The influence of circular agriculture on the financial performance of dairy farms in the Netherlands

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Abstract

Circular agriculture is a solution to the depletion of soil, water and raw materials and the increasing global temperatures. The objective of this study was to generate insight into the influence of circular agriculture on the financial performance of dairy farms. This insight can guide dairy farm management. Data from 238 Dutch dairy farmers were analysed with a linear regression, t-test and MANOVA. Circular farms had a higher margin than non-circular farms. Livestock sales, concentrate costs and transport costs were the main influencing factors. For all farms, a positive relationship was found between grazing and the margin, and between protein autonomy and the margin. A negative relationship was found between CO_2 emissions and the margin. Circular agriculture combines environmental and financial benefits by practising grazing, by optimizing the amount of concentrates fed as well as optimizing N and P-use efficiency at farm level.

Keywords: costs, circular dairy farming, financial performance, margin, sustainable agriculture

Introduction

In 2018, the Dutch Ministry of Agriculture, Nature and Food Quality (LNV), published a vision, 'Valuable and Connected', on transition to circular agriculture under the expectation that this transition would instigate more sustainable use of raw materials and meet society's desire for sustainable dairy farming. Stuiver and Verhoeven (2010) defined circular agriculture as the optimization of production with selective use of external inputs, long-term income generation and respect for natural systems. The transition to circular agriculture is hampered by legislation and regulations and an unclear revenue model (Maij *et al.*, 2019). Successful transition is expected to have a positive impact on the environment and society, but is it is important for farmers to know whether it is financially sound to proceed with the transition to circular agriculture. In addition, understanding which factors influence the financial performance can help improve farm management. The objective of this study is to generate insight into the influence of circular agriculture on the financial performance of dairy farms.

Materials and methods

This study used data from 238 anonymous Dutch dairy farms, all of which are clients of Dirksen Management Support (DMS) and mainly located in the centre of the Netherlands. The dataset contained the annual accountancy report and the Annual Nutrient Cycle Assessment (ANCA, Dutch: Kringloopwijzer) for 2019. The Life Cycle Analysis (LCA) regulations and the Product Environmental Foodprint Category Rules (PEFCR) apply to all calculations of the ANCA (Van Dijk *et al.*, 2019). This study defined circular agriculture based on the vision statement of the Ministry of Nature, Agriculture and Food Quality (2018), operationalized with values of the Milieukeur Foundation (SMK) (2020). SMK is a certification institute that develops, manages and tests sustainability criteria. The farms were divided into a circular and non-circular group based on the criteria of Table 1 that can be found in the ANCA. Only farms that complied with all the requirements of Table 1 were selected as circular farms.

The data were analysed with the programme RStudio version 3.6.2. Before the analysis, the data were checked for appropriateness given the type of analysis. A multiple linear regression provided insight into the

Table 1. Technical aspects defining circular farms.[1]

Technical aspects of circular farms	
Grazing	Yes
Protein autonomy (%)	≥50
CO_2 emission (g kg of milk^{-1})	≤1199
N soil surplus (kg ha^{-1})	≤150
Permanent grassland (% of farm area)	≥40
Renewable energy	Yes
Natural vegetation (% of farm area)	≥5
NH_3 emission (kg ha^{-1})	≤80

[1] All technical aspects have been adopted from the vision statement of the Ministry of Nature, Agriculture and Food Quality (2018) and the Milieukeur Foundation (2020).

Table 2. Fifteen independent financial parameters defining the financial performance of the farms.[1]

Financial parameters (€ 100 kg^{-1} FPCM)	
Milk sales	(Hire of) machinery
Livestock sales	Transport (fuel) costs
Other revenues	Livestock costs
Silage costs	Labour costs
Concentrate costs	Other costs
Fertilizer costs	Overhead
Crop protection costs	Margin
Purchased seed	

[1] The financial parameters are derived from Chen and Holden (2018) and March *et al.* (2017).

relationship between the margin and the technical aspects; for this analysis no division was made between circular and non-circular farms. After the multiple linear regression, the farms were divided into two groups. Farmers do not always correctly fill in the proportion of natural vegetation in the ANCA, as it is difficult to register and has little added value for farmers. The other parameters are considered to be reliable. As natural vegetation was therefore unlikely to be a reliable selection criterion, a population Y1 (of which circular farms n=9, non-circular farms n=229) with natural vegetation selection, and a population Y2 (of which circular farms n=39, non-circular farms n=199) without natural vegetation selection were made. A t-test provided insight into whether there was a difference between the margins of circular farms and non-circular farms for both populations. A Wilcoxon rank sum test with continuity correction was performed to reduce the effect of outliers. To substantiate any differences in the margins between circular and non-circular farms, a MANOVA was carried out with the parameters described in Table 2.

Results and discussion

The relationships between the margin and the technical aspects presented in Table 2 are shown in Table 3. Y1 showed no difference in the margin between circular and non-circular farms. When natural vegetation was not included as a selection criterion (Y2), there was a difference between the margin of circular and non-circular farms (P=0.006, Wilcoxon rank-sum test is performed). A MANOVA provided insight into which financial parameters contributed to the difference in the margin. For Y2, livestock sales (P=0.05), concentrate costs (P=0.003) and transport costs (P=0.05) contributed to differences in the margin. The study of Ma *et al.* (2022) also showed that lower feed costs and young livestock costs contribute to higher net profits in cooperative crop-livestock systems.

In this study, it is expected that feeding less concentrate contributes to the correlation between lower CO_2 emissions and a higher margin, since the amount of concentrate fed contributes largely to the amount of CO_2 emissions in the calculation methodology of the ANCA (Van Dijk *et al.* (2019). Circular farms showed management with a high milk production (>10,000 kg fat and protein corrected milk

Table 3. Multiple linear regression analysis between the margin and the technical aspects.[1]

Variable	Estimate	*T*-value	*P*-value
Intercept	1.002	0.261	0.794
Margin and grazing	0.013	2.554	0.011*
Margin and protein autonomy (%)	0.058	2.018	0.045*
Margin and CO_2 emissions (g kg milk^{-1})	-0.006	-2.380	0.018*
Margin and N soil surplus (kg ha^{-1})	0.002	0.340	0.735
Margin and permanent grassland (%)	-0.007	-0.554	0.580
Margin and renewable energy	0.007	0.895	0.372
Margin and natural vegetation (%)	0.009	0.169	0.866
Margin and NH_3 emission (kg ha^{-1})	0.022	0.821	0.412

[1] Multiple R^2=0.072, Adjusted R^2=0.040. * = (P<0.05).

(FPCM)) and higher N- and P-use efficiency at farm level than non-circular farms. This study analysed the data based on the definition of circular agriculture given by the Dutch government. The results are influenced by these selection criteria and the corrections that were carried out for (non-)circular farms. The results of this study apply to the Dutch definition of circular agriculture only. The research showed no difference in the margins when natural vegetation was included as a selection criterion. It should be noted that the size of the population of Y1 (n=9) made it more difficult to demonstrate effects. Many studies assume that farmers strive for maximum profit. However, they may be motivated by other aspects, for example the recognition of other farmers or animal welfare (Kristensen and Jakobsen, 2011).

Conclusions

Circular agriculture combines environmental and financial benefits by practising grazing, by optimizing the amount of concentrates fed, optimizing N- and P-use efficiency at farm level, as well as increasing farm efficiency (maximum output with optimal input and minimum waste). Circular agriculture results in a higher margin (selection on natural vegetation not taken into account) and contributes to the financial performance of Dutch dairy farms.

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