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Does animal welfare influence dairy farm efficiency? A two-stage approach

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ABSTRACT

This article investigated how process-based animal welfare indicators (PAI) affected the technical efficiency of German dairy farms. A sample of 115 North-Rhine Westphalian dairy farms was used to estimate their technical efficiency with data envelopment analysis. A censored regression model was then applied to quantify the effects of PAI on technical efficiency. The results indicated that in particular a higher percentage of cow losses, a higher replacement rate, and a longer calving interval had, at their respective mean, a negative marginal effect on the technical efficiency of the sample farms. In contrast, a lower age of first calving, a higher in-milk performance, and a higher somatic cell count were positively correlated with technical efficiency. Some of the PAI followed a polynomial trend (i.e., their influence on technical efficiency did not have a constant sign, and levels for minimum/maximum technical efficiency were present). The minimum efficiency score at constant returns to scale was obtained when farmers had cow losses of 0.4%, a calving interval of 430 d, and a cell count of 146,000 per milliliter. However, maximum technical efficiency was obtained at a milk yield of 9,796 kg per cow and year. The corresponding amounts in case of technical efficiency under variable returns to scale were at a similar level, except that milk yield showed a positive linear influence on technical efficiency. Moreover, technical efficiency under variable returns to scale was positively correlated with the fat content of milk. The lowest level of technical efficiency was reached at a fat content of 4.1%. Subsequently, we found that efficient dairy farms did not always correspond with recommended values concerning animal welfare criteria. Finally, the results showed that the assumption of a monotone effect direction of PAI on farm efficiency was inappropriate, and that this issue would need to be addressed in future research.

Key words: animal welfare, technical efficiency, dairy farm

INTRODUCTION

In the last decade, various approaches to cost accounting have been widely used to quantify and compare the performance of dairy farms (e.g., German Agricultural Society; DLG, 2004). In addition, the concept of efficiency has been a widely used tool to evaluate economic success (e.g., Latruffe et al., 2004; Chavas et al., 2005; Perrigot and Barros, 2008). In contrast to cost accounting, efficiency analysis takes the whole farming system into account, including nonmonetary inputs. Farrell's (1957) seminal paper distinguishes between technical and allocative efficiency. Whereas the former focuses on avoiding the wasting of resources in the production process, allocative efficiency considers given prices and production technology to establish whether an optimal combination of inputs and outputs is chosen. The main goal of efficiency analysis is to benchmark firms and designate those with the highest output/input ratio as efficient (Färe et al., 1985). Two methodologies are available to estimate efficiency: data envelopment analysis (**DEA**; a deterministic and nonparametric method) and stochastic frontier analysis (**SFA**; a stochastic parametric method; Meeusen and Van Den Broeck, 1977; Charnes et al., 1978). The advantage of DEA is that no assumptions about the functional form of the production frontier need to be made. The DEA models can also take account of constraints imposed by policy such as the milk quota in the European Union (Breustedt et al., 2011).

In addition to this type of economic performance assessment, animal welfare criteria are increasingly being used to evaluate agriculture production (Lusk and Norwood, 2011). Improvements in animal welfare are often used to justify to the public modern husbandry methods, new cattle housing, or increased natural yields. Hence, public awareness of animal welfare has increased (Curtis, 2007; Meyer zu Wehdel, 2011; Deutsche Agrarforschungsallianz, 2012). In the scientific literature, different definitions of, and associations with, the term animal welfare exist, and various ap-

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proaches for assessment are available (Botreau et al., 2007; Curtis, 2007). Curtis (2007) suggests a concept of animal welfare indicators based on the rationale that a gap between the potential and the observed production and reproductive performance indicates deficiencies in animal welfare. If animal-based indicators such as metabolic stress or the number of mastitis cases per cow are not available, standardized variables such as milk yield performance, cell count, or average economic lifetime of a herd are often used as proxies for animal welfare (Oltenacu and Broom, 2010).

In the economic performance evaluation of farms, such animal welfare criteria mostly play a subsidiary role (DLG, 2004). Exceptions are studies by Lawson et al. (2004a,b), Hansson and Öhlmér (2008), and Barnes et al. (2011), which all include at least one animal welfare criterion in their economic analysis. Lusk and Norwood (2011) point out, however, that the relationship between animal welfare criteria and production economics has been insufficiently explained in the scientific literature. Hence, it is necessary to systematically analyze the relationship between animal welfare indicators and economic success and quantify this relationship through adopting a broader approach.

The aim of the present study thus was to investigate the effect of animal welfare criteria on the technical efficiency of a sample of German dairy farms as a proxy for economic success by adopting a two-step procedure consisting of DEA and a censored regression. Because price data on some agricultural inputs (e.g., family labor) were not available, the term efficiency in the remainder of the paper always refers to technical efficiency.

MATERIALS AND METHODS

Study Design

Because all sample farms had their own heifer rearing operation, it was necessary to include both milk production and heifer rearing in the analysis. The farms were thus modeled with respect to an economic livestock balance sheet. As an analogy to the popular farm-gate balancing approach, we used the barn gate as system boundary. Specifically, the economic livestock balance sheet included all inputs used for milk production and heifer rearing. As a complement, all proceeds from milk production and heifer rearing were counted as output. Efficiency scores were estimated input-oriented, meaning that the maximum possible contraction of inputs was investigated under constant output. The reason for choosing this orientation was the EU milk quota regimen, which did not allow farms to increase their milk output. Input-oriented efficiency analysis is in this case tantamount to assuming that dairy farmers aim to minimize their production costs.

According to our economic livestock balance sheet, forage and concentrates, intermediates, labor, as well as depreciation were used as inputs. Forage contains all roughage (e.g., hay and straw) and feeds of high moisture content (e.g., silage). The costs of forage harvesting and conservation were not included. Intermediates consist of expenses for veterinarians, insemination, electricity, water, insurance, as well as imputed interest on working assets, buildings and milk quota, lease rents for milk quota, super levy payments, land and capital leasing rates, as well as overheads and maintenance costs. Labor encompassed both own and hired labor and was expressed in full-time equivalents. The capital input was accounted for by annual depreciation rates. Considering the milk quota as a production limit, the ECM quota was modeled as a nondiscretionary input variable. Total revenues as the model's output variable consisted of the produced milk quantity multiplied by the mean milk price, returns from slaughtered cows, as well as proceeds from heifer sales. Milk quantity and milk prices were recalculated into ECM equivalents, allowing us to control for differences in milk quality between farms. Direct payments linked to the production of milk and heifers (e.g., suckler cow premium) were also included in the output variable. Animal manure was not included because its output share, and thus its effect on efficiency, would be negligible (Gräfe, 2008).

Data

The data set is a balanced panel of specialized dairy farms from the state of North Rhine-Westphalia, Germany. The panel contained 575 observations, which encompassed 115 farms over a time period from financial year (**FY**) 2007/08 to FY 2011/12. In the calculations, we used 5-yr averages per farm to control for year effects such as varying prices or weather effects. The Chamber of Agriculture of North Rhine-Westphalia provided the data set, with the Chamber providing advisory services to the sample farms. All recorded accountings were in net values (i.e., without value-added tax). To compare and aggregate the observations among single FY, we inflated monetary inputs and outputs to the base FY 2011/12 by using price indices from the Federal Statistical Office (Statistisches Bundesamt, 2013). The ECM price was exempted thereof. Instead we used the mean milk price across all observed farms so as to not confound the results by differences in milk marketing success.

Table 1 presents the descriptive statistics for all variables that were used for the efficiency analysis. The average farm used 429 t of forage and 231 t of concen-