Explaining Differences in Farm Sustainability: Evidence from Flemish Dairy farms

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Abstract

An important objective of European agricultural policy is to have a sustainable, efficient farming sector, which uses environmentally-friendly production methods. Agricultural policy makers aim to combine strong economic performance with a sustainable use of natural resources. There is thus a need for tools allowing quantification of farm sustainability as well as for empirical research assessing, analysing and explaining differences in farm sustainability. Using a large dataset of dairy farms, we apply the concept of sustainable value creation to benchmark farm sustainability performance. An effect model captures the determinants of the differences in sustainability among Flemish dairy farms. Our empirical model shows that both managerial and structural farm characteristics are significant in explaining differences in sustainability performance and that the most important factors are farm size, farmer's age and the dependency on support payments. Furthermore, we observe a high sustainability performance on farms with higher levels of economic efficiency.

Keywords: sustainability assessment, efficiency, dairy farming, performance measurement
JEL classification: Q51, Q56, Q57, Q58, Q12

1 Introduction

In the European Union, progress is made towards a more sustainable agricultural sector. The guiding principle of the Common Agricultural Policy is to have a sustainable, efficient farming sector. Sustainability is thereby seen as a key element towards a profitable long-term future for farming and rural areas. Policy makers aim to combine strong economic performance with the sustainable use of natural resources in the field of agriculture (Boel, 2005; European Commission 2004). To achieve a competitive agriculture, farms have to apply conventional inputs as efficiently as possible, and to create an environmental friendly agriculture farms have to deal efficiently with the natural resources (Reinhard, 1999). Against this background, it is therefore important to measure farm sustainability. Assessing farm sustainability is important because individual farms can be viewed as essential to achieve a sustainable agriculture as they play an important role in the attainment of sustainability goals, due to their central role in agricultural activities and development. The use and development of sustainability indicators can be an effective way to make the concept of agricultural sustainability operational (Rigby et al., 2001; van Calker et al., 2006). Public sector investment to increase farm performance requires accurate assessment of the efficiency of farmers and identification of the sources of inefficiencies in order to develop policy and institutional innovations to minimize inefficiencies (Sherlund et al., 2002). In Van Passel et al. (2006) the sustainable value approach is applied to measure farm sustainability, the aim of this paper is to explain differences in farm sustainability in more detail and to analyse the link between economic efficiency (technical and allocative) and sustainable efficiency. The Flemish dairy sector is used as test-case and example to identify farm sustainability and to find out why farms differ in sustainable efficiency. The reasons behind the observed differences are studied using an empirical model.

2 Measuring sustainability

The idea of sustainable development had gained importance in the past decades. Moreover, the concept of sustainable development has become a leading paradigm of policy makers and researchers. However, sustainability proved to be a remarkably difficult concept to define and to apply in practice. Real measurement of sustainability is fraught with difficulties of principles and practice. Hence, there are understandably, though still disappointingly, few published empirical studies (Pezzey & Toman, 2002). The need for indicators and procedures to measure sustainability is increasingly recognized (Tyteca, 1998). Indicators of sustainable development need to be developed to support decision making at all levels (Capello & Nijkamp, 2002; Becker, 1997). Decision makers need indicators that show the link between social, environmental and economic goals to better understand how to achieve economic growth that is in harmony with the natural systems within we live (Farrell & Hart, 1998). In recent years, different frameworks and indicator systems have emerged that claim to evaluate sustainability both at firm level and at higher level. Most of the focus in measuring and evaluating progress towards sustainable development has been at the national level (Veleva & Ellenbecker, 2000; Figge & Hahn, 2004).

Sustainability is a global concept and a firm is only a small subsystem that interacts in various ways with surrounding systems. Nevertheless, companies are essential actors in socio-economic life and contribute to the realization of sustainable development (Tyteca, 1998). Several sustainability frameworks at firm level are developed, examples are *The Global Reporting Initiative* , *ISO 14031*, and the *Eco-efficiency framework* of the World Business Council for Sustainable Development[1]. Other interesting examples and ideas to assess sustainability can be found in Tyteca (1998), Callens & Tyteca (1999), Rigby et al. (2001), Pacini et al. (2003), Figge & Hahn (2004,2005), Krajnc & Glavi (2005), van Calker et al. (2006)[2].

