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Agnar Hegrenes
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About NILF

- Research and analyses on agricultural policy, food industry, commodity trade, economics, farm management and rural development.

- Documentation of financial results in the agricultural sector at national and farm level. This includes acting as secretariat for the Budget Committee for Agriculture and publication of annual Account Results in Agriculture and Forestry.

- Development of tools for farm management and accountancy.

- Funded by the Ministry of Agriculture, the Research Council of Norway and by assignments for public and private clients.

- Main office in Oslo; regional offices in Bergen, Trondheim and Bodø.

Preface

The Nordic Association of Agricultural Scientists (NJF), sections IX and X, in co-operation with The Norwegian Agricultural Economics Research Institute (NILF) organised NJF-seminar 345 "Farm Management" 2–4 October 2002. The seminar was planned by a group consisting of

- Agnar Hegrenes, Norwegian Agricultural Economics Research Institute
- Ulf Torben Larsen, The Danish Advisory Centre
- John Sumelius, University of Helsinki
- Bo Öhlmer, The Swedish University of Agricultural Sciences.

The overall purpose of the seminar was to present recent and ongoing research in the Nordic and Baltic states on farm management and related topics, and to present and discuss experiences from practical advisory work in agriculture.

Eighteen papers were presented at the seminar. Some papers were based on finalized research projects, other papers presented ongoing research while some papers presented projects that are at an early stage. However, we find all papers so interesting that they deserve to be published. We hope that the report adds valuable insights into the multifaceted topic of farm management. The papers express the views of the individual authors.

The papers have been grouped into four sections (number of papers in parentheses):

- Financial Analysis and Accounting (4)
- Advisory Service (4)
- Production Economics (6)
- Strategic Planning and Management (4)

We gratefully acknowledge financial support from the Norwegian Research Council through the research programme "Agromanagement". NILF has also contributed by financing printing costs etc. The report is edited by Agnar Hegrenes, and Berit Grimsrud has been responsible for the final preparation of the manuscript for publishing.

Oslo, February 2003

Leif Forsell

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Development of Grain-Growing Farms' Profitability over the Next Few Years in Finland

Matti Ylätalo[a], Timo Karhula[a] and Arto Latukka[b]

Abstract

Before joining the EU the Finnish pricing policy for the agricultural sector followed the so-called high-price system, where product prices were largely determined by the domestic cost level. Following EU membership the so-called average-price rule was adopted, resulting in a sharp fall in prices with farmers' loss of earnings being compensated for with direct subsidies.

The aim of this study is to examine the development of the profitability of grain growing farms and the restructuring of their income base, based on an analysis of their financial statements. In addition, the simulation model devised in the study will be used to assess the situation in 2003.

The average turnover of a grain farm was € 64,000 in 1997–1998, some 49% of which was formed by subsidies. The projected turnover for 2003 will fall to € 62,000, the share of subsidies rising to 54%. The coefficient of profitability was 0.5 for grain growing farms in 1997–1998 and will be 0.4 in 2003. This means that in 2003 grain growing farms will only receive compensation amounting to some 40% of the goals set for them (wage claim and interest claim).

Profitability can be viewed as the most central economic prerequisite for continuing a business. The results indicate that average sized grain growing farms' profitability is weak and it would appear that it will continue to weaken. The profitability of production at these farms is highly dependent on various subsidies, which indicates that their income structure is distorted.

Harsh natural conditions cause a disadvantage to Finnish grain growing farms competing with farms in Central Europe, where the climate is more favourable; direct subsidies have been used to compensate for this. However, a growth in direct subsidies and drop in product prices gives rise to many undesirable effects, such as farming becoming more extensive and the capitalisation of direct subsidies into rents and the price of land.

Keywords: Grain farm, Profitability, Subsidies

[a] University of Helsinki, Department of Economics and Management, PO Box 27, FIN-00014 University of Helsinki, Finland. *matti.ylatalo@helsinki.fi*, *timo.karhula@helsinki.fi*

[b] MTT Agrifood Research Finland, Economic Research (MTTL), Luutnantintie 13, FIN-00410 Helsinki, Finland. *arto.latukka@mtt.fi*

Introduction

Before joining the European Union, the Finnish pricing policy for agricultural products followed the so-called high price system, in which product prices were largely determined by the domestic cost level. After Finland become an EU member, the so-called average price rule was adopted, resulting in a sharp fall in prices with farmers' loss of earnings being compensated for through subsidies. As a result of the Agenda 2000 policy reform, the administrative prices of grains have decreased further in 2000 and 2001. This is leading to a situation in which the price of a kilogramme of cereals does not cover the variable costs of production especially in an average or low yield. This risk is considerably greater in Finland than in the Central European EU member countries, in which the yields are clearly higher than in Finland, and which thus have lower variable costs per produced kilo of cereals.

As a result of the Agenda 2000 decision, the amount of direct subsidies has continued to increase. When at the same time the price of grains has decreased, the share of direct subsidies of the gross return of grain farms has further increased. The share of subsidies of the gross return of a grain farm is considerable, and the subsidies may come to a larger amount than family farm income.

In Finland, the profitability of grain production with current product prices is weak without support measures compensating differences in natural conditions. In Finnish grain production, additional costs originate in, among others, high harvesting humidity and low yields caused by the short growing season. Due to natural conditions and Finland's historic development, the average size of field parcels is small and distances great. Also the transportation costs of cereals both inside and outside the farm are high.

The aim of this study is to examine the development of the profitability of grain farms and the restructuring of their income base, based on an analysis of their financial statements.

Data and method

This study employs farm accounting data on grain farms gathered in 1997–1998[1] by MTT Agrifood Research Finland, Economic Research (MTTL). We examine support areas A and B, which include a sufficient number of grain farms in order to obtain reliable results. The support area A has 42 grain farms and the support area B has 32, i.e. a total of 74 farms.

The development of grain farms' income base, result and profitability up to the year 2003 is studied by means of a simulation model. Development assessments are based on the profit and loss statements and balance sheets calculated from the material gathered in the 1997–1998, information on prices and subsidies and their forecasts for 2003. Development forecast is based on the simulation model in which the farms' production structure, input use and production quantities are as-

[1] Accounting year 1999 is available, but there was no time to include it in this study.

sumed to be in 2003 on the average level of 1997–1998. The intervention prices of the products are presumed to change according to the Agenda 2000. The decrease in intervention prices is respectively assumed to decrease producer prices. Annual depreciations are presumed to be at the same average level as in 1997–1998, because farms are assumed to make replacement investments[2] corresponding to annual depreciations (cf. Karhula, 2001). In the simulation model, the increase of input prices is represented by an annual inflation rate of 1.8% until 2001. After that year, the input prices are presumed to grow 2% a year.

$$Profit_{2003} = P_{2003} * Y_{1997,1998} + S_{2003} - I * W_{1997,1998} * X_{1997,1998} - F_{1997,1998} \quad (1)$$

In the simulation, the product prices of 2003 (P) and subsidies (S) are based on assessments according to Agenda 2000. Input use (X), outputs (Y) and depreciation (F) are on the average level of 1997–1998 ($X_{1997,1998}$). Input prices (W) are calculated from the level of 1997–1998 considering the inflation coefficient (I). The monetary values in the calculations are deflated into 2001 price level.

