Sustainable Value: an application to the Swiss dairy farms of the mountainous area

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Abstract— The improvement of the sustainable performance of the agricultural sector is a priority of the Swiss agricultural policy. The sustainability of Swiss dairy farms located in the mountainous area might be critical as many of them show a weak performance in the use of their economic and/or social resources, and sometimes also of their environmental resources. An improvement of the sustainability of these farms prerequisites to better know on a large scale their sustainable performance and its determinants. For a representative sample of 480 dairy farms, we perform an assessment of their sustainable efficiency with the "sustainable value", an approach to assess corporate sustainability based on the capital and opportunity cost theories. Using a linear regression, we analyze the determinants of the sustainable efficiency. The results show a tight positive relationship between sustainable performance and pure economic performance. The intensity of the use of intermediate consumptions is found to be the most important determinant of the sustainable efficiency. Farms with a high sustainable efficiency are those that use their intermediate consumptions in the most efficient way. The part of direct payments in the gross profit is shown to negatively affect the sustainable efficiency. The structural characteristics of the farms and the sociologic characteristics of the farmer managers are shown to hardly influence the sustainable efficiency.

Keywords— corporate sustainable performance, dairy farms, Switzerland

I. INTRODUCTION

Since the publication of the Brundtland Report in 1987 [1], sustainability has become an issue of major concern in the debate on the future of agriculture [2][3]. Promoting a sustainable agriculture is one of the major objectives of the Swiss agricultural policy, the principle of a sustainable agriculture being anchored in the Federal Constitution [4].

Many definitions of the concept of "sustainable development" have been formulated [5][6]. The different definitions differ by various aspects such as the dimensions of sustainability considered and the perspective from which sustainability is examined. Originally, sustainable development is a macro-economic concept. Its central aim is to increase the well-being per inhabitant coupled with the alleviation of poverty and inequality without depleting the "resources basis" of the national and global economies [7]. The concept of sustainable development is based on two pillars: the equity principle (inter- and intra-generational equity) and the tri-dimensionality principle, the concept involving economic, ecological and social aspects [8][9][10]. More formally, economists very often use the capital theory approach when studying sustainability [11]. Capital is made of man-made capital, human capital, natural capital and social capital. It follows, according to the constant capital rule, that a development is sustainable, if it ensures constant capital stocks or at least constant capital services over time [12][13].

In Switzerland, 28% of the farms are located in the mountainous area [14], which includes the mountainous zones 2, 3 and 4 [15] and which can be roughly defined as the agricultural production area located between 800 and 1500 meters above sea level. The mountainous area accounts for 28% of the total agricultural production area of Switzerland [16] whereas it amounts to approximately 60% of the total Swiss land area. The farms located in the mountainous area are principally grazing livestock farms and more particularly dairy farms. These dairy farms are not only important for the Swiss dairy sector, as they generate one third of the Swiss milk production [17] but also play a major role in the conservation of national resources, the upkeep of rural scenery and the decentralised inhabitation of the country. These latters are three objectives assigned by the Swiss legislator to the Swiss agriculture [4].

The sustainability of these farms may be questioned as they generally show a weak performance in the

efficiency of the use of their socio-economic resources and also, sometimes, of their environmental resources. A typical example of this weak performance in the resource use concerns the socio-economic resource labour. On the period 2003-2005, the median work income per family work unit of the reference dairy farms located in the mountainous area of the Swiss Farm Accountancy Data Network was 48% lower than the comparative salary[1] of the mountainous area and 25% lower than the work income of the dairy farms located in the plain region [18][19]. The efficiency of the labour resource use shows a high variability among farms. Whereas the work income of the farms of the last work income decile was in 2006 23% higher than the comparative salary of the mountainous area, the work income of the farms of the first work income decile was 119% lower than the comparative salary of the mountainous area (own calculations based on Swiss FADN data).

As illustrated in the previous section, the sustainable performance[2] of the farms is not only weak "on average" but also very variable. In order to promote the sustainability of the Swiss dairy farms located in the mountainous area, a better understanding of the sustainable performance of these farms is required. Blandford and Hill [20] assert that for the purpose of investigation of sustainability "the focus must be on the institutional units in which production takes place – the firms responsible for bringing together the land, labour and capital that, when combined with other inputs, results in the production of agricultural goods and services." Some studies have already been carried out to assess the sustainability of the Swiss agricultural holdings [21][22][23]. However, these analyses are restricted to case studies at farm level (real cases or typical cases) or to an evaluation for a particular region and makes it thus impossible to draw conclusions for the whole Swiss dairy sector located in the mountainous area.

