Farm Management Information system: case study

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Abstract. Through the development and adoption of a Farm Management Information System (FMIS) that incorporates linear and non-linear optimization, this paper investigates whether FMISs are a suitable tool for significantly improving of the overall profitability of a medium-sized and diversified farm. Consequently, profit maximization and cost efficiency are the solitary aims. The developed linear and nonlinear models consider all production processes and services of the selected case study farm that is located in North Rhine-Westphalia (Germany). Particular attention is paid to the farm's internal interconnections between the different production processes and its services as well as the resulting synergy effects. This paper shows that at a given price level for input and output factors, it is possible to increase the annual gross profit on this farm from 292,812 EUR to 342,461 EUR, which represents a rise of 17.0%. This improvement can be achieved by solitarily optimizing the farm's allocation of the available resources.

Keywords: Farm management, Diversified farm, Optimization

1 Introduction

Successful farm management has become a more challenging task over the past decades. Today's farmers are increasingly exposed to various risk factors like the weather or pests (Mußhoff *et al.*, 2007), and at the same time they have to tackle difficult economic decisions which are subjected to technological, political and social changes. Therefore, an agricultural sector is nowadays exposed to a more complex and faster changing environment than ever before. However, the rise of complexity is not solitarily routed in the external environment, but also within the farms themselves. Most farms in the developed countries have undergone a tremendous change in the past sixty years in order to sustain. Thus, farmers have either augmented their productions capacities to benefit from economies of scale, or they have diversified their farms to benefit from economies of scope and to reduce their risk exposure.

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Therefore, for both type of farms, augmented and diversified, a proper management has become a sophisticated task, which demands additional skills from farmers. Prior, it was sufficient to have expert knowledge in land cultivation and stock breeding, which is, however, not adequate any longer. Farmers have had to shift their self-perception from the “classical” role as a cultivator and breeder to a manager of an enterprise. Therefore, they must gain knowledge in risk assessment, controlling, auditing and taxations. All this holds true for diversified farms in particular, since they do not only have to deal with the new conditions and elevating risk level, but also with their complex farm structure. Thus, in order to sustain and to improve the profitability of their farms, farmers are in need of a sophisticated planning, controlling and optimization tool (Nagel, 2000).

Farm Management Information Systems (FMISs) are such powerful tools to support farms to retain their independence and to increase their profitability.

FMISs, consist of a set of business systems designed to provide crucial information for decision making and to assist the manager in strategic planning (Capron and Perron, 1993).

The models applied in FMISs can aid to deal with internal and external complexity and to achieve the optimal distribution of a farm’s scarce resources to its various production processes and other activities. This is a vital success factor for any agricultural business (Parker, 2003). However, many farmer still rely more on their intuition than on management tools when it comes to running their business (Pannell, 1996). This fact is closely related to the complexity of agricultural businesses. In this kind of environment, intuitive decisions may be considered useful when it comes to generating ideas and responding to urgent matters (Suter, 1992). This is true, although, modeling of farms has started already in the 50‘s and 60‘s of the last century. Since then, vast numbers of researchers and agricultural advisors tried to enthrall farmers with their models and to implement FMISs throughout the farming business. However, their success has been rather limited (McCown and Parton, 2006).

A well-designed FMIS provides an easy access to all information, which are crucial for the farms profitability and sustainability. In this context, the “universal” FMIS opts for the optimal resource allocation, because only in this way it can effectively support the farmer in attaining better management decisions, while making his farm more profitable.

Farms can be considered as legal and fiscal business entities, in which a transformation process is ongoing by combining commodities and services, aiming on the production of marketable output factors. (Kistner and Steven, 2002; Reisch, 1995). So, the fundamental question from the microeconomic point of view is: why should any farmer be interested in FMIS? As simple as this question might look, the answer to it is not. Undoubtedly, the skillful and conceived management of farms is one of the most important success factors for their proper functioning, their sustainable development and their survival in today’s fast changing environment (Forster, 2002; Mishra *et al.*, 1999; Muhammad *et al.*, 2004).

Nevertheless, farmer’s major aim always was to maximize their profit, because only when a farm is well-managed, it can generate the funds to finance its sustainable development and thereby its survival in today’s fast changing environment. The major leverage to achieve this aim has been to increase the productivity of their farms, or more precisely of the various production processes on their farms.

