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How do direct payments influence machinery investments of Swiss dairy farms?

Wie beeinflussen Direktzahlungen die Maschineninvestitionen von Schweizer Milchviehbetrieben?

Daniel Hoop*

Managerial Economics in Agriculture, Agroscope, Switzerland

**Correspondence to:* daniel.hoop@agroscope.admin.ch

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Summary

Using regression analyses based on accountancy data, this study analyzes whether direct payments influence machinery investments of Swiss dairy farms. The direct payment regime before 2014 incentivized farmers to increase machinery assets per hectare. Under the regime from 2014 onward, farmers who increased direct payments per hectare over the years were not incentivized to increase machinery assets per hectare. The comparison of farms receiving different amounts of direct payments revealed that – regardless of the regime in place – higher direct payments per hectare were associated with higher machinery assets per hectare. However, this effect was less pronounced for the direct payment regime from 2014 onward, which reconfirms the finding that this regime has provided little incentives to invest in machinery assets.

Keywords: agriculture, machinery asset, subsidy, policy change, Switzerland

Zusammenfassung

Diese Studie untersucht unter Verwendung von Regressionsanalysen und Buchhaltungsdaten, ob Direktzahlungen die Maschineninvestitionen von schweizerischen Milchviehbetrieben beeinflussen. Gemäß der Analyse führte das Direktzahlungssystem vor 2014 zu einer Steigerung im Maschinenanlagevermögen pro Hektar landwirtschaftlicher Nutzfläche. Im Direktzahlungssystem ab 2014 konnte nicht beobachtet werden, dass Betriebe, deren Direktzahlungen pro Hektar zunehmen, auch in zusätzliches Anlagevermögen pro Hektar investieren. Der Vergleich von Betrieben mit unterschiedlich hohen Direktzahlungen pro Hektar zeigte aber, dass höhere Direktzahlungen pro Hektar mit einem höheren Anlagevermögen pro Hektar einhergingen. Dieser Effekt war im Direktzahlungssystem ab 2014 aber weniger stark ausgeprägt, was die Schlussfolgerung nahelegt, dass dieses System wenig Anreize für Maschineninvestitionen schafft.

Schlagworte: Landwirtschaft, Analagevermögen Maschinen, Subventionen, Politikwechsel, Schweiz

1 Introduction

Machinery costs are an important cost item in agriculture. From 2018 to 2020, the cost of machinery maintenance and depreciation was CHF 51,200 for an average Swiss farm. Relative to the total external costs of CHF 298,400, this figure corresponds to 17%. Therefore, the cost of machinery is as important as the cost of buildings, and it is crucial to the economic success of a farm (Hoop et al., 2021).

Whether a farm owns machinery and which machinery it owns depend on investment decisions made in the past. Various studies have investigated investment decisions by farm managers. Jacobsen (1996) summarized several studies trying to explain investment decisions by means of different econometric models. The reviewed studies found that investments are determined by, among other factors, tractor prices, the size of the farm, the age of the farm manager and revenues. Vanzetti and Quiggin (1985) found that the income in the previous year influences investment decisions. Other studies covered topics such as investment and labor allocation (Ahituv and Kimhi, 2002; Andersson et al., 2005) or on-farm vs. off-farm investments (Serra et al., 2004). Regarding the driving force for an investment, various motives can be at play. Investments can be a means to increase profits, to reduce risk, to improve working conditions or to enhance the quality of live. They can be necessary because of new regulations, but they can also be related to the status of the farm manager. Direct payments could influence investment decisions because they determine (or change) the profit function, or because they require special (environmentally friendly) technology. They could also provide additional income that is used by the farmer to buy machinery even if it is not necessary, either for personal pleasure or as status symbol.

Sckokai and Moro (2009) and Viaggi et al. (2011) investigated the impact of agricultural policy on investment behavior of Italian farm managers. Analyzing interviews, Viaggi et al. (2011) found that the majority of farmers would not change their investment decisions when agricultural policies changed. Based on accountancy data and modeling, Sckokai and Moro (2009) found that mainly output price interventions may change investment decisions (because of reduced price volatility) whereas single farm payments have a much smaller impact.