This paper assesses the corporate sustainable performance of the Swiss dairy farms located in the mountainous area and investigates the determinants of the sustainable performance of these farms. The data

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[1] Median salary of the employees of the secondary and tertiary sector.
[2] Joint economic, ecological and social performance

and methods used to perform this study are described in chapter II. In chapter III, we present the results of this investigation. In the subsequent part (chapter IV), the results are discussed and general conclusions are drawn.

II. DATA AND METHODS

A. The Sustainable Value approach

The Sustainable Value is a "value-oriented" approach to assess the corporate contribution to sustainability [24][25][26]. This approach based on the capital and opportunity costs theories analyzes how much more (less) value added is created by a company because it uses more (less) efficiently its set of capital (economic, ecological and social) than the benchmark considered [26]. For a company using a set of n forms of capital i, the Sustainable Value created by this company is given by equation 1 (adapted from Figge and Hahn [26]).

$$ SV = \frac{1}{n} \sum_{i=1}^{n} x_i \underbrace{\left(\underbrace{\frac{y}{x_i} - \frac{y^*}{x_i^*}}_{\text{Value spread}} \right)}_{\text{Value contribution}} \quad (Eq.1) $$

with :
  SV = sustainable value
  y = value added (output) of the evaluated firm
  x_i = amount of capital i used by the investigated company
  y* = value added (output) of the benchmark
  x_i* = amount of capital i used by the benchmark
  n = number of forms of capital considered

For every form of capital i, we calculate the return on capital i of the firm investigated as the ratio between the value added produced by this firm and the amount of capital i used to generate this value added. In a second step, we calculate the opportunity cost of the capital i as the ratio between the value added created by the benchmark and the amount of capital i used by the benchmark. Adopting the opportunity cost logic of the financial markets we compare then the return on capital i of the firm investigated to the

opportunity cost of this capital. The so-called value spread in Eq. 1 defines how much more (less) value is created per unit of capital employed by the company in comparison with the benchmark. The value contribution is calculated by multiplying the value spread of capital i by the amount of capital i used by the company. The Sustainable Value created by the entity is then obtained by adding up the value contribution of each form of capital considered. To correct for the overestimation caused by summing up the value created by each form of capital, we divide the sum obtained by a factor n (the number of resources considered to calculate the sustainable value). As emphasized by Figge and Hahn [26], dividing by n "does not serve to weight the different forms of capital but only to avoid double counting of value creation". As a result we obtain a single monetary figure expressing the corporate contribution of a firm to sustainability. Sustainable Value indicates "whether the value added created by a firm exceeds the costs of its capital use" [26].

Sustainable efficiency[3] of capital use is determined by relating the value added created by the firm to the opportunity cost of all forms of capital used (see Eq. 2). The opportunity cost of this capital is given by the difference between the value added created by the firm and its sustainable value [26].

$$SE = \frac{y}{y - SV} \quad (Eq. 2)$$

with:
SE = sustainable efficiency
SV = sustainable value
y = value added (output) of the evaluated firm

A sustainable efficiency higher than one implies that the value added created by the company is higher than the opportunity cost of its capital. This company is thus contributing to "more" sustainability than the benchmark. If SE is lower than one, then it is the opposite, i.e the firm is contributing to "less" sustainability than the benchmark.

The definition of the benchmark for the above presented method if of crucial importance [26]. There are many possible benchmark definitions (best performance benchmark, average benchmark, weighted *versus* unweighted benchmark…). The benchmark should be carefully selected taking into account the research question that has to be answered [26].

B. Assessment of the sustainable performance of Swiss dairy farms located in the mountainous region

Three questions have to be addressed for the application of the sustainable value methodology [26]: (1) the choice of the economic activity or entity to be analysed (2) the choice of the forms of capital to be taken into account (3) the choice of the benchmark. These three issues are addressed in the following sections.

ENTITIES ANALYSED AND DATA SOURCE

In this article, we focus on the Swiss dairy farms located in the mountainous area. A dairy farm is defined here according to the farm typology of the Swiss Farm Accountancy Data Network [27]. To be qualified as a dairy farm, a farm has to meet the following criteria:
- the proportion of open arable area in the total usable agricultural area is below 25%
- the proportion of special crops (vineyard, market gardening, tobacco…) in the total usable agricultural area is below 25%
- the proportion of cattle in the total livestock units of the farm is higher than 75%
- the proportion of cows in the cattle livestock units is higher than 25%
- the proportion of suckler cows in the cattle livestock units is below 25%

The data used for the current assessment are retrieved from the Swiss Farm Accountancy Data Network which is managed by the Research Group of Farm Economics of the Agroscope Reckenholz-Tänikon Research Station. This study is based on a sample of 480 dairy farms located in the mountainous area. The descriptive statistics of this cross section (year 2006) are presented in table 1 (interval scaled variables) and table 2 (categorical variables).

