# Strategies Regarding Input Use on Dairy Farms in Austria - Results of a Cluster and Matching Analysis

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## Abstract

In order to increase competitiveness of their farms, dairy farmers select certain strategies regarding input use. We identify these strategies in an agricultural bookkeeping dataset and assess economic impacts of the strategy selection under volatile prices situations using cluster analysis and direct covariates matching. We find one low-input cluster with low levels of input use and three clusters with rather higher input levels. Those clusters differ in site conditions, farm size and milk production but have similar farm income. Furthermore the results indicate that low-input farms are competitive under volatile markets.

**Keywords**: Dairy Farming, Farm Competitiveness, Farm Strategies, Cluster Analysis, Matching Method

## 1. Introduction

Due to the high share of grassland and quite good natural site conditions dairy farming plays a major role in Austrian agriculture. Dairy farms are often small and plot structure is scattered, so profitability tends to be low. However, from the societal point of view dairy production goes beyond pure milk production, but contributes to maintain touristic and ecologically valuable areas as well as to increase welfare in rural areas. Consequently, maintaining dairy farms is an important goal of Austrian agrarian policy. But, as public payments will get reduced and milk quota will be abolished, market influence and farm competiveness will gain in importance. A decisive factor for the competiveness of farms is their size. Complementary to several international studies (Schmitt, 1988; Inderhees, 2007; Schaper et al., 2011) Kirner and Kratochvil (2006) show the extraordinary importance of this factor also for Austrian dairy farms. Next to farm size, also natural site conditions the availability of capital and labour might influence the competitiveness of farm holdings (cf.eg. Kirner and Gazzarin, 2007; Bronsema, 2013). Apart from these structural factors farmer's management skills, his attitudes such as openness for innovation and risk tolerance as well as economic strategies are relevant for farm competiveness (Schaper et al., 2011).

In this paper we concentrate on analysing farm strategies which focus on input use in Austrian dairy farming. High-input strategies are nowadays very conventional in Austrian dairy farming, since many farmers try to maximise profit by a high turnover. On the other hand low-input strategies try to achieve high profits by minimizing costs through low inputs in dairy faming, even if revenues are small. Volatile input and output prices might influence the competitiveness of farms of those strategies differently. In order to detect strategies in the Austrian dairy farming sector we use bookkeeping data and the cluster analysis to identify homogenous farm groups regarding use of inputs. Furthermore we measure the influence of choosing a low-input strategy on farm competitiveness. To do so we control for other factors like farm size and site conditions using the matching method. Our paper is structured as follows: Chapter 2 displays the applied methodology as well as the used data basis. In chapter 3 the results of the cluster analysis and the matching procedure is show and in chapter 4 we draw some conclusions.

## 2. Methodology and data basis

We identify farm strategies by applying a cluster analysis. This technique creates homogeneous farm groups which differ by the predefined cluster variables. From the technical point of view we apply an agglomerative hierarchical clustering, which treats each unit as a single cluster in the beginning and merges units in an increasing hierarchy (Backhaus, 2011). As measure of dissimilarity we use Euclidian distance metric, as linkage criterion the ward's criterion. Our cluster analysis is based on three standardized input variables: Firstly we identify the expenses per livestock units for concentrate feed (expenses for concentrate feed). Secondly we consider depreciation and maintenance costs for machinery as well as for machinery leasing and hired machinery work per hectare utilized agricultural area (expenses for machinery). Thirdly we calculate the energy expenses per hectare, based on costs for electricity, fuel, fertilizer and roughage.

In order to assess the impact of the identified strategies on economic performance we apply Direct Covariate Matching (DCM). Matching basically controls for observable variables assuming that under a given vector of observable variables (Z), the outcome (Y) of one individual is independent of treatment (T):

$$\{Y0, Y1 \perp\!\!\!\perp T\} \mid Z \tag{1}$$

where $\perp\!\!\!\perp$ denotes independence (Sekhon, 2009). In this paper we consider a certain strategy selection as treatment. Our matching model is based on the nearest neighbour approach: for each farm of a certain cluster (treated farm) we determine the farm from another cluster (the so-called control unit) with the smallest distance with regard to predefined covariates. DCM identifies control units directly on the absolute value of the covariates. The used matching algorithm is a calliper algorithm with replacement. These callipers define the maximum allowed divergence within the matched pair in the case of continuous variables. Exact cut-off values are applied for dummy and multinomial variables. If there is no control unit within the predefined boundaries, the treated farm is dropped from the sample. In the DCM procedure we control for the following observable variables potentially influencing farm income and/or the decision to select a certain milk production strategy: as proxies for site quality and other site conditions we apply mountain farm cadastre points, mountain farm zone, the share of grassland and the value for taxing real-estate based on government valuation ("Einheitswert") per hectare land (the so called "Hektarsatz"). Furthermore we control for the size of the farm by using utilized agricultural area (UAA).

