The Relationship between Direct Payments and Efficiency on Swiss Farms

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Abstract

Economic theory suggests several possible mechanisms through which direct government farm payments might influence the efficiency and structural change in agriculture. This study estimates identify the main determinants of efficiency, particularly, what effect farm payments have had on efficiency and farm structure by using a farm-level Tobit model for 1990 to 2001. The results suggest that the inclusion of direct payments does not cause a change in returns to scale of the underlying technology. Nevertheless, results find evidence of effects of direct payments on efficiency. Farms that received greater direct payments were less efficient on aggregate than other farms.

Key words: *Switzerland, farms, direct payments, technical efficiency, DEA.*

Introduction

Economic theory and empirical evidence both suggest several possible mechanisms through which direct government payments to farmers might influence farm efficiency. Although direct payments for the agricultural sector can conserve employment and increase capital investments, the main question is whether they can affect farm efficiency and productivity. There are at least two reasons to suspect a positive connection between direct payments and efficiency. Firstly, if the direct payments help to advance the technological development of the recipient farms, then efficiency increases. Secondly, if the direct payments can help the farms to better utilise economies of scale[1], efficiency might increase as well. However, the use of producer income support is not unproblematic. Resources might be transferred to less productive farms, or as OLSON (1982) argues: "Special-interest groups also slow growth by reducing the rate at which resources are reallocated from one activity to another in response to new technologies or conditions. One obvious way in which they do so is by lobbying for bail-outs of failing farms, thereby delaying or preventing the shift of resources to areas where they would have a greater productivity".

Another problem with direct payments, which we examine in more detail in the empirical part of this paper, is that they might make farms less productive for at least two reasons. Firstly, because income support gives the recipient farms an incentive to change the capital/labour mix, it can give rise to allocative inefficiencies in the sense that a farm which, for example, is granted a direct payment might over-invest in capital.

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Secondly, direct payments can give rise to technical (X-) inefficiencies: if the direct payment is captured by the farms as higher profits, then it gives the company stakeholders, in particular managers and workers, the potential to capture these profits in the form of lack of effort. LEIBENSTEIN (1966) has argued that monopolies which earn supernatural profits tend to be less efficient (i.e. more X-inefficient) because: "…where the motivation is weak, firm management will permit a considerable degree of slack in their operations and will not seek cost-improving methods".

Similarly, if the direct payments help the supported farms to avoid bankruptcy then these farms are not forced to reorganise their activities and improve their performance to the same extent as a situation without support , with facing potential bankruptcy. Finally, the farms which are potential recipients of subsidies might, if the pay-off is high enough, become more interested in investing in subsidy-seeking activities (e.g. lobbying) than other, more productive. In short, the effect of government farm payments on farm efficiency is theoretically ambiguous.

Given the theoretical ambiguity of the effect of payments on efficiency, we choose to address the empirical question as to whether the level of farm payments affects farm efficiency and the survival of individual farms, using a non-parametric approach.

The objectives of this paper are twofold. First, we examine the effects of direct payments on farms efficiency in Switzerland. Second, we analyze the determinants of technical efficiency variation among these farms.

To achieve the mentioned objectives, the remainder of the paper is organized as follows. In section 2, we describe the frontier/inefficiency models assumed for the sample of Swiss farms. Section 3 presents the empirical results and discussions, and section 4 concludes with some remarks on policy implications.

Empirical framework

Efficiency measurement

The study employs an input- oriented farm level model using Farm Accountancy Data Network established by Agroscope Reckenholz-Tänikon Research Station (ART). After excluding farms with missing or invalid observations, usable data consisted of cross-section observations ranging between 3016 and 2174 for 1990 to 2001. The panel observations for 1990 to 2001 include only those appearing for a minimum of two years in the ART database. The output variables used were returns from crop production (CHF[2]), returns from livestock production (CHF) and miscellaneous production (CHF). Miscellaneous returns are returns from trade, services and plant, including in particular wages and rent for machines. Government direct payments output (ecological deliverance hectare bound and animal bound payments and so forth) is defined as the fourth output variable. Five inputs were included: agricultural area utilised in hectares as a land factor, annual work units (days) as a labour factor, depreciation plus interest as a capital factor, livestock and intermediate consumption as a variable input factor. The input factor capital is approximated in this investigation as depreciation plus interest in own capital and credit. The fourth final input variable (intermediate consumption) summarises material expenditures and other farm-internal expenditures. All monetary variables are normalized by the base year prices indices (1990).

