Economic impacts of strategy selection in Austrian dairy farming: an empirical assessment

S. Kirchweger, M. Eder and J. Kantelhardt

Institute of Agricultural and Forestry Economics, University of Natural Resources and Life Sciences, Vienna

Abstract: In order to cope with changes in agricultural policy and an increasing volatility in agricultural input and output markets, dairy farmers might select certain strategies regarding external input use to increase competitiveness. The selection of one strategy has different impacts on economic farm performance under different prices. The objective of this paper is to identify such strategies in an agricultural bookkeeping dataset and assess economic impacts of a low-input strategy selection under volatile prices situations. We use data from 509 specialised dairy farms and apply cluster analysis and direct covariates matching. The cluster analysis can identify one low-input cluster with low levels of input use and three clusters with higher input levels. Those clusters differ in site conditions, farm size and milk production but have similar farm income. The results indicate that low-input farms are less depending on external markets and volatile input price markets and competitive with high-output farms.

Keywords: dairy farming, farm strategies, cluster analysis, matching method

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 influence farm competitiveness. Due to comparatively low opportunity costs for land and labour, mountainous dairy farms show a higher farm income and better financial stability than non-mountainous dairy farms (Kirner and Gazzarin, 2007). It is to annotate that this does solely apply under moderate unfavourable conditions. A further factor, which is to mention, is the availability of capital (Bronsema, 2013). Due to the high share of net worth on total assets in Austrian dairy farming (Kirner and Gazzarin, 2006), this factor is not limiting in farm development. A last factor is labour. Apart from these structural factors the farm manager and its strategic focus is of relevance for farm competiveness. Of major importance are, beside the farmer’s management skills, his attitudes such as openness for innovation and risk tolerance (Schaper et al., 2011).

In this paper we concentrate on analysing farm strategies. Literature describes a variety of strategies in agriculture. A very common strategic question is the decision between diversification and specialization. This aspect is often analysed in literature, underlining the economic potential of specialization (cf. eg. Schaper et al., 2011 and Bronsema, 2013), but also highlighting the risk reduction potential of diversification. A further important strategy affects the question how to deal with external input use. High-input strategies are nowadays very conventional in Austrian agriculture and try to maximise profit by a high turnover. Low-input strategies try to achieve high profits by minimizing costs through low external inputs, even if revenues are small. Therefore volatile input and output prices might influence the farm competitiveness of farms of those strategies differently. Literature is rare regarding this topic, especially in connection with competitiveness. For example, van der Ploeg (2003) identifies and analysis such strategies in the Dutch dairy sector from a rather sociological point of view.

In order to detect strategies in the Austrian dairy farming sector we use bookkeeping data and use cluster analysis to identify homogenous farm groups regarding external input use. On the other hand we try to measure the influence of choosing such a strategy on farm competitiveness. To do so we control for other factors like farm size and site conditions using the matching method and estimate the impact of a rather low-input strategy on farm income and other variables. The 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 our conclusions.

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 bought roughage.

The choice of the strategy does not solely depend on farmer's skills and attitudes, but also on structural aspects (e.g. farm size) and natural site conditions. Due to the fact that the clusters might distinguish with regard to these aspects, no conclusions about the economic success of a strategy choice can be drawn. Therefore, in order to assess the impact of the identified strategies on economic performance, we cannot compare the clusters directly. For instance, a higher farm income within a certain cluster might be caused by good site conditions rather than choosing an appropriate strategy. To avoid this problem, 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): $\{Y0, Y1 \perp\!\!\!\perp T\} | Z$, 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 will be dropped from the sample.

In the DCM procedure we control for all observable variables influencing farm income and/or the decision to select a certain strategy. Namely, these are 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") as proxies for site quality and other site conditions. 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. The dataset represents the majority of the Austrian agriculture in all regions, leaving out the very small and big farms. We consider all specialised dairy farms having bookkeeping recordings in the period of 2005 to 2010. These restrictions result in a dataset of 509 dairy farms.

Results

Results from cluster analysis

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".