Most frameworks are burden-based approaches, in other words these frameworks assume that the cost of a resource depends on the burden that it inflicts. This burden must be expressed in monetary terms to be able to subtract costs from return. Although considerable efforts and progress in valuation methodologies, it remains very difficult to express costs of using environmental and social resources in monetary terms by using burden-based approaches (Figge & Hahn, 2004). Therefore Figge and Hahn (2004, 2005) propose a value-based approach. They use the concept of opportunity costs to assess corporate sustainable performance. In other words, in their approach the cost of a resource is not determined by the burden that it causes but by the return that can be created by an alternative use of the resource. In practice, it showed to be much easier to determine the cost of different resources with a value based approach. Therefore, we base our analysis of the differences in sustainability performance of Flemish dairy farms on the sustainable value approach. In what follows first

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[1] An overview and critical analysis of some of the best-known indicator frameworks for evaluation of business sustainability can be found in Veleva & Ellenbecker (2000) and in Neumayer (2003);

[2] More details can be found in Van Passel et al. (2006)

the methodology is explained, next the empirical results are presented. Finally, the results are briefly summarized and discussed.

3 Methodology

As explained, Figge & Hahn (2004) introduced the concept of *sustainable value*, a new approach to measure corporate contributions to sustainability. In a 2005 publication, Figge & Hahn (2005) present a further development of their approach. The sustainable value methodology shows in monetary terms the value that a company creates or destroys by the use of a set of different resources. A first application of the sustainable value approach to farms can be found in Van Passel et al. (2006).

The idea of the sustainable value approach is that a company contributes to more sustainable development whenever it uses all resources (or capital forms) more efficiently than another company. In practice there is no such super-company, meaning that it must be determined if the higher efficiency of the use of one form of capital can compensate for the lower efficiency of the use of another form of capital (Figge & Hahn, 2005). When assessing different capital forms, an aggregation problem is encountered. Figge & Hahn (2004, 2005) use the concept of opportunity cost to circumvent this problem. The opportunity cost of a capital form is the cost of an opportunity foregone (and of the benefits that could be received from that opportunity), or of the most valuable foregone alternative. Hence, one can consider the opportunity costs of all forms of capital. The opportunity cost (or capital cost) can be calculated as: $opportunity\ cost = \frac{value\ added_{benchmark}}{capital_{benchmark}}$. A firm creates value when it uses capital more efficiently than the (bench)market. Benchmarking is a necessary and useful tool to evaluate corporate policies and performance (Krut & Munis, 1998). Hence, we can calculate the value spread by subtracting the opportunity cost (determined by the benchmark) from the efficiency of capital use in company i (Figge & Hahn, 2005):

$$value\ spread_i = \frac{value\ added_i}{capital_i} - \frac{value\ added_{benchmark}}{capital_{benchmark}}$$

$$sustainable\ value_i = \frac{1}{n} \sum_{s=1} (value\ spread_i^s * capital_i^s)$$

The sustainable value created by company i can be calculated by adding up the value contributions for every form of capital s ($s \in [1;n]$[3]). To correct the overestimation of the value created; we divide by a factor n to calculate the sustainable value[4]. To take into account the farm size a return to cost ratio can be calculated. In this way, the performance of different farms can be compared. This ratio is calculated by dividing the return that the farm has achieved with its resources with the return that the benchmark would have achieved with the amount of resources. The return to cost ratio represent an integrated indicator of sustainable efficiency (Figge & Hahn, 2005) and can be calculated as:

$$sustainable\ efficiency_i = \frac{value\ added_i}{value\ added_i - sustainable\ value_i}$$

The more sustainable value is created the more the value added of a firm exceeds the opportunity cost of its capital base (Figge & Hahn, 2005). The sustainable efficiency of a firm equals unity if the value added corresponds to the cost of all forms of capital (sustainable capital). A sustainable efficiency lower (higher) than one means that the company is overall less (more) efficient than its benchmark.

