J. Dairy Sci. 97:3498–3508
http://dx.doi.org/10.3168/jds.2013-7444


# A stochastic frontier approach to study the relationship between gastrointestinal nematode infections and technical efficiency of dairy farms

**Mariska van der Voort,*†‡[1] Jef Van Meensel,* Ludwig Lauwers,*† Jozef Vercruysse,‡ Guido Van Huylenbroeck,† and Johannes Charlier‡**
*Social Sciences Unit, Institute for Agricultural and Fisheries Research (ILVO), Burg. Van Gansberghelaan 115, 9820 Merelbeke, Belgium
†Department of Agricultural Economics, Faculty of Bio-Engineering, Ghent University, Coupure Links 653, 9000 Ghent, Belgium
‡Department of Virology, Parasitology and Immunology, Faculty of Veterinary Medicine, Ghent University, Salisburylaan 133, 9820 Merelbeke, Belgium

## ABSTRACT

The impact of gastrointestinal (GI) nematode infections in dairy farming has traditionally been assessed using partial productivity indicators. But such approaches ignore the impact of infection on the performance of the whole farm. In this study, efficiency analysis was used to study the association of the GI nematode *Ostertagia ostertagi* on the technical efficiency of dairy farms. Five years of accountancy data were linked to GI nematode infection data gained from a longitudinal parasitic monitoring campaign. The level of exposure to GI nematodes was based on bulk-tank milk ELISA tests, which measure the antibodies to *O. ostertagi* and was expressed as an optical density ratio (ODR). Two unbalanced data panels were created for the period 2006 to 2010. The first data panel contained 198 observations from the Belgian Farm Accountancy Data Network (Brussels, Belgium) and the second contained 622 observations from the Boerenbond Flemish farmers' union (Leuven, Belgium) accountancy system (Tiber Farm Accounting System). We used the stochastic frontier analysis approach and defined inefficiency effect models specified with the Cobb-Douglas and transcendental logarithmic (Translog) functional form. To assess the efficiency scores, milk production was considered as the main output variable. Six input variables were used: concentrates, roughage, pasture, number of dairy cows, animal health costs, and labor. The ODR of each individual farm served as an explanatory variable of inefficiency. An increase in the level of exposure to GI nematodes was associated with a decrease in technical efficiency. Exposure to GI nematodes constrains the productivity of pasture, health, and labor but does not cause inefficiency in the use of concentrates, roughage, and dairy cows. Lowering the level of infection in the interquartile range (0.271 ODR) was associated with an average milk production increase of 27, 19, and 9 L/cow per year for Farm Accountancy Data Network farms and 63, 49, and 23 L/cow per year for Tiber Farm Accounting System farms in the low- (0–90), medium- (90–95), and high- (95–99) efficiency score groups, respectively. The potential milk increase associated with reducing the level of infection was higher for highly efficient farms (6.7% of the total possible milk increase when becoming fully technically efficient) than for less efficient farms (3.8% of the total possible milk increase when becoming fully technically efficient).
**Key words:** *Ostertagia ostertagi*, stochastic frontier analysis, technical efficiency, animal health economics

## INTRODUCTION

Volatile milk prices and an upward trend in production costs put pressure on dairy farmers' incomes (Thornton, 2010). Subtle changes in production efficiency can make the difference between profit and loss. Efficient dairy farming with an optimal management of inputs such as stock, feed, and labor has, therefore, become increasingly important (Kelly et al., 2013). Optimal management also requires taking care of animal health conditions, as these conditions may affect the economic performance of farms. This paper uses efficiency analysis to study the impact of gastrointestinal (**GI**) nematode infections on the technical efficiency of dairy farms.

*Ostertagia ostertagi* and *Cooperia oncophora* are considered to be the most important GI nematode species in dairy cattle in temperate climate regions (Charlier et al., 2011; Sargison, 2011). Although GI nematode infections generally stay at a subclinical level, they can be responsible for decreased feed intake and reduced milk production and fertility (Forbes et al., 2004; Charlier et al., 2009a; Delafosse, 2013). Research addressing the impact of GI nematode infections and related prevention strategies traditionally focuses on the effect on particular technical key performance indicators, such as

Received August 29, 2013.
Accepted February 12, 2014.
[1]Corresponding author: mariska.vandervoort@ilvo.vlaanderen.be

daily weight gain and average milk yield per cow. Knowing the effects on these key performance indicators is useful (Charlier et al., 2012a,b) because they are often correlated with the aggregate economic performance of dairy farms (Bandyopadhyay et al., 2010). But an important drawback of this approach is that the key performance indicators are mostly partial measures of productivity. They do not represent the overall input-output transformation on dairy farms and, thus, the effect on the overall performance of the farm remains unclear (Van Meensel et al., 2010b).