2 Methodology and Data Sources

Within the scope of this research the "Whole-Farm Modeling" approach is considered as the most suitable. Makeham was one of the first fostering this approach - he called it "whole farm project" (Makeham, 1971, p. 100) - and it has been tested widely already. For instance in Western Australia within the software MIDAS (Model of an Integrated Dryland Agricultural System) (Pannell, 1996).

For the development of the cost calculation model, firstly a database was set up, comprising all necessary activities for conducting each single production process or service. Consequently, the cost calculation was conducted for each production branch separately. Nevertheless, input factors like the available arable land or the working time of the farmer are treated globally within the entire model. To each activity the needed working time, machinery hours, diesel consumption and other inputs like seeds, spraying chemicals was assigned. Then market prices for each single input factor were attached in order to receive the exact costs of each activity. Finally, all standardized direct cost factors for every production branch's input(s) were received.

The turnover calculation was carried out according to the cost calculation. Thus, depending on the availability, the farm's average selling price or a current market price was applied. With these prices, each production branch's activity was evaluated in order to receive the turnover per output factor. Standardized cost was then subtracted from the turnover per activity in order to obtain the specific gross profit of each activity.

The tools chosen for depicting and solving the linear optimization model are the software package Lindo™ API 6.1 and MS Excel in combination with the AdIn OpenSolver 2.1. Both incorporate a very capable simplex algorithm, whereas the former is commercial while the latter is freeware. In addition, does the usage of two different software solutions ensure that the obtained results are independent form the software in use?

3 Results of Research

Variant 1, which focuses on the effectiveness of the resource allocation has been solved with two separate software packages: Lindo and the Excel AdIn Open Solver 2.1. This procedure has been chosen in order to ensure that the obtained results are independent from the applied algorithm. Unlike the procedure of Variant 1, Variant 2 has solitarily applied Lindo™, since after having confirmed the consistency of the obtained results, it has been no longer necessary to apply Open Solver 2.1 as well.

Firstly, when it comes to implications for recommended actions, effectiveness mostly comes before efficiency. This is because the negative impact of doing the right thing (effective) in a non-efficient way is still better than doing the wrong thing (non-effective) in the most efficient way. In other words, the consequences from running a farm ineffectively are dire than the consequences of running it inefficiently. Furthermore, a major premise of both models has been that financial funds are not considered a limiting factor. However, the limitation of financial funds is the major reason, why focusing on efficiency, or more precise, cost efficiency. In contrast, the available farmland and stable capacities actually have been considered limiting factors. And both factors are related to effectiveness.

Secondly, and more importantly the actual results of Variant 1 ("Linear") and Variant 2 ("Non-Linear") do not differ in a substantial way as prior mentioned. Table 1 displays all values and costs of production and the consequent gross profits for the different production processes and services, which have been calculated according to the same price level for all variants. The total gross profit is nearly identical. As a matter the differences are solitarily routed in the sector of plant production, whereas the hog fattening activity and the pension horses remain the same in both variants

Table 1: Comparison of Variants 0-2 (all values in EUR)

	Variant 0 Non-optimized 2012/2013	**Variant 1 Linear Optimization**	**Variant 2 Non-Linear Optimization**
Total Value of Production	760,004	833,452	820,954
Total Variable Cost of Production	467,192	490,991	480,865
Gross Profit	292,812	342,461	340,090
Fixed Cost	181,487	181,487	181,487
Total Cost	648,679	672,478	662,352
Efficiency	**1.171617822**	**1.239374573**	**1.239453792**
Change in Efficiency in %	**100.0%**	**105.8%**	**105.8%**

Actually, out of the 198 available activities only a fraction, namely 25 shows different results. And out of these 25 activities 18 show a divergence of less than 1000 EUR.

The subsequent paragraphs will focus not only on the deviations between the results of Variant 1 and Variant 2, but also consider the outcomes of the non-optimized Variant 0. However, the focus will clearly lie on the results of the former two.