Results and discussion

The average gross return of a grain farm was € 64,000 in 1997–1998, some 49% of which was formed by subsidies (Table 1). According to the simulation model, in 2003 the gross return will decrease to € 62,000 of which subsidies form 54%.

Table 1 Key economic concepts and figures

	Gross return			Return concepts		Profitability concepts			
	Sales	Subsidies	Other income	Farm family income	Net result	Entrepreneurs' profit	Return on equity	Hourly wage	PC
	€/farm	€/farm	€/farm	€/farm	€/farm	€/farm	%	€/hour	
1997–1998	30289	31410	2215	11979	-50	-11820	0	0.17	0.50
2003	26672	33257	2137	9049	-3245	-14979	-1.4	-0.23	0.40

The average family farm income of grain farms in 1997–1998 comes to € 12,000, and according to the simulation model approximately € 9,000 in 2003. By deducting imputed wage of the farmer and his family (wage claim) from the family farm income, we come to the net result, which represents the return on equity. In 1997–1998, the net result in cereal farms was approximately € -50, and according to the results of the simulation model approximately € -3,200 in 2003. A negative net result means that equity invested in farming yields no returns, nor does a farmer's labour input get properly compensated. In order to even fulfil wage claims to their full amount, a grain farm has to earn off-farm income of approximately € 3,200 in 2003.

[2] Equities and depreciation calculated on the basis of inventory of fixed assets are used in the study.

The entrepreneur's profit represents the profit the entrepreneur also gains when the interest claim for equity in addition to the wage claim is deducted from the family farm income. In grain farms, the average entrepreneur's profit in 1997–1998 was € -12,000 and approximately € -15,000 in 2003. The entrepreneur's profit should be € 15,000 larger so that the entrepreneur could earn the targeted hourly wage (€ 7.5 per hour) and interest claim (5%). The entrepreneur's profit represents the absolute profitability of the enterprise, because all production costs are deducted from the gross return.

The return on equity percentage, which represents profitability, is calculated by dividing the net result with the amount of equity. Its average in 1997–1998 was 0%, and according to the simulation model it will be -1.4% in 2003. When examining the profitability of grain farms, the return on equity percentage may be compared with, for example, interest paid on the market on an investment with similar risk.

When calculating return on equity percentage, labour is prioritised over equity as a production factor, when the wage claim of the farmer and his family is deducted from the family farm income as a cost, leaving the return on equity a residual. If equity costs are prioritised and deducted from the family farm income, the result is earnings. It thus represents the share of the family farm income, which is the wage of the farmer and his family. When this wage (earnings) is proportioned to working hours, we have hourly wage. In grain farms, the average hourly wage in 1997–1998 was € 0.17 per hour, and in 2003 it will be approximately € -0.23. This hourly wage, which represents the profitability of enterprise, may be compared with, for example, the wage earner's hourly wage.

Family farm income does not apply to demonstrating profitability, as it does not observe the amount of entrepreneur's work and equity and the changes in them. If one wishes to keep the entrepreneur's work and equity as equal factors of production in profitability examinations, their compensation, family farm income, is proportioned to the targets of these production factors (sum of wage and interest claims). The result is profitability coefficient (PC). The profitability coefficient applies to monitoring the profitability and development of farms of different production lines and sizes. The average profitability coefficient of grain farms in 1997–1998 was 0.5. According to the simulation model, the profitability coefficient in 2003 will be 0.4, when grain farms would only receive compensation amounting to some 40% of the goals set out for them. That is, the farmers' hourly wage will be € 3 per hour, and the return on equity is 2%, when in 1997–1998 the corresponding figures were approximately € 4 per hour and 3%. The profitability of the grain farms is largely dependent on the size of the farms (Figure 1). In the smallest farm size group (below 30 hectares of cultivated land) the profitability coefficient is lowest (close to zero) but increases by farm size and reaches the highest value 0.88 in the biggest farm size group (more than 90 hectares). Thereby the profitability seems to improve when the size of the farm increases. However even in the biggest farm size group the targets of the imputed wage and interest claims have not been reached. The white bars in the figure show also clearly that the estimated level of the profitability will slightly decrease in the year 2003.

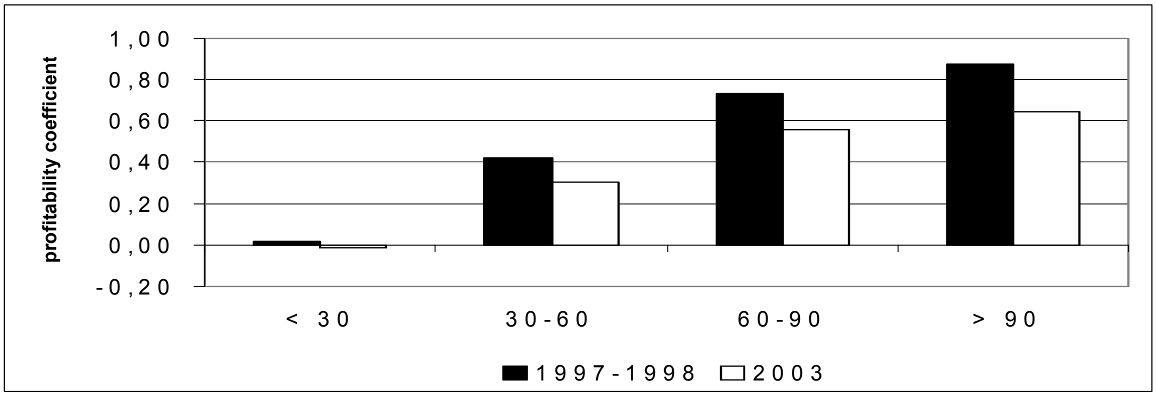

Figure 1 Profitability coefficient according to farm size group (hectares)

The subsidy dependency of grain farms may be evaluated on the basis of the profit and loss statement by, for example, proportioning subsidies to the gross return or by comparing the amount of subsidy income to family farm income or the sum of family farm income and depreciation, that is, to the amount of money which is not paid out as money from the business. The subsidy income of grain farms is approximately one half of the gross return. The subsidy income is some three times larger than the family farm income, and on an average, about 17% larger than the sum of family farm income and depreciation.

Conclusion

The key figures indicate that grain farms have problems, but they do not indicate the reasons for these problems. The profound reasons for the changes in key figures are almost never found in the analysis of financial statements, as the reasons are found in real process. Disentangling these reasons would require extending the examination outside the analysis of the financial statements (e.g. Barry et al., 2000).