Because Swiss agricultural policy differs from the policy in Italy, and price levels are higher than in the rest of Europe, it is not clear if the results from Italian studies can be transferred to Switzerland. An average farm – having 35.0 livestock units and managing 27.0 ha of agricultural area – generates revenues of CHF 350,700 of which CHF 77,500 come from direct payments (subsidies), which translates into CHF 2670 in direct payments per hectare agricultural area (Hoop et al., 2021). Therefore, even though the effect of policy measures on investment decisions might be small, the relatively high sum of direct payments could still influence investment decisions made by farm managers. In addition, with the introduction of a new direct payment scheme in 2014, the Swiss context offers a real-world but trial-like situation to measure the impact of a change in direct payments on machinery investments.

Whereas “protecting the environment […]” or “fair and adequate remuneration for the services provided” are goals of the Swiss federal agricultural policy (article 104 of the federal constitution), the promotion of machine ownership is not. Therefore, for policy makers, it is important to understand whether the direct payment regime incentivizes farmers to invest in machinery – which is the main research question investigated in this study. If this was the case, further research would be necessary trying to understand how these investments were related to the goals of the agricultural policy. In case of trade-offs, ways would need to be found to make the direct payment program more targeted to fulfill its mandate according to the constitution.

2 Data and Methods

2.1 Data

Swiss farm accountancy data from the years 2004 to 2020 stemming from two successive samples were analyzed (sample A: Hoop and Schmid, 2015; sample B: Renner et al., 2019). The data include detailed information on different cost items, such as machinery cost or cost for contractors. To assure a certain degree of homogeneity, the sample was restricted to dairy farms having at least eight hectares of agricultural area and eight ruminant livestock units.

Machinery assets per hectare agricultural area (MA) was chosen as the variable of interest to analyze net investments at the farm level (assets on December 31 = assets on January 1 + investments − disinvestments − depreciation). By using regression models, the effect of direct payments per hectare on MA was investigated. Other explanatory variables were included to control for farm-specific characteristics that may also influence MA.

Before conducting the regression analyses explained in the following sections (i.e., before calculating differences between years), all variables except dummy variables were converted by applying the natural logarithm to minimize the effect of extreme values and to mitigate heteroscedasticity, which would otherwise have been a problem. In the rare case of negative values (which can result from offset entries to correct bookings in previous years, for instance), the natural logarithm of one was inserted. The farm income (see section 2.2) was the exception, where six farms or approx. 2% of farms had to be dropped owing to negative values.

2.2 Regression (model 1) evaluating the change of the direct payment regime

The change of the direct payment regime in 2014 offered a rare possibility to analyze the ceteris paribus impact of a change in direct payments on MA, because the amount of direct payments received by some farms changed (due to the policy change) even though these farms did not change structurally. For this purpose, sample A was restricted to farms that were available in both years 2013 and 2014. To be part of the regression analysis, the total agricultural area of the farm, the proportion of arable land and the ruminant livestock density of each farm had to change less than 1% from 2013 to 2014. For the remaining 264 farms, the change in MA between 2013 and 2014 was explained using the following independent variables (see also Table 1): the change in direct payments per hectare (hereinafter called "DP") from 2013 to 2014, the change in the agricultural income per hectare ("FarmIncome") from 2012 to 2013 and the change in cost for contractors per hectare ("CostContract") from 2013 to 2014. Because the farm size, the stocking density and the proportion of arable land changed less than 1% (by definition), they were not included in the model.

2.3 Multi-year panel regressions (models 2 and 3) for two separate direct payment regimes

In a subsequent analysis, the multi-year panel structure of the data was exploited using the mixed-effects regression approach described in Equation 1 and suggested by Bell and Jones (2015) (Bates et al., 2015; R Core Team, 2021). It allows differentiating between , i.e., the effect a change in direct payments over the years has on MA (*within* observation effect), and , i.e., the effect different levels of direct payments on different farms have on MA (*between* observation effect). For example, there could be a strategy that receives more DP but depends on more MA. When a farm implements this strategy, both DP and MA increase. Farms already implementing the strategy have higher MA compared to other farms. In the ideal case, the coefficients of the within and the between effect are equal. If they differ significantly, this indicates that omitted farm characteristics are associated with higher DP. The between effect incorporates (parts of) these characteristics and must therefore be interpreted with caution. Compared with the fixed-effects model specification often applied in econometrics, which captures only the within observation effects, this model formulation yields more accurate coefficient estimates (Bell and Jones, 2015).