Having said that, it seems worthwhile to focus once again on the similarities of Variant 1 and 2. As table 1 shows, the overall gross profit of Variant 1 is only 2.371 or 0,69% higher than that one of Variant 2. Thus the differences between Variant 1 and 2 are virtually negligible. The differences of the total turnover and the total variable costs are slightly more significant (833.452 EUR to 820.954 EUR and 490.991 EUR 480.865 EUR). When comparing these results with the non-optimized figures of 2012/13 the potential for the optimization process becomes clear. Both, Variant 1 and Variant 2 are capable of increasing the gross profit by nearly 50.000 EUR (Variant 1: 49.649 EUR; Variant 2: 47.278 EUR).

To be fair, one has to mention that the improvement had been slightly smaller (ca. 4.400 EUR) if the pig stall had performed as expected. Nevertheless, the augmentation of the attainable gross profit had been remarkable also in this scenario.

Besides the gross profit, also in terms of efficiency Variant 1 and Variant 2 outperform the non-optimized Variant 0 significantly, but hardly differ from each other (Variant 1: 1,2394 to Variant 2 1,2395).

Table 2 shows the actual resource allocation of Variant 0 and the results of Variant 1 and 2. The table shows that in 2012/2013 the land usage differs for most crops considerably from the optimal solutions of variant 1 and 2. This is in particular true for winter wheat, winter barley and winter canola, which show some major deviations. This deviation can be explained by the strict application of the crop rotation constraint in the model, which states that these three crops have to be cultivated on an area of the same size. In reality a rather rigorous adherence to the crop rotation plan is difficult to accomplish. Also the suggested cultivation of 8,0 ha grain maize in Variant 1 differs from the zero hectares in Variant 0 and 2. The optimum solution of Variant 2 actually suggests replacing the area under grain maize nearly completely by silo maize. This does not come as a surprise, since the production of silo maize is by 30% cheaper than that one of grain maize, and therefore complies very well with the aim of cost efficiency. The same explanation holds true for the fact that Variant 2 fosters the extensive use of grazing land (3 ha) more than Variant 1 (2 ha). As earlier mentioned, the Greenland area in Variant 0 also included the grazing land for pasture, as the farmers have not distinguished between the two so far.

Table 2. Allocation/Usage of farmland /Stable Capacities Variant 0-2 (in ha/headcount and %)

Producion Process	**Variant 0**		**Variant 1**		**Variant 2**	
	Abs.	**%**	**Abs.**	**%**	**Abs.**	**%**
WW	19.8	27.2%	12.7	17.2%	12.8	17.3%
WB	17.2	23.7%	12.7	17.2%	12.8	17.3%
WC	5.2	7.2%	12.7	17.2%	12.8	17.3%
PO	8.6	11.8%	7.1	9.6%	7.8	10.5%
GM	0.0	0.0%	8.0	10.8%	0.0	0.0%
SM	1.6	2.2%	0.0	0.0%	7.7	10.4%
GL	6.9	9.5%	4.9	6.6%	3.9	5.3%
SB	12.1	16.6%	12.6	17.0%	12.6	17.0%
RB	1.3	1.8%	1.3	1.8%	0.6	0.8%
GR	0.0	0.0%	2.0	2.7%	3.0	4.0%
Hogs	1,590.0	94.0%	1,692.0	100.0%	1,692.0	100.0%
Large Horse Stable	3.0	100.0%	3.0	100.0%	3.0	100.0%
Normal Horse Stable	7.0	100.0%	7.0	100.0%	7.0	100.0%

As Variant 0 and Variant 1 suggest the same number of hectare Variant 2 suggest a reduction by more than 50%. Again, the very intensive production methods and the consequently high costs of cultivation of 6.313 EUR per hectare explain, why a reduction of raspberry cultivation makes sense from an efficient related point of view. In contrast to the differences in the land cultivation process there are no differences in the level of activity of hogs and pensions horses.

The difference in crop yield, originating from the various sizes of cultivated areas per crop and fruit for each variant are displayed in table 3.

