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The effect of environmental cross compliance regulations on Swiss farm productivity

Abstract

This paper analyzes the evolution of Swiss farm productivity during the implementation of environmental policy reforms. We employ a production model formulation with technology parameters defined as the functions of subsidies, as well as individual farm characteristics. Our estimates for two groups of farms – milk-producing and crop farms – show that introducing environmental regulations induced serious changes in the production technology and productivity of inputs, especially of land, labor and fertilizer. The overall effect of the subsidies on the production output has been found negative. At the same time, we find that farms do not use their resources optimally, which indicates some deficiencies in structural adjustments, primarily in the land and labor markets.

JEL Classification: Q120, D240.

Key words: environmental regulations, productivity analysis, Swiss agriculture.

Introduction

Since the early 1990s, the Swiss agricultural sector has been subject to a series of policy reforms. Initially, these reforms were primarily caused by increasing public concerns about the ecological soundness of farming in Switzerland and were principally aimed at lessening negative externalities from agricultural production. Soon thereafter, the World Trade Organization's (WTO) Uruguay round agreements posed additional challenges to Swiss agricultural policy and enforced reforms related to agricultural trade liberalization.

While there are numerous investigations (Koch, 2002; Götz, 2005; Zgraggen, 2005) which have evaluated the impact of reforms on the Swiss farming sector prior to the introduction of a particular policy instrument, there are only few empirical studies which analyze the effect of the reforms on the economic performance of Swiss farms (Hofer, 2002; Ferjani, 2005). Yet, evaluating the effectiveness and impact of past policy instruments might provide valuable insights for their further targeting, as well as the design of new policies. In this context, the objective of this paper is to analyze the impact of policy reforms implemented from 1991 to 2006 on the productivity of Swiss farms. In particular, we seek to answer the following research questions: (i) how has the productivity of Swiss farms evolved during the implementation of the reforms; (ii) which policy instruments in the series of reforms have had a particularly noticeable impact on farm productivity; and (iii) in particular, how has the introduction of ecological cross compliance regulations affected farm productivity?

We employ a production function approach that regards subsidies as an additional facilitating input in the production technology. This approach allows us to define the coefficients of the production function as functions of subsidies, and thus to consider the impact of subsidies on output directly and indirectly, i.e., by affecting input productivity and technological change

(Sipiläinen and Kumbhakar, 2007). We further extend this specification by considering the effect of several farm-specific factors on farm output.

In our empirical analysis we employ the unbalanced panel data provided by the Swiss Farm Accounting Data Network (FADN) from 1993 to 2006. We estimate the model for two types of farms: crop and milk-producing farms in Swiss plain regions. To evaluate the effect of individual policy instruments, we distinguish between two policy implementation periods, viz., 1993 to 1998 and 1999 to 2006, respectively. The first of the aforementioned periods was characterized by reductions of output price guarantees and the introduction of decoupled payments, while the second period was associated with the abolition of the price support program and introduction of ecological cross compliance instruments. Accordingly, the model was estimated for each farm group and period under consideration.

The rest of the paper is organized as follows. First, we summarize the main goals and developments of the Swiss agricultural policy reforms since the early 1990s. Section 2 presents the econometric model that allows us to consider the effect of subsidies on production technology. We then briefly describe the FADN data employed in the study. Section 4 presents and discusses our results and research findings, while Section 5 concludes.

1. A short overview of the Swiss agricultural policy since 1992

Switzerland was among the first Western European countries to introduce environmental regulations for agricultural production. Since the early 1990s, the Swiss agricultural sector has been subject to a series of policy reforms that were influenced by two important developments both within and outside the country: on the one hand were growing public concerns about the ecological soundness of farming, and on the other hand was the implementation of the WTO Uruguay round agreements, which were aimed at agricultural trade liberalization (BLW, 2007).

These developments required immediate adjustments in the agricultural support programs and obliged the Swiss government to move from the direct subsidization of agricultural output prices to a system of environmental cross compliance regulations. Accordingly, the main objectives of agricultural policy reforms were:

- a steady reduction of price support,
- reducing incentives for increasing output supplies,
- lessening negative externalities from agricultural production by introducing ecological cross compliance regulations, and at the same time,
- maintaining farm income support.

Prior to the reforms (i.e., before 1992) two major farm income support mechanisms were available to Swiss farmers: price support and direct payments, including structural improvement payments. In the initial reform phase between 1992 and 1998, ecological cross compliance (ECC) regulations were introduced on a voluntary basis: all producers retained access to direct payments, however, those farms which complied with ecological regulations received additional subsidies related to ECC. Since 1999, any kind of direct payments have become contingent upon compliance with ecological regulations. Furthermore, the government set up a stronger differentiation of subsidies starting in 1999. This was done to increase incentives to comply with individual ECC regulations, and also to ease monitoring.