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[3] Sustainable efficiency is defined by Figge and Hahn [26] as "the integrated efficiency of the use of all different forms of capital…"

Table 1: Descriptive statistics of interval scaled variables

Variable	Mean	SD	Min.	Max.
Milk produced [kg] (prodmilk)	89'471	43'495	12'800	359'893
Value Added [CHF]	96'313	44'363	7'601	312'607
Usable Agricultural Area [ha]	21,2	10,3	5,6	64,6
Farm capital without land [1000 CHF]	643,7	299,8	93,5	2'544,7
Labour [Normal Working Days]	479	156	163	1034
Intermediate consumptions/Gross profit [%] (intcons)	46	11	19	94
Direct payments/Gross Profit [%] (directpay)	33	9	12	67
Borrowing ratio [%] (borrow)	43	26	0	145
Age of the farmer [years] (age)	45	9	25	72

The names in brackets are the names given to the variables in the model.

Table 2: Descriptive statistics of categorical variables

Variable	%
Production form (prodform)	
- proof of ecological performance[4]	72,5
- organic farming	27,5
Proportion of part-time farms (parttime)	21,2
Stall type: proportion of farms with: (stall)	
- tie house	83,1
- loose house	16,9
Proportion of farms with (silagefree)	
- silage milk	69,4
- silage free milk: cheese milk[5]	30,6
Proportion of farms whose manager has an agricultural education (agreduc)	66,9

The names in brackets are the names given to the variables in the model.

[4] In Switzerland all direct payments require a certain "ecological performance proof". These requirements are actually equivalent to those of the former Swiss integrated production label, which was in force until 1998. Conventional farming is not existing any more in Switzerland.

[5] In Switzerland, the farms producing milk for the production of cheese are not allowed to feed silage to their cows. This is the reason why two different production systems are distinguished: (i) "silage milk" (the milk is used for the elaboration of dairy products other than cheese) and (ii) "silage free milk" (the milk is used for cheese production).

FORMS OF CAPITAL

We consider the following forms of capital: (1) land (2) farm capital (3) labour (4) nitrogen use and (5) energy use.

Land, farm capital and labour are the typical economic forms of capital accounted for in traditional assessments of economic performance. Labour can be considered as both an economic and social form of capital and can be thus referred to as a socio-economic form of capital.

Nitrogen use and energy use are environmental forms of capital. These two environmental forms of capital are selected for the current analysis since they are the two forms of environmental capital with the highest relevance for dairy farms of the mountainous area. The use of pesticides and the associated environmental impacts generated[6] (aquatic, terrestrial and human ecotoxicity) have not been considered in the present investigation as dairy farms located in the mountainous area hardly make use of pesticides.

METHOD OF ASSESSMENT OF THE AMOUNT OF EACH FORM OF CAPITAL USED

The amount of land used is measured in ha. The amount of labour used is measured in total number of normal working days on the farm. Farm capital is the total own and borrowed capital in Swiss francs from which we subtract the asset value of the land owned by the farmer to avoid double counting. The above described quantities are all collected in the Swiss Farm Accountancy Data Network.

The two environmental forms of capital considered (energy and nitrogen use) are not stored as such in the FADN databank.

For the amount of energy used, we consider both the direct and indirect energy input to the agricultural production system. For both the direct and indirect energy input, we use the primary energy demand as defined by Gaillard et al. [28]. It includes the preparation energy, the process energy and the intrinsic energy.

The direct energy input comprises the primary energy demand associated with the use of diesel, electricity and other energy sources (such as heating material) that are used on the farm. The indirect

[6] which can be considered as an indicator of a flow of resources reflecting the amount of environmental capital used

energy input includes the primary energy demand for the following items: mineral fertilizers, concentrates, minerals and salts for cattle, forages imported on the farm, straw or litter material imported on the farm, own machinery and seeds.

The computation of the total primary energy demand for each of the farm inputs listed above consists in deriving the physical amount of farm input from the monetary variable available in the FADN data (cost position) and then in multiplying this physical amount by the primary energy demand per physical unit of this input. The values used for the primary energy demand for each farm input are shown in table 3.