Profitability can be viewed as the most central economic pre-requisite for continuing a business. In order to production be profitable, the entrepreneur should also gain acceptable compensation for the equity invested in the business and the labour he has provided. The results indicate that the profitability of Finnish grain farms is weak, and according to the simulation model, it would appear that it will continue to weaken in the future. Farm families do not even gain reasonable compensation for their work and equity. If costs should increase more than assumed in the simulation model (2% per year), so as to gain the profitability level according to the results of the model, it would require, among other things, an increase in productivity or adjustment measures on behalf of the farms.

Finnish grain farms have to compete on the Common Market with those in Central Europe, where the climate is more favourable and whose production technologies cannot be transferred to Finland (see Rabinowicz, 1999). The competition disadvantage of Finnish grain farms is compensated through direct subsidies, although they also have many undesirable effects. The decrease of grain price according to the Agenda 2000 agreement and its partial compensation with direct subsidies means that the subsidy dependency of grain farms increases. However, subsidies[3] are not linked to the crop yield, and are dependent on political decision-making, which fact increases uncertainty in grain production. At the same time, input prices rise according to general price development. A growth in the share of direct subsidies leads to more extensive farming and the capitalisation of direct subsidies into field rents and the price of land. The income structure of grain farms may be considered distorted, as the profitability of grain production is significantly dependent on direct subsidies. The growth of direct subsidies to become a larger item than sales income decreases entrepreneurs' motivation and increases the threat of negligent farming. Furthermore, with current grain prices, the sales income does not cover variable costs in all farms, but only a part of them and the fixed costs have to be covered with direct subsidies independent from yields. In a study made in the University of Helsinki's Department of Economics and Management in 1994, it is stated that in order to ensure the continuation of agricultural production in Finland, a significant share of the subsidies should be earned though the price of the products, that is, as price subsidy (Latukka et al., 1994). The results of this study strengthen the same conclusion.

References

Barry, P. J., Ellinger, P. N., Hopkin, J. A. & Baker, C. B., 2000. *Financial management in agriculture*. 6th ed. Interstate Publishers.

Karhula, T., 2001. *Maidontuotantotilojen talous vuosina 1997 ja 2003*. Unpublished pro gradu thesis. University of Helsinki, Department of Economics and Management.

Latukka, A., Pyykkönen, P., Ryhänen, M., Sipiläinen, T. & Ylätalo, M., 1994. *Maatalousyritysten taloudellinen sopeutuminen Euroopan liiton jäsenyyteen*. Summary: Adjustment of the finnish farms on the EU membership. University of Helsinki, Department of Economics and Management, Publications no. 4.

Rabinowicz, E., 1999. Redesigning the CAP to meet the challenges of EU enlargement and the WTO: what can agricultural economics research contribute? *European Review of Agricultural Economics*. 26(3).

[3] Also the drying subsidy for cereal production may be included in the direct subsidies which is a part of CAP subsidy.

Farm Accounting: the Present Situation and the Future in Estonia

Anu-Ell Visberg[a] and Viia Parts[b]

Abstract

Accounting and reporting are organized in accordance to the legislation in force in a specific country; additionally, guidelines issued by an institution, governing the given specialty, are used. The guidelines are developed in accordance to standards, arising from international practices. International Accounting Standard for Agriculture (IAS 41), considering the specific features of agricultural production, has been enforced, compulsory for fulfilment from January 1, 2003. The objects studied are the legislation, establishing the principles for reporting and accounting in Estonia, IAS 41 Agriculture, reporting and accounting data from Estonian agricultural producers and different papers. The current paper presenting results of the research is divided into two parts: in the first part Estonia's current economic situation and the situation in agricultural accounting are analysed, the second part presents some of the principles of IAS 41 Agriculture, and analyses the effect the new principles enforced may have on the accounting and reporting procedures, implemented by Estonian agricultural producers.

The following methods were used in the study: empirical observation, comparison, personal observation.

Keywords: Farm accounting, IAS 41 Agriculture, Biological assets, Fair value.

[a] Estonian Agricultural University, Institute of accounting and finances, Kreutzwaldi 64-231, 51014 Tartu, Estonia *anu@eau.ee*

[b] Estonian Agricultural University, Institute of accounting and finances, Kreutzwaldi 64-231, 51014 Tartu, Estonia *viia@eau.ee*

The present situation of farm accounting in Estonia

The international definition of farming is the following: on farm—to use an area of land, used for growing crops or keeping animals. In Estonia we don't have specific definition attached to farm/farming, but in accordance to Estonia legislation there are agricultural producers—sole proprietors and trading companies the main operating area of thereof being manufacture of agricultural produce. According to the data of Tax Board of Estonia, there was 66 565 sole proprietors in Estonia on January 1, 2002. Approximately 35% of sole proprietors declare having gained revenues from agricultural production. On January 1, 2001 there was 680 agricultural trading companies.

The Accounting Act of the Republic of Estonia (valid since January 1, 1995) states that the entities which must have established accounting are legal entities and sole proprietors (SP).

The differences in accounting systems, used by SP-s, arise from the VAT status. Legal entities and SP-s, that are liable to value-added tax, must make use of accrual basis accounting principle and the double-entry book-keeping. As the financial year ends, they must compile the annual financial statements (balance sheet, income statement and annexes). Legal entities must submit to the Registration Departments of Courts and the Tax Board their business year report, one part of which is the annual financial statements, no later that by June 30 of the next year.

SP-s that are liable to value added tax, must fulfil almost the same liabilities as the legal entities. There are also two differences—they are not liable to audit and in certain cases they are also not liable for compiling reports as they start their economic activities. SP-s that are not liable to VAT can use cash basis accounting principle and they must only apply certain statutes arising from the Accounting Act. All SP-s must develop a tax return, arising from the Income Tax Act, to the Tax Board no later than by March 31 of the next year.

As we look at the number of sole proprietors, we can assume that the accounting principles must be applied by many people who lack the required knowledge. The application of different accounting principles has made the data included in the statements not suitable for comparison. (Poppe, 1993) The financial institutions have also problems when assessing the financial and economic status of the entrepreneurs, as the balance sheet and income statement information is used in the process of assessing the loan applications. With the purpose of getting a more fair picture of the economic results of the entrepreneurs a requirements was established, demanding the applicants for SAPARD investment support, to make use of the accrual basis accounting principle of start applying from the next year following the reception of the support. Special guidelines—*Farm Accountancy Data Network* (FADN)—are presently used to compare the data of different entrepreneurs (for example, volume indicators are used to assess sales value of the assets).

