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UNDER THE EU MILK QUOTA SYSTEM AND ORGANIC SUBSIDIES**

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ORGANIC OR CONVENTIONAL? OPTIMAL DAIRY FARMING TECHNOLOGY UNDER THE EU MILK QUOTA SYSTEM AND ORGANIC SUBSIDIES

Gunnar Breustedt, Uwe Latacz-Lohmann und Torben Tiedemann¹

Abstract

We analyse the relative competitiveness between organic and conventional dairy farming under different hypothetical agricultural policies using a DEA-based comparison of each farm's earning potential in both technologies. This model allows us to identify a farm's *ex post* optimal technology based on input-output observations. Results for Bavarian dairy farms indicate that more than 70% of the farms in both technologies – organic and conventional – have chosen their optimal farming system. The remaining organic (conventional) farmers could increase their profit by roughly 7% (18%) on average by switching to the other technology. Abolishment of the EU milk quota reduces the number of sample farms for which organic farming is the optimal technology considerably. This finding suggests that *ceteris paribus* organic dairy farms may lose competitive advantage with the deregulation of the EU's milk market regime in 2015. Simulations show, that this effect may be offset by a price decline for conventional milk of more than 10% relative to the price for organic milk. Another finding reveals that subsidies specifically paid to organic farmers roughly double the number of farms who have a higher earning potential in organic than in conventional dairy farming.

Keywords

Organic farming, EU milk quota, Data Envelopment Analysis, subsidy payments.

1 Introduction

Over the past ten years, the number of organic farms in the European Union has more than doubled to about 190.000 certified organic farms in 2008 (EUROSTAT, 2010), representing a significant share of farms and agricultural land. On the other hand, there is evidence of organic farmers reverting to conventional farming methods (DEFRA, 2002). As a consequence, organic and conventional farmers may ask themselves whether they have chosen their optimal farming technology. This question is of particular relevance to EU dairy farmers who will face substantial changes to dairy market policies.

In EU agriculture, profits from dairy farming are heavily influenced by the EU's milk quota regime that combines price support with supply control at the farm level. However, these market interventions will be abolished in 2015. Furthermore, increasing organic farming is among stated political objectives of most EU member states resulting in specific subsidies paid to organic farming. Policy makers may wish to know how the competitive positions of organic and conventional farming systems are likely to be affected by these policy instruments and by changes of them. For example, one may ask whether the organic subsidies are effective in the sense that they improve the competitive position of organic farming. On the other hand, is this effect complemented or jeopardised for organic dairy farming when the milk quota is abolished?

Based on an efficiency analysis we identify for individual farms the *ex post* most profitable technology given the policy environment of subsidy payments and milk quota restrictions. We

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also compute the increase in profit that a farmer could have reaped had he chosen his optimal (i.e. most profitable) technology. In a second step, we assume changes in the policy environment and identify each farm's optimal technology under the new circumstances. By comparing the share of farms which should use organic rather than conventional dairy farming in the different policy settings, we assess the potential impact of policy changes on the relative competitiveness of organic dairy farming. Our analysis is based on farm records from over 1,000 conventional and more than one hundred organic dairy farms in the Federal State of Bavaria, Germany. The lack of reliable studies on the future of organic dairy farming after the end of the EU milk quota makes our empirical analysis valuable for policy makers. However, our quantitative estimates for Bavaria cannot be extrapolated to the EU milk sector as a whole.

We first set out the methodology to conceptualise and to conduct empirically a farm-level profit comparison between conventional and organic farming. Section 3 presents the results comparing the profit potentials of conventional and organic dairy farming under different hypothetical policies. The last section concludes with a discussion of conceivable policy implications.

2 Methodology

Whether organic or conventional dairy farming is more profitable for a farmer depends on several trade-offs: on one hand, physical yields in organic farming are lower than in conventional farming, e.g. milk yield per cow or forage production per hectare grassland are – in general – lower in organic than in conventional dairy farming. On the other hand, market price for organic milk is commonly higher than for conventional milk. Finally, there are public payments for organic farms in most EU member states (cf. OFFERMANN ET AL. 2009) in addition to the subsidies conventional farmers receive. Consequently, the decision between organic and conventional farming is far from straightforward for a farmer.

