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Influence of milk yield on profitability—A quantile regression analysis

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ABSTRACT

This paper analyzes the factors that influence the economic success of Swiss dairy farms, as measured by the annual income per family work unit, using panel data regression techniques. Based on more than 5,400 farm-year observations, the main focus of the analysis concerns the milk yield per cow and year as the key explanatory variable, which can be adjusted by the farm manager in the medium term. We apply both a random effects model and a quantile regression based on deciles, which allows us to study the heterogeneity of the sample in greater detail. Consistent with the current literature, the random effects model shows the positive contribution of the milk yield, namely an additional 1,000 kg/cow results in an increase of CHF 2,660; that is, 6% of the annual income. The quantile regression reveals that the effect of the milk yield differs between deciles, with a high milk yield being most beneficial for the best-performing farms, accounting for up to CHF 7,210 per 1,000 kg. Our analysis further shows the influence of the milk yield on profitability to be highly heterogeneous among Swiss dairy farms, indicating business-specific extension services and not suggesting the requirement for an increased milk yield at each level of economic success.
Key words: milk yield, quantile regression, Switzerland, economic performance

INTRODUCTION

Besides cattle genetics, breeding objectives, and feed composition, milk yield is a key factor for milk production systems. A higher milk yield is usually associated with more intensive production (i.e., higher gross margins per area), but also higher costs (e.g., of concentrate input; Nix, 2015). As a farm manager can adjust the milk yield in the medium term, its influence on a farm's economic success is often analyzed. It is generally considered positive, even based on different success indicators. According to Vandehaar (1998), a positive relation between the milk yield and profitability persists to very high levels of production for US dairy farms. Winsten et al. (2000) found milk produced per cow to positively affect the profitability of Northeastern US dairy farms (for confinement feeding, management-intensive grazing, and mixed production systems), as did Ford and Shonkwiler (1994) for milk sold per cow in relation to the net income of Pennsylvania dairy farms; 2 further studies (Kauffman and Tauer, 1986; Gloy et al., 2002) found similar results for milk yield with respect to return on assets of New York dairy farms. Using the production costs for 1 kg of milk as an economic indicator for Swiss combined dairy and arable crop farms, Hoop et al. (2015) found that milk yield per cow reduces costs. All mentioned analyses focused on mean value regression, not the entire distribution of economic performance.

Doole and Kingwell (2015) studied ecologically constrained profit maximization for New Zealand dairy farms, based on optimization, not an econometric analysis. They predicted a nonlinear concave dependence of farm profit on milk yield not borne out by the previously mentioned econometric models. Macdonald et al. (2011) found either a linear or a quadratic effect of stocking density on operating profit for New Zealand dairy farms, depending on the milk pricing system.

Economic success of Swiss dairy farms is highly heterogeneous. In 2014, the mean income per family work unit (**FWU**) of the lowest performing quarter was CHF 14,200, that of the highest quarter CHF 70,000, or 5 times more (Dux et al., 2016).

In contrast to mean value regression, quantile regression (**QR**) allows for the analysis of different levels, or the distribution, of a dependent variable. Hence, we expect QR to shed light on potential nonlinear effects of the explanatory variables and better explain the heterogeneity of dairy farms' economic success. Quantile regression has been used in farm management research before (Chidmi et al., 2011; El Osta, 2011; Bakucs et al., 2013; Khanal and Mishra, 2016; Tauer, 2016; Hadrich et al., 2017).

In the present paper, we examined the influence of the milk yield, among other independent variables, on a

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dairy farm's economic success by a 2-fold analysis, comparing a random effects model based on mean values with a panel-based QR. To our knowledge, such a comparison has not previously been used in the literature; similar studies analyzed technical efficiency or relied on single years and variables less focused on production (Chidmi et al., 2011; Hadrich et al., 2017). Our approach will determine whether the use of QR provides additional insights.