In order to 33evaluate whether direct payments cause a change in the basic structure of Swiss agriculture, two production frontiers are constructed. The first frontier considers conventional input and output combinations, that is, direct payments are excluded from the calculation of the frontier. The second frontier includes government payments as revenue for the farm. These two frontiers are compared in terms of an efficiency gain across farm size and region and also tested for any changes in their basic structure by comparing the returns to scale across the two frontiers.

Source of efficiency

The second step in the analysis is to relate the efficiency scores to a number of explanatory variables, including observed characteristics of the farms. The study is focused on investigating management inefficiencies. For this reason, the technical efficiency score is chosen as the independent variable in the analysis of factors explaining the efficiency differences. Because the efficiency distribution is censored at one, the Tobit model is preferred (CHILINGERIAN, 1995). The Tobit model to be used is defined by equations (2) and (3).

(1) $$y_t = \begin{cases} y_t^* & \text{if } y_t^* \succ 1 \\ 1 & \text{otherwise} \end{cases}$$

(2) $$y_t^* = \beta + X_{et}\gamma + \mu$$

where y* denotes the dependent variable (efficiency score), X_e are the exogenous variables (listed previously in Table 3), β and γ are vectors of parameters to be estimated, μ is an error term and the subscript *t* represents the values for the *t*-th observation.

Empirical results and discussion

Table 1 illustrates informally the change in mean efficiency scores across regions when government payments are included or not as an output. Results show that if direct payments are included the mean efficiency scores improve for all regions, but the improvement is most marked for the mountain region. The percentage improvement in efficiency varies between regions. As seen from Table 1, the mountain region presents the greatest degree of variation. The mean technical efficiency is lowest in this region (57.5) and the standard deviation (13.7) is the highest. Valley farms were on average more technically efficient than hill and mountain region farms and a higher share of valley farms had a score of unity. In 1990-2000 the valley farms had on average a total technical efficiency of 76.5, meaning that they could reduce their inputs by 23.5 per

Table 1. Regional measures of efficiency, by Swiss agricultural production region

Region	Frontier without direct payments as output			Frontier with direct payments as output		
	Mean	Standard Deviation	Percentage of efficient units	Mean	Standard Deviation	Percentage of efficient units
Valley	76.5	12.5	4.6	77.7	11.1	5.7
Hill	67.9	11.5	1.5	76.9	9.9	3.6
Mountain	57.5	13.7	0.9	79.8	11.3	8.4

cent without reducing output. The hill and mountain farms could reduce their inputs even more, by 32.1 and 42.5 per cent respectively.

Effects of direct payments on agricultural structural change

In this section we test whether direct payments cause a structural change in Swiss agriculture. In this method two production frontiers are calculated. While Hofer (2002) has shown that direct payments in Switzerland slow down structural change in terms of farm size, we are interested in the incentives direct payments provide for switching in a farm's portfolio. The first frontier is constructed with conventional input and output combinations, that is, government payments are excluded from the calculation of the frontier. The second frontier is constructed including government payments as an output of the farm. These two frontiers are informally compared in terms of a gain in efficiency across farm size and are also formally tested for any changes in their basic structure (by comparing the returns to scale across the two frontiers). In other words, does the inclusion of direct payments in the calculation of overall efficiency induce one or more types of farm to become more or less efficient than the others? Each farm's efficiency score is calculated using its radial distance from the frontier.

In order to test for structural change, returns to scale assumptions for the two frontiers are tested (BANKER, 1996). We develop a variety of procedures to test the null hypothesis of returns to scale assumptions against the alternative of the constant returns to scale for a particular period t based on the assumed structure for the distribution of F(o)-1. The following illustrate the test procedures for the different cases of distribution:

a) Banker's Sum Ratio Test: if θ is exponentially distributed over $[1,\infty)$, then under the null hypothesis of variable returns to scale, the test statistic is calculated as

$$T_{EXP} = \frac{\sum_{j=1}^{N}(\theta_j^{VCR} - 1)}{\sum_{j=1}^{N}(\theta_j^{CRC} - 1)}$$

and evaluated relative to the Half-F distribution $|F_{2N,2N}|$ with (2N,2N) degrees of freedom

b) Banker's Sum of Squares Ratio Test: if θ is half-normally distributed over $[1,\infty)$, then the test statistic is calculated as

$$T_{HN} = \frac{\sum_{j=1}^{N}(\theta_j^{VCR} - 1)^2}{\sum_{j=1}^{N}(\theta_j^{CRC} - 1)^2}$$

and evaluated relative to the critical value of the Half-F distribution $|F_{N,N}|$ with (N,N) degrees of freedom.