Following inputs cannot be considered in the assessment of the total primary energy demand for data availability reasons:
  - organic fertilizers imported on the farm
  - heifers or cows imported on the farm (i.e. grown up out of the farm).
  - farm buildings
  - field work through third parties (contractor, machinery ring)

The descriptive statistic of the energy use of the sample of farms considered is presented in table 4.

For the second form of environmental capital (nitrogen use), the amount of capital used is defined as the total nitrogen supply in kg N related to the dejections of the farm animals and the use of inorganic fertilisers.

The nitrogen supply due to animal dejections is calculated on the basis of the inventory of animals held on the farm and on the basis of the reference values of the nitrogen supply of each animal category (according to the species, sex and age).

The reference values applied for the present work are those commonly used by the Swiss farm extension services as given in Agridea and FOAG [32] and Walther et al. [33]. The nitrogen supply through mineral fertilisers is calculated on the basis of the FADN cost position for mineral fertilisers making some assumptions on the type of mineral fertiliser used and considering the average market price of one unit of fertiliser. These average market prices are made available in the annual "profit margin" catalogue published by the Swiss farm extension services [34].

Table 3: Reference values used for the primary energy demand of each farm input considered

Farm input	Unit	Primary energy demand in MJ per unit of farm input	Source
Diesel and heating oil	kg	50,5	[28]
Electricity	kWh	15,8	[28]
Mineral fertilizer N	kg N	56,3	[28]
Mineral fertilizer P	kg P_2O_5	19,7	[28]
Mineral fertilizer K	kg K_2O	11,6	[28]
Mineral fertilizer Mg	kg Mg	5	[28]
Energy concentrates for dairy production	kg product	5,2	[29]
Protein concentrates for dairy production	kg product	13,2	[29]
Milk production concentrates	kg product	7,5	[29]
Minerals	kg product	5,00	[30]
Cattle salts	kg product	4,9	[29]
Grass silage	kg D.M.[7]	1,50	[29]
Hay	kg D.M.	2,4	[29]
Straw or litter	kg D.M.	1,00	[30]
Herbicide	kg product	129,5	[28]
Seeds	kg product	14,8	[28]
Own machinery	l diesel consumed	12	[31]

Table 4: Descriptive statistics related to the environmental capital forms

Variable	Mean	SD	Min.	Max.
Nitrogen Use (in kg N)	2'172	1'094	467	8'131
Energy Use (in 1000 MJ)	571,7	293,0	70,8	2'146

The statistics of the nitrogen use of the sample of farms considered are shown in table 4.

OUTPUT PARAMETER AND BENCHMARK CHOICE

We choose the value added as output parameter. Since this study focuses on the sustainable performance heterogeneity and the determinants of this heterogeneity, a weighted benchmark is superior to an unweighted one since it is "much closer to how

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[7] Dry Matter

resources are really used" [35]. Using an unweighted average benchmark "would imply that every farm (regardless of size) gets the same share if resources put on the market, which is rather unrealistic" [35]. The opportunity cost of each form of capital is thus calculated by dividing the sum of the value added of all observations in the sample by the sum of the amount of capital i used of all observations.

C. Assessing the determinants of the sustainable efficiency

As already mentioned in the introduction, the main objective of the actual study is to investigate the determinants of the sustainable efficiency[8]. For that purpose, we perform a multiple linear regression analysis with the cross-sectional data of the 480 dairy farms using the sustainable efficiency as dependent variable and the three following types of variables as independent variables: structural characteristic of the farm, sociologic characteristics of the farm manager and economic indicators. The general specification of the model is as following:

$$y_i = \beta_0 + \beta_k x_{ik} + \varepsilon_i$$

with:
   i the subscript for the individual i
   y_i the dependent variable
   x_{ik} the kth independent variable
   ε_i the stochastic error

or in matrix notation:

$$Y = X\beta + \varepsilon$$

This model is estimated with the Ordinary Least Squares procedure which minimises the sum of squared residuals to estimate the β_k parameters of interest. By performing a regression with the classical linear regression model, following assumptions have to be met [36]:
- linearity in parameters
- additivity of the error term
- no autocorrelation (i.e. random sampling): the error terms are independent from each other cov $(\varepsilon_i;\varepsilon_j)=0$ for $i \neq j$

- mean independence assumption (no omitted variables): the expectation of the error terms is equal to zero: $E(\varepsilon_i/X)=0$
- homoscedasticity assumption: the error terms have a constant variance: Var $(\varepsilon_j)=\sigma^2$
- assumption of full rank of the X matrix: no perfect multicollinearity between the explicative variables
- normal distribution of the error terms:
   $\varepsilon / X \sim N(0,\sigma^2 I)$

The independent variables presented in table 5 are considered for the specification of the model.