Against this background, we wish to: (1) determine for each individual farm the *ex post* optimal technology – organic or conventional dairy farming – under different policy scenarios, and (2) estimate a farm's profit increase had it used the optimal instead of its actual technology. Therefore, we have to compare the profit potential of each farm under both technologies. For each technology, we calculate a profit frontier representing farms' profit potential by means of efficiency analysis.

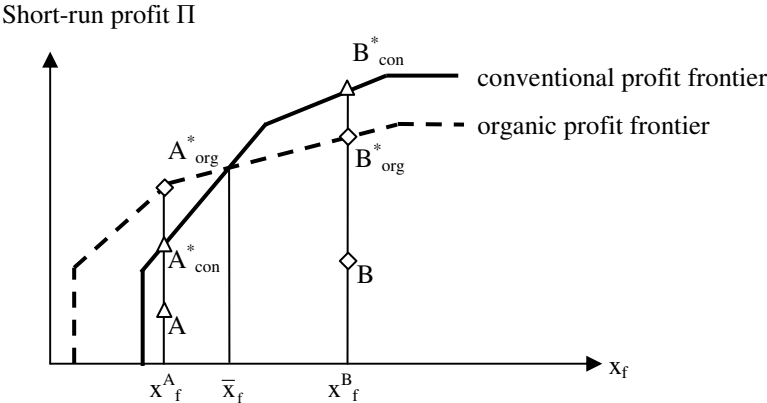
The most common methods for such efficiency or frontier analyses are SFA (Stochastic Frontier Analysis) and DEA (Data Envelopment Analysis). The DEA approach can be traced back to CHARNES ET AL. (1978). They were the first to construct a non-parametric piece-wise linear frontier for the analysed firms by means of linear programming. The frontier is constructed from efficient firms, i.e. those which produce the highest output for a given input combination, and by convex linear combinations of these firms. In contrast, SFA is based on a regression framework. KUMBHAKAR ET AL. (2009) use SFA to estimate productivity differences between conventional and organic dairy farming technology in Finland. However, their focus is neither on profits including subsidies nor on milk quota restrictions.

We consider DEA to be more appropriate than SFA for evaluating the profit potential of individual dairy farms for two reasons. First, the restrictions on milk sales due to the EU quota regime cannot be easily represented in a standard SFA approach. The marginal impact of milk quota on output would hardly be interpretable in a regression framework because the *ceteris paribus* assumption does not necessarily hold. In general, a farmer cannot increase milk output by means of more milk quota without changing the bundle of other inputs at the same time. Second, our sample farms differ substantially in size. In our view, using a frontier benchmark which is influenced by 'large' farms (by Bavarian standards) with, say, over 100

cows is not appropriate for evaluating the performance of a ‘small’ farm with only 8 cows. This, however, happens in the SFA framework by estimating the frontier’s parameters. We argue with KUMBHAKAR ET AL. that SFA is appropriate if one is interested in average measures of performance of the sample farms, such as the average productivity difference between conventional and organic farming. But if the objective is to determine whether a specific farm has chosen its most profitable technology, we prefer DEA because it constructs the benchmark for a specific farm from frontier farms with similar input levels.

In farming reality, the input level of several production factors cannot be easily adjusted in the short-run. While the level of variable inputs X_v such as feed from grain, seed, diesel etc. can be easily adjusted farmers can hardly increase the level of inputs such as family labour, stable, land, or milk quota in the short-run. Although the flexibility of input use may differ among farmers and regions, we model the latter inputs as fixed inputs X_f (cf COELLI ET AL. 2005, p. 188).² We measure profit as revenues minus costs of variable inputs, and then search for a farm’s profit maximum given its levels of fixed inputs. For comparing the profits from both technologies we, thus, assume that a farm’s level of fixed inputs would be the same in both technologies. Figure 1 represents this DEA approach for two farms. For simplicity we refer to only one fixed input x_f .

