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Low-input dairy farming in Europe: Exploring a context-specific notion

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A R T I C L E I N F O

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A B S T R A C T

Frequently acknowledged as coming forward to environmental issues by reducing external input use, low input (LI) dairy farming is gaining attention. The absence of a clearly delineated description of LI dairying, however, hampers identification and analysis of these farming systems. This paper aims at empirically examining, EU wide, the farm structure, production intensity and productivity of LI with respect to their high input (HI) conventional counterpart and to organic dairying (ORG). A pragmatic quartiles-based categorization of farms from the Farm Accountancy Data Network of 20 important EU dairy countries, with the value of external input costs per grazing livestock unit (GLU) is used as prior discriminating indicator between LI and HI. LI dairy farms are smaller than HI dairy farms, in particular when farm size is expressed as total farm capital. Other variables that differentiate between LI and HI in most countries are number of dairy cows per GLU and area of forage and grassland on total agricultural area. Partial productivities in HI farms exceed those in LI farms, most apparent is milk production per cow. Differentiation of forage production between LI and HI is less uniform throughout Europe. A pairwise matching of differentiation profiles between countries indicates that differentiation between LI and HI is country specific. A similar diversity in country-specific differentiation between ORG and LI farming is found.

1. Introduction

Interest in 'low input' (**LI**) agriculture in general, and LI dairy farming in particular, emerged after recognition that during the last decades, a shift occurred towards intensification, driven by the introduction of land and labour saving technologies. Gains in economic efficiency of milk production across Europe were realised through an increased use of external inputs. Intensification led to partial productivity increases per unit of land, per livestock unit and per labour unit. However, intensification also led to negative environmental impacts in terms of pollution of water, soil and air and damage to certain ecosystems (Poiret, 1999; Pau Vall and Vidal, 1999). High input use, in particular, external inputs originating from outside the farm, are often seen as the major cause for wider environmental problems and loss of farmland biodiversity (Boatman et al., 1999; Wadsworth et al., 2003; Buckwell and Armstrong-Brown, 2004).

Development of LI and analysis of actions towards effective reduction of external resources (through policy measures or farm strategies) warrants adequate benchmarks and workable definitions to identify LI farms. While organic farming is clearly defined and legally regulated (EC Regulation 834/2007), the concept of LI farming is not commonly defined (Poux, 2007). While some approaches focus on the level of purchased inputs (intensity), others focus on the nature of the inputs, on the output level (productivity), or on management practices. Some approaches led to categorization, such as Butler et al. (2008) who made a distinction between conventional high input farms, organically certified LI farms, and non-organically certified LI farms in the UK, based on feeding and production strategies. However, an approach relying on management practices might be difficult since strategies to shift towards less off-farm inputs might vary a lot across Europe as European dairy farming systems operate over a wide range of environments. This wide range in farming practices and environmental context across Europe might partly explain why LI is defined or conceptualized in different ways. Nevertheless, analysis of LI across regions or nations needs a simple and workable approach, for example, to take profit from databases such as the Farm Accountancy Data Network (**FADN**), as the primary agri-economic database within Europe.

The objective of the paper is to clarify the fuzzy notion of LI dairy farming across Europe by using an approach that can benefit from information in existing databases and is generic enough to be applied

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across regions with different dairy farm types. Exploring the variability across European dairy farms according to their input use is achieved by a quartiles-based categorization based on external input use intensity at the whole farm level. Although this pragmatic categorization cannot stand for a definition as such, it is a step towards further identification of possible differentiating variables of high versus LI farms within and across a set of 20 important EU dairy countries. Variables included in the analysis involve farm structural data (related to farm size and organization of production factors), production intensity and partial productivity. Finally, the categorization is used to assess the question of how LI conventional farms correspond with organic farms.

The paper is structured as follows: Based on a short literature review on LI farming and on a proposed production-theoretic framework, the need for a pragmatic approach to characterize LI dairy farms is demonstrated. The method section reflects on the choice of the prior discriminating indicator to explore variability among holdings in the level of inputs used; examines the motivation behind the quartiles-based categorization and the statistical analysis is given. The results section comprises a description of those farm structure, intensity and productivity values that distinguish LI and HI from each other, and then provides further results to assess differentiation profiles of LI. The discussion mainly concerns the sensitivity of results to prior choices and market circumstances before deriving robust conclusions.