The sustainable value approach provides a quantitative and integrated measure of corporate sustainable performance. It applies the established valuation logic of the financial markets (opportunity cost thinking) to sustainability assessments and translates sustainable performance into the language of management and business decision making. On the other hand, the approach does not indicate whether the overall capital use is sustainable, it only shows how much a firm contributes to a more sustainable use of his resources in comparison with its peers. Another disadvantage is that the applicability of the methodology is limited to the available data on corporate capital use and on the opportunity cost of the different resources. However, given the richness of the FADN data base, we think that the sustainable value approach is a valuable method to assess farm sustainability. This because the approach can be seen as a fully integrated value oriented assessment tool which can give useful and good guidance for all stakeholders involved in their aim towards sustainability.

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[3] There are *n* different capital forms

[4] Dividing by n does not serve to weight the different forms of capital but only to avoid double counting of value creation (Figge & Hahn, 2005)

4 Assessing farm sustainability: empirical results

4.1 Variables and data

Three questions need to be addressed for the application of the sustainable value methodology (Figge & Hahn, 2005): (i) the choice of the economic activity or entity to be analyzed; (ii) the choice of the forms of capital to be taken into account; (iii) the choice of the benchmark.

The scope of the present analysis is the Flemish dairy sector. Accountancy data from a group of dairy farms in Flanders will be used during the period 1995-2001. This data is provided by the European farm accountancy data network (FADN) database that is collected by all EU countries. The Belgian FADN-data are collected and managed by the Centre for Agricultural Economics. Our dataset consists of 647 observations (unbalanced panel data) during the period 1995-2001. Descriptive statistics of the sample data can be found in table 1.

Table 1: Descriptive statistics of the data set of dairy farms

Variable	Minimum	Maximum	Mean	Std. Deviation
Total output (Euro)	20445	622791	150125	68751
Land use (hectare)	6,72	83,08	31,71	11,28
Labor (man equivalent units)	0,63	3,50	1,48	0,34
Capital (Euro)	37338	789404	284136	152102
Intermediate consumption (Euro)	13600	295465	66324	31508
Energy consumption (MJ)	268185	287532492	1772540	11453723
Nitrogen surplus (kg N)	1934	25570	8878	3878

The different resources that we take into account are: (i) labour, (ii) farm capital, (iii) utilized land, (iv) energy use and (v) nitrogen surplus. Labour, farm capital and land can be seen as conventional inputs. Energy use and nitrogen surplus are environmental capital forms. In Flanders, as in other European regions, N losses are a major concern in agricultural practice. Nitrogen is an important input in dairy farming, but the conversion of nitrogen into agricultural products is relative low. Part of the nitrogen input is taken up by plants, but a large part is emitted to the environment. The nitrogen pollution leads to nitrate contamination of surface water and also groundwater. Nitrogen also evaporates as ammonia and causes acidification and over fertilization of other ecosystems. The selected five different forms of capital are critical for the sustainability performance of a dairy farm (as in Reinhard et al., 2000). Information on other important resources (e.g. social aspects and other environmental aspects) was not available in our data set and could not be taken into account.

The choice of the benchmark reflects a judgement as it determines the cost of all resources (or capital forms). This means that the benchmark level determines the explanatory power of the results of the sustainable value analysis. It should therefore be chosen with great deliberation (Figge & Hahn, 2005). In this research the average of the FADN set of dairy farms is used as benchmark to calculate the sustainable value and sustainable efficiency of each dairy farm in the FADN set. The sector benchmark is calculated by using the weighted average return on capital. We opted for this benchmark because an important aim of this study was to understand why farms differ in their sustainable efficiency[5].