Since 1992 the direct payment system has consisted of general direct payments and ecological direct payments, each of which have different sub-categories (DZV, 1998). General direct payments provide compensation for basic farming tasks as set out in the Swiss constitution: in particular for ensuring food supplies, maintaining landscapes and assisting in the preservation of infrastructure in rural areas. The amount of these payments depends on the farm's size, which is a combination of farm land and the number of grazing animals. In upland and mountainous areas, additional payments reimburse farmers for production under unfavorable conditions. Since 1999, general direct payments are contingent on the following basic ECC regulations[1]: maintaining a certain limit of ecological compensation areas, an even nutrient balance, regular crop rotation, limited and regulated soil protection and the targeted use of plant treatment products, as well as precise prescriptions regarding animal treatment and breeding. Ecological direct payments compensate farmers who participate in voluntary programs such as organic farming, animal welfare, the ecological compensation area program, preserving biodiversity, etc. (DZV, 1998).

Though price support has been steadily reduced, the total amount of governmental support increased substantially immediately after the introduction of the reforms, i.e., from 1992 to 1997, and stayed rather constant after 1998 (Joerin, 2007). In 2006, Swiss farms received direct payments in the total amount of ca 2.5 bn. Swiss Francs. Currently, a larger part of direct payments – approximately 80 percent – has been provided in the form of general direct payments. The remaining 20 percent corresponds with different types of ecological direct payments.

2. Econometric model

The production technology used to produce an aggregate output y is described by a production function $y = f(x)$, where x is a vector of production inputs. Farmers also receive direct payments[2] that are decoupled from production. If we assume that a subsidy S directly affects output as an ordinary input and technological change captured in the time trend variable t, the production technology can be defined as follows (Sipiläinen and Kumbhakar, 2007):

$$y = f(x, S, t) \ . \qquad (1)$$

[1] called der Ökologischer Leistungsnachweis (ÖLN) in German.
[2] Direct payments are separated from the farms' output.

However, a subsidy may affect the production output directly as well as indirectly, i.e., by influencing input use as well as inducing technological adjustments. This requires a more general formulation of the production technology in (1), i.e.:

$$y = f\left[x(S), S, t(S)\right] . \tag{2}$$

Further, by assuming that the production technology is described by a Cobb-Douglas function, we can rewrite (2) as:

$$\ln y = \beta_0 + \sum \beta_k \ln(S_k) + \sum \beta_j(S) \ln x_j + \beta_t(S)t + \varepsilon \tag{3}$$

where

$$\beta_j(S) = \alpha_j + \sum \alpha_{jk} \ln S_k \tag{4}$$

$$\beta_t(S) = \alpha_t + 0.5\alpha_{tt}t + \sum \alpha_{tk} \ln S_k \ , \tag{5}$$

ε is the stochastic noise term, $j \epsilon J$ is the index of the input type, $k \epsilon K$ is the index of the subsidy type, and finally, $\beta_j(S)$ and $\beta_t(S)$ are the input use and technology coefficients, respectively (Sipiläinen and Kumbhakar, 2007). To capture the effect of subsidies on input use and technological change, $\beta_j(S)$ and $\beta_t(S)$ are specified as the functions of subsidies. If we write $\beta_0(S) = \beta_0 + \sum \beta_k \ln(S_k)$ in (3) then all the parameters of the production function are affected by S from which some special cases can be derived and empirically tested.

Since $\beta_j(S)$ represent output elasticities of respective production inputs, their values have to be non-negative. To impose this non-negativity restriction we employ the following re-parameterization of (4):

$$\beta_j(S) = \exp\left(\alpha_j + \sum \alpha_{jk} \ln S_k\right). \tag{6}$$

Substituting (5) and (6) into (3), we then obtain:

$$\ln y = \beta_0 + \sum_k \beta_k \ln S_k + \sum_j \left[\exp\left(\alpha_j + \sum_k \alpha_{jk} \ln S_k \right) x_j \right] + \left(\alpha_t + 0.5\alpha_{tt} t + \sum_k \alpha_{tk} \ln S_k \right) + \varepsilon . \quad (7)$$

The econometric model in (7) can be further extended by considering the effect of farm characteristics such as a farm manager's age, education, experience, farm location, etc. Similar to subsidies, these traits might affect the technology parameters. Accordingly, considering the effect of different farm characteristics, F_l , we extend (7) to the following specification:

$$\begin{aligned} \ln y = \beta_0 + \sum_k \beta_k \ln S_k + \sum_j \left[\exp\left(\alpha_j + \sum_k \alpha_{jk} \ln S_k + \sum_l \alpha_{jl} F_l \right) \ln x_j \right] \\ + \left(\alpha_t + 0.5\alpha_{tt} t + \sum_k \alpha_{tk} \ln S_k + \sum_l \alpha_{tl} F_l \right) t + \varepsilon \end{aligned} . \quad (8)$$

From (8), the output elasticity of the subsidy type k can be obtained by taking the first derivative with respect to the respective type of the subsidy, i.e.:

$$\frac{\partial \ln y}{\partial \ln S_k} = \beta_k + \left[\sum_j \ln x_j \exp\left(\alpha_j + \alpha_{jk} \ln S_k + \alpha_{jl} F_l \right) \alpha_{jk} \right] + \alpha_{tk} t . \quad (9)$$

The expression in (9) shows that the effect of subsidies comprises three components: first, a direct subsidy effect; second, an input-specific component; and, third, a technology component.