Figure 1: Profit frontiers and technology recommendations



Source: Own illustration

We start with conventional farmer A who uses x_f^A and who earns profit $\Pi(A)$ (without taking into account the costs for x_f^A). The profit frontier for conventional farming indicates that benchmark farmers achieve a higher profit than $\Pi(A)$; if farmer A was profit-efficient he would earn $\Pi(A^*_{con})$. Profit $\Pi(A)$ relative to profit $\Pi(A^*_{con})$ is the common DEA measure for profit efficiency of farmer A. Obviously, this measure is less than one for farmer A indicating that A is not profit-efficient. We now turn to the question whether organic farming is more profitable for A than conventional farming. For the input level x_f^A we have to compare the frontier profit under conventional farming $\Pi(A^*_{con})$ with the frontier profit under organic farming $\Pi(A^*_{org})$. Since the latter profit is higher farmer A would have received a higher profit under the organic technology.³ For such a conclusion we have to assume that farmer

² An additional technical reason for modeling fixed inputs is that opportunity costs for the use of fixed inputs – such as family labour or stable – are not observable to the researcher.

³ In terms of efficiency analysis we use an output-oriented DEA, i.e. we focus on potential profit increases without increasing fixed inputs. Alternatively, one could calculate potential reductions of fixed inputs (without decreasing profits). However, we prefer output-orientation because of the hardly adjustable level of fixed inputs. In this respect COELLI ET AL. (2005) argue that ‘one should select the orientation according to which quantities (inputs or outputs) the managers have most control over’ (p. 180). KUMBHAKAR ET AL. (2009) also measure output-oriented productivity differences among conventional and organic dairy farming.

A's (hypothetical) profit efficiency in organic farming is not smaller than the calculated profit efficiency under his actual conventional technology.

For organic farmer B the situation is similar. He is not efficient in the technology he has chosen, i.e. $\Pi(B_{\text{org}}^*) > \Pi(B)$. In addition he should have chosen the other technology because $\Pi(B_{\text{con}}^*) > \Pi(B_{\text{org}}^*)$ applies for his fixed input level. Consequently, both farmers have chosen the wrong technology *ex post* in our example. In figure 1 all farms with a lower input use than \bar{x}_f should produce organically because the organic frontier profit is higher than the conventional frontier for these farms. The opposite is true for all farms with a higher input level than \bar{x}_f , conventional farming offers a higher profit potential for these farms.⁴

To calculate the (short-run) profit frontiers in figure 1 we use a DEA model specification proposed by COELLI ET AL. (2002, p. 270) for variable returns-to-scale:

$$\begin{aligned}
 \max_{x_{vi}^*, y_i^*, \lambda} \quad & \Pi_i^* = p_i y_i^* - w_{vi} x_{vi}^* \\
 \text{s.t.} \quad & Y \lambda \geq y_i^* \\
 & X_v \lambda \leq x_{vi}^* \\
 & X_f \lambda \leq x_{fi} \\
 & N1' \lambda = 1 \\
 & \lambda \geq 0
 \end{aligned}
 \tag{1}$$

The maximum short-run profit Π_i^* for farm i is the maximum difference of revenues minus costs for variable inputs. Price vectors for outputs p_i and variable inputs w_{vi} are exogenously given. The optimal output vector y_i^* and the optimal vector of variable inputs x_{vi}^* are determined by a (convex) linear combination of all farms in the sample. X_v , X_f and Y indicate matrices holding the vectors of variable and fixed inputs as well as the output vectors of all sample farms. In this respect the first inequality demands that the optimal output for i does not exceed the output of that linear combination while the second and third inequality show that the optimal input level cannot be smaller than the input level of the linear combination. In other words, the benchmark for farm i is represented by the profit-maximising (convex) linear combination of farms in the sample. To this end the vector of non-negative weights λ in the best linear combination is determined by linear programming. The sum of weights adds to one to allow for variable returns-to-scale.

Following e.g. COELLI ET AL. (2005, p. 207) different qualities of inputs and outputs among farms may bias the estimates of farms' efficiencies. This problem is relevant in our data because e.g. milk prices depend on the fat and protein content, beef prices depend on beef quality while the feed price depends on the feed's energy content. In line with other empirical studies like OUDE LANSINK ET AL. (2002), KUMBHAKAR ET AL. (2009), BRÜMMER (2001), BRÜMMER ET AL. (2002) we assume that the „Law of one price“ holds for standardised outputs and variable inputs and that the observed price differences in our Bavarian sample farms are generally caused by quality differences. Therefore, the physical output and variable input levels are to be represented by its monetary counterparts, revenue R and variable costs vC .