c) Kolmogorov-Smirnov Test: if no such assumption is maintained about the distribution of θ, then the Kolmogorov-Smirnov test statistic is employed to compare the distributions of θ^{CRS} and θ^{VRS}:

$$T_{KS} = \max\left\{F(\theta_j^{CCR}) - F(\theta_j^{BCC}) \ \middle|\ j = 1, \ldots, N\right\},$$

where F(.) is the distribution function

Table 2 provides the results from the first round of tests. In these tests efficiency scores based on a frontier that does not include government payments as an output are used. Values of the test statistic for Banker's sum of deviations and sum of squared deviations tests are presented in the first two columns of Table 2 respectively, for each year. The Kolmogorov-Smirnov test results are presented in the last column of Table 3. All three tests indicate the rejection of the null hypothesis of returns to scale in favour of constant returns to scale for all 12 years. Table 2 provides results from the second round of tests.

In this round government payments are included as an output in the calculation of efficiency. If government payments cause a structural change in the production structure of agriculture, one should see a change in returns to scale from including government payments. As before, Banker's and Kolmogorov-Smirnov tests are used to test our null hypothesis. Once again we find that variable returns to scale are rejected in favour of constant returns to scale. Using our sample of farms we find evidence of constant returns to scale in Swiss agriculture. The inclusion of direct payments as an output in the calculation of the efficient frontier does not alter this result, leading us to believe that direct payments do not cause structural change in the production structure of Swiss agriculture.

Table 2. Tests for Returns to Scale

Year	**Government Payments not Included**			**Government Payments Included**		
	Banker's Sum Ratio Test	*Banker's Sum of Squares Ratio Test*	*Kolmogorov-Smirnov Test*	*Banker's Sum Ratio Test*	*Banker's Sum of Squares Ratio Test*	*Kolmogorov-Smirnov Test*
1990	1.142	1.219	0.115	1.111	1.168	0.101
1991	1.117	1.178	0.103	1.104	1.159	0.095
1992	1.148	1.236	0.125	1.102	1.166	0.109
1993	1.126	1.183	0.098	1.111	1.167	0.098
1994	1.115	1.176	0.086	1.097	1.145	0.076
1995	1.129	1.200	0.093	1.075	1.112	0.064
1996	1.142	1.217	0.120	1.125	1.217	0.095
1997	1.145	1.225	0.108	1.107	1.166	0.081
1998	1.123	1.182	0.087	1.093	1.147	0.083
1999	1.122	1.174	0.096	1.094	1.135	0.074
2000	1.138	1.196	0.095	1.120	1.193	0.103
2001	1.127	1.184	0.093	1.099	1.147	0.074

Factors accounting for technical efficiency variations

In this part of the study we investigate the nature of the relationship between direct payments and the technical efficiency of the farm by using the frontier constructed without including direct payments as an output. The dependent variables used in the models are the measures of technical efficiency in percentages. Because efficiency scores are constrained between zero and 1, Tobit models are used. The vector of explanatory variables contains the previously defined set of variables in linear form. In this Tobit regression model we investigated the role of socio-economic factors, farm characteristics, environmental factors and non-physical factors in influencing farm efficiency during the period 1990-2001.

Results of the estimation are summarized in Table 3. As the dependent variable is the efficiency score, the parameters with positive signs indicate sources of efficiency and vice versa. The vector of explanatory variables contains the previously defined set of variables in linear form. The variables used are listed in Table 3 with t-statistics indicating whether their means are significantly different between regions. The geographic location is the other farm characteristic that is used to account for any site-specific factors (e.g. soil fertility, differences in weather) not included in the production function but that may affect the farmer's technical efficiency level. Valley region and hill region have a higher efficiency as indicated in Table 1. This suggests that the regional location of the farm has an impact on farm efficiency. The specific characteristics of this regional location are taken into consideration in the Tobit model. Specifically, there were three subsamples (one for each region).