Consequently, technological change can be estimated as follows:

$$\frac{\partial \ln y}{\partial t} = \alpha_t + \alpha_{tt} t + \sum_k \alpha_{tk} S_k + \sum_l \alpha_{tl} F_l , \quad (10)$$

which shows that the rate of technological change consists of neutral technological change, a component affected by individual subsidies and also a farm-specific component.

The output elasticities with regard to single inputs also incorporate the effect of subsidies and farm specifics, that is:

$$e_j = \frac{\partial \ln y}{\partial \ln x_j} = \exp(\alpha_j + \sum_k \alpha_{jk} S_k + \sum_l \alpha_{jl} F_l) . \quad (11)$$

These elasticities can be used to calculate the marginal product of each input:

$$MP_j = \frac{\partial y}{\partial x_j} = \frac{\partial \ln y}{\partial \ln x_j}\frac{y}{x_j} = e_j \frac{y}{x_j} \quad . \tag{12}$$

Since the marginal product incorporates the elasticity of the respective input, it is also influenced by subsidies and farm idiosyncrasies. The second component of the marginal product is the respective partial input productivity. These marginal products can then be compared to the respective input prices to analyze whether inputs are over (under) used and whether regulatory measures were helpful in using the inputs optimally.

3. Data

We employ an unbalanced panel data set provided by the Swiss FADN from 1993 to 2006. We distinguish between two groups of farms, (milk-producing and crop farms in Swiss plain regions) and two policy implementation periods (from 1993 to 1998 and 1999 to 2006), i.e., before and after coupling direct payments to compliance with environmental standards (ÖLN). As the introduction of cross compliance regulations was expected to have a serious impact on the farms' production technology, to obtain consistent technology parameter estimates we estimate the model for the two periods separately[3].

The following three criteria are used to include a farm in the sample: (i) farm crop acreage ≥ 10 ha; (ii) no special crops such as grapes, vegetables etc; (iii) the share of non-agricultural income in farm revenue < 0.40. The number of annual observations (on average) fulfilling these criteria in the first period are 198 and 106 for milk and crop farms, respectively. For the second period, the average number of farm observations was reduced to 106 and 30, respectively.

[3] In addition, since 1999 Swiss farms have become eligible to trade milk quotas. This development could induce serious changes in Swiss milk farm production. Accordingly, the estimation of the model for the whole period from 1993 to 2006 could produce biased estimates.

The average size of milk-producing farms is 26 ha of crop land and 30 cows. Crop farms have 27 ha of crop land on average. We use the Swiss equivalent for the farm's revenue from agricultural production (so called Rohertrag) as the measure of output. For both groups of farms we distinguished between 5 inputs: crop land, capital (measured by machine and buildings' depreciation value), labor (man-years of farm and hired labor in agricultural production), fertilizer (cost of mineral fertilizer), and materials (cost of intermediate inputs). For milk farms we consider an additional input, i.e., cows (measured as the number of standardized animal-units). Since most of the output and input variables provided by FADN are monetary values, we adjust the output and relevant input variables by their respective price indices as provided by the Swiss Federal Department of Agriculture (BLW, 2000-2007) and the Swiss Farmers' Association (SBV, 2008).

Furthermore, we aggregate different types of subsidies into the following three categories[4]:

- general direct payments without ECC, which were available before 1999[5] (dp),
- general direct payments with ECC (dp_ecc),
- ecological direct payments (dp_eco).

The list of farm-specific characteristics includes the farmer's age and education, the share of land rented, the share of agricultural income of total farm income, the share of hired labor, the altitude (above sea level) of the farmland and the animal density (the number of animals per ha of land).

4. Results

[4] The model was initially estimated considering a stronger differentiation of ecological direct payments. However, the majority of the parameter estimates were not significant. Thus, we aggregated them into one variable dp_eco.
[5] Accordingly, this type of subsidy was not considered in the model estimates for the 1999-2006 period.

Table 1 presents the model's parameter estimates for two selected groups of farms, i.e., milk farms and crop farms, and two reforms' sub-periods: before and since 1999 (1993-1998 and 1999-2006), respectively[6]. We began our analysis by examining the direct effect of subsidies on the farms' output. According to our estimates, the direct effect of the general subsidies on the crop farms' output was significantly negative in both periods, i.e., from 1993 to 1998 and from 1999 to 2006. For the milk farms, this impact was significant in the period from 1993 to 1998 only. In contrast to the crop farms, the direct effect of the ECC payments on output was positive for the milk farms that adopted the ECC regulations. At the same time, ecological direct payments – considered in both an aggregated and disaggregated form – were not found to significantly affect the output in both groups of farms.