Table 3: Crop Yield Variant 0-2 (in t and %; Index 100% Variant 0)

Producion Process	**Variant 0**		**Variant 1**		**Variant 2**	
	Abs.	**%**	**Abs.**	**%**	**Abs.**	**%**
WW	193.9	100.0%	132.2	68.2%	133.9	69.0%
WB	121.7	100.0%	109.7	90.1%	110.6	90.8%
WC	21.2	100.0%	57.8	273.3%	59.1	279.5%
PO	0.0	N.A.	0.0	N.A.	0.0	N.A.
GM	0.0	N.A.	83.7	N.A.	0.0	N.A.
SM	7.0	100.0%	0.0	0.0%	35.0	501.6%
GL	50.8	100.0%	36.3	71.5%	29.2	57.5%
SB	121.9	100.0%	140.0	114.8%	140.0	114.8%
RB	3.3	100.0%	3.4	103.1%	1.5	45.8%
GR	0.0	N.A.	0.0	N.A.	0.0	N.A.

The tables 4 and 5 show the value/turnover of production and the variable cost for every crop and fruit and each variant. From these tables the later on introduced table for the gross profit is derived. Besides, tables 4 and 5 provide some interesting insights.

For instance, the different percentage values, representing the proportion with regards to the overall turnover respectively overall variable costs for each individual crop/fruit. As for some crops, like winter wheat, these percentage values are balanced (4,4% of the overall turnover to 4,3% of the overall variable cost; Variant 1), for some they are not. Winter barely is an example for a negative relation (3,4% of the overall turnover to 3,8% of the overall variable cost; Variant 1), whereas strawberries are an excellent positive example (39,5% of the overall turnover to 27,0% of the overall variable cost; Variant 1). The mentioned relations make it possible to draw conclusions concerning which crop/fruit should be preferred over another crop/fruit in general. However, the relations do not give evidence if a crop or fruit is profitable or not. Referring to the example of winter barely, one can observe in table 5 that, despite the unfavorable relation, winter barely is actually profitable.

Table 4: Value/Turnover of Production (in EUR and %)

Producion Process	Variant 0		Variant 1		Variant 2	
	Abs.	%	Abs.	%	Abs.	%
WW	53,821	7.1%	36,717	4.4%	37,164	4.5%
WB	31,518	4.1%	28,404	3.4%	28,630	3.5%
WC	9,077	1.2%	24,814	3.0%	25,375	3.1%
PO	12,040	1.6%	9,926	1.2%	10,890	1.3%
GM	0	0.0%	19,666	2.4%	0	0.0%
SM	2,586	0.3%	0	0.0%	12,966	1.6%
GL	6,703	0.9%	4,791	0.6%	3,854	0.5%
SB	297,192	39.1%	341,293	40.9%	341,293	41.6%
RB	12,753	1.7%	13,151	1.6%	5,836	0.7%
GR	0	0.0%	520	0.1%	774	0.1%
Hogs	309,573	40.7%	329,432	39.5%	329,432	40.1%
Large Horse Stable	8,178	1.1%	8,178	1.0%	8,178	1.0%
Normal Horse Stable	16,562	2.2%	16,562	2.0%	16,562	2.0%
Total	760,004	100.0%	833,452	100.0%	820,954	100.0%

Table 5: Variable Cost of Production (in EUR and %)

Producion Process	Variant 0		Variant 1		Variant 2	
	Abs.	%	Abs.	%	Abs.	%
WW	32,927	7.0%	21,129	4.3%	21,317	4.4%
WB	25,525	5.5%	18,855	3.8%	19,022	4.0%
WC	5,996	1.3%	14,649	3.0%	14,779	3.1%
PO	0	0.0%	0	0.0%	0	0.0%
GM	0	0.0%	16,558	3.4%	0	0.0%
SM	2,323	0.5%	0	0.0%	11,167	2.3%
GL	5,410	1.2%	3,842	0.8%	3,075	0.6%
SB	127,280	27.2%	132,526	27.0%	132,526	27.6%
RB	8,206	1.8%	8,206	1.7%	3,642	0.8%
GR	0	0.0%	226	0.0%	336	0.1%
Hogs	241,226	51.6%	256,700	52.3%	256,700	53.4%
Large Horse Stable	5,490	1.2%	5,490	1.1%	5,490	1.1%
Normal Horse Stable	12,810	2.7%	12,810	2.6%	12,810	2.7%
Total	467,192	100.0%	490,991	100.0%	480,865	100.0%

4 Conclusion

In the last 40 years the agricultural sector has been exposed to a much more complex and faster changing environment than ever before. The conducted research addresses the mentioned risk factors and proposes as a solution a FMIS that incorporates a (non)linear optimization model as a key feature.