In accordance to the understanding, widely spread in Estonia, the application of the cash basis accounting principle is equal to the calculation of the revenues to be taxed, that is, no accounting is kept over the revenues and expenditures over the year; instead, the income before taxes and expenditures to be subtracted from the income are only calculated as the tax return is developed. The result obtained in such a way is considered to be the outcome of cash basis accounting (also the profit or loss). Such an erratic concept may easily cause some unpleasant surprises for the entrepreneur as it comes to his/her income before taxes and the income tax to be paid. The authors consider changing the widely spread concepts to be a very difficult task as one must also explain the entrepreneurs the difference between income tax calculations and accounting. (Põllumajandusraamatupidamise…, 2002)

Rural advisors and entrepreneurs have also some problems when adopting accrual basis accounting principle—how to value the assets that were acquired as the cash basis principle was used. For a while it was customary to develop a balance sheet, showing the cash and status of bank accounts, claims receivable, accounts payable—the differences was recorded as the equity—that is, the assets acquired, using the cash basis principle, are already accounted for as expenditures and can't be shown as assets any more. Still, the authors are of the opinion that the balance sheet should also account for assets already acquired, using the purchase value shown in documents. The capital assets should also show both the purchase value and accumulated depreciation that could be calculated backwards in accordance to their service time.

Current assets shall be reported on the balance sheet at the lower of cost or net realisable value. Net realisable value is the selling price minus expected selling expenses. Purchased inventories shall be recorded at cost. Work-in-progress and finished goods shall be recorded at conversion cost. Inventories (excl. work-in-progress goods) are valued using either the FIFO or weighted average cost formulas.

In accordance to the practice, applied in Estonia, young cattle and fattening cattle can be reported as work-in-progress or finished goods. In case the first principle is applied, the actual cost price of the cattle must be reported while in second case, the cattle must be reported at its cost price that will be conversed in accordance to the FIFO or weighted average cost formulas. Still, here we may easily run into some contradictions with the Accounting Act which states that the current assets, including the livestock, must be reported at cost price or net realisable value—depending on which value is reported as lower—while it does not say whether the reported value is equal to purchase value. Growing crops are also reported as work-in-progress in agriculture, that is, it should be reported at production cost price when reporting. The grain and oil crops, potatoes and other crops that have already been harvested are reported as finished goods.

Companies that employ accountants with a long period of employment are known to use old principles for accounting. For example, the real expenditures made for the maintenance of dairy cattle over a year are divided between milk and the calves, the ratio being 90:10, while the crop production yield is reported as conventional production and the expenses are divided in accordance to the coefficients available. The entrepreneurs that have started their business over the last couple of years do not fancy such principles of accounting, as the gross margin calculations give the information required for management information. The production cost price depends on the expenditures inserted in the calculation formulae. In accordance to the Accounting Act, one is not supposed to add period expenses to the production cost price, but we can still find some companies in Estonia that make use of such old-fashioned techniques and divide such expenditures between the production cost accounts. The result is distorted cost price. The production cost prices, used by trading companies and SP-s, are also not comparable: in accordance to the Estonian legislation, SP can't pay himself/herself any wages, therefore, the cost prices are relatively lower. In Canada, agricultural proprietors make use of a simple and practical modified direct-costing method, that can be used to divide all the expenses (with the exception of the wages paid to the managers) into production expenses and other expenses. (Kinnell, 2001) In case Estonia will stick to the application of production cost price techniques, the Accounting Standards Board should develop and publish methodological guidelines that could be used for levelling out the costs. (Kõiv et al., 2001)

Agricultural proprietors can make use of unique objects of material capital assets: breeding herds, land, plantations etc. Unfortunately, there is still no common understanding of accounting principles in Estonia when it comes to breeding herds: some proprietors consider these as inventory while the other as capital assets. The purchase price of breeding herd is the expenditures made to bring them up (real production cost price), that will not be adjusted over the lifetime of the animal. It is commonly accepted not to depreciate the breeding herds reported as capital assets. In accordance to the Accounting Act, all the assets must have a purchase price, made up of the purchase price and the expenditures arising from putting the assets in use. The land, gained by a proprietor as the result of the property reforms or inheritance, has no purchase price and therefore, is also not shown on his/her balance sheet. If this is the case, expenditures made to get the land should be included in the purchase value of land. In practice, such expenditures are reported as personal costs or periodic costs.

In Estonia, there is also the question of reporting the purchase price of a plantation. Some accountants have expressed their wish to sum up all the costs related to a plantation (cultivation costs, price of fertilisers and pesticides, price of the seedlings, price of plastic sheets used); after that, the maintenance costs made until the plantation starts to give some yield will be added to the initial costs as a material asset not to be depreciated.

During the current period of changes absurd and frequently changing requirements are established for accounting. For example, the amendment to the Accounting Act states that SP-s registered in the Registration Departments of Courts are expected to submit their annual book-keeping and financial reports to the Registration Departments of Courts while the registers rejected the claim and did not accept the reports by referring to the Commercial Code that does not request the submission of such reports. Quite a large number of SP-s using cash basis accounting principle are also registered in Registration Departments of Courts; nevertheless, the claim for the submission of annual reports does not extend to this group of entrepreneurs. There are no legal grounds stating that SP-s have to submit their annual reports to the Tax Office, nevertheless, all the SP-s making use of accrual accounting principle are expected to submit their annual reports.

The new draft Accounting Act (expected to take force on January 1, 2003) being devised pays sufficient attention to the organization of accounting of subsidiaries and branches of a company and related submission of consolidated reports. Still, the draft Accounting Act fails to give any reference to the recording of assets in agricultural production. As the new Accounting Act takes force it will be more complicated for SP-s to organise their book-keeping, provided that the present requirement, stating that cash basis accounting principle is only valid for SP-s whose net turnover didn't exceed the margin established for VAT eligibility by the Tax Office. According to the principle SP-s only starting their business should use accrual basis accounting principle during their first year while transferring to cash basis principle the next year. Nevertheless, the implementation of such principles is in contradiction with current situation providing for the transition from cash-based accounting to accrual accounting, not the other way round. The balance sheet scheme applied in the Accounting Act currently in force gives clear and understandable principles for the calculation of SP's equity using the following records:

- owner's opening equity in the beginning of year under reporting;
- owner's disbursements/investments (net amount);
- net income or loss for the financial year.

According the to new draft Accounting Act SP-s are expected to replace the record *Share or stock capital* with a record reflecting their equity.

International Accounting Standard IAS 41 Agriculture and implementation of the IAS 41 principles in Estonia

The objective of IAS 41 is to establish standards of accounting for agricultural activity—the management of the biological transformation of biological assets (living plants and animals) into agricultural produce. IAS 41 defines two definitions of high importance:

1. Biological assets are living animals and plants.
2. Agricultural produce is the harvested product from biological assets.