Furthermore, our estimates suggest an indirect effect of subsidies on the farms' production output. In particular, direct payments seem to have a positive impact on technical change in both farm groups. This impact was, however, more pronounced in the first phase of the reforms. In fact, in this period farms were actively searching for practices which could compensate production output losses caused by the introduction of ECC. In particular, to increase the productivity of plants and animals, farms relied more strongly on improved genetic selection. Through improved fertilization timing, farms sought an increased effectiveness of fertilizer utilization.

Please place Table 1 here.

A similar tendency is observed regarding the impact of direct payments on input productivity: it was more distinct in the first phase of the reforms. The impact of direct payments was especially pronounced in the crop farms with respect to labor: the coefficient estimates for all three considered subsidy categories are highly significant with regard to this input. According to

[6] To ensure efficient estimates, we reduced the respective model specifications by the variables with insignificant parameter estimates.

our estimates, direct payments without ECC negatively affected labor productivity, whereas the ECC direct payments had a positive impact on the productivity of labor in crop farms prior to 1999. This suggests that in general, the shift from price support to the system of direct payments caused a reduction in labor productivity. Yet, it seems that the adoption of ecological cross compliance regulations alleviated this negative effect to some extent. The latter is most likely related to technological adjustments such as a more reasonable fertilization timing, which can be a prerequisite for higher labor input during short spans, but can concurrently allow an increase in its productivity. Ecological direct payments were revealed to affect labor productivity negatively. This result is in line with empirical evidence: organic farming is associated with more extensive labor use compared to conventional production practices.

The effect of ECC direct payments on labor productivity was different in the milk farms: they influenced labor productivity negatively after 1998. This finding is consistent with the processes observed in Swiss agriculture: new regulations on animal breeding treatment have induced more extensive labor use in livestock farms.

While the effect of general direct payments without cross compliance was found to be not significant, the direct payments with ECC negatively affected the elasticity of land in the crop farms. This has to be caused by regulations prescribing the maintenance of ecological compensation areas and the limited use of nitrogen and other fertilizers. In fact, to comply with environmental regulations, farms had to establish ecological compensation areas; that caused a reduction of the farms' productive acreage by 7 percent.

In the milk farms, land productivity was negatively influenced by the direct payments without ECC. This is most likely because between 1993 and 1998, the direct payments without ECC were attainable by the farms with an animal density less than 3 standard animal units per hectare. To maintain direct payments, livestock farms with a higher animal density had to reduce their animal stock, which obviously reduced the productivity of their land. Milk farms with a lower intensity of animal breeding instead benefitted from ECC reforms; as they were able to introduce the necessary adjustments relatively easily, they adopted the ECC reforms first. In line with this empirical evidence, we have found a positive effect of direct payments on land productivity in the farms that introduced ECC. It even seems that there were many milk farms that had the potential to improve their productivity and still comply with environmental regulations. This potential first became evident after the introduction of reforms, when – due to the scarcity of arable land – the land markets became more competitive. Furthermore, we found a tendency for reducing the productivity of intermediate inputs that is most likely associated with a reducing scale of the production and restrictions on the use of particular plant treatment agents (i.e., after the ECC adoption, farms were obliged to use a narrow selection of plant protection agents that probably reduced the effectiveness of plant protection).

Table 2 summarizes the effect of direct payments. These results indicate that the effect of the direct payments without ECC was rather comparable in both farm groups, while the ECC direct payments influenced the productivity of the milk and crop farms rather differently: the ECC payments increased the output of the milk farms by approx. 3 percent on average during the period from 1993 to 1998, while their effect was negative (- 0.4 percent on average) in the crop farms after 1999.[7] The opposite development was found with respect to the effect of the ECC direct payments on input productivity. In particular, while in the milk farms the direct payments with ECC caused a reduction in total input productivity (by 2.72 and 0.33 percent on average, before and after 1998), they induced crop farms to increase the productivity of input use by 0.5 percent. The ecological direct payments were not found to have any statistically significant

[7] This development can be also related to the fact that Swiss milk producers were eligible to increase their milk contingents from 1997 to 1999.

influence on the milk farms' output, yet before 1999 they had a tendency to considerably reduce the input productivity (i.e., labor) of the crop farms that participated in ecological programs.

Furthermore, before 1999, the total effect of subsidies on technical change was substantial in both groups of farms. This effect was mainly caused by the direct payments without ECC. Though no serious influence of the ECC direct payments on technical change was found for the crop farms, they had a slight but positive effect on the technological level of the milk farming in the later period of reforms.

The total effect of the direct payments on the farms' output was negative in both groups of farms during the whole period of reforms. Yet this effect actually decreased during the reforms. Additionally, as our results suggest, the effect of direct payments was more pronounced in the crop farms. Indeed, in the 1993-1998 period, the crop farms reduced their output by -2.33 percent on average annually, while in the milk farms, production was decreasing by only -0.52 percent.