The final model is determined by performing a stepwise forward regression. The basic procedure of a stepwise forward regression involves the following steps [37]. In the first step, the regressor that shows the highest correlation (positive or negative) with the dependent variable is included in the model. In the following steps, the regressor with the highest partial correlation with the dependent variable is incorporated in the model.

Table 5 : Regressors considered for the specification of the model (the names in brackets are the names given to the variables in the model)

Category	Variable
Structural characteristics of the farm	Size: amount of kg milk produced per year (*prodmilk*)
	Production form (*prodform*) 0: proof of ecological performance 1: organic farming
	Part-time farming (*parttime*) 0: no 1: yes
	Housing type for cows (*stall*) 0: tie-stall 1: free-stall
	Silage free milk (*silagefree*) 0: no 1: yes
Sociologic characteristics of the farmer	Age of the farmer in years (*age*)
	Agricultural education (*agreduc*) 0: no 1: yes
Economic indicators	Intensity of the use of intermediate consumptions (*intcons*) Ratio: intermediate consumptions/total gross profit*100
	Dependence on direct payments (*directpay*) Ratio: (direct payments/total gross profit)*100
	Borrowing ratio: (borrowed capital/total capital)*100 (*borrow*)

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[8] This variable has been given the name "*susteff*" in the model.

A variable is incorporated in the model when the significance level associated with the F-value of its partial regression coefficient is lower than 0,05. If the significance level is higher than 0,05, the variable is eliminated.

From the rank order of the incorporation of the variables, it is possible to identify the statistical importance of the variables [37].

III. RESULTS

The distribution of the sustainable efficiency scores of the farms of the sample investigated is presented in figure 1. The sustainable efficiency scores closely follow a normal distribution.

Before performing the stepwise forward linear regression, we investigate the degree of the collinearity between the regressors using the variance inflation factor (VIF).

The variance inflation factor of an independent variable is obtained by performing a linear regression between this independent variable and all other remaining independent variables. It is calculated according to the following equation [37]:

$$ VIF(\hat{\beta}_j) = \frac{1}{1 - R_j^2} \text{ (Eq. 3)} $$

<u>with:</u>

R_j^2 the coefficient of determination of the regression between the independent variable j and all other remaining independent variables.

Fig. 1: Distribution of the sustainable efficiency scores
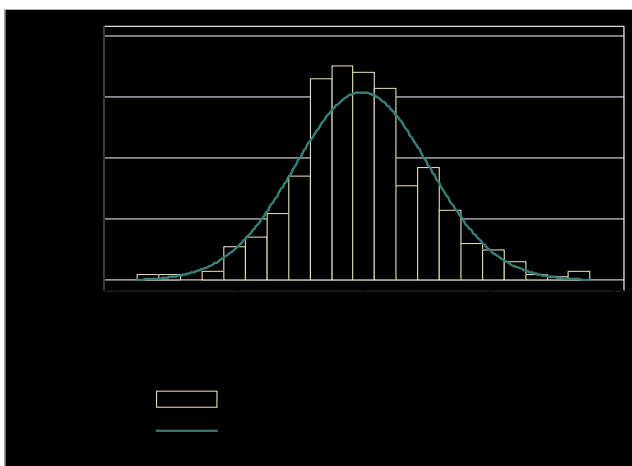
The VIF shows the increase of the standard error of the regression coefficient of the independent variable j due to its correlation with the other independent variables [37]. Values above 20 are suggested as indicative of a multicollinearity problem [38]. In the present case, the VIF scores do not exceed 1,4, which shows that multicollinearity is of minor importance.

The definitive specification of the model is determined by performing a stepwise forward regression using the sustainable efficiency as dependent variable and the variables presented in table 5 as independent variables. Out of the 10 potential explaining variables of the initial model, only the variables *agreduc* and *stall* are not included in the final version of the model.