A negative relationship between debt-to-asset ratio and technical efficiency was found. These results can be explained by the adjustment hypothesis and the agency cost[3]: farmers with lower debt-to-asset ratios would adjust more easily to the change and would therefore be more efficient. This result is consistent with SHANKER ET AL. (1984) and WEERSINK ET AL. (1990) for dairy farms in Ontario. They argue that a high ratio may be related to overcapitalization and that the higher level of debt may constrain a farmer's allocation decisions and, thus, negatively affect efficiency. Table 3 shows that the age variable is associated negatively with farms' technical efficiency. This result is probably reflective of older producers who use traditional methods and are less willing to innovate, alter crop mix, or try other new activities. This result contrasts with the common belief that a farmer's efficiency increases to maximum in the middle years and then decreases with further age. TAUER and LORDKIPANIDZE (2000) explained that experienced older farmers are still using older technology efficiently. "Seeing a decrease in production isn't always devastating". The variable education is the number of years of formal education completed by the head of household (high/low). Education is believed to be positively linked to better allocation decisions, but the effect is likely to be significant only when an exogenous change in technology or in market conditions occurs (AZHAR, 1991). The variable education is used as a proxy for managerial input. Increased farming experience coupled with a higher level of educational achievement may lead to better assessment of the importance and complexities of good farming decisions, including efficient use of inputs. Results in Table 3 suggest that education is an important positive determinant of a farmer's technical efficiency in the valley region.

Household size (number of adults in the household) is a proxy for the family labour available to work on the farm. Family labour is believed to be more motivated than hired labour, can undertake supervisory roles and can engage in off-farm employment.

Table 3. Tobit Analysis of Technical Efficiency: Marginal Effects (with standard errors in parentheses)

Explanatory Variables	**Valley region**	**Hill region**	**Mountain region**
Constant	67.522 *** (1.670)	60.965*** (1.517)	53.911*** (1.758)
Utilised agricultural area (ha)	0.105*** (0.013)	0.127 *** (0.013)	0.060*** (0.014)
Share of rented land (%)	0.035*** (0.003)	0.044*** (0.004)	0.036*** (0.006)
Share of hired labour (%)	-0.006 (0.006)	-0.004 (0.006)	0.008** (0.011)
Stocking density (livestock units/ha)	2.813 *** (0.193)	4.868 *** (0.025)	1.042 ** (0.537)
Share of direct sale in total production (%)	0.348*** (0.018)	0.285*** (0.020)	0.301*** (0.023)
Age of farm operator (years)	-0.165*** (0.011)	-0.143 *** (0.013)	-0.087*** (0.019)
High level education (1= master's or university degree, 0= none)	2.312 *** (0.665)	1.039** (0.472)	2.256 *** (0.432)
Agricultural education level of farm operator (1= basic agricultural education, 0= none)	2.810*** (0.930)	0.789 (0.807)	1.687 ** (0.695)
Debt to assets ratio (%)	-0.071 *** (0.004)	-0.057*** (0.005)	-0.032*** (0.007)
Household size (number of family members)	0.046 (0.082)	-0.374 ** (0.095)	0.097 (0.131)
CC (1= participation in the PER programme and 0 = none)	4.118 *** (0.353)	1.996*** (0.405)	3.321*** (0.601)
Crop farm (1= crop and none 0)	7.983 *** (0.452)	10.814*** (2.985)	-23.95** (10.23)
Livestock farm (1= animal and 0 for the others)	-0.912** (0.247)	-0.249 (0.249)	1.381** (0.577)
Low dependency on direct payments and participation in the proof of ecological performance	6.593*** (0.595)	8.482*** (0.379)	10.507*** (0.445)
High dependency on direct payments and participation in the proof of ecological performance	-8.225*** (1.944)	-11.307*** (1.344)	-14.063*** (0.524)
Dummy variable for year 1993	-3.235 *** (0.512)	-3.277*** (0.593)	-4.523*** (0.840)
Dummy variable for year 1994	-2.118*** (0.489)	-1.696** (0.562)	-3.006*** (0.762)
Dummy variable for year 1995	-1.810*** (0.470)	-0.844 (0.545)	-0.507 (0.770)
Dummy variable for year 1996	1.399 *** (0.463)	1.346** (0.529)	2.145 ** (0.782)

Explanatory Variables	**Valley region**	**Hill region**	**Mountain region**
Dummy variable for year 1997	-2.695 *** (0.482)	-5.795** * (0.523)	-5.804*** (0.730)
Dummy variable for year 1998	-3.961*** (0.478)	-5.738 *** (0.509)	-1.367 *** (0.698)
Dummy variable for year 1999	0.984 ** (0.480)	-0.897 (0.517)	-5.012 (0.709)
Dummy variable for year 2000	-6.513*** (0.494)	-7.353*** (0.519)	-7.528 *** (0.690)
Number of observations	**12426**	**6968**	**3713**
Log likelihood	**8114.50**	**6013.85**	**3118.39**
Note: triple, double and single asterisks (*) denote statistical significance at the 1%, 5% and 10% levels, respectively. Numbers in parentheses are standard errors.			