Please place Table 2 here.

Figures 1 and 2 demonstrate the trends for returns to scale in the milk and crop farms, respectively. The areas dashed differently correspond to the individual input elasticities. The comparison of both figures demonstrates clearly that the crop farms had to undertake more serious adjustments in technology during the reform period. These adjustments caused a substantial reduction of returns to scale in the crop farms, i.e., from 1.13 in 1993 to 0.98 in 2006. This development can be explained primarily by reducing the output elasticities of quasi-fixed inputs, i.e., land, capital and labor. In the milk farms, returns to scale didn't change considerably, although they had a tendency to approach constant returns to scale. While labor elasticity was decreasing in these farms as well, land elasticity has doubled here**.** Currently, the production in both groups of farms seems to exhibit decreasing returns to scale, i.e., a proportional increase in all inputs causes a less than proportional increase in the production output, which suggests a suboptimal scale of production in Swiss farms.[8]

Please place Figures 1 and 2 here.

Finally, we analyze the optimality of input use in Swiss farms. Figure 3 presents the marginal products and the respective input-output price ratios[9] for the six considered production factors. Regarding quasi-fixed inputs, both groups of farms underuse land[10], but overuse labor and capital.[11] This result suggests that a sub-optimal scale of production in Swiss farms is caused by a disproportionate use of labor and capital.

At the beginning of reforms, there were considerable differences in the marginal products of land in crop and milk farms, whereas in the course of reforms, these differences almost disappeared (for both groups of farms, the respective marginal product ranged between 16,000 and 18,000 CHF between 2004-2006). The marginal products of labor also seem to be quite similar between the considered farms' groups. Yet, regarding capital, the marginal product was found to be substantially lower in the crop farms compared to the milk farms. This finding indicates that crop farms seem to have much more abundant capital than milk farms.

Please place Figure 3 here.

The marginal product of keeping milk cows was increasing during reforms (Figure 3d); this finding is in line with the previously presented results, suggesting an increase in milk productivity due to improved genetic selection. Despite this fact, milk farms tend to keep a less than optimal number of cows. This is most probably related to the ECC boundary on animal

[8] That is, the farms seem to overuse resources.
[9] Since farm output is a monetary variable, the price ratios between inputs and the output is equal to the price of a respective input.
[10] Land rent prices are regulated in Switzerland. Thus, it can happen that the rent price of land does not reflect its real value.
[11] If the farms would have maximized profit, then the marginal product would have been equal to the price ratios of inputs and output.

density. A similar tendency was revealed concerning fertilizer: Figure 3e demonstrates that their marginal productivity increased considerably in the course of reforms, especially concerning crop farms. This result is in line with empirical evidence: in view of ECC regulations, Swiss farms have to apply fertilizer at a level lower than the optimal one considering relative prices at present. The same is observable with regard to intermediate inputs. Since under ECC, farms are subject to very restrictive regulations primarily considering fertilizer application and plant protection, they have rather limited options for optimizing variable input use. Yet our results suggest that Swiss farms might considerably improve their economic situation by reducing sub-optimality in the quasi-fixed input use.

Finally, a farm's individual characteristics also seem to be a significant determinant of Swiss farm productivity. Land productivity tends to be higher in farms that own a considerable part of the farm land and which generate a larger share of their income from agriculture. Land ownership also seems to influence the productivity of the milk farms. Here, they have a significant effect on the speed of technical change. Educational background is decisive for improving labor productivity in the crop farms. It also significantly influences the productivity of cows in milk farms.

5. Conclusions

The paper analyzes the evolution of Swiss farm productivity in the course of reforms implemented since 1992. The analysis is done by employing an econometric approach that allows us to model the effect of subsidies on production technology. The model was estimated for two groups of farms: milk and crop farms from the Swiss plain regions for two sub-periods.

Our results indicate that the adoption of environmental cross compliance has induced serious changes in production technology. This development was particularly distinctive in Swiss crop farms and suggests that environmental regulations were more restrictive for crop production. Further, we found a different effect of regulations on the productivity of single inputs in milk and crop farms, which presumably was caused not only by differences in technology, but also in the input use intensity prior to reforms in these two groups of farms.

Moreover, our analysis also shows that most technological adjustments were undertaken before 1999, i.e., before direct payments were contingent on ECC. This finding suggests that Swiss farms have adequate monetary incentives to comply with ecological regulations. We also found an indication for a positive effect of reforms on technical change: under environmental regulations, farms began to look for technological options for maintaining high productivity of input use not by increasing input intensity, but rather the effectiveness of input utilization.

Furthermore, we found a negative total effect of direct payments on farm production output. This indicates that the policy has sent the right signals to Swiss farmers. However, further research is required to analyze whether policy objectives could be achieved by spending a lower amount of public funds. Another positive effect of reforms is that they reduced the discrepancies in marginal land rents, which suggests a more productive use of this input across different farm types.

