive externalities of farms i.e. carbon sequestration, sink of biodiversity and others.

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