4.2 The evolution of the sustainable value of Flemish dairy farms

Analyzing the results of the period considered (figure 1) we first observe a negative sustainable value (calculated as explained in section 3). Then the sustainable value increases up to a maximum in 1999. Finally, the sustainable value decreases from 1999 to 2001. The main reason for this decrease is the lower economic results of the farm sector in general. Figure 1 shows also the value contributions of the different resources. Nitrogen surplus has an important bad impact in the first three years (1995-1997). Later on, the improvements of nitrogen use result in a positive effect of the capital form nitrogen surplus on the sustainable value. In this way the reduction of nitrogen surpluses in specialized dairy farms[6] has been taken in account when calculating the sustainable value of the dairy farms. Calculating the average sustainable efficiency in each year, a low average sustainable efficiency of 0.8 is found in 1996. From 1996 till 1999, the average sustainable efficiency increases, the sustainable efficiency in 1999 reaches almost 1.3. In 2000 and 2001, the average sustainable efficiency of the observed dairy farms decreases.

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[5] We also calculated the sustainable efficiency using other benchmarks (e.g. best performance as benchmark). The rank correlation between the sustainable efficiencies of the different benchmarks was very high and significant. This indicates that the ranking of the farms will not differ much using another benchmark to calculate the sustainable value creation (Van Passel et al., 2006).

[6] More information about the evolution of nitrogen surpluses and nitrogen use efficiency can be found in Nevens et al. (2006) and in Meul et al. (2005).

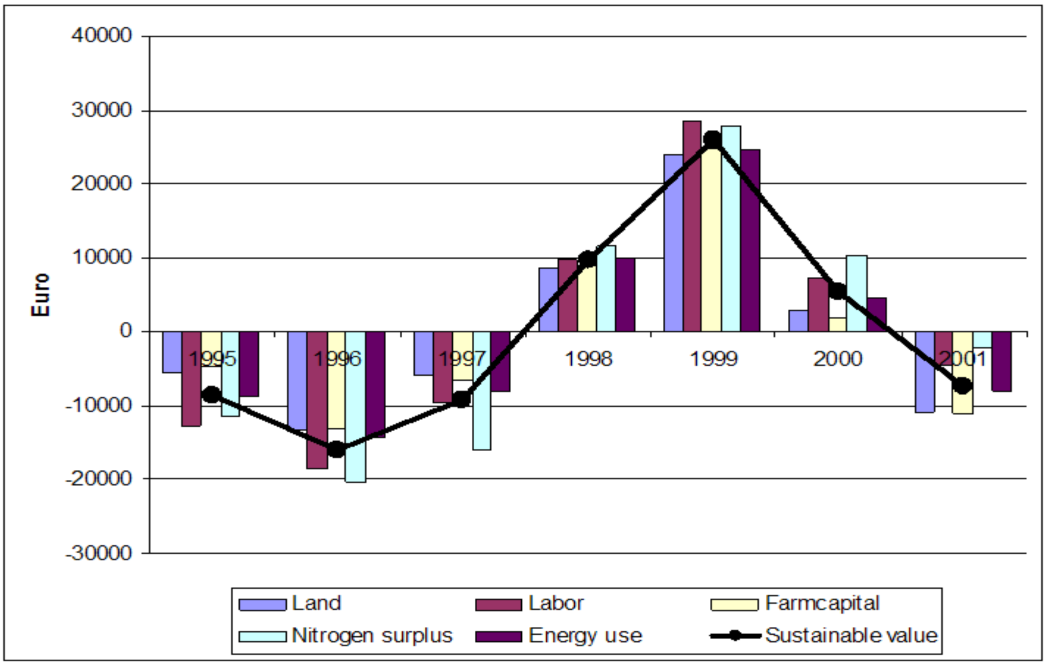

Figure 1: the average value contribution of the considered resources and the evolution of the average sustainable value of dairy farms in Flanders