However, our analysis revealed considerable sub-optimalities with regard to almost all farm resources. Though farms might have very limited options for optimizing variable input use (this particularly concerns fertilizer and crop protection application), under environmental cross-compliance regulations, Swiss farms have substantial reserves to improve their economic situation by adjusting their allocation of quasi-fixed inputs. This, however, presupposes the development of proper institutional and political conditions for further structural adjustments in Swiss rural areas. Finally, we found only scarce empirical evidence suggesting the effect of ecological direct payments on farms' production. This might be an indication of low effectiveness of the support programs in this field. Considering this, there is apparently a potential for further targeting single cross compliance instruments in Swiss farming.

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Figures

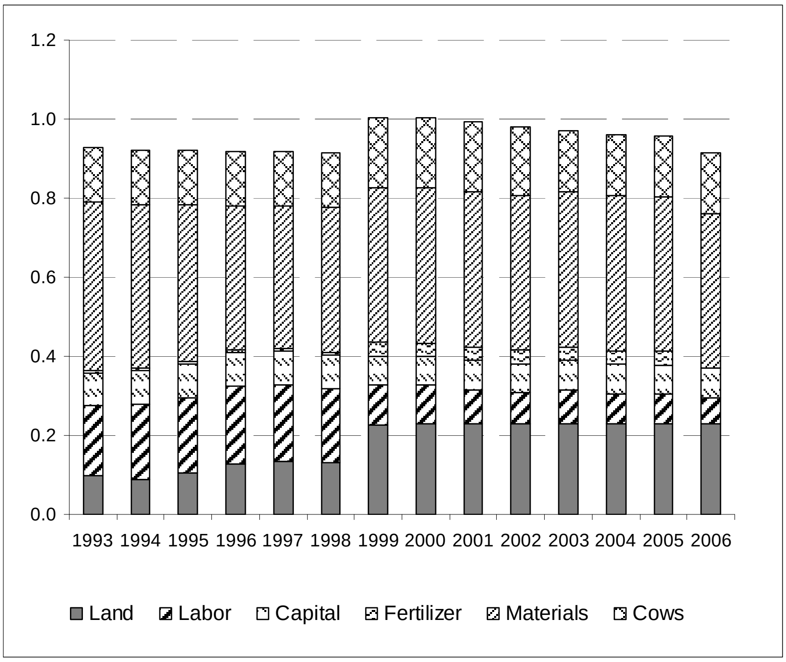


Figure 1 Return to scales: milk farms

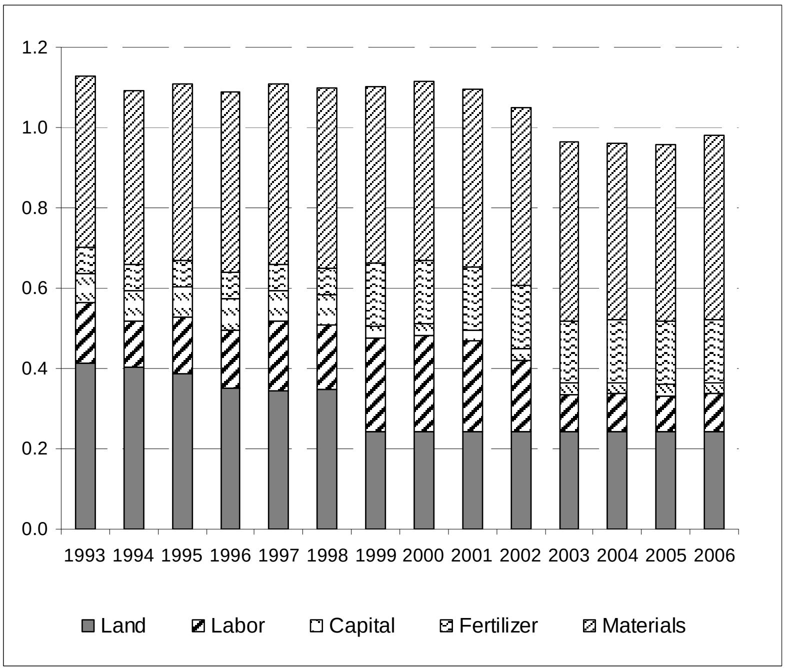
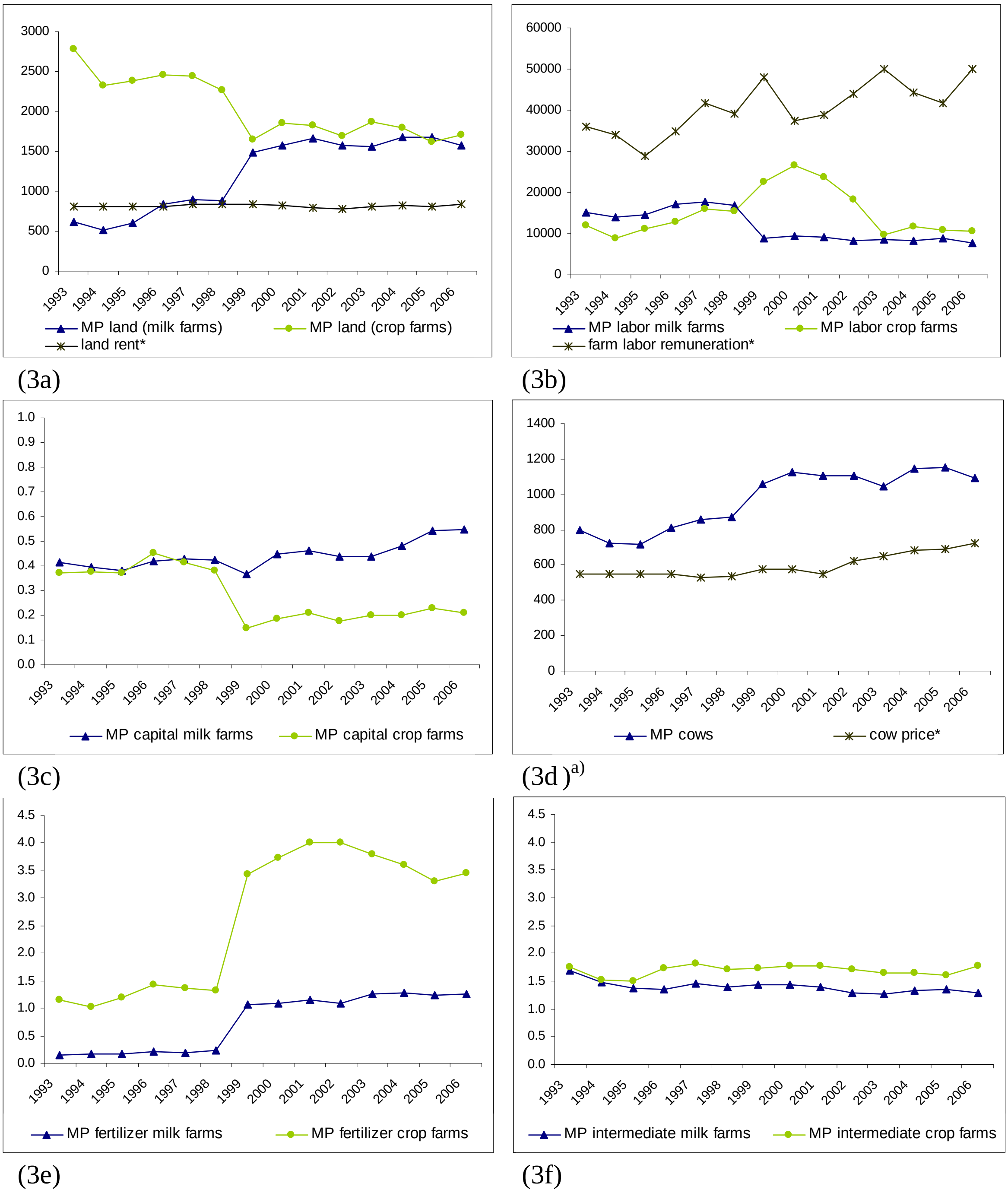


Figure 2 Return to scales: crop farms



[a] cow prices were adjusted considering the annual rotation rate of 0.29 (LBL, srva and FIBL, 2003).

Figure 3

Marginal productivity of land (3a), labor (3b), capital (3c), cows (3d), fertilizer (3e) and intermediate inputs (3f) in the milk and crop farms