All the biological assets are reported at their fair value less the expected point-of-sale costs at each balance sheet date, unless fair value cannot be measured reliably. The agricultural produce is reported at fair value at the point of harvest less expected point-of-sale costs. The change in fair value of biological assets during a period is reported in net profit or loss. All costs related to biological assets that are measured at fair value are recognised as expenses when incurred, other than costs to purchase biological assets. If fair value cannot be reliably measured, the asset is measured at cost less accumulated depreciation and impairment losses. But that enterprise must still measure all its other biological assets at fair value. If circumstances change and fair value becomes reliably measurable, a switch to fair value less point-of-sale costs is required. Boone and van Bommel (2000) clearly presented different methods in their paper in Pacioli seminar.

Fair value can be:

- The quoted market price in an active market for a biological asset or agricultural produce. If an active market does not exist, IAS 41 provides guidance for choosing another measurement basis. First choice would be a market-determined price such as the most recent market price for that type of asset, or market prices for similar or related assets.
- If reliable market-based prices are not available, one must make use of the present value of expected net cash flows from the asset discounted at a current market-determined pre-tax rate.
- If little biological transformation has taken place or the impact of biological transformation on price is not expected to be material, cost is being used.

Fair value measurement stops at harvest. IAS 2 Inventories, applies after harvest. Biological assets that are physically attached to land are measured as biological assets separate from the land.

IAS 41 also specifies the information to be revealed in statements, for example:

1) carrying amount of biological assets;
2) description of an enterprise's biological assets, by broad group;
3) change in fair value during the period;
4) fair value of agricultural produce harvested during the period;
5) description of the nature of an enterprise's activities with each group of biological assets and non-financial measures or estimates of physical quantities of output during the period and assets on hand at the end of the period;
6) information about biological assets whose title is restricted or that are pledged as security;
7) commitments for development or acquisition of biological assets;
8) financial risk management strategies;
9) methods and assumptions for determining fair value;
10) reconciliation of changes in the carrying amount of biological assets, showing separately changes in value, purchases, sales, harvesting, business combinations, and foreign exchange differences.

If fair value cannot be measured reliably, additional required disclosures include:

1) description of the assets;
2) an explanation of the circumstances;
3) if possible, a range within which fair value is highly likely to fall;
4) gain or loss recognised on disposal;
5) depreciation method;
6) useful lives or depreciation rates;

7) gross carrying amount and the accumulated depreciation, beginning and ending.

If the fair value of biological assets previously measured at cost now becomes available, certain additional disclosures are required. Disclosures relating to government grants include the nature and extent of grants, unfulfilled conditions, and significant decreases in the expected level of grants.

The authors of the current paper have developed different balance sheets, making use of the data, gathered from a real Estonian agricultural entrepreneur. The balance sheets have been compiled on December 31, 2000 (see Table 1). The farmer cultivates summer grain crops, roughage and green fodder, keeps dairy cattle, replacement and fattening cattle. The land he uses has been rented. In accordance to the accounting principles, adopted by the farm, replacement and fattening cattle is reported as work-in-progress while the grain and fodder is shown as finished production. The second column of the table shows the balance sheet, reporting biological assets, measured in accordance to the Accounting Act, in force in Estonia (that is, at their real production cost price or net realisable value—the lower value is used). At such conditions, the balance sheet value of the farm totalled to 6599 thousand kroons (1 EUR = 15.6466 Estonian kroons) while the profit totalled to 1143 thousand kroons. The real production cost price of replacement and fattening herd turned out to be higher than the net realisable value. The third column represents the biological assets, measured at its real production cost price—at such conditions, the balance sheet value of the farm totalled to 7443 thousand kroons while the profit totalled to 1987 thousand kroons. The application of IAS 41 principles, that is, measure the biological assets at their market price, is shown in column four of the table. As these principles were applied, the balance sheet value of the farm totalled to 8097 thousand kroons while the profit was 2641 thousand kroons, in other words, as the biological assets are measured at their market price the balance sheet values increases by 22.7% while the profit increases by 131%. The data shown here will give us the reason to state that the proprietors are probably interested in measuring the biological assets at the market price, especially as the market price tends to increase. Still, there is a danger that excessive financial risks will be taken and in case of a failure (for example, outbursts of cattle infections) the proprietors won't be able to meet the claims of the creditors. As the market price starts to drop (for example, prices of beef), the result might easily be a considerable financial loss.

According to the Income Tax Act in force in Estonia SP-s shall pay income tax on the difference between the income received and expenditures made (that is, cash basis principle is used to calculate income before taxes). Also the companies are not yet paying income taxes in accordance to the principles applied in well-developed countries. In case a company or SP should pay income tax in accordance to the revenues, calculated in accordance to the net income from income statement, the amount of the taxes will also differ considerably.

Table 1 Biological assets, measured in an Estonian agricultural farm, 31.12.2000 (Th. EEK)

	Biological assets, measured in accordance to the Accounting Act principles	Biological assets, measured at their real cost price	Biological assets, measured at their market value
Cash and bank accounts	**4**	**4**	**4**
Accounts receivables	**640**	**640**	**640**
Other claims	**49**	**49**	**49**
Total inventory	**4069**	**4913**	**4393**
Materials	132	132	132
Work in progress	1979	2357	1979
Finished production	1956	2422	2280
Goods for sale	2	2	2
Total material fixed assets	**1837**	**1837**	**3011**
Breeding herd	730	730	1904
Other material fixed assets	1107	1107	1107
Total ASSETS	**6599**	**7443**	**8097**
Current liabilities	**3680**	**3680**	**3680**
Long-term liabilities	**4**	**4**	**4**
Total equity	**2915**	**3759**	**4413**
Shares	1770	1770	1770
Retained profit of previous periods	2	2	2
Profit made over the year under reporting	1143	1987	2641
Total LIABILITIES	**6599**	**7443**	**8097**

Table 2 shows the unfinished production at the closing of years 2000 and 2001. As it can be seen, in 2001 the number of animals and their weight increased. The price of young stock also went up from 8.00 EEK/kg to 13.50 EEK/kg. Therefore, the changes in the value of biological assets can be respectively related to changing market prices—1361 thousand kroons—and increase in the amount of assets 1908 thousand kroons.

In case a decision is taken to report biological assets at their fair value in Estonia, one should immediately initiate a market price information system that could be used for obtaining data on the fair value of the biological assets by proprietors of different regions.

Table 2 Work in Progress 2000–2001

	Number of animals	Weight (kg)	Biological assets, measured at their market value (Th. EEK)
2000, 31 December	1178	247429	1979
2001, 31 December	1611	388783	5248
Difference	+433	+141354	+3269

Implementation of the IAS 41 principles in Estonia would help to level out the principles for reporting the value of biological assets and agricultural produce in different statements. Simultaneously, major changes will take place in the philosophies of agricultural accounting. The definition of biological assets and the principles for grouping, principles for measuring fair value, reporting of detailed information in statements—these will all be new for the accountants not only in Estonia, and considerably different from the principles, used presently. Implementation of new principles presumes complementary training provided for the accountants and informing all the related persons about the changes to occur.