$$y_{ij} = \beta_0 + \beta_1(x_{ij} - \bar{x}_j) + \beta_4\bar{x}_j + \beta_2 z_j + (u_j + e_{ij}) \tag{1}$$

where

y_{ij} is the dependent variable with j denoting the farm and i the year,

x_{ij} is a time-variant explanatory variable for observation j in year i,

$\bar{x}_j$ is the average value of a time-variant explanatory variable for observation j,

z_j is a time-invariant explanatory variable,

β_0 is the intercept,

β_1 is the so-called within effect,

β_4 is the so-called between effect,

β_2 is the effect of an independent, time-invariant variable,

u_j is the error term for each observation, and

e_{ij} is the error term for each observation in each year.

To be able to differentiate the effect the two direct payment regimes before 2014 and from 2014 onward have on MA, the regression was performed twice: once using data from 2004 to 2013 from sample A containing 1126 farms per year on average and 1979 distinct farms in total, once using data from 2016 to 2020 from sample B containing 547 farms per year on average and 926 distinct farms in total. The within–between regression model included all variables from the first regression except FarmIncome. FarmIncome could not be included because the average MA can causally influence the average FarmIncome of an observation (in Equation 1) even when a time lag would be used.[1] On the other hand, ruminant livestock units per hectare ("RumiLu"), the proportion of arable land in the agricultural area ("PropArab") and the change in the utilized agricultural area of the farm ("UAA") were included as explanatory variables. In addition, the regression approach allowed for including the production zone and year dummies as explanatory variables. Finally, the average age of the farmer was included as a time-invariant effect (see table 1). Owing to the unbalanced nature of the panel dataset, in the regression model each farm occurrence was weighted inversely proportional to the number of occurrences per farm over the years so that the results would not be influenced more strongly by farms that delivered their data in many years.

3 Results

Table 2 shows descriptive statistics for the analyzed sample used in the first and second regression models (years 2004 and 2013, sample A) and the third regression model (year 2020, sample B) and for the Swiss average in 2004 and 2020 for all farms (not only dairy farms). It is worth mentioning that the ruminant livestock density on the analyzed farms increased in the period under consideration. Compared with the Swiss average, the ruminant livestock density was higher in all analyzed years. Because only dairy farms were analyzed, the proportion of arable land was considerably lower than the Swiss average. Machinery assets and direct payments per hectare differed less than 10% from the Swiss average.

Table 3 shows the coefficient estimates of the three regression models explaining MA by means of different variables. Significances of coefficients were calculated based on the Satterthwaite approximation (Kuznetsova et al., 2017). The first regression analysis included farms that changed less than 1% in size, stocking density and the proportion of arable land, which is why these time-variant variables were not included in the model. The remaining variables did not show any significant (within) effect on MA. Therefore, a change in DP due to the change in the direct payment regime from 2013 to 2014 does not seem to have influenced machinery investments.

1 This was another reason to use the regression model 1, where income could be included as an explanatory variable.

Table 1: Explanatory variables and expected effects on machinery assets per hectare agricultural area (MA)

Variable (unit; abbreviation)	Expected effect	Explanation	Used in regression
Within and between effects			
Direct payments per hectare (CHF/ha; DP)	?	It is possible that direct payments incentivize farmers to possess more machinery.	1, 2, 3
Utilized agricultural area (ha; UAA)	–	The larger the farm, the less machinery is owned per hectare because of economies of scale.	2, 3
Ruminant livestock units per hectare (LU/ha; RumiLu)	?	It is possible that farms with high stocking densities rather produce roughage instead of letting the cattle graze. Because harvesting roughage is only possible during short periods, some machinery has to be owned. Outsourcing might be difficult.	2, 3
Proportion of arable land in the total UAA (ha; PropArab)	?	No hypothesis regarding the expected effect.	2, 3
Cost for contractors per hectare (CHF/ha; CostContract)	–	The more work a farm outsources to contractors, the less machinery it needs to own.	1, 2, 3
Farm income per hectare in the previous year (CHF/ha; FarmIncome)	+	High income in the previous year may increase investments (Vanzetti and Quiggin, 1985).	1
Time-invariant effects			
Age of the farmer (years; Age)	–	Older farmers tend to invest less in new machinery, which is why they have older machinery that is already (partially) depreciated.	2, 3
Production zone (dummies; Hill and Mountain1 to Moutnain4)	+	According to Hoop et al. (2021), MA are higher in higher production zones.	2, 3
Other			
Year (dummies)			2, 3

