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Dairy farming on permanent grassland: Can it keep up?

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ABSTRACT

Based on an extensive data set for southern Germany, we compared the productive performance of dairy farms that operate solely on permanent grassland and dairy farms using fodder crops from arable land. We allowed for heterogeneous production technologies and identified more intensive and extensive production systems for both types of farms, whereby we based our notion of intensive versus extensive dairy production on differences in stocking density and milk yield per cow and year. To be able to compare the productivity levels and productivity developments of the various groups of farms, we developed a group- and chain-linked multilateral productivity index. We also analyzed how technical change, technical efficiency change, and a scale change effect contribute to productivity growth between the years 2000 and 2008. Our results revealed that permanent grassland farms can generally keep up with fodder-crop farms, even in an intensive production setting. However, extensively operating farms, especially those on permanent grassland, significantly lag behind in productivity and productivity change and run the risk of losing ground.
Key words: dairy farm, permanent grassland, total factor productivity, stochastic production frontier

INTRODUCTION

In addition to being an important basis for agricultural production, grasslands provide a variety of essential environmental and social benefits. For instance, grasslands act as a carbon sink (Soussana et al., 2007) and generally ensure a high level of biodiversity because they provide habitats for flora and fauna (Pflimlin and Poux, 2005). The preservation of ground and surface water quality and the provision of an attractive environment for recreational activities and tourism are additional benefits (e.g., Peeters, 2009; Prochnow et al., 2009; Sanderson et al., 2012). Hence, the preservation of permanent grassland is an important topic in the agricultural conservation policy of the United States and the European Union. The US Grassland Reserve Program was established as part of the 2002 Farm Bill and is one example for these efforts (USDA, 2013). In the European Union, several agri-environmental programs contain grassland protection elements. In addition, plans exist to strengthen legislation that prevents the conversion of grassland to arable land as part of the greening strategy of the 2013 reform of the Common Agricultural Policy (European Commission, 2013). The productive potential of permanent grassland can be exploited only by ruminants and, with some limitations, biogas plants. Hence, dairy farming plays the key role in agricultural production in many grassland regions. In the European heartland, the regions with agricultural production based solely on permanent grassland are generally found in elevated and mountainous areas (e.g., in the surroundings of the Alps and the Massif Central). Dairy farms in these areas often face some natural disadvantages. Most notably, the cultivation of fodder crops, such as corn silage, is not feasible because of comparably high precipitation, lower average annual temperature, and a shorter vegetation period (Meisser and Wyss, 1998; Hein, 2002). The relatively low energy yield per hectare of permanent grassland compared with corn silage illustrates these circumstances effectively. In 2010, the numbers varied between 42 to 67 GJ of NE_L/ha for grass silage and 87 to 110 GJ of NE_L/ha for corn silage for dairy farms in Bavaria (LfL, 2012). Moreover, Thaysen et al. (2010) show that the disadvantage of grassland regarding the energy content of the forage increases over time. Analyzing data from northern Germany between 1985 and 2008, they found an average annual increase in NE_L yield of approximately 1 GJ/ha per year for corn silage compared with only approximately 0.45 GJ/ha per year for grass silage. Nevertheless, grassland dairy farmers have to compete with farmers growing fodder crops on arable land because in most cases they act in the same markets. First, the distances to the more favorable areas are minor. Referring to the zones of ruminant rearing systems in Europe identified by Pflimlin et al. (2005), we find areas labeled as “arable land and livestock regions” and “forage crop regions with temporary grassland plus corn” in close proximity to the permanent grassland regions

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in parts of Austria, Switzerland, southern Germany, and the eastern part of France. Second, the produced milk is not promoted to generate higher farm prices in many cases (for example, as "mountain or hay milk"). However, certain approaches in the marketing of these products can be observed (e.g., the promotion of high-quality cheese in the context of a protected designation of origin). Given the ongoing market liberalization in the dairy sector and the latest farm-price fluctuations, serious concerns exist (e.g., Hopkins, 2011) as to whether dairy farms that operate solely on permanent grassland can compete with farms that use arable land to produce fodder crops.