In 2000, a sector study was initiated and implemented by the Ministry of Agriculture. The subject of the study was *Implementation of international agricultural accounting standards, state support and taxes in agriculture, reporting of such items in accounting*. One of the output of the study was the development of the draft for Estonian agricultural accounting guidelines, based upon Exposure Draft E65 Agriculture. The draft guidelines were also sent to the Estonian Accounting Standards Board. In 2001 major changes took place in the membership of the Board. The New Accounting Standards Board has informed the public of its intent to have all the international accounting standards (including IAS 41) translated and apply these in Estonia. By now six draft guidelines are available from internet. After the Accounting Standards Board has approved the guidelines for agriculture, these must be harmonised with IAS 41 presently in force.

Estonia has taken a principal decision to access European Union, therefore, it is inevitable to develop reports, submitted in public, in accordance to common principles.

Results and conclusions

1. The changes in agricultural accounting, brought along by the implementation of IAS 41 *Agriculture* in Estonia, have a wide scope and bring along major changes in accounting philosophies. The definitions of biological assets, grouping principles of biological assets and implementation of fair value are quite new principles. IAS 41 shall be applied at international level from the accounting period starting from January 1, 2002. As for Estonia, there is no translation of IAS 41 available at the moment and therefore, people having to make use of

accounting and book-keeping services are not yet ready to apply the respective regulation beginning with that deadline.

2. The results, arising from the implementation of the standard, are the following:
- development of a common understanding of agricultural accounting;
- decrease in the number of errors, arising from different accounting methodologies adopted;
- reports developed by agricultural users become comparable;
- integrity of Farm Accounting Data Network.

3. There are also new accounting principles that should be applied by the farmers and principles for developing the reports.
4. Immediate initiation of a market price information system of biological assets in Estonia is necessary for implementing of IAS 41.
5. There is an emerging need to explain the new principles for agricultural accounting to the agricultural producers and accountants; the subject must also be added to the curricula of educational institutions, teaching agricultural accounting.

As Estonia are going to apply for the full member status of the EU, Estonia's system of accounting and reporting has to meet the international (and also applicable in the EU) standards.

References

Boone, K.; van Bommel, K., 2000. Fair value in agriculture – first implemention of IASC E65. Pacioli 8 seminar, Ráckeve, Hungary.

IAS 41 Agriculture, IASC 2001.

Kinnell, I.R., 2001. Jack and the bean counter. *Camagazine* (June-July 2001), http://www.camagazine.com.cica/camagazine.nsf/

Kõiv, K.; Lobjakas, L.; Parts, V.; Visberg, A.-E., 2001. *International Accounting Standard Agriculture*. Estonian Association of Agricultural Economists No. 15/2001, pp. 93–101.

Oja, M., 2002. *Value Added Tax and the Possibilities of its Simplified Application in Estonia*. Master's Theses, (in Estonian).

Poppe, K.J., 1993. *Financing in Western European Agriculture: A Comparative Perspective. Capital and Finance in Western and Eastern European Agriculture*. Wageningen Economic Studies 29, pp. 13–55.

Põllumajandusraamatupidamise rahvusvaheliste standardite kasutamine, riiklikud toetused ja maksud põllumajanduses, nende arvestamine raamatupidamises, 2000. *Jäneda Õppe- ja Nõuandekeskus* (in Estonian).

The Accuracy of Pig Producers' Forecasts in a Changing Economic Environment in the Years 1994–96

Mikko Siitonen[a]

Abstract

This study examines the applicability of certain time series concerning pig husbandry for forecasting the prices of pigmeat and piglets as well as for supporting producers' own forecasts. The study is also concerned with the accuracy and rationality of producers' forecasts, their learning process related to forecasting, and background variables for the decision-making.

The time series were mainly concerned with meat production quantities as well as the producer, consumer and wholesale prices. The properties of the series were linked to their aggregation and length. The tests show that the series as such are not very well suited for price forecasts or for supporting the forecasting process of the producers.

The empirical data for the study were compiled in ten interviews based on gross margin calculations in which a fattening pig was assumed to be sold after six months from the interview. It was easier for the producers to forecast the physical quantities than the prices, and forecasting the prices of piglets seemed more difficult than in the case of pigmeat. The accuracy of the forecasts depends on the period of time when the forecast was realised. The producers have in general succeeded quite well in their forecasts, if measured by RMSE or MAPE. The tests do not reveal the differences in the accuracy of the forecasts in relation to the background variables of the producers nor between the producers in terms of the ability to learn more accurate forecasting during the EU membership of Finland.

The tests concerning the rationality of the forecasts indicate that the forecasts were biased. The weak and strong-form efficiency varies according to the type of error, but in the cross-section data the tests meeting the criteria are concentrated to rounds of interviews and in the panel data to the periods involving the greatest uncertainty concerning the prices and/or support for pigmeat or the effects of these on the piglet prices.

Keywords: Pigmeat price, Piglet price, Forecasting error, Rationality

[a] University of Helsinki, Department of Economics and Management, P.O. Box 27, FIN-00014 University of Helsinki; ProAgria Association of Rural Advisory Centres - ARAC, P.O. Box 251, FIN-01301 Vantaa, *mikko.siitonen@maaseutukeskus.fi*

Introduction

The relationships between inputs and outputs as well as the biological productivity and the used technology are of great importance in agricultural production. When the decision to produce is being made, the future economic result will depend on the expected income and costs, which in most cases occur at different times. Under uncertainty the problem will be, how reliable the expectations, calculations, and forecasts concerning the future development are. Still the decision to start or to run further the production activities ultimately depends on the entrepreneur's own expectations or the ones at his or her disposal and the economical standards he or she has set for the economy.

In their classical publication on time series analyses Box and Jenkins (1976) state on the meaning of forecasting:

> "The use at time t of available observations from a time series to forecast its value at some future time $t + l$ can provide a basis for (a) economic and business planning, (b) production planning, (c) inventory and production control, (d) control and optimization of industrial processes."

Brandt and Bessler (1983) see the purpose of the price forecasts from the economic point of view so that information [price forecasts] should help to increase net income or to decrease income fluctuation or both, when compared with the level reached without this information. The importance of reliable price forecasts is also underlined since the entrepreneur could economically benefit by timing his or her production against the general production cycle. On the other hand, it has been found that the hog cycles have changed and become less price-elastic, longer, and more irregular. Therefore, the period with profitability problems will lengthen, which development has also been contributed by e.g. epizootics in some past years (Tangermann, 1992; The Hog Cycle, 1995; Buhl, 1998).

Other factors being unchanged, a pigmeat producer may have some influence on his or her economic result by timing the purchases and sales between given limits in the most advantageous time. This kind of timing can be applied in buying fattening batches provided that the entrepreneur is able to conduct his or her own forecasts or will have in his or her disposal reliable forecasts of the economic results of batches sold at different points of time provided that the piglet and material markets will not react against the producer's objectives.