1.1. LI, a fuzzy sustainability concept

As mentioned earlier, there is no official nor formal definition of LI farming systems, at least not in the sense of the legal regulation of organic farming. Each definition remains fuzzy in one or more ways, which leaves it open to debate and provides difficulties to identify LI farms in practice. This 'fuzziness' is mainly due to the absence of a comprehensive understanding on the motivation behind reducing external input use. Farmers may be driven by environmental concerns. But besides these environmental concerns, economic motives in order to cope with the increasing prices of external inputs might as well motivate farmers to use less external inputs. In more extreme situations, such as regions with vulnerable landscapes, semi-natural habitats and suboptimal land, LI dairying is the only alternative (Strijker, 2005). Depending on the motivation behind input reduction, different levels of reduction will be achieved, different strategies will be followed with varying environmental benefits as a result. These strategies might be categorized according to the efficiency-substitution-redesign (ESR) framework as a conceptual framework for the transition to sustainable agriculture (Hill and MacRae, 1995). Efficiency refers to actions to increase the efficiency of conventional practices in order to reduce the quantity of external inputs without reducing farm dependence on external inputs. Actions to replace external inputs by more environmentally benign alternatives refers to substitution while redesign warrants a more holistic approach to create a system building on a new set of ecological processes (Bellon et al., 2010).

An important starting point to illustrate the absence of a comprehensive understanding on LI, is the overall approach of Parr et al. (1990) who stated that LI systems are those that "*seek to optimize the management and use of internal production inputs (i.e. on-farm resources) … and to minimize the use of production inputs (i.e. off-farm resources), such as purchased fertilizers and pesticides, wherever and whenever feasible and practicable, to lower production costs, to avoid pollution of surface and groundwater, to reduce pesticide residues in food, to reduce a farmer's overall risk, and to increase both short –and long term farm profitability*." This approach stresses on management, so on deliberate choices, to rely on internal instead of external inputs, with a broad range of management steering objectives such as costs and risk reduction, decrease of environmental burden and increase of profitability. This definition has been subject of debate because it might be applicable to management strategies improving efficiency and/or substitution approaches as well as holistic approaches to redesign the farming system, just depending on what is meant by 'optimizing' and 'minimizing' the inputs (Norman et al., 1997; Poux, 2007). Poux (2007) made the link with the output level by stating that: "*Compared to farming systems heavily relying on off-farm bought inputs (thus high input farming systems), low-input farming systems will have a physical productivity limited by the maximum on-farm resources that can be mobilized. Low-input farming systems can then be associated with lower output.*"

Other authors do acknowledge that the impact of 'LI farming' on the environment is not only depending on the level of 'low' in 'LI' and on the 'input(s)' itself, but also on the efficacy of the inputs used (Viaux, 2008). They stress the urgency of system redesign, in which optimal contribution of external input reduction to environmental problems is achieved by "*capitalizing as fully as possible on the natural resources used, and by maximising natural control processes*" (Viaux, 2008). In summary, literature provides some anchor points on the concept of LI but also shows that LI is approached differently according to its underlying motivations and management strategies to attain them. Our objective is not to state which one of the approaches is better or worse, but to give insights in how dairy farms characterized by low input use differ from farms that relatively use more inputs and how this differentiating profile differs across Europe.

1.2. Production-theoretical framework

Reasoning based on a production-theoretic framework motivates why identifying LI farms succeeding in lowering input use while maintaining profitability and reducing negative externalities, warrants full understanding of the functioning of the farming system. Fig. 1 illustrates three production response curves (LL′, MM′, HH′), in which the amount of milk produced, varies with the amount of concentrates given. These production response curves, as illustrative examples, are chosen in order to demonstrate how various farming systems react differently on varying level of external inputs, here concentrates. The production response curves correspond to different production technologies: 'high input technology' (**HIT**), 'medium input technology' (**MIT**) and 'low input technology' (**LIT**). These technologies differ with respect to the cows, their theoretical milk production, their ration and stocking rate (details as Supplementary material). By use of the MilkBot® lactation model (Ehrlich, 2011), we estimated lactation curves for each production technology (HIT, MIT, LIT). These lactation curves were used to estimate yearly milk production with varying kg concentrates on a yearly basis. This way, we generated for each production technology a series of data points to picture the milk production (L/year) with different amounts of concentrates given (kg/year). Subsequently, a Cobb Douglas function was fitted through these points. The production response curve MM′ corresponds to the following Cobb Douglas mathematical function:

$$\ln(Y) = a + b*\ln(X) \quad (1)$$

with: Y = milk production per cow per year (L), X = concentrate use per cow per year (kg).

For the MIT, the parameters were a = 7.49 and b = 0.175. For the HIT (HH′), these parameters were 7.66 and 0.176 for a and b respectively. Assuming a combination of production factors with lower production potential (LIT), yielded a = 8.52 and b = 0.027 in formula (1). According to the law of diminishing returns, the increase in milk production diminishes to a level that its value does no longer compensate for the costs of the additional input (MIT_{opt}), which is the optimum from an economic point of view (Rasmussen, 2012). With a milk price of 0.30€/L and a concentrate price of 0.25€/kg, the economic optimum (MIT_{opt}) corresponds to a concentrate use of 1300 kg/cow/year and a production of 6257 L of milk/cow/year. Reducing concentrate use to an amount of 350 kg (MIT_{350}) deviates substantially from the optimum. Similar optima can be derived on the LL′ and the HH′ curves and deviations from optima through lower input use can be shown. A concentrate use of 350 kg/cow/year on the high input technology curve