CHF: Swiss Francs, ha: hectares, LU: livestock units

Table 2: Descriptive statistics for the analyzed sample in 2004 and 2013 (regression models 1 and 2), the analyzed sample in 2020 (regression model 3) and the Swiss average in 2004 and 2020

Figure	CH 2004	Sample A 2004	Sample A 2013	Sample B 2020	CH 2020
UAA	19.77	20.30	23.90	24.82	27.03
Total ruminant LU	21.33	24.47	30.61	32.27	28.33
Age	44.64	44.43	40.91	44.52	48.09
Variables per ha:					
MA	2920.56	2797.42	2979.91	3348.68	3168.48
DP	2448.01	2514.13	3013.12	2924.54	2868.12
RumiLu	1.08	1.21	1.28	1.30	1.05
PropArab	23%	5%	5%	5%	27%
CostContract	375.25	252.84	309.18	328.77	435.11

The meaning of abbreviations and the units of measurement can be found in Table 1.
Source: Own calculations based on Swiss Farm Accountancy Data Network data

Table 3: Results of regression model 1 explaining machinery assets based on the change in the direct payment regime from 2013 to 2014, and of regression models 2 and 3 explaining machinery assets in a panel regression from 2004 to 2013 and from 2016 to 2020, respectively.

Figure	Regression model 1 2013/14	Regression model 2 from 2004 to 2013		Regression model 3 from 2016 to 2020	
	Within effect	Within effect	Between effect	Within effect	Between effect
DP	–0.10 (0.40)	*** 0.31 (0.05)	*** 0.58 (0.09)	* –0.16 (0.06)	*** 0.27 (0.07)
UAA		*** –0.31 (0.08)	*** 0.17 (0.05)	*** –0.88 (0.12)	*** –0.25 (0.06)
RumiLu		*** 0.27 (0.06)	*** 0.46 (0.08)	0.13 (0.09)	*** 0.53 (0.10)
PropArab		0.01 (0.01)	0.00 (0.01)	* 0.00 (0.00)	0.00 (0.00)
CostContract	–0.03 (0.03)	* 0.02 (0.01)	0.01 (0.02)	0.00 (0.01)	0.01 (0.03)
FarmIncome	–0.01 (0.02)				
		Time-invariant effect		Time-invariant effect	
Intercept		*** 4.73 (0.81)		*** 8.21 (0.73)	
Age		*** –0.59 (0.07)		*** –0.48 (0.10)	
Hill zone		0.01 (0.05)		* –0.13 (0.06)	
Mountain1		0.05 (0.05)		–0.01 (0.07)	
Mountain2		0.02 (0.06)		0.10 (0.08)	
Mountain3		0.16 (0.09)		** 0.35 (0.11)	
Mountain4		* 0.26 (0.11)		0.25 (0.14)	

*, ** and *** indicate significances at the 0.05, 0.01 and 0.001 level, respectively.
The standard error of each coefficient estimate is given in brackets.
The meaning of abbreviations can be found in Table 1.
Source: Own calculations based on Swiss Farm Accountancy Data Network data

Next, the results from the second regression model based on the dataset from 2004 to 2013 will be described. Both the within and the between effect of DP were positive and significant. A value of 0.31 for the within effect implies that the dependent variable increases by 0.31% when DP increase by 1%. The between effect (0.58) was almost twice as high. The effect of RumiLu on MA was positive, and once again, the between effect (0.46) was considerably larger than the within effect (0.27). The within effect of UAA on MA was −0.33 meaning that MA decreased disproportionally when farms grew over time. The between effect was positive (0.17) meaning that larger farms had higher MA. Older farm managers had lower MA (−0.59) than younger ones. MA were highest in mountain zone 4 (0.28). The effects of the other zones were not significant. The effects of CostContract and PropArab were negligible.