The entrepreneur experiences risk and uncertainty as a deviation between the planned and realised results. The deviation will be the more probable the more uncertain the economic environment is. Therefore the accuracy of the forecasts should also be possible to measure by means of the parameters used in business economics. Because the forecast errors can accumulate or cancel each other, the forecast errors cannot be analysed on the basis of the deviations found in these parameters only.

The objective of the study

The accuracy of forecasts can be measured by means of forecast errors and only afterwards. At that time the situation can totally differ from the one when the forecasts were worked out. When preparing his or her own forecasts, the entrepreneur utilises information by processing it in his or her brain. In this process different information will have different weight, which can also change in course of time. This fact includes a crucial research problem: what kind of influences the use of information and the actually utilised information have on the accuracy of forecasts.

The accuracy of forecasts is also influenced by the quality and availability of used information. All the entrepreneurs cannot use all relevant information. Neither can the signals from different sources of information necessarily be interpreted unambiguously. Information may renew quickly and therefore will not be always available for all entrepreneurs at the same time. It is a difficult task to measure the applicability of a source of information. The easiest and most unambiguous way to do that may be to study the statistical characteristics and mutual relationships of time series.

Studying the accuracy of forecasts resembles studying behaviour. Because one cannot follow a person's thinking it is not possible to follow how information is processed. Therefore the factors influencing on the accuracy of forecasts have to be measured by means of indirect indicators. These can be parameters describing the entrepreneur's personal qualities, which may represent the entrepreneur's ability or interest to utilise the available information. Yet this kind of approach will not reveal what kind of information has been at the entrepreneur's disposal and which information he or she has actually used. Such being the case, the interpretation of the results cannot be thoroughly unambiguous and exact, though the aim of the study would be to find the scientific truth.

The entrepreneur's decision making may include many kinds of rationality, which cannot be measured especially in an informatively uncertain situation like the one in Finland, when the country was preparing her EU membership in the latter half of the year 1994. According to the definition of rationality used in business economics a forecast is considered rational, if the entrepreneur's forecast and its realisation are equal on an average and the range of the forecast error is as small as possible after he or she has used all relevant information (Parkin, 1996).

This study examines the applicability of certain time series for forecasting the pigmeat and piglets prices as well as for supporting producers' own forecasts. The study is also concerned with the accuracy and rationality of producers' forecasts, their learning process related to forecasting, and background variables for the decision-making.

Methods

In order to test the applicability of the available time series, the study examines their stationarity, paired cointegration, and cross-correlations. Furthermore the following price models are built:

PPorkF = f(P, Q, CPI, s1995p1, Seasonal) and
PPigl = g(P,Q,CPI, s1995p1, Seasonal),

where P means price series, Q quantity series, CPI Consumer Price Index, and Seasonal monthly dummy variable. The explanatory variables of the pigmeat price (PPorkF) are its own lag, the prices of piglet, barley, and beef as well as the quantity of beef. The ones of the piglet price (PPigl) are its own lag, the prices of barley, pigmeat, and beef as well as the number of pigs and the quantity of pigmeat.

The accuracy of the forecasting errors of the prices and gross margins is appraised by means of MSE, RMSE, MAD, and MAPE as well as the tests of rationality. According to the rational expectations hypothesis, the decision maker's subjective and objective probability distributions about the outcome of any variable are identical, if the same information is used (Muth 1961). The characteristic is called unbiasedness. The hypothesis includes implicitly that the decision maker's forecast $P_{f,t+1}$ conducted at time t about the outcome of the price P_{t+1} at time $t + 1$ is identical with the expected value of the price forecast provided the decision is based on all available information.

The rational expectations paradigm also includes an assumption that the market efficiently utilises all available information when forming expectations. The characteristic is called efficiency. The independence of the forecast from the previous forecast errors is called weak-form efficiency and the independence from all linear combinations of the information space Ω is called strong-form efficiency. Furthermore the expected value of every individual decision maker's personal error term should be equal to nought with a finite variance and the average over all error terms nought. It is also supposed that there is no autocorrelation between the individual error terms and no correlation between different decision makers (Lovell, 1986; Colling et al., 1992; Wallius, 1992; Andersson et al., 1995).

Because the decision maker have no reason to change his or her rational forecast on the basis of the available information, the short and long term expectations should be consistent with each others. So, consistency is a necessary condition to the rationality of expectations, but it is a weaker characteristic than rationality. Mainly related to unbiasedness, the rational expectations should become more exact when the time of realisation is approaching or the newer expectations should be more accurate than the older ones. Furthermore the realised variance of a variable should be larger than the expected one, which feature is called the variance attribute.

In Finland Honkapohja (1984) has paid attention to the equilibrium nature of rational expectations when studying the use of the method in economic research.

According to Wallius (1992) the use of the method has obviously been restricted because of the inaccuracy and scarcity of data. The lack of interview data has reflected in the goals of interest, which have mainly been the forecasts of economic conditions (e.g. Ilmakunnas, 1989a and 1989b).

The rational expectations model has been used for agricultural research e.g. in the Nordic Risk Project (Weckman, 1995). Because entrepreneurs' expectations are rather complicated, it is advisable that the rationality of price expectations is also studied by using panel data, too (e.g. Runkle, 1991; Romstad, 1996; Siitonen, 1999). The studies concerning the rationality of expectations vary i.e., because the hypothesis about expectations rationality and the corresponding tests differ from each other.

When rational expectations are modelled, it is supposed that individual decision makers form their understanding of the future development of different factors, such as the prices of inputs and outputs as well as the quantities of products. Because the only perceivable variables are practical decision makers' behavioural reactions and because it is difficult to measure information used, one can use the qualities related to the entrepreneur or to his or her enterprise as explanatory variables.

This study examines the rationality of forecasts by testing their unbiasedness as well as their weak and strong-form efficiency in cross-sectional and panel data. The unbiasedness of forecasts are tested in the cross-sectional data by means of the following accuracy regressions run for each round of interviews (cf. Leuthold, 1973)

$$P_t = a + bP_{f,t} + e_t,$$

where P_t is the outcome and $P_{f,t}$ the forecast. The hypotheses a = 1 and b = 1 are tested simultaneously. In an accuracy regression the error term *e* may be autocorrelated or it has a MA process in the case that the outcomes of the former round are not known when the forecasts of the next round are formed (Ilmakunnas 1989a).

The weak-form efficiency of the forecasts (cf. Wallius, 1992) is tested in the cross-sectional data by estimating the following model for each round of interviews

$$F_t = a + \Sigma_k b_k F_{t-k} + u_t,$$

where $F_t = P_t - P_{f,t}$ is the forecasting error or its absolute or squared value. Depending on the round, 1–3 lags are also added. The hypothesis $b_k = 0$ is tested. The test of the hypothesis a = 0 is a test of the unbiasedness of the forecast.