⁴ This concept could be translated into a metafrontier approach for comparing competing technologies: our methodological approach is also a metafrontier concept in efficiency analysis conceptually set out by O'DONNELL ET AL. (2008) and implicitly applied by KUMBHAKAR ET AL. (2009) to estimate productivity differences among competing technologies. In contrast to most metafrontier efficiency analyses this concept is not based on a convex but rather on a non-convex metafrontier.

The objective still is to maximise the difference between revenue and variable costs, but under this assumption the above model can be simplified to:

$$(2) \quad \begin{aligned} \max_{\lambda} \quad & \Pi_i^* = \lambda(R - vC) \\ \text{s.t.} \quad & X_f \lambda \leq x_{fi} \\ & N1' \lambda = 1 \\ & \lambda \geq 0 \end{aligned}$$

In this model the benchmark (short-run) profit for farm i follows from the profit-maximising linear combination of farms that does not use more fixed inputs than farm i . Calculating the benchmark profit for farm i in his chosen technology is common DEA practice based on the second model with R , vC , X_f including all farms who have chosen i 's technology.

To calculate the benchmark profit of farm i in the other (not chosen) technology we can also apply the second model. However, vectors R , vC , and matrix X_f do not include data of farm i but only data of farms who are observed in this technology. Only x_{fi} is taken from farm i to ensure that the benchmark profit is not produced with more fixed inputs than available to farm i . Finally, the technology with the higher benchmark profit is the most profitable technology *ex post* for farm i . A positive difference between the profit from the alternative technology and the profit of the chosen technology represents the profit forgone from having chosen the wrong technology.

3 Empirical analysis

After presenting the data, we first ask whether dairy farmers have chosen the farming technology with the highest earning potential: organic or conventional. We finally simulate different policy environments (e.g. abolition of milk quota and/or organic subsidy payments) and trace the impacts on the competitive position of the two technologies. A policy scenario of quota abolishment is complemented by simulations of changes of relative prices between organic and conventional milk. A discussion of our approach as well as data finishes this section.

3.1 Data and policy scenarios

The small to medium sized sample farms are all located in Bavaria, in the south of Germany. Data are taken from the farms' profit-and-loss accounts and balance sheets for financial year (FY) 2004/2005. In general, the state of Bavaria subsidised organic farms with € 255 per hectare of land and year. We have included in the analysis only farms that generate at least two-thirds of their output from milk and milk product sales. The sample contains 102 dairy farms which had been in organic farming for at least three years prior to 2004/2005. On average, the organic farms are slightly smaller than the 1239 conventional farms in the sample (Table 1).⁵ The average organic dairy farm has a milk quota of 224,000 kilograms per year, while the conventional average is 312,000 kilograms per year.

⁵ We restrict our analysis to Bavaria in order to reduce problems resulting from regional heterogeneity. Our DEA benchmarks would be inappropriate if a farm in the Alps would be benchmarked against a farm near the North Sea. Although farm inputs may be nearly identical, climate, soil, and market conditions are very different. We, however, have to admit that production environments may exhibit some heterogeneity in Bavaria, too.

Table 1. Descriptive statistics

Organic farms (n=102)		Mean	Standard deviation	Min	Max
<i>Short-run profit</i>					
Revenue	€	121 781	64 321	9 937	365 560
Organic subsidy payments	€	12 474	5 104	582	27 783
Intermediate inputs	€	44 101	31 592	5 359	178 046
Short-run profit	€	90 154	40 551	8 385	206 278
<i>Fixed inputs</i>					
Land	ha	48.1	21.1	11.6	122.2
Labour	FTE	1.70	0.50	0.46	4.44
Capital	€	31 605	16 169	1 442	87 496
Milk quota	kg	223 743	121 203	32 366	700 000