4.3 Explaining differences in sustainable efficiency

Calculating the sustainable efficiency using the average of the whole dataset as benchmark, a value for each dairy farm in our dataset is obtained (calculated as explained in section 3). Among the 647 observations during 7 years (unbalanced panel data), a large difference in the level of sustainable efficiency is found (from 0.02 to 2.2). The performance of dairy farming differs clearly a lot. Therefore, understanding why farms differ in their sustainable value creation can be seen as crucial. To analyse the observed differences, we calculate the average value of some determinants of all dairy farms and of the 10%-best-scoring-observations and of the 10%-worst-scoring-observations. Descriptive statistics are provided in table 2. Possible determinants in our dataset which may partly explain the differences in performance are: (i) managerial characteristics (e.g. education of the farm manager), (ii) structural characteristics (e.g. farm size), (iii) milk composition (e.g. protein level) and (iv) farm strategy[7] (e.g. farm growth).

[7] We use farm strategy to describe farm behaviour (e.g. farm growth) although it is often not clear if the behaviour of the farm manager is intentional

Table 2: Descriptive statistics of all observations, best scoring observations and worst scoring observations (mean values)

Variable	**All farms**	**Best 10% observations**	**Worst 10% observations**
Sustainable efficiency	1,034	1,656	0,490
Sustainable value	0[a]	58107	-81640
Managerial characteristics			
Age of manager	43,13	40,57	47,28
Higher education (in %)	55	58	35
Successor on farm (in %)	11	8	8
No successor on farm (in %)	40	42	34
Doubt about succession (in %)	49	51	58
Number of dependent children	1.61	1.83	1.12
Off farm earnings (in %)[b]	19	32	22
Structural characteristics			
Size unit [c]	16,44	20,31	13,05
Milk quotum (l)	312288	411386	187616
Number of cows	52.4	64.4	39.1
Additional milk levy (in Euro)	349	89	398
Solvency[d]	0,42	0,39	0,57
Subsidiesinterest[e] (in %)	1.9	1.5	2.0
Subsidiesrevenues[e](in %)	0.1	0.0	0.4
Subsidiesincome[e](in %)	3.1	3.1	4.3
Environmental tax (in Euro)	266	378	170
Shareland[f](in %)	28.6	28.2	33.2
Only 1 type milk cow on farm (in %)	38	29	38
Cattle intensity (number of cows/ha)	1.70	1.82	1.44
Milk composition (quality)			
Fat level (l)	23514	32683	12894
Protein level (in %)	3.464	3.485	3.408
Milk quota growth (l) [g]	4443	2280	499
Share on-farm selling (in %)	1.29	1.07	1.19
Number of observations	647	65	65

[a] the mean sustainable value equals zero which is the consequence of choosing the weighted average as benchmark
[b] off farm income is measured as a dummy, (1 if farmer or partner receive significant off farm earnings)
[c] calculated for all farms in the dataset based on standard gross margin (FADN,s.d.)
[d] measured as own capital divided by total capital
[e] the subsidies are calculated as a percentage of total revenues, indicating the dependency on support payments
[f] measured as land in property (in ha) divided by total land (in ha)
[g] calculated as the difference in milk quota of the actual year with the previous year

Observing the descriptive statistics of the managerial characteristics in table 2, we notice that the best scoring farms have a younger and better educated farm manager. Furthermore, the farms with a high sustainable efficiency have also more children on the farm and the farm manager and/or partner receive more off-farm earnings. Observing the structural characteristics we observe that the best scoring farms are bigger (higher size unit, higher milk quota and more cows) and have a lower solvency rate. Farms with a high sustainable efficiency pay also less additional milk levies but pay more environmental taxes (e.g. manure tax) and are less dependent on support payments. Furthermore, among the best-scoring farms there are fewer farms with only 1 type of milk cow. On the other hand, the best scoring farms have more cows per hectare, in other words these farms have higher cattle intensity. Analysing the milk composition, we observe a higher milk quality on farms with a high level of sustainable efficiency. Based on structural and technical data, we can distinguish different farm categories or strategies (Vandermersch, 2006). As in Ondersteijn et al. (2003) and Vandermersch (2006), we observe fine-tuners (high milk quality), growers (growth in milk quota) and diversifiers (share on farm selling). Fine-tuning (high fat and protein level) results in a higher sustainable efficiency. Growing (increasing milk quota) has a diverse effect, farms with a low sustainable efficiency barely increase their milk quota level. On the other hand, farms with a high sustainable efficiency have also a smaller increase of their milk quota level than the overall average.