- 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 mean of the cluster variables as well as structural and monetary values for the four identified clusters are displayed in Table 1. Whereas farms from Cluster 1, 2 and 3 are mainly located in the pre alpine regions of Lower and Upper Austria as well as of Styria, the farms from Cluster 4 are rather situated in the alpine regions of Salzburg and Tyrol. However, with regard to site conditions indicators "cadaster points" and "Hektarsatz" we observe no statistical differences. The share of organic farming is with 31% the highest in Cluster 2, all other clusters have a share of about 20%. As mentioned earlier, the clusters differ in ha UAA: Cluster 1 and 4 farms have an average size of 25 hectares, whereas Cluster 2 and 3 farms are rather large with 30 and 35 hectares, respectively. Farm size differences are mainly driven by differences in farm-own grassland area; with regard to arable land and rented land area we observe no significant differences between clusters. In contrast to that, there is a clear divergence in husbandry intensity: Farms in Cluster 2 keep 34 livestock units (LU), farms in Cluster 1 solely 36 LU. The mean LUs in Cluster 3 and 4 are 41 and 42, respectively. A similar diverging picture is to observe for dairy cows and milk production: Cluster 2 farms produce in average 106 tons of milk with 18 dairy cows, Cluster

1 farms 148 tons with 22 cows, Cluster 3 farms 164 tons with 23 cows and Cluster 4 farms 183 tons with 25 cows.

Table 1: Cluster variables as well as structural and monetary values for the four identified clusters from the cluster analysis. *(Statistical differences are calculated using Kruskal-Wallis rank sum test: 0 '***' 0.001 '**' 0.01 '*' 0.05 ' ' 1)*

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	
Number of farms	155	174	135	45	
Concentrate feed expenses for per LU	262 (80)	179 (46)	333 (84)	298 (101)	***
Machinery expenses per UAA	696 (241)	468 (146)	448 (132)	792 (344)	***
Energy expenses per UAA	272 (39)	154 (44)	184 (45)	419 (86)	***
Mountain farm cadaster	83 (73)	93 (73)	86 (64)	86 (83)	
Organic Farming (%)	19 (40)	31 (46)	21 (41)	20 (40)	
UAA (ha)	25.52 (10.43)	30.51 (12.17)	34.93 (14.45)	25.27 (12.99)	***
Share of grassland (%)	66 (28)	71 (27)	72 (26)	72 (29)	
Share of rented land (%)	26 (21)	24 (21)	29 (26)	27 (20)	
Total livestock units (LU)	36.56 (14.89)	33.72 (12.54)	40.74 (19.43)	41.81 (26.08)	**
Dairy cows (LU)	22.35 (9.41)	18.26 (7.18)	23.18 (10.46)	25.35 (16.06)	***
Produced milk (kg)	148164 (76020)	105721 (47369)	164029 (84690)	182504 (133570)	***
Public payments (€)	22041 (9091)	24447 (9860)	27900 (12089)	25276 (13113)	***
Total output (€)	107241 (42201)	89942 (33119)	117828 (48801)	129186 (63376)	***
Total input (€)	69754 (27837)	52036 (21340)	75993 (34760)	88478 (43221)	***
Farm income (€)	37487 (20826)	37907 (17935)	41835 (22465)	40708 (26375)	
Family labour input (WU)	1.89 (0.5)	1.76 (0.45)	1.91 (0.53)	2.00 (0.65)	*
Farm income per family labour input(€)	20680 (13728)	22034 (9747)	22240 (11559)	20945 (12331)	

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

In particular the differences in milk production cause a statistical significant divergence of total output. It differs the most between Cluster 2 and Cluster 4, where the medium-sized low-input Cluster 2 show an output of 89,000 € and the small-sized high-output Cluster 4 farms an output of 129,000 €. The other two clusters are situated in between Cluster 2 and 4 results and have mean values of 107,000 € (Cluster 1) and 118,000 € (Cluster 3). Total output differences are not solely driven by dairy output, but also by differences with regard to public payments. Whereas the medium-sized low-input farms receive in average 24,000 € public payments, the comparable large but more intensive Cluster 3 farms get 28,000 €. The small and average intensive Cluster 1 farms receive 22,000 € and the farms similar sized but more intensively cultivating Cluster 4 farms receive 25,000 €. The differences in public payments are caused by the differing participation rate on agri-environmental program measures and the differing level of the single area payments.

Also total inputs show clear divergences between clusters. So the low input farms in Cluster 2 have a total input of 52,000 €, the smaller and average input Cluster 1 farms of 70,000 €, the large and average input Cluster 3 farms of 76,000 € and the high input Cluster 4 farms of 88,000 €. These differences primarily result from the differences in depreciation, feedstuff expenses and energy expenses. Similar differences occur in expenses for medicine and insemination.