Conventional farms (n=1239)		Mean	Standard deviation	Min	Max
<i>Short-run profit</i>					
Revenue	€	165 571	43 465	29 249	343 004
Intermediate inputs	€	68 431	16 576	8 884	162 373
Short-run profit	€	97 140	32 268	18 638	242 676
<i>Fixed inputs</i>					
Land	ha	54.1	18.3	9.5	125.4
Labour	FTE	1.72	0.45	0.50	3.82
Capital	€	36 760	13 673	2 771	102 367
Milk quota	kg	311 703	92 089	56 991	684 450

Source: Own calculation

Total farm revenue comprises the value of agricultural production, including agricultural services and all non-organic subsidy payments, except investment aid. Organic subsidy payments are included for the organic farms since they can clearly affect the competitiveness of organic and conventional dairying.⁶ To come to the short-run profit of farms we subtract costs for intermediate inputs from revenues and subsidies.⁷ The short-run profits are about € 90,000 for organic farms, on average, and € 97,000 for conventional farms, respectively. The fixed inputs are labour (measured as full-time equivalents per year), capital (depreciation on machinery and buildings), and land (measured in hectares of arable and pasture land). In general, organic farms use slightly less input on average than conventional farms. The average labour input is nearly identical, while organic farms use approximately 30% less of intermediate inputs. The minimum and maximum values show that both subsamples span a similar range of farms as measured by their input and revenue quantities. In the organic sample, some large farms skew the distributions of most variables to the right.

We analyse the impact of four policy scenarios on the competitive position of conventional and organic farming:

⁶ See OFFERMANN ET AL. (2009) for a summary of subsidies being paid to organic farms.

⁷ In most data sets, it is nearly impossible to separate labor input on farms into variable and fixed inputs. We, thus, use costs for intermediate inputs as the only variable costs.

Scenario 1 (benchmark): Status quo in FY 2004/05

Scenario 2: With milk quota but without organic farming payments

Scenario 3: Without milk quota but with organic farming payments

Scenario 4: Without milk quota and without organic payments (subsequently referred to as the ‘double-zero’ scenario).

The second DEA model will be calculated for these scenarios. Milk quota can be seen as an input necessary to sell milk and we thus include it as a fixed input in scenarios 1 and 2. We compute scenarios 3 and 4 to analyse whether milk quota abolishment changes the optimal technology for a given farm. To simulate abolishing milk quota restrictions on production milk quota is not included in the DEA model in the latter scenarios. To study the impact of organic direct payments on the relative competitiveness of organic dairy farming we consider two scenarios without organic direct payments (scenario 2 and 4).

If we find that milk quota abolishment impacts the competitiveness between conventional and organic milk production second-round effects may occur. For example, if organic farming becomes relatively less profitable the (relative) supply quantity of organic milk compared to conventional milk may decrease and, consequently, the price of organic milk may increase relative to the price of conventional milk. In this case, the second-round effect reduces the impact of milk quota abolishment on the (relative) competitiveness of organic dairy farming. Unfortunately, we cannot predict changes of relative prices between conventional and organic milk due to the policy changes in our scenarios. Nevertheless, we simulate hypothetical second-round effects, i.e. milk price changes, on the relative competitiveness of both farming systems. This gives us some indication about the level of price change that may compensate the first-round effect of the policy change.

3.2 Results

The results are structured into three subsections. We, first, evaluate the actual farmers’ technology choice ex post, i.e. we run the second DEA model for the status quo conditions of 2004/05 (benchmark scenario). Second, we simulate policy changes – abolishment of milk quota and organic subsidies – and calculate how many farms could have earned higher profit in organic dairy technology, *ceteris paribus*. Finally, we skip the *ceteris paribus* assumption and simulate relative milk price changes under the scenario of quota abolishment.

Status quo

We analyse whether there is potential for the sample farms to increase their profit by switching technologies. The first row of Table 2 shows that under the current system 29.5% of conventional farmers and 72.5% of organic farmers, respectively, should have produced organically. In other words, every fourth organic farm and three of ten conventional farms should have chosen the other technology. If these farms had chosen their optimal technology, they could have increased their profit by 7% (organic) and 18% (conventional) on average. On a per-hectare basis, the respective organic farms could have enhanced their profit by € 160 per hectare and the conventional farmers by € 227 per hectare. We thus conclude that:

- (I) conventional dairy farming does not ensure the highest profit for all sample farms;
- (II) more than 70% of the conventional farms apply their optimal technology;
- (III) nearly three fourth of the organic farms apply their optimal technology;
- (IV) however, some of the farms that have chosen the ‘wrong’ technology can reap substantial profit gains by switching to the other technology.