We addressed 2 additional issues. First, we established concentrate input as a relevant determinant in our analysis, reflecting its increased use in Swiss milk production over the last decade (Erdin and Giuliani, 2011). Second, we addressed education in a wider context than prior studies. Besides the educational level of the farm manager and his or her partner, we distinguish education in agriculture, facility management, and other industrial sectors.

MATERIALS AND METHODS

Data Source

We based our analysis on information obtained from the Swiss Farm Accountancy Data Network (**FADN**), which annually retrieves data from more than 3,000 farm operations to assess the economic situation of Swiss agriculture. The data concerning each farm were provided based on operational accounting using direct costing. We focused on specialized dairy farms between 2010 and 2014. During this period, no significant changes in Swiss agricultural policy took place that affected this type of farm. The resulting panel data set is an unbalanced panel consisting of 5,459 observations split between 1,832 farms, with an average of 3 observations per farm over the time period considered. A quarter of the reported farms had either 1 or 5 observations, while the remaining half of the farms was relatively evenly split between 2, 3, and 4 yr of observations.

Dependent Variable: Annual Income per FWU as a Measure of Economic Performance

The net farm income comprises the remuneration of the family's own labor and capital and is key indicator for economic success for farms mainly operated by family members. Mishra and Morehart (2001) considered operators' labor and management income to be an indicator of the longer-term survival of a farm. Moreover, as the composition of own labor and capital differs among dairy farms, net farm income is of limited suitability as a dependent variable for our analysis. As a consequence, a decomposition of farm income was carried out by deducting the opportunity costs (i.e., the interest rate of federal term bonds) for the remuneration of own capital, which also includes the family owned land. Subsequently, we divide by the number of FWU yielding the annual income per FWU. As in Roesch (2015), this figure is used as a dependent variable. Based on current opportunity costs, the remuneration of labor is 24 times the remuneration of capital (Lips and Gazzarin, 2016) for Swiss farms, underlining the importance of the annual income per FWU.

Key information about the sample is provided in Table 1, including information about the mean values of the decile intervals ordered by the annual income per FWU. For example, if each year comprised 100 observations, the value underneath the third decile would be the mean value of the respective variables attached to the 21st to the 30th largest observations of the income per FWU [e.g., the number of livestock units (**LU**) attached to those income figures] for each year of the period 2010 to 2014.

On average, a dairy farm features 30.3 LU and 23.1 ha of utilized agricultural area. The average milk yield per cow and year was 6,410 kg, whereas the annual income of a FWU amounts to CHF 42,800 with an average number of 1.33 FWU on a dairy farm (The average exchange rates for 2016 were CHF 1 = €0.86 = $1.01; https://data.snb.ch). Total farm assets average 853 kCHF and equity tied to own land 75 kCHF (computed as equity capital times the ratio of the value of own land divided by all farm assets). If the decile intervals were ordered according to the annual income, all the discussed variables except FWU—milk yield, agricultural area, number of livestock units, total farm assets, and equity tied to own land—showed an increasing tendency; that is, for 3 out of 10 occasions, the subsequent quantile mean is allowed to be smaller than the preceding one.

Choice of Explanatory Variables and Hypotheses

Based on the prior literature, we formulated hypotheses and defined 6 sets of variables that were used to explain the economic performance of Swiss dairy farms, as measured by the annual income per FWU. Swiss FADN data contained several hundred time series, so we had to rely on the literature to narrow down our set of variables.

The first set of regional dummies (set **R**; 7 variables) based on cantons (Switzerland consists of 26 which are comparable to districts) comprises the location of the farm within 1 of Switzerland's 7 macroregions (i.e., southwestern Switzerland, i.e., Geneva, Vaud, and Valais; "Espace Mittelland," i.e., Berne, Solothurn, Fribourg, Neuchâtel, and Jura; Northwestern Switzerland, i.e., 2 half-cantons of Basel and Aargau; Zurich; eastern