Our analysis is based on the Austrian dataset of voluntary bookkeeping farms. We consider all specialised dairy farms having bookkeeping recordings in the period of 2005 to 2010. These restrictions result in a dataset of 528 dairy farms.

## 3. Results

The cluster analysis yields four clusters which show varying combinations of the three cluster variables "expenses for concentrate feed", "expenses for machinery" and "expenses for energy" (see Table 1): **Cluster 1** (small-sized average-input farms) embraces farms with average expenses for concentrate feed per livestock unit but high expenses for energy and machinery per UAA. The high expenses are amongst other factors caused through the rather small size of these farms. **Cluster 2** (medium-sized low-input farms) is the biggest cluster, and shows with regard to all three cluster variables mean values below the respective averages. This is due to small total expenses for all inputs, especially for concentrate feed. In average, the Cluster 2 farms are larger than the in Cluster 1 and 4 and smaller than Cluster 3 farms. Farms in **cluster 3** (large-sized high-output farms) have the highest expenses for concentrate feed, but relatively low expenses for machinery and energy. In particular machinery expenses per UAA are low due to the large farm size. **Cluster 4** (small-sized high-output farms) are with regard to all cluster variables above the average. The high expenses for machinery and energy can be traced back to the small farm size, which allows a bad utilization of their machinery but also force the farms to buy roughage in quite high quantities. The ccharacteristics regarding structure and economics of these clusters are displayed in Table 1. The results indicate that we are able to identify one low-input cluster, which shows low total input, labour input and milk production. There are three clusters with rather higher input levels, but also higher milk production and output levels. Those three clusters differ in site conditions and farm size. When looking at total input and total output the biggest differences occur between cluster 2 and cluster 4. Cluster 1 and 3 are in between of those two. Even though those differences occur, all four clusters have similar mean values and distributions for the variables farm income and farm income per family labour.

**Table 1: Cluster variables as well as structural and monetary values for the four identified clusters from the cluster analysis.**

| | Cluster 1 | Cluster 2 | Cluster 3 | Cluster 4 | |
|---|---|---|---|---|---|
| Number of farms | 155 | 174 | 135 | 45 | |
| Expenses for concentrate feed per LU (€) | 262<br>(80) | 179<br>(46) | 333<br>(84) | 298<br>(101) | *** |
| Expenses for machinery per UAA (€) | 696<br>(241) | 468<br>(146) | 448<br>(132) | 792<br>(344) | *** |
| Expenses for energy per UAA (€) | 272<br>(39) | 154<br>(44) | 184<br>(45) | 419<br>(86) | *** |
| Mountain farm cadaster points | 83<br>(73) | 93<br>(73) | 86<br>(64) | 86<br>(83) | |
| Organic Farming (%) | 19<br>(40) | 31<br>(46) | 21<br>(41) | 20<br>(40) | |
| UAA (ha) | 25.52<br>(10.43) | 30.51<br>(12.17) | 34.93<br>(14.45) | 25.27<br>(12.99) | *** |
| Total livestock units (LU) | 36.56<br>(14.89) | 33.72<br>(12.54) | 40.74<br>(19.43) | 41.81<br>(26.08) | ** |
| Dairy cows (LU) | 22.35<br>(9.41) | 18.26<br>(7.18) | 23.18<br>(10.46) | 25.35<br>(16.06) | *** |
| Produced milk (kg) | 148164<br>(76020) | 105721<br>(47369) | 164029<br>(84690) | 182504<br>(133570) | *** |
| Total output (€) | 107241<br>(42201) | 89942<br>(33119) | 117828<br>(48801) | 129186<br>(63376) | *** |
| Total input (€) | 69754<br>(27837) | 52036<br>(21340) | 75993<br>(34760) | 88478<br>(43221) | *** |
| Family labour input (WU) | 1.89<br>(0.5) | 1.76<br>(0.45) | 1.91<br>(0.53) | 2.00<br>(0.65) | * |
| Farm income per family labour input(€) | 20680<br>(13728) | 22034<br>(9747) | 22240<br>(11559) | 20945<br>(12331) | |
| Share of net worth on total assets (%) | 90<br>(15) | 94<br>(10) | 86<br>(19) | 87<br>(19) | *** |

Numbers in parentheses are standard deviations. LU = Livestock Unit, UAA = Utilized Agricultural Area, WU = Working Unit; Kruskal-Wallis rank sum test is used for equally of distributions: Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 ' ' 1
Source: Own calculations

Since we are mainly interested in the low-input strategy, we apply the matching analysis for cluster 2 and compare economic values of cluster 2 farms with economic values of their corresponding control farms. As matching (or control) variables we use site conditions and farm size. Through that, eight farms from the low-input cluster were dropped because no comparable control exists. The comparison ranges from 2005/06 to 2010, so that we can assess the development of cluster 2 farms in relation to the development of their control farms. The mean distances are displayed in Table 2.