The high shares of farms applying their optimal technology according to (II) and (III) show that our determination of the optimal technology is far from tossing a coin. This indicates that our approach gives some reasonable indication for a farm's optimal technology. Nevertheless our model cannot capture the whole complexity involved in farmers' actual technology choice. The related shortcomings will be discussed in chapter 3.3.

Policy changes without market adjustments

We now turn to the impact of different policy scenarios on the competitive position of organic and conventional farming. We start with the 'double zero' policy scenario of no organic subsidies and no milk quota. Results are quite sensitive to these changes: only 1.1% of the conventional farms in the sample should switch to organic farming and only 2.0% of the organic farmers should maintain their current farming system (bottom row in Table 2).

Table 2. Portion of farms that should produce organically in different policy scenarios

Policy scenario	Milk quota	Organic payments	Observed technology		Overall
			Organic	Conventional	
1.	with	with	72.5%	29.5%	32.7%
2.	with	without	48.8%	11.3%	14.1%
3.	without	with	5.9%	2.9%	3.1%
4.	without	without	2.0%	1.1%	1.2%

Source: Own calculation

These findings may have important policy implications. In the benchmark scenario (status quo in FY 2004/05), organic farming emerges as the optimal technology for 439 (32.7%) of the sample farms. In the absence of both milk quota and organic subsidies – but everything else being equal – organic farming is the optimal technology for only 16 (1.2%) of the sample farms. These results clearly indicate that organic dairying has benefited significantly from the existence of organic subsidy payments and the milk quota system. However, the low share (1.2%) of optimal organic farms in the 'double zero' scenario is likely to increase if one accounts for the rise in organic milk prices resulting from the slump in supply due to fewer organic dairy farms. We refer to this issue in the next subsection.

We proceed with policy scenario 3. If organic subsidies were abandoned⁸ while keeping the milk quota in place, the relative competitiveness of the organic system would also decline, although to a lesser extent than in the 'double zero' scenario. Organic farming would remain the optimal technology for 189 (14.1%) of the sample farms compared to 439 in the benchmark scenario. The considerably smaller number of farms that should choose organic farming in scenario 3 than in the 'double-zero' scenario suggests that milk quota seems to be more important for organic dairy farming's competitiveness than organic subsidies. The results of policy scenario 2 support this interpretation.

Policy scenario 2 simulates abolishing the milk quota while keeping organic subsidies in place. The second row in Table 2 shows the portion of farms for which organic production remains the optimal technology under this policy scenario: 42 farmers in total, or roughly 3.1 per cent. 94.1 per cent of the farms currently in organic production should revert to conventional farming.⁹ One can thus expect that abolition of the milk quota will significantly

⁸ A recent study by OFFERMANN ET AL. (2009) offers projections for organic farmers' subsidy income due to anticipated changes in EU and national subsidy policies.

⁹ Results do not change considerably when we weight the farms by their land acreage. These results can be sent upon request.

enhance the competitive position of conventional dairy farming.¹⁰ Again, this effect is likely to be attenuated by the relative price increase for organically produced milk in response to a drop in the supply of organic milk.

But why does milk quota enhance the competitiveness of organic dairying? We believe that milk quota has been the most limiting factor for many of our sample farms. In the German quota trading system, interregional trade had been prohibited up until 2007. Although regional trade of quota was allowed, only 1.75% of Bavarian quota changed hands per year (BLFL, 2009). Consequently, milk quota has been quite immobile - similar to land - and therefore purchasing additional milk quota has been very capital-intensive and thus expensive. In particular, the highest milk quota prices in 2004/05 were observed in Bavaria (BMVEL, 2005). Assuming low opportunity costs for family labour and farm buildings, farmers act rationally by maximising their profits with respect to the milk quota. Under these circumstances, organic milk production may be more profitable because it allows for a higher milk price per kilogram of milk quota than conventional farming. This is in line with empirical findings of GARDEBROEK (2002).