Hence, household size is expected to have a positive influence on efficiency. The results shows that household size is negative statistically significant only for the hill region. In examining the factors affecting farm efficiency, it is important to take into account the change in the Swiss agricultural policy environment.

To capture these relationships between agricultural policy and technical efficiency, two variables were used in the regression efficiency model. The dependence on direct payments is defined as the share of direct payments in total production and the farm's participation in cross-compliance (CC). There is a marked negative relationship between direct payments and efficiency in all regions. In other words, the greater a farm's share of direct payments within gross output, the lower its efficiency in using its resources. In contrast, the participation in proof of ecological performance is shown to increase the average level of farm technical efficiency. This relationship between the farm's dependence on direct payments and efficiency is noteworthy. Significant direct payments are made to the three regions but support to mountain farmers continues through regional support. However, because efficiency is measured relative to best practice within each system, the dependence on the direct payments variable is not simply picking up the more efficient use of resources by some farming systems. Rather, it appears to reflect the fact that eligibility for payments may make a farmer deliberately pursue technically less efficient production practices (as required to qualify for CC or extensification payments). There is an evident tension between short-run income support or environmental objectives and long-run competitiveness.

Low direct payments farms are defined as those where direct payments make up less than 33 per cent of their gross margin. High direct payments farms are defined as those where over 66 per cent of their gross margin comes in the form of direct payments. The efficiency of both the low-payments-dependent CC participation farms and the high-payments-dependent CC participation farms is measured relative to farms with an average dependence on direct payments. The level of farm efficiency is found to be higher than average on CC participation farms with very low dependence on direct payments. In contrast, the level of farm efficiency on CC participation farms with very high dependence on direct payments is lower than farms with average dependence on such payments.

These findings have important policy implications. The positive association between dependence on direct payments and farm technical inefficiency suggests that reform of Swiss agricultural policy is encouraging a less competitive agricultural sector. Indeed, it may be that dependence on direct payments not only increases inefficiency but also slows down the take-up of technical innovations and is thus responsible for the decreasing rate of technical change over time. On the other hand, there are environmental benefits from the more extensive farming methods encouraged by the present policy. Quantifying the negative effects on agricultural efficiency and the positive effects on the environment of the direct payments regimes has not been explored in this study and will be the subject of separate research.

Conclusions

We use DEA (a multi-output, multi-input nonparametric framework) to calculate efficiency scores and then use these efficiency scores to test for returns to scale with and without the inclusion of direct payments as a source of revenue. The inclusion of direct payments does not alter returns to scale in Swiss agriculture. Swiss agriculture is characterized by constant returns to scale technology. Nevertheless, we find evidence of an indirect effect of government payments on efficiency. Using efficiency scores calculated without including government payments as a dependent variable in a second stage regression we find that farms that received greater government payments on aggregate were more inefficient than other farms. Having identified significant differences between adopters and non-adopters of this voluntary participation in cross-compliance, future research should focus on explaining their origin. Measuring and analysing the adaptation of technologies and environmental impact over time and a detailed analysis of how different components of agricultural policy impact on farmers' decisions would help to give a better understanding of the causes of the differences we measured.

Notes

[1] Many explanations have been offered for economies of scale in agriculture. HAYAMI and RUTTAN (1985) attribute economies of scale in agriculture to the lumpiness or indivisibility of fixed capital. A similar explanation was offered by BIERI, DE JANVRY and SCHMITZ (1972), who expected farm size to increase with the size of farm equipment. KISLEV and PETERSON (1996) theorized the indivisibility of entrepreneurial ability and labour as the main reason for growth in farm size. As farm wages rise, farmers need larger farms to gain parity with incomes earned off the farm and this drives growth of farm size.

[2] 1CHF = 1 $

[3] The agency theory has been employed by Nsar, Barry and Ellinger, 1998 and Shankar et al., 2001. This approach emphasises the costs of monitoring the borrowers by lenders, costs that might be transferred to borrowers. As a result, more heavily indebted borrowers are also higher cost, thus less efficient.

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