The first intention of this research was to demonstrate that it is possible to develop a FMIS for diversified farms that incorporates all modules and features needed to attain reasonable management decisions for the respective farm. For that purpose, a diversified farm in Germany has been selected as a case study. The research has shown that the general model of the FMIS provides an adequate basic structure and the rudimentary functionalities for the development of the concrete FMIS for the case-study farm.

The additional requirements of the model to be easily adjustable, user-friendly and simple, whist also being capable of dealing with the special demands of the case-study farm has been only partially achieved.

Another fundamental benefit of using a FMIS and (non-) linear optimization lies in the fact that the farmer gains a much deeper understanding and knowledge of how his farm works, especially if there are numerous internal interdependencies. Also, scenario analysis and "what if" analysis, which are possible with the new tools, can substantially contribute to the already mentioned better management decisions.

The optimized results of the case study farm have shown, that this aim has been attained, albeit the degree of accomplishment might have been expected to be higher. In fact, compared with Variant 0 an improvement of 17,0% or 49.649 EUR (Variant 1) respectively 16,1% or 47.278 (Variant 2) at a yearly turnover of roughly 800.000 EUR does not look that impressive. An explanation for the relative modest level of amelioration is the highly professional management of the farm, that existed already before the optimization process. The farmer of the selected case study has over 40 years of experience and also participates in various training programs on a regular basis. Furthermore, he keeps most of his machinery and other equipment on up to date.

References

1. Capron, H.L. and Perron, J.D. (1993), *Computers & information systems: Tools for an information age,* 3rd ed., Benjamin/Cummings Pub. Co., Redwood City, Calif.
2. Forster, R. (2002), "Methodische Grundlagen und praktische Entwicklung eines Systems zur Planung dispositiver Arbeiten in landwirtschaftlichen Unternehmen", Techn. Univ, München,
3. Kistner, K.-P. and Steven, M. (2002), *Produktion, Absatz, Finanzierung: Mit 17 Tabellen, Betriebswirtschaftslehre im Grundstudium*, Vol. 1, 4., aktualisierte Aufl., Physica-Verl, Heidelberg.
4. Makeham, J.P. (1971), *Farm management economics*, Gill Publications, Armidale, New South Wales.

5. McCown, R.L. and Parton, K.A. (2006), "Learning from the historical failure of farm management models to aid management practice. Part 2. Three systems approaches", *Australian Journal of Agricultural Research*, Vol. 57 No. 2, p. 157.
6. Mishra, A.K., El-Osta, H.S. and Steele, C.J. (1999), "Factors affecting the profitability of limited resource and other small farms", *Agricultural finance review*, Vol. 59, pp. 77–91.
7. Muhammad, S., Tegegne, F. and Ekanem, E. (2004), "Factors contributing to success of small farm operations in Tennessee", *Age (years)*, Vol. 6, p. 15−4.
8. Mußhoff, O., Odening, M. and Xu, W. (2007), "Management von klimabedingten Risiken in der Landwirtschaft-Zum Anwendungspotenzial von Wetterderivaten", *Agrarwirtschaft und Agrarsoziologie*, Vol. 1 No. 2007, pp. 27–48.
9. Nagel, J. (2000), "Determination of an economic energy supply structure based on biomass using a mixed-integer linear optimization model", *Ecological Engineering*, Vol. 16, pp. 91–102.
10. Pannell, D.J. (1996), "Lessons from a Decade of Whole-Farm Modeling in Western Australia", *Review of Agricultural Economics*, Vol. 18 No. 3, pp. p 373–383.
11. Parker, W.J. (2003), "Why measures of farm business success matter", *Proceedings of the New Zealand Grassland Association*, Vol. 65, pp. 199–2004.
12. Reichert, T. (2005), "EU-Agrarsubventionen und ihr Verhältnis zum WTO-Agrarabkommen", *Hamm, Berlin: Arbeitsgemeinschaft bäuerliche Landwirtschaft, Germanwatch*.
13. Suter, R.C. (1992), *The professional farm manager and management consultant*, Retus, West Lafayette, Ind.