Price changes under quota abolishment

So far, we have presented results of first-round effects of policy changes only. The results have clearly shown that the relative competitiveness of organic dairy farming is expected to decrease under the simulated policy changes. Consequently, supply of organic milk may decrease and the price for organic milk may increase relative to conventional milk in a second-round effect. However, then the competitiveness of organic production may be higher than our above calculations imply. The following table shows the results for policy scenario 3 (quota abolishment) with additional simulated reductions of conventional milk prices.

Table 3. Portion of farms that should produce organically under reduced prices of conventional milk

Policy scenario	Milk quota	Organic payments	Reduction of conventional milk price	Observed technology		Overall
				Organic	Conventional	
1.	with	with	0%	72.5%	29.5%	32.7%
3.	without	with	0%	5.9%	2.9%	3.1%
3.	without	with	5%	12.7%	8.1%	8.4%
3.	without	with	10%	32.4%	22.4%	23.1%
3.	without	with	11.5%	40.2%	29.5%	30.3%
3.	without	with	12.1%	44.1%	31.8%	32.7%
3.	without	with	18.1%	72.5%	63.5%	64.2%
3.	without	with	20%	78.4%	75.1%	75.3%

Source: Own calculation

For example, in the third row the price reduction for conventional milk is set to 5%. We have simulated this lower price in the DEA by reducing the milk revenues of conventional farms

¹⁰ However, one has to bear in mind that EU direct payments in the year of the analysis were partly linked to production, e.g. headage payments for beef cattle. The effect of decoupling on the relative competitiveness between organic and conventional dairy farming is not clear cut. Comprehensive theoretical or simulation-based analyses of the effect are missing in the literature. NIEBERG ET AL. (2007) calculate only the joint impact of several market and policy changes, including decoupling, on total income change for organic and conventional farms between 2002 and 2013.

by 5%. Then, organic dairy farming is more profitable than conventional farming for 8.4% of the sample farms. Compared to the second row (quota abolishment without price changes), organic farming becomes the optimal technology for more farms, of course. However, compared to the benchmark of policy and market conditions in 2004/05 there are less farmers for whom organic dairy would be optimal. Consequently, a 5% reduction of the conventional milk price does not offset the first-round effect of quota abolishment. Depending on the criterion chosen, a price reduction of conventional milk prices of 11% to 18% seems to offset the first-round effect of quota abolishment.¹¹ For these values the share of organic and conventional farmers, who would earn more money with organic farming, equal the respective shares in the benchmark scenario. However, one has to bear in mind, that farmers will probably adjust their production to changing market prices. Unfortunately, we cannot predict such reactions.

3.3 Discussion

We emphasise that our approach to choosing among competing technologies is only appropriate for evaluating technology choices *ex post*. Only to the extent that expectations of the technologies' potentials are appropriately reflected by historic data can our approach be used for making *ex ante* recommendations. One could then base the analysis on the 'expected' profit for any planned input combination for each technology.

However, the choice between conventional and organic farming is unlikely to be influenced by profit considerations only. Risk considerations, the cost of switching technology or personal preferences may have a role to play as well. Our model does not cater for this complexity.¹² In addition, our analysis is based on input-output observations from only one year. The relative competitiveness of both farming systems may change over time due to changes in relative prices and differences in the rate of technical progress in both production systems.

We finally discuss limitations of our empirical approach to evaluating technology choices. All *ex post* technology comparisons in the manner of KUMBHAKAR ET AL. (2009), O'DONNELL ET AL. (2008) and our analysis suffer from the same basic problem: a technology's frontier output is underestimated if firms that are not observed in this technology would be more profitable or more productive with this technology than the firms that are actually applying it. If some of the very productive farmers have not chosen their optimal technology, the maximum frontier profit over all technologies may thus be underestimated. However, one may expect that most such productive farmers would choose the technology that is optimal for them. If a farmer outperforms his peers in his own technology he can be expected also to recognise and adopt the technology that best suits his individual circumstances. Furthermore,

¹¹ We get similar results when we increase the price for organic milk in the DEA. Results can be sent upon request.