In the following, the assumption of normal distribution of the residuals is checked. The distribution of the residuals is shown in figure 2. The application of the Kolmogorov Smirnov test leads us to reject the H_0 hypothesis of normality of the residuals distribution. Two strategies are used to remove this problem. In the first one, we perform a transformation of three independent variables (*intcons*, *directpay* and *prodmilk*) in order to yield, for each of these variables, a distribution which is as close as possible to a normal distribution. For the variables *intcons*, *directpay*, the squared root transformation yields the closest distribution to a normal distribution whereas for the variable *prodmilk* the log transformation is the most appropriate. Despite these transformations the residuals obtained after a second regression with the transformed variables are still not normal distributed (Kolmogorov Smirnov test, p<0,001). In a second strategy, we eliminate the outliers in the distribution of the residual errors and perform again a regression with the non transformed variables. After elimination of 11 outliers, we yield a normal distribution of the residuals[9]. We compare then the results of this regression with the results of the first one (regression with non-transformed variables without eliminating the outliers). Since the results of these two regressions are not significantly different and considering the fact that the observations

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[9] We eliminate the observations whose residuals are higher than 33% (11 observations). We carry out then a regression without these 11 outliers and yield residuals which are normally distributed (Kolmogorov Smirnov, p=0,13)

eliminated can't be considered *strictu senso* as outliers[10], the regression model is applied to non transformed independent variables without ignoring any data.

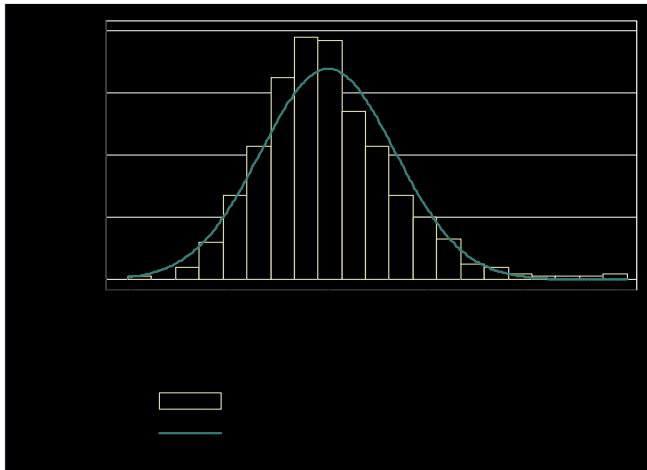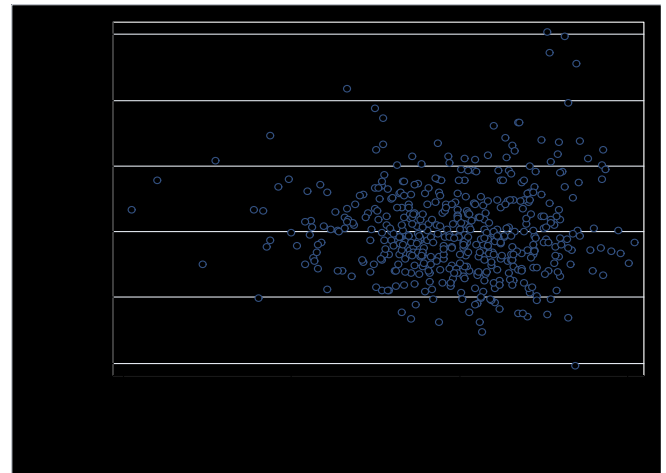Figure 2: Distribution of the residuals of the regression

Figure 3 shows that the homoscedasticity assumption is not satisfied. This finding is also supported by the Breusch-Pagan test (p<0,001).

This represents a problem as heteroscedasticity in the disturbances leads *inter alia* to inconsistent covariance matrix estimates and, as a result, to faulty inferences [39]. Thus, in the present case, we use the heteroscedasticity-consistent covariance matrix estimator (also called "White (robust) standard errors estimator") proposed by White [39] to estimate the model. This estimator has the advantage that "without specifying the type of heteroscedasticity, we can still make appropriate inferences based on the results of least squares" [38]. White uses a correction matrix based on the observed residuals to estimate the variance-covariance matrix.

Figure 3 clearly shows that the assumption of no auto-correlation is fully met.

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[10] The examination, for these farms, of the values taken by the different variables (both dependent and independent variables) doesn't give any evidence of the presence of outliers.

Figure 3: Distribution of the residuals in dependence of the linear prediction

The mean independence assumption is also satisfied as shown by the results of a regression performed between the residuals of the model and the independent variables (probability associated with the F-Test of overall significance is equal to 1.0).

The results of the regression performed with the non transformed independent variables *intcons, directpay, prodform, age, borrow, parttime, silagefree, prodmilk*, using robust standard errors are presented in table 6.

The coefficient of determination of the model is equal to 0,74, which means that 74% of the total variance of the dependent variable is explained by the model.