Analyzing the data in table 2, some important differences arise. To determine the significance of the impact of the managerial and structural factors on the farm sustainability, we estimate an econometric panel data model. The essential structure for an effect model using panel data is:

$$y_{it} = \alpha_i + \gamma_t + \beta x_{it} + \varepsilon_{it}$$

With as dependent variable (y_{it}) the sustainable efficiency of each farm in each year and the independent variables (x_{it}) as possible determinants. In effect models variation across farms or time is captured in simple shifts of the regression function (changes in intercepts). Traditionally, there are fixed effects models and random effects models. In fixed effects models model α_i is a separate constant term for each unit: $y_{it} = \alpha_i + \beta x_{it} + \varepsilon_{it}$.

In random effects models we have an individual specific disturbance: $y_{it} = \alpha_i + \beta x_{it} + \varepsilon_{it} + u_i$

We found a large Hausman statistic (37.69) which argues in favour of the fixed effects model. The results of the calculation of the one way fixed effects model are shown in table 3.

Table 3: Panel data estimation of determinants of sustainable efficiency

Variable	Coefficient	Variable	Coefficient
Dummy 1995	-0.0248	Size unit[a]	0.0122**
Dummy 1996	-0.1068***	Solvency[b]	-0.1084
Dummy 1997	-0.0407	Subsidiesinterest[c]	-1.4609**
Dummy 1998	0.1431***	Subsidiesrevenues[c]	0.6085
Dummy 1999	0.4373***	Subsidiesincome[c]	-1.9392***
Dummy 2000	0.1129***	Shareland[d]	0.0432
Diploma	0.0147	Additional levy	-0,0000*
Age	-0.0288**	Fat level	0.0000
Age^2	0.0003**	Protein level	0.0069
Successor on farm	0.0226	Growth in milk quota [e]	0.0000
Doubt about succession	0.0284	Share on-farm selling	1.0947***

Dependent variable : sustainable efficiency
* significant at 10%; ** significant at 5%; *** significant at 1%
[a] calculated for all farms in the dataset based on standard gross margin (FADN,s.d.)
[b] measured as own capital divided by total capital
[c] the subsidies are calculated as a percentage of total revenues, indicating the dependency on support payments
[d] measured as land in property (in ha) divided by total land (in ha)
[e] calculated as the difference in milk quota of the actual year with the previous year

The results in table 3 show that size matters. Larger farms have a higher sustainable efficiency. Further, age has a significant negative effect on the sustainable efficiency of dairy farms. In general younger farmers have a higher sustainable efficiency. But after a certain age, the negative impact of age is decreasing (indicated by the squared age term in the model). Furthermore, higher dependency on support payments and higher amounts of additional levies on milk production result in a lower sustainable efficiency. Finally, farms with a larger share of on-farm selling of milk or milk products have a significant higher sustainable efficiency. Observing the dummy year variables in our model, we see that on average 1996 has a lower sustainable efficiency than 2001 and the sustainable efficiency in 1998, 1999 and 2000 was higher than in 2001 (see also figure 1). We can conclude that both structural and managerial farm characteristics explain differences in sustainable efficiency.

Table 4 reports results of economic performance analysis (technical, allocative and economic efficiencies). Farms with a high sustainable efficiency are farms with a high technical and allocative efficiency (and thus also a high economic efficiency).