The objective of this paper was to measure the levels and growth rates of total factor productivity (**TFP**) of dairy farms in Bavaria and examine whether grassland dairy farms are able to keep up with their fodder-crop counterparts in terms of productive performance. If dairy farming in permanent grassland areas is getting less productive compared with areas with arable land, either agricultural production will be abandoned in these regions or payments directed toward these areas (e.g., less-favored area payments) have to increase over time. MacDonald et al. (2000) discussed some of the undesirable effects agricultural abandonment in mountainous regions can have on environmental parameters (e.g., reductions in biodiversity and landscape quality).

In general, when comparing the productivity of various groups of farms (e.g., organic vs. conventional, intensive vs. extensive, irrigated vs. rain fed, and country A vs. country B) it is important to have information on both the difference in absolute productivity levels and the differences in productivity growth. Only the combination of these components can give a full picture of the present and future performance of one group compared with another. Nevertheless, many studies on the performance of groups of dairy farms concentrate on differences in the TFP growth rates and its decomposition; examples are Brümmer et al. (2002) for the dairy sector in various European Union countries, Newman and Matthews (2006) for specialist versus "other" dairy farms, and more recently, Ma et al. (2012) for dairy farms of various size classes. We followed this strand of the literature and calculated TFP growth. Using the generalized Malmquist productivity index described by Orea (2002), we decomposed productivity growth into technical change, technical efficiency change, and a scale change effect. However, this procedure was not enough to fully answer our research question. Two groups can have equal growth rates, and yet one of them may be much less productive. Likewise, 2 groups can be equally productive at a point in time and still drift apart over time because of very different growth rates. To get a full picture of what is going on in this sector, we needed to map the TFP levels of both groups over time. To do this, we provided a group- and chain-linked multilateral productivity index based on the indices first introduced by Caves et al. (1982) and refined by Good et al. (1997).

MATERIALS AND METHODS

Empirical Model

To model the multi-input, multi-output technology of agricultural production, we use a parametric output-oriented distance function $D^O(\mathbf{x}, \mathbf{y}, t)$, where D^O is the output-oriented distance function, $\mathbf{x}$ refers to a nonnegative vector of inputs used to produce a nonnegative vector of outputs $\mathbf{y}$ in time period t. See Färe and Primont (1995) for the theoretical derivation of the distance function and its properties. We chose output orientation because we assumed that the farms in our sample were less flexible in the adjustment of their inputs than their outputs. Labor input, which predominantly consists of family workforce, is one example for a rather inflexible input. Breustedt et al. (2011) also noted the low flexibility of the inputs of labor and land in Bavarian dairy farming. Contrariwise, although the aggregated amount of milk is limited by the quota system, the very well-established quota trading system in Germany ensures unrestricted output at the single-farm level. Hence, we argue that farmers decide on a set of short-term inflexible inputs for a given year and aim to obtain the maximum output from those inputs. Our assumptions are in line with Brümmer et al. (2002), Newman and Matthews (2007), and Emvalomatis (2012) who also chose output-orientated distance functions as representations of production technologies for dairy farms in various European Union countries.

We used a flexible translog functional form to limit a priori restrictions on the relationships among inputs and outputs (Morrison Paul et al., 2000; Karagiannis et al., 2004). Hence,

$$\ln D_{it}^{O}(\mathbf{y},\mathbf{x},t) = \alpha_0 + \sum_{m=1}^{M}\alpha_m \ln y_{mit} + \sum_{k=1}^{K}\beta_k \ln x_{kit} + \frac{1}{2}\sum_{m=1}^{M}\sum_{n=1}^{M}\alpha_{mn} \ln y_{mit} \ln y_{nit} + \frac{1}{2}\sum_{k=1}^{K}\sum_{j=1}^{K}\beta_{kj} \ln x_{kit} \ln x_{jit} + \sum_{m=1}^{M}\sum_{k=1}^{K}\delta_{mk} \ln y_{mit} \ln x_{kit} + \tau_1 t + \frac{1}{2}\tau_2 t^2 + \sum_{m=1}^{M}\zeta_{mt}\, t \ln y_{mit} + \sum_{k=1}^{K}\theta_{kt}\, t \ln x_{kit}. \quad [1]$$

In Equation [1], the subscripts $i = 1, 2, \ldots, N$ and $t = 1, 2, \ldots, T$ denote individual farms and time