The order of incorporation of the variables is the following: *intcons, directpay, prodform, age, borrow, parttime, silagefree, prodmilk.* The variable *intcons* has a very high explaining power in the model as it explains 61% of the total variance of the sustainable efficiency scores of the sample. The variable *directpay* is also of major importance as its partial correlation coefficient with *susteff* holding *intcons* constant is equal to –0,46. The third most important regressor is the variable *prodform*. Its partial correlation coefficient with *susteff* holding both *intcons* and *directpay* constant is equal to +0,32. The three variables *intcons*, *directpay* and *prodform* explain 72% of the total variance of the sustainable efficiency scores. The variables *age, borrow, parttime, silagefree* and *prodmilk* are also included in the model. They are however of minor importance as their inclusion in the

model leads to an increase of the coefficient of determination by only 2% .

Table 6 : Ordinary Least Squares estimation of the model with robust standard errors

Variable	Coefficient	t	P>|t|	[95% Conf. Intervall]	
intcons	-1,77	-23,77	0,000	-1,91	-1,62
directpay	-1,02	-9,6	0,000	-1,23	-0,81
prodform	10,36	7,11	0,000	7,50	13,22
age	-0,32	-3,93	0,000	-0,47	-0,16
borrow	-0,07	-2,42	0,016	-0,13	-0,01
parttime	-5,05	-3,06	0,002	-8,29	-1,80
silagefree	-3,19	-2,40	0,017	-5,80	-0,58
prodmilk	-3,49e-05	-1,97	0,050	-7,00e-05	-5,70e-08
constant	233,48	36,07	0,000	220,76	246,20

Number of observations	= 480
F(8, 471)	= 159,29
Prob > F	= 0,0000
R-Squared	= 0,74
Root MSE	= 13,75

The intensity of the intermediate consumptions use has a significant negative impact on the sustainable efficiency. An absolute increase of 1% of the ratio "intermediate consumptions/gross profit" leads *ceteris paribus* to a decrease of 1,77% of the sustainable efficiency[11]. The proportion of direct payments in the gross profit has also a significant negative effect on the sustainable efficiency. If the ratio "direct payments/gross profit" absolutely increases by 1%, the sustainable efficiency will decrease absolutely by 1,02% (all other factors kept constant). Organic farms show *ceteris paribus* a 10,4% higher SE than non-organic farms. The age of the farm manager has a significant negative effect on the sustainable efficiency. One additional year age leads *ceteris paribus* to an absolute decrease of 0,3% of the sustainable efficiency. The borrowing ratio has also a negative significant effect on the sustainable efficiency. However the amplitude of the effect remains quite marginal (1% absolute increase of the

borrowing ratio induces a 0,07% absolute decrease of the sustainable efficiency). Part-time farms show a significantly lower (-5%) sustainable efficiency in comparison with similar non part-time farms. Farms producing cheese milk show a sustainable efficiency significantly lower (-3%) than similar farms producing silage milk. The size of the farm has also a significant effect on the sustainable efficiency. An increase of 100'000 kg of the quantity of milk produced leads to an absolute decrease of the sustainable efficiency by – 3,5%. This effect remains very moderate. As already mentioned previously, the agricultural education of the farm manager does not have a significant effect on the sustainable efficiency.

IV. DISCUSSION AND CONCLUSIONS

The results of the regression performed highlight the major role of the economic performance in the sustainable performance. From a certain point of view, these results fit in the provocative statement of Friedman [40], that the "social responsibility of business is to increase its profit".

Farmers, who use their intermediate consumptions in a very parsimonious way are also those whose farms show the highest sustainable efficiency. Sustainable efficiency is a question of how efficiently the farmers use the ecological, economic and social resources they need for their production. The proportion of intermediate consumptions in the gross profit is an indicator of the parsimonious behaviour of the farmers in their inputs use. This indicator is relevant for both economic and ecological resources. Indeed, most of the ecological relevant resources used on a farm are in form of intermediate consumptions. For example, fertilizers, concentrates, diesel and electricity are inputs which are all included in the intermediate consumptions and which are of high relevance for the assessment of the amount of environmental resources used or the amount of generated environmental impacts.

The fact that the farmer's ability to use efficiently the intermediate consumptions has a much larger influence on the sustainable efficiency of the farm than the farm size and than the other structural characteristics of the farm clearly gives the evidence that there is a strong individual effect associated with

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[11] For example, if the ratio "intermediate consumptions/gross profit" increases absolutely by 1% from 40% to 41%, the sustainable efficiency decreases absolutely of 1,77% from SE to SE-1,77%.

the management competences of the farmer and especially his "costs saving attitude".