Tables

Table 1 Coefficient estimates for two farm groups and two periods

Coefficient	milk farms		crop farms	
	1993-1998	1999-2006	1993-1998	1999-2006
b0	5.69 ***	5.34 ***	4.61 ***	4.90 ***
by_dp	--	--	-0.02 **	--
by_dp_ecc	0.03 **	--	--	-0.004 ***
at	-0.06 ***	0.09 ***	-0.03 *	0.05 ***
att	0.02 ***	-0.002 **	0.01 *	-0.01 **
at_dp	0.001 **	--	0.002 **	--
at_dp_ecc	--	0.0003 *	--	--
a_land	-1.95 ***	-1.65 ***	-0.81 ***	-1.42 ***
a_labor	-2.66 ***	-1.17 ***	0.15	-3.96 ***
a_capital	-2.48 ***	-2.62 ***	-3.23 ***	-4.60 ***
a_fert	-1.98 ***	-2.10 ***	-2.88 ***	-1.85 ***
a_interm	-8.05 ***	-3.37 ***	-0.77 ***	-0.84 ***
a_interm_euz	0.07 ***	--	-0.55 ***	0.40 ***
a_cows	-0.87 ***	-0.92 ***	--	--
a_land_dp	-0.04 ***	--	--	--
a_land_dp_ecc	0.03 ***	--	-0.01 ***	--
a_labor_dp	0.02 ***	--	-0.11 ***	--
a_labor_dp_ecc	--	-0.03 ***	0.05 ***	--
a_labor_dp_eco	--	--	-0.09 ***	--
a_capital_dp	--	--	0.02 ***	--
a_interm_dp	--	--	-0.003 **	--
a_interm_dp_ecc	-0.01 ***	-0.004 *	0.003 ***	--
at_age	--	-0.02 ***	--	--
at_lrent	--	-0.05 ***	--	--
at_lrent2	--	0.03 ***	--	--
a_land_aginc	0.002 ***	0.002 ***	--	--
a_land_lrent	--	--	-0.25 ***	--
a_land_lrent2	--	--	0.24 ***	--
a_labor_educ	--	--	--	0.46 ***
a_labor_altit	0.001 ***	--	--	--
a_labor_whire	--	--	-0.02 ***	--
a_labor_adense	--	--	-0.75 **	--
a_capital_aginc	--	--	--	0.01 *
a_capital_adense	--	--	0.34 ***	--
a_fert_whire	--	--	0.01 ***	--
a_interm_aginc	--	--	0.0002 **	--
a_cows_educ	0.066 *	0.07 **	--	--
R^2	0.81	0.87	0.85	0.85

Table 2 Output elasticity of direct payments

	milk farms		crop farms	
	1993-1998	1999-2006	1993-1998	1999-2006
DP without ECC				
output	--	--	-1.75	--
input	-1.13	--	-0.78	--
technical change	0.31	--	0.36	--
DP with ECC				
output	3.03	--	--	-0.40
input	-2.72	-0.33	0.49	--
technical change	--	0.09	--	--
ecological DP				
input	--	--	-0.65	--
total	-0.52	-0.24	-2.33	-0.40

Appendix

Summary statistics

Variable	Abbreviation	1993-1998				1999-2006			
		Mean	SD	Min	Max	Mean	SD	Min	Max
Milk farms									
Output, CHF	output	166723	56302	66098	443933	195353	70874	68147	546160
Land, ha	land	28	9	13	83	29	10	14	71
Labor, man-years	labor	2.0	0.6	0.8	4.6	1.9	0.6	0.8	4.3
Capital, CHF	capital	38723	16428	5373	124972	36265	16338	2395	108523
Fertilizer, CHF	fert	8135	4368	912	34720	6932	3440	1053	25202
Intermediate inputs, CHF	interm	47681	22227	13091	189733	61678	31934	14532	245120
Cows	cows	30	11	8	94	31	12	8	98
Direct payments without ECC	dp	20530	6233	0	58696	--	--	--	--
Direct payments with ECC	dp_ecc	11436	9232	0	39063	40885	14616	0	100296
Ecological direct payments	dp_eco	4510	4368	0	36396	9166	5584	0	34874
Share of rented land	l_rent	0.5	0.3	0.0	1.0	0.5	0.3	0.0	1.0
Share of agricultural income in total farm income	aginc	0.9	0.3	-3.2	6.9	0.8	0.5	-1.3	1.7
Age	age	44	10	23	72	45	9	24	67
Educational level	educ	5	1	2	7	4	1	0	8
Altitutude, meters	altit	519	96	260	804	517	89	312	864
Share of hired labor	w_hire	0.3	0.2	0.0	0.9	0.3	0.2	0.0	1.0
Animal density	adense	1.1	0.3	0.4	3.0	1.1	0.3	0.3	3.3
Crop farms									
Output, CHF	output	158932	56986	39146	400068	184239	68598	42361	416261
Land, ha	land	25	9	13	83	26	9	13	71
Labor, man-years	labor	2.0	0.6	0.8	4.1	1.8	0.6	0.7	4.2
Capital, CHF	capital	34785	15642	5975	123765	34318	16264	2914	107100
Fertilizer, CHF	fert	9757	5629	2005	46524	8957	4763	2491	28209
Intermediate inputs, CHF	interm	43898	19226	7984	144546	50533	23649	14244	202673
Direct payments without ECC	dp	17605	6573	5924	64148	--	--	--	--
Direct payments with ECC	dp_ecc	10665	9586	0	44676	37104	14598	0	100296
Ecological direct payments	dp_eco	3051	3163	0	19890	5202	3543	0	33081
Share of rented land	l_rent	0.5	0.3	0.0	1.0	0.5	0.3	0.0	1.0
Share of agricultural income in total farm income	aginc	0.8	0.3	-2.4	1.7	0.8	0.2	-1.9	1.1
Age	age	44	10	24	70	45	10	24	69
Educational level	educ	5	1	0	8	5	1	1	7
Altitutude, meters	altit	490	85	300	804	474	69	315	760
Share of hired labor	w_hire	0.3	0.2	0.0	0.8	0	0	0	1
Animal density	adense	0.8	0.3	0.0	1.7	0.7	0.2	0.0	1.3