In the third regression model, based on data from 2016 to 2020, some coefficients had different signs and significances than in the second model. It is worth highlighting that the within coefficient of DP was negative (−0.16) and significant. The within effect of RumiLu was small and not significant. Regarding UAA, the within effect was much more pronounced (−0.88), and the between effect (−0.25) was negative and significant. In contrast to the second model, the effect of the hill zone (−0.13) was negative and significant, and mountain zone 3 showed the largest effect on MA (0.35). To save space, Table 3 does not contain year dummies for either of the models. In summary, all coefficients from 2005 to 2013 were negative, and no development over time could be observed. This means that the year 2004 was an outlier with unusually high levels of MA. In the third regression model, three year-effects were slightly negative and two were not significantly different from zero.

4 Discussion

The finding that the within coefficient for DP was not significantly different from zero in the first model and even negative in the third model indicates that the direct payment regime introduced in 2014 (which is still in place today) has not created incentives for farmers to invest in machinery when the amount of DP increases, which affirms the findings of Sckokai and Moro (2009) and Viaggi et al. (2011). It even seems that dairy farms that receive more DP over time invest less in MA. Because cost accounting was applied in sample A before 2014 (used for the second model), but financial accounting was applied in sample B afterward (used for the third model), it is possible that this observation was caused by a change in the farms' depreciation behavior. However, given the five-year period analyzed in the third model, such effects should even out, and therefore this explanation seems rather unlikely. In general, independently of the accounting system, the results may have been influenced by the limited flexibility of farmers to adjust MA when reacting to DP. Consequently, the effect of DP on MA could be delayed (e.g., one- or two-year lag), which was tested in additional calculations. In the second model, shifting the DP by one or two years changed the within coefficient from 0.31 to 0.18 or 0.20, respectively. Therefore, investments seem to have been distributed over several years after DP increased. In the third model, the within coefficient of DP was estimated 0.00 and 0.07, respectively, when time lags of one and two years were introduced. Both values did not differ significantly from zero (as opposed to −0.16 estimated without time lag). This indicates that the results from the second analysis are robust whereas the negative within coefficient from the third analysis should be interpreted with caution.

For both the second and the third model, the positive between effect of DP differing from the within effect indicates that some omitted variables were captured by the between effect, which separates farms with higher DP from those with lower DP. Such an omitted effect could be, for instance, adverse production conditions, so that farms need more MA and receive more DP to compensate for the additional costs. In this case it would be hard to argue whether DP lead to higher MA, or whether higher MA are the reason for higher DP. On the other hand, it is possible that some farms received more DP (e.g., because of farm characteristics beyond their control) and used this additional revenue to invest in machinery (that may not be necessary).

The within effect of UAA in the third model was −0.88, signifying that a 1% growth resulted in a 0.88% reduction in MA. This describes a situation where growth was possible with little necessity to invest in additional machinery. The coefficient of −0.31 in the earlier period (from 2004 to 2013) indicates that growth was accompanied by larger investments during this time. The positive between effect in that model is counterintuitive. An explanation might be that larger farms were in a situation where they had to invest in larger machinery, but their size was not enough to offset the additional assets – therefore assets per hectare were higher.

The positive effect of RumiLu on MA and the negative effect of the farmer's age on MA were expected (see Table 1). The negligibly small coefficient for CostContract (in all models) was surprising given that a substitution between owning machinery and outsourcing work to contractors is possible. Therefore, a negative coefficient was expected. A positive effect of FarmIncome on MA could not be observed, which is in contrast to the findings of Vanzetti and Quiggin (1985). The different effects of the zones in the third model might result from relatively small sample sizes in some zones.

5 Conclusions

This study analyzed whether direct payments influence machinery assets owned by Swiss dairy farms. In the direct payment regime before 2014 (in force from 1999 to 2013), payments were granted per hectare *and* per ruminant livestock basis. According to the results of this study, this regime incentivized farmers to increase machinery assets per hectare. In the direct payment regime from 2014 onward (in force until today and beyond), where payments have been granted on a per hectare basis, it could not be observed that farms receiving more direct payments over time would increase machinery assets. The comparison of farms receiving different amounts of direct payments revealed that – regardless of the regime in place – higher direct payments per hectare were associated with higher machinery assets per hectare. However, this effect was less pronounced for the direct payment regime from 2014 onward, which reconfirms the finding that this regime provides little incentives to invest in machinery assets. Because the change in the direct payment regime affected different farm types differently, these conclusions cannot be generalized to all Swiss farms. For instance, additional research would be necessary to determine the effects of direct payments on machinery investments of arable farms.

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