It is surprising that the proportion of the direct payments in the gross profit has a negative effect on the sustainable efficiency. Before drawing any preliminary conclusions, a further analysis is required to investigate more precisely the direction of the causal relationship between the sustainable efficiency and the proportion of the direct payments in the gross profit. In fact, it might be that the least efficient farms, especially from an economic point of view, are also those which are located in the most unfavourable agricultural production regions. It might thus be that the low efficiency of the resources use is not due to the height of the direct payments but due to the local natural conditions. Since one of the objective assigned by the Swiss Confederation to the agriculture is "the upkeep of the rural scenery and the decentralised inhabitation of the country" [4], it might be that the highest proportion of the direct payments in the gross profit is the result of policy measures of the Swiss Confederation to keep an agricultural activity in these less favoured regions. This would imply that the causal relationship between the sustainable efficiency and the proportion of the direct payments in the gross profit is reverse: because these farms are less efficient in their resources use (as a result of less favourable production conditions), they receive more direct payments.

The positive effect of organic farming on the sustainable efficiency results primarily of a higher value added creation. In fact, despite the fact that the organic farms of the sample produce 15% less milk than the non-organic farms, the value added they generate is 8% higher than the one of the non-organic farms.

The negative effect of the quantity of milk produced on the sustainable efficiency is quite surprising. In fact, similar to the pure economic performance, we could expect that due to the presence of economy of scales bigger farms would show a higher sustainable efficiency, which is not the case. The analysis of the correlation coefficients between the sustainable efficiency and the work productivity is very enlightening in this regard. The correlation coefficient between work productivity (expressed in kg milk per work unit) and the sustainable efficiency is very low (0,07) and not significant. This clearly shows that the "gross" work productivity, which is highly correlated with the farm size (R^2=0,75), is of insignificant relevance for the sustainable efficiency.

The negative effect of the variable *parttime* on the sustainable efficiency is evident. This effect remains very low if we compare it with the difference between the average SE of part-time farms and the average SE of non part-time farms. This is due to the fact that *parttime* is highly positively correlated with *intcons* (R^2=0.45; $p<0.001$) and thus the variable *parttime* affects negatively the variable *susteff* in a direct and in an indirect (over *intcons*) way. Note that the regression coefficient associated with the part-time variable has to be interpreted in a *ceteris paribus* way. It indicates the effect of the independent variable on the dependent variable, all other independent variables (inclusive *intcons*) kept constant. Further investigation would be necessary to investigate the direction of the causal relationship between these two variables. Do the part-time farms show a lower sustainable efficiency because they are part-time farms or are these farms part-time farms because their sustainable efficiency is lower?

The fact that farms producing cheese milk have *ceteris paribus* a lower sustainable efficiency than farms producing milk destined to other milk products than cheese may be due to the production restrictions induced by the silage free alimentation of the dairy herd. The effect of the variable *silagefree* should be however relativized as this variable does not account for a major part of the total variation of the model.

The fact that the education of the farm manager has no effect on the sustainable efficiency is surprising as we would expect that farm managers with an agricultural education are more aware of sustainability issues.

Surprisingly, the type of stall has no effect on the sustainable efficiency.

Finally, the methods used within this study will be shortly discussed.

It is important to emphasize that the method used to assess the farms sustainability is efficiency oriented. It shows how much more (less) efficiently a farm uses its resources in comparison with a benchmark. By performing an assessment of the sustainable

performance it is necessary to consider not only the efficiency of the resources use but also the carrying capacity of the ecosystem. In fact, a farm might be very efficient in the use of its resources or in the generation of its environmental impacts but, since the environmental impacts it generates per ha exceed the carrying capacity of the local ecosystem, this farm may be in definitive less sustainable than the benchmark.

A further limitation of the present sustainability assessment is that qualitative environmental and social aspects are ignored (e.g. the preservation and the enhancement of the biodiversity, the soil protection or the number of work accidents).

The effects of the direct payments on the sustainable efficiency should be investigated in a broader context. The sense of the causal relationship should be examined. It would also be necessary to perform an assessment of the corporate sustainable performance of the farms correcting the monetary output figure (value added) for the policy measures (in form of market support or direct payments) that have a pure market protection function.

It is also necessary to mention here that the method used to assess the corporate sustainable performance is a relative approach and not an absolute one. In fact, it only shows how much more (less) sustainable a farm is compared to a benchmark. However, we cannot conclude if the farm is sustainable in absolute terms.

Finally, an investigation of the determinants of the sustainable efficiency with panel data would be more reliable than with a cross section.

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