Farm income is derived by subtracting total input from total output. This subtraction balances almost all previously described differences, so that farm income has no statistical significance. Farm income for Cluster 2 farms is 38,000 €, for Cluster 1 farms 37,000 €; Cluster 3 and Cluster 4 farms have a slightly higher income with 42,000 € and 41,000 €, respectively. Family labour input is significantly lower in the low-input cluster than in the high-output clusters. So use the Cluster 2 farms only 1.76 working units (WU), whereas Cluster 1, 3 and 4 farms dispose 1.89, 1.91 and 2.00 WU, respectively. Consequently the average farm income per WU family labour is almost the same in all clusters. It accounts for 22,000 € for Cluster 2 and 3, and differs with 21,000 € almost negligible with regard to Cluster 1 and 4.

Matching results

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 in-put cluster were dropped because no comparable control is found. 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.

Cluster 2 farms have a comparable size as their controls; the differences remain small and not significant over the complete observation period. The farms have 4.70 less livestock units, 4.39 less dairy cows and about 50 tons less milk production in the initial situation. These negative impacts rise continuously during the observation period, as low-input farms grow less than the high-output controls. So the differences in 2010 are -7.44 total LU, -5.86 dairy cows and about -66 tons of produced milk.

As expected, the group of low-input farms has significantly lower inputs. In the initial situation the average distance to the control farms is -23,577 €. The distance is significantly growing over the observation period which is mainly due to increasing input prices. Highest differences occur in the year 2008 (-30,498 €). This raise comes especially from a higher increase on high-output control farms for concentrate feed and machinery expenses. In the following years the negative mean impact on total input drops slightly to -28,890 € even though the control farms have increased their production quantity.

Table 2: Mean distances between low-input-farms and their controls, identified through the matching procedure. *(Statistical differences are calculated using the T-test: 0 '***' 0.001 '**' 0.01 '*' 0.05 ' ' 1)*

	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)	
Share of grassland (%)	0 (4)		-1 (6)		-1 (7)		-1 (8)		-2 (9)	
Total livestoch 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)	***
Public payments (€)	-2000 (9486)		-2514 (9572)	*	-3001 (11751)	**	-2862 (12759)	*	-2903 (12497)	*
Farm income (€)	-3843 (26585)		389 (30951)		-3323 (31682)		-2071 (27500)		-7038 (32191)	*
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)	

[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

There is also a significant distance with regard to total output. Also the development of this distance is clearly influenced by the general price developments: Whereas the mean impact for total output is about -27,420 € in the base period 2005/06, the distance clearly increases in 2008 when the milk price was high (-33,821 €). This is mainly due to the lower milk quantities on low-input farms. When milk prices decrease in 2009 the negative impact for low-input farmers goes down to about -30,362 €. The again higher negative impact in 2010 in comparison to 2005/06 is mainly driven by the increased production but also higher output from non-husbandry activities on control farms. Furthermore, we find that in average the distance regarding public payments between low-input farms and their high-output control farms gets bigger over the time period. Whereas the difference is -2,000 € in the period 2005/06, it is 2,903 € in 2010.

As both total outputs and total inputs have similar impacts on low-input farming, the mean distance on farm income for 2005/06 is almost balanced (-3,843 €) and not statistical significant. In 2007 the mean distance increases to almost zero, as input prices rise earlier than output prices. When output prices increase in 2008, the mean impact on farm income decreases again to -3,323 €. In 2009 the difference is still -2,071 €. Even though the mean values differ, the differences are not statistically significant. This changes in 2010, when the distance decreases to -7,038 € and becomes statistically significant. This is due to an extraordinary increase in total output for control farms.

In the base period 2005/06 we observe a statistical significant distance of -0.16 WU for family labour input. Over the complete observation period this result gets slightly smaller, but remains significant. With regard to farm income per family labour input results are similar to farm income results, but more in favour of low-input farms due to reduced family labour.

Discussion and conclusion

In our study we use three variables which should indicate on one hand the external input use in feeding, on the other hand the external input use in land cultivation on a dairy farm. We find that the used cluster variables are good indicators for intensity of external 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 external inputs and one group with lower. Next to the differences in those input expenses, the clusters also differ in farm size. There are two clusters with relatively small UAA and quite high expenses for machinery and energy per UAA. Furthermore 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 quite strong 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 should give those farms the potential to increase non-farm activities.

The used approach makes it possible to capture parts of 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 might be an indicator that there are other variables influencing the farm income. But those variables are unobservable. This shows the weakness of the applied matching approach which solely allows for controlling on observable variables. 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 would also give information about if the identified farms actually pursue this strategy.

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