Efficiency analysis can be used to analyze the impact of animal diseases on the performance of the whole farm (van der Voort et al., 2013). The approach is based on production theory, which studies the transformation of input(s) into output(s). Efficiency analysis bundles partial productivities into an aggregate performance measure. The advantage of efficiency analysis is the identification of performance benchmarks, which allow calculation of the farm-specific performance levels and optimization paths. Despite its frequent use in management science, efficiency analysis has not often been applied in animal health sciences. Methods for efficiency analysis evolve quickly. Today, numerous deterministic and stochastic approaches are available (Cook and Seiford, 2009; Darku et al., 2013; Liu et al., 2013). The growing interest in incorporating noneconomic factors in productive efficiency models has resulted in some studies that introduce animal health factors into efficiency analysis (e.g., Lawson et al., 2004a; Van Meensel et al., 2010a; Barnes et al., 2011).

The objective of this study was to analyze the relationship between GI nematode infection in dairy cattle and the technical efficiency level of dairy farms. We investigated to what extent the exposure to GI nematodes affects the transformation of inputs(s) into output(s) on dairy farms. We applied 2 functional forms of the production function, representing the input-output transformation, to study which model is best to frame the relationship between infection and efficiency.

## MATERIALS AND METHODS

### Data

To study the effect of animal health parameters on farm economics, it is essential to merge 2 (usually independently monitored) data sources. In our case, we used farm accounting data and animal health parameters. Here, the animal health parameter of interest was infection with the abomasal dwelling nematode *Ostertagia ostertagi*. The source of infection data was a yearly parasitic monitoring campaign, with sampling performed from 2006 to 2010 (Bennema et al., 2009). In that campaign, the cows' exposure to GI nematodes was monitored using the antibody detection *O. ostertagi* ELISA (SVANOVIR *O. ostertagi*-Ab; Boehringer Ingelheim Svanova, Uppsala, Sweden) applied to bulk-tank milk as described by Charlier et al. (2009b). The test results of antibody detection serve to measure the antibodies to *O. ostertagi* and use optical density ratio (**ODR**) as a unit of measure. This provides an indication of the level of exposure of a herd to GI nematodes (Charlier et al., 2009a).

Farm accountancy data used in this study were collected from 2 networks: the Belgian Farm Accountancy Data Network (**FADN**, Brussels, Belgium) and the Tiber Farm Accounting System (**TFAS**) of Boerenbond (Leuven, Belgium), a Flemish farmers' union. The FADN data are based on a stratified sample and are representative for Flanders (De Becker, 2007), whereas the TFAS sample is based on voluntary participation in the farm-economic accounting system of Boerenbond. When farms from FADN or TFAS were also present in the infection data set, they were included in our study. As FADN and TFAS do not apply the same accounting principles, data from these 2 sources could not be included in 1 sample. Therefore, we constructed 2 data samples that linked FADN and TFAS data to the parasitic information. The final data sets were constructed using several inclusion criteria. First, individual farm data from at least 2 consecutive years had to be present to construct a panel data set. Second, farms with input variables equal to 0 were excluded. Third, 1 FADN farm in the year 2009 was considered as an outlier. It was deleted from the data set because in the year 2009, this farm doubled in size and almost tripled its input use. This could also be empirically observed: compared with the other farms in the sample, this farm had a deviated input/output use.

The final data sets consisted of technical, economic, and parasitic farm data of 50 FADN and 152 TFAS dairy farms. As data were not available for each farm for each year during the period 2006 to 2010, we constructed unbalanced data panels consisting of 198 FADN and 622 TFAS observations.

### Efficiency Analysis

Efficiency analysis is based on production theory. It compares the current performance level of a farm with the potential optimal performance level by determining a production frontier (Farrell, 1957). The production frontier represents the fully technically efficient transformation of input(s), such as feed or labor, into output(s), such as milk or meat, in the dairy farm industry at a particular point in time. Farms situated on (or close to) this frontier achieve the best technical