Table 4: Efficiencies of all observations, best scoring and worst scoring observations

Variable	All farms (mean value)	Best 10% observations	Worst 10% observations	F-value
Technical efficiency (in %)	85.7	89.2	80.3	31.8*
Allocative efficiency (in %)	49.0	51.1	40.4	22.2*
Economic efficiency (in %)	42.0	45.7	32.2	37.8*

* F-values are significant (higher than the test value 3.00 (F(0.95;2;774)
the efficiencies are calculated by estimating the production frontier using stochastic frontier analysis (random effect model). Selected inputs were labour, total capital, nitrogen and concentrates. Output is measured in litres milk. The Kopp and Diewert (1982) cost decomposition procedure is used to estimate technical, allocative and economic efficiencies (as in Bravo-Ureta and Rieger (1991) and Singh et al. (2001)).

Executing a one way ANOVA, we can test if there are significant differences between the efficiencies (technical, allocative and economic) in the different groups (all observations, 10 % worst and best observations). High F-values are found, indicating significant differences in respectively technical, allocative and economic efficiency between all observations and the observations with very high and low sustainable efficiency scores. Furthermore, we found that farms with a high (low) sustainable efficiency have a significant higher (lower) economic efficiency than the average farm. This means that in general economic performance goes hand in hand with sustainability performance.

5 Discussion and Conclusion

This research tried to quantify the economic, social and ecological determinants of sustainability. In other words, our analysis wanted to make the sustainability concept operational. Using the methodology developed by Figge & Hahn (2004, 2005) we calculated the sustainable value of dairy farms. Besides calculating the sustainable value of farms, it was our objective to explain the differences in sustainable efficiency in more detail. Although sustainability is a global concept and a farm is only a small subsystem that interacts in various ways with surrounding systems, farms can be seen as essential actors to contribute to the realization of sustainable development. Our analysis showed that the sustainable value approach is suitable to assess farm sustainability. It covers the use of economic, environmental and social resources in the farming sector and thus integrates economic, ecological and social challenges. Sustainable value provides an integrated monetary assessment of the sustainable performance of farming enterprises. It gives decision makers environmental information in a form they are familiar with and which can readily be compared with other types of information.

Not only the performance measurement itself, but also the analysis of the determining factors for differences in relative efficiency provides us with several new insights and can give feedback to policy makers. Using the large amount of data available in the FADN database, an effect model is constructed to capture the determinants of the sustainable efficiency of farming. Our empirical model shows that both managerial and structural farm characteristics matter. In general, bigger farms have a higher level of sustainable efficiency, thus farm size matters. Also farmer's age, the dependency on support payments and the amount of additional milk levies are important characteristics in explaining differences in sustainable efficiency. We also found that farms with diversification strategies have higher sustainability levels. For example farms who decide to sell milk (products) directly to costumers on their farm obtain a higher level of sustainable efficiency, because they can improve the value added of the produced milk. Furthermore, our results reveal that economic performance and sustainability performance is not contradictory. Farms with a high economic efficiency show to have a high sustainable efficiency, indicating that they create higher economic value using their resources. Hence, our results show that the aim of the European policy makers to combine strong economic performance with the sustainable use of resources is attainable and achievable and not far-fetched.

Finally, we can draw some lessons for public authorities. Policy measures that improve the passing of farms from elder less efficient farmers to younger farms will contribute to an improvement in sustainability performance. However, policy makers should also be careful in subsidising farms as our results show a negative correlation between sustainable efficiency and the dependency on support payments. Apparently farms depending on subsidies are not stimulated to search for higher value added solutions while a high value added proves to be very important both for the economic performance as for the sustainability performance of farms. Therefore, farm policies should give incentives to develop value added strategies rather than keeping less economic efficient farms in production. Our results indicate e.g. that stimulating on-farm selling of farm products or other diversified activities can contribute to a more sustainable dairy sector in Flanders. Our results of course do not incorporate other contributions of farming to society such as contributions to biodiversity or landscape creation which may contribute to the creation of wealth in other rural sectors such as the real estate, tourism or drinking water provision sector. Further research taking into account these aspects should be stimulated.

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