¹² This complexity may explain that we identify relatively more conventional farmers who should change their technology than organic farmers. E.g. the risk in organic farming might be expected to be higher than in conventional dairy farming. Then a higher profit is not sufficient to change technology. FLATEN ET AL. (2005) for example found that organic dairy farmers in Norway perceived themselves to be less risk averse than their conventional colleagues. Further on, the costs of switching from conventional dairy farming to organic dairy farming are higher than vice versa because of a mandatory transition period for farms becoming organic. Also, the switching costs might be too high to be outweighed by the efficiency gain we measure for some farmers. SCHRAMEK and SCHNAUT (2004) report switching costs of somewhat 1300 €/ha for a sample of German dairy farms in 2003. They also report that many conventional farmers overrate these switching costs compared to actual switching costs of similar farms. Finally, there might be non-economic reasons not to change to organic dairy farming. A survey of DARNHOFER ET AL. (2005) shows that some farmers believe that organic production is not technically and/or economically feasible. PIETOLA and OUDE LANSINK (2001) point out that adoption of organic farming technology is also influenced by the social acceptance of organic farming.

a problem with DEA-based comparisons of different technologies can arise from low numbers of observations for a technology. Additional observations can make a technology's frontier only shift upwards (but never downwards). Thus, one underestimates the technology's frontier if the technology's best farms are not observed, implying that the technology's frontier profit relative to the other technologies' frontier profits is also underestimated. In our empirical analysis, however, this distorting effect is likely to be limited because more than one hundred organic farms have been included in the analysis. Other DEA studies on organic farming (e.g. OUDE LANSINK ET AL., 2002; DIMARA ET AL., 2005) include fewer farms than we do.

4 Concluding remarks

We analysed the competitive position of organic and conventional dairy farming under different policy scenarios. We estimate each farm's profit potential in both technologies by means of DEA to identify a farm's *ex post* optimal technology based on input-output observations. In particular, we assessed the potential impact of abandoning the EU milk quota on the relative competitiveness of organic and conventional dairy farming for a sample of Bavarian farms. The lack of reliable studies on the future of organic dairy farming after the end of the milk quota in the EU makes our empirical analysis valuable for policy makers. We emphasise however that our findings cannot be extrapolated to the dairy sector as a whole since our data set reflects the regional circumstances of Bavaria. Furthermore, our approach does neither account for switching costs, risk consideration nor personal preferences of farmers.

Results indicate that more than 70 per cent of the farms in both systems apply their optimal farming technology under current policies in 2004/05. The remaining organic (conventional) farmers could increase their profit by around 7% (18%) on average by switching to the other technology. In our analysis, organic farming turns out to be the optimal technology for 32.7% of sample farms under the policy setting of FY 2004/05. Results are sensitive to assumptions about agricultural policies. Assuming away both milk quota constraints and organic subsidy payments, organic farming remains the optimal technology for only 1.2% of sample farms. Abandoning only organic subsidy payments reduces the number of farms who are most profitable in organic farming to 14.7% indicating a high effectiveness of these subsidies in increasing organic farms' profit relative to conventional farms.

In the absence of the milk quota only, organic farming would, *ceteris paribus*, remain the most productive technology for only 3.1% of sample farms. This finding has two important implications: it, first, suggests that milk quota is more important for organic dairy farms' competitiveness than organic subsidies. Second, organic dairy farming may lose market share when the EU milk quota system is abandoned in 2015. The latter effect is likely to be attenuated by an increase in the relative price of organically produced milk following a slump in organic supplies. However, to fully outweigh the impact of quota abolishment on organic farms' competitiveness the price for conventional milk must decrease more than 10% relative to the price for organic milk.

We do not want to formulate more concrete policy conclusions because our approach has to be based on some restrictive assumptions about the choice between organic and conventional farming and because we want to avoid extrapolating results from a Bavarian data set to the EU level. However, there are not any studies yet concerned with the future of organic milk production in the EU after quota abolishment. But our results give clear and demonstrative indications that the relative competitiveness of organic dairy farming is likely to decrease due to the quota abolishment. Hence, policy makers and the dairy industry are recommended to initiate comprehensive in-debt analysis on the future of organic milk production in the EU.

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