**Table 2: Mean distances between low-input-farms and their controls, identified through the matching procedure.**

| | 2005/06[1] | 2007 | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|
| Number of farms | 166 | 166 | 166 | 166 | 166 |
| UAA (ha) | 0.19 (6.39) | 0.26 (8.18) | 0.22 (9.56) | -0.21 (11.39) | -0.71 (12.06) |
| Total livestock units (LU) | -4.70** (12.36) | -5.76*** (13.13) | -6.47*** (13.66) | -7.15*** (14.23) | -7.44*** (15.39) |
| Dairy cows (LU) | -4.39*** (9.28) | -4.67*** (9.27) | -4.83*** (9.94) | -5.29*** (10) | -5.86*** (10.69) |
| Produced milk (kg) | -49833*** (69819) | -55791*** (76005) | -59257*** (80318) | -63384*** (80534) | -66229*** (86675) |
| Total input (€) | -23577*** (29753) | -25686*** (33189) | -30498*** (37172) | -28290*** (36532) | -28890*** (41368) |
| Total output (€) | -27420*** (43273) | -25298*** (51658) | -33821*** (53837) | -30362*** (48215) | -35927*** (56175) |
| Family labour input (WU) | -0.16** (0.66) | -0.15** (0.69) | -0.14** (0.64) | -0.14* (0.64) | -0.13* (0.63) |
| Farm income per family labour input(€) | -509 (16982) | 2786 (19452) | 240 (18446) | 502 (16298) | -1985 (17909) |
| Share of net worth on total assets (%) | 5** (18) | 5** (19) | 4** (23) | 4* (22) | 3* (22) |

1) Mean values from the years 2005 and 2006; Numbers in parentheses are standard deviations; LU = Livestock Unit, UAA = Utilized Agricultural Area, WU = Working Unit; t-test is used for equally of means: Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 ' ' 1; Source: Own calculations

Cluster 2 farms have a similar size as their control farms; the differences remain small and not significant over the complete observation period. This is contrary for livestock units, dairy cows and milk production where farms choosing the low-input strategy show significant lower values than their control farms in the initial situation (2005/06). These negative impacts rise continuously during the observation period, as low-input farms grow less than the high-output controls. Complementary to these findings we observe a statistical significant lower input of family labour on farms of cluster 2 over the complete observation period.

As expected, the group of low-input farms has significantly lower total inputs. The distance is significantly growing over the observation period which is mainly due to increasing input prices. Highest differences occur in the year 2008. This raise comes especially from a higher increase on high-output control farms for concentrate feed and machinery expenses. But on the other hand, there is also a significant distance with regard to total output. The development of this distance is also clearly influenced by the general price developments. With regard to farm income per family labour input results are not statistical different between low-input farms and their control farms. A final aspect we want to mention is the share of equity. Even though share of net worth on total assets is generally high in Austrian agriculture, low-input farms still have a higher share of net worth on total assets than their control farm group.

## 4. Discussion and conclusion

In our study we use three cluster variables which indicate on one hand the intensity of concentrate use in feeding, on the other hand the external input use in land cultivation on a dairy farm. The applied cluster variables are good indicators for intensity of input use on the total dairy farm, as those clusters with the highest values in the cluster variables show high values in total input variables and milk production. The cluster analysis identifies three farm groups which have higher expenses for inputs and one group with lower. Next to the differences in those input expenses, the clusters differ in farm size. There are two clusters with relatively small UAA and quite high expenses for machinery and energy per UAA. Even though the UAA in the low-input cluster is relatively big, total input and output are still lower than in all other clusters. All in all, the cluster analysis clearly shows that farms successfully apply different strategies to generate a sufficient family income.

The result from the impact estimation of a low-input strategy selection indicates that no continuous growth in husbandry is needed to remain competitive, which goes in line with the findings of van der Ploeg (2003). Through non-intensification in husbandry, labour and total input quantity on low-input farms do not increase as much as on their high-output controls, which makes them less depending on external and volatile input price markets. Van der Ploeg (2003) also describes low-input, or so-called economical, farms rather autonomous to external markets, whereas high-output, or so-called intensive, farms have rather strong external market linkages. Through that low-input farms are even under the price scenarios of 2008 competitive regarding farm income. Furthermore the lower labour input on low-input farms give those farms the potential to increase non-farm activities.

The used approach makes it possible to capture farmers' attitudes and strategic management and its impacts on farm competitiveness in dairy farming. However, there is still high variance in farm income impact estimates, which indicates that there are more variables influencing farm income. However, due to missing data we have either no information on these variables or variables are in general unobservable. It therefore might be necessary to go beyond classical statistical sources and to include qualitative aspects in the analysis by conducting qualitative in-depth research. Furthermore such analysis might also give more detailed information on the individual motivation of farmers to apply a low-input strategy.

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