The strong-form rationality (cf. Wallius 1992, p. 86) is tested in the cross-sectional data by estimating the following model

$$F_t = a + \Sigma_k b_k F_{t-k} + cX + u_t.$$

In the model X means the 16 dummy variables listed in Table 5. They are background variables, which are supposed to have influence on utilisation of information (e.g. Westermarck, 1966). Those variables, which are not directly related to the use of information or belong to the sphere of the entrepreneur's experience, reflect his or her way, habit, or ability to utilise the available information as in support of conducting his or her forecasts. The hypotheses $b_k = 0$ and $c = 0$ are tested. Testing the strong-form rationality means that it is tested, whether the coefficients of the lagged forecasting errors and the ones of the variables describing information are simultaneously noughts.

All the models are also estimated in the panel data by adding the dummy variables corresponding the interview rounds in the regression. There is no need to use the entrepreneurs' individual dummy variables, because the background variables are the same during all the rounds. The entrepreneurs' learning was studied by means of MAPE and the stability of the quality of the entrepreneurs' forecasts by their order.

Data

The study is a part of the Nordic Risk Project (Weckman, 1995). The time series were received from the official statistics and slaughterhouses. The empirical data for the study were compiled in ten interviews made every two months from February 1994. The rounds are numbered 0–9. Altogether 58 pig producers from Southern Ostrobothnia (Pohjanmaa) and Varsinais-Suomi were interviewed. The interviews were based on gross margin calculations, in which a fattening pig was assumed to be sold after six months from the interview including a raising period of four months. The first interview was made in person, and this also covered that background information of each producer. The subsequent inquiries were made by post.

It is supposed that the entrepreneurs have been informed of the pricing principles applied during each interview. The changes, which happened by the realisation of the forecast, have been taken in account so that the content of the collected information corresponds to the one during the interview. The value added tax, which came into force in the beginning of the year 1995, is not included in the prices.

The realised prices are calculated on the basis of the price lists of the slaughterhouses. The pigmeat price is the price paid by the slaughterhouse exactly six months after answering and the piglet price is the one of a piglet exactly two months later. The realised prices correspond to the quality and weight classes given by the entrepreneur in the interview. The changes in pricing and quality classification are taken in account so that the realised prices correspond to the forecasted prices.

The pigmeat price paid by the slaughterhouses was corrected by adding to the price/kg the extra price of 2.81 FIM/kg paid in 1995 and the storage compensation, which was paid in according of the age of the pig in the beginning of the year. In February 1996 the price/kg was corrected in the same way by adding the subsidy of the transition period, which was 218 FIM/pig. In the piglet prices the transport and transmission costs were taken in account. The interviewees were given an opportunity to check, if the interpretation concerning the piglet and pigmeat prices was correct.

In all cases the forecasting errors of the piglet and pigmeat prices are calculated as the difference between the outcome and the forecast. So, a positive value proves that the outcome has been greater than the forecast and vice verse.

The forecasting error of the pigmeat price

The pigmeat price means the price paid by the slaughterhouse added by the subsidies. The price expectations can be grouped by the time when the pig is sold. The rounds 0–2 contain the time before Finland's EU membership, rounds 3 and 4 the first period of the membership (compensation from the price collapse and production subsidy), and rounds 5–8 the rest of the year 1995 (production subsidy). The round 9 contains the situation in the beginning of the year 1996, when the subsidy was paid per animal. The yearly price fluctuations seem to be covered by other larger fluctuation during the study.

Before the referendum in 1994 and the final decision in the Parliament on the Finnish EU membership, the price level of the forecasts was mainly determined by the respondents' understanding of Finland's joining the EU. Those who believed that Finland would stay outside of the EU kept their forecasts on the former level or diminished them somewhat, because they anticipated that the price level in the EU would have some influence on the Finnish prices. Those who believed in Finland's membership diminished the price level of their forecasts immediately in the beginning of the year 1995, some of them even earlier. Still a part of them thought that the high fodder and piglet costs in fattening had to be compensated in any case to the producers in some way or the other and took it into account in their estimations concerning the price relationships.

Because the producers had answered in different ways and with different assumptions to the questions especially about the pigmeat price, their answers were checked by means of an extra interview. It was found that there were 8 producers in Southern Ostrobothnia and 4 producers in Varsinais-Suomi, who considered Finland's membership unlikely during the round 3. During the round 4 there were still 4 respondents in Southern Ostrobothnia who thought in the same way. There were one producer in Southern Ostrobothnia and two in Varsinais-Suomi, who could not define their opinion in this respect. The rest of the interviewees considered the membership probable.

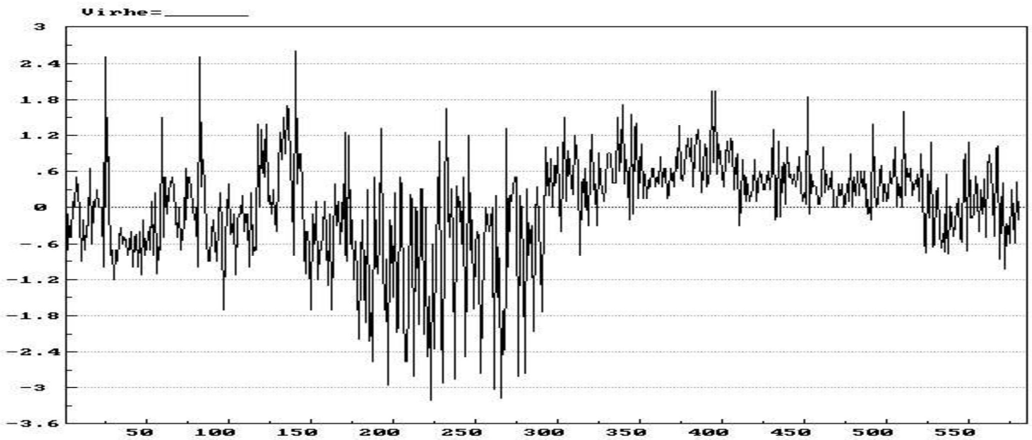

Figure 1 *The forecast error of the pigmeat price (FIM/kg) by observations*

The forecasts of the basic pigmeat prices are the entrepreneurs' expectations about the prices paid by the slaughterhouses. It has been calculated by subtracting the subsidies from the pigmeat price. Because the subsidies were paid during the rounds 3–9 only, the forecasts of both pigmeat prices are equal during the rounds 0–2. The interviewees' expectations about Finland's EU membership influenced on the price level of their forecasts of the basic pigmeat prices during the rounds 3 and 4. Therefore the forecast of the basic price is a continuum of the former price level in the case when producers doubted the membership. In the other cases the forecasts correspond to the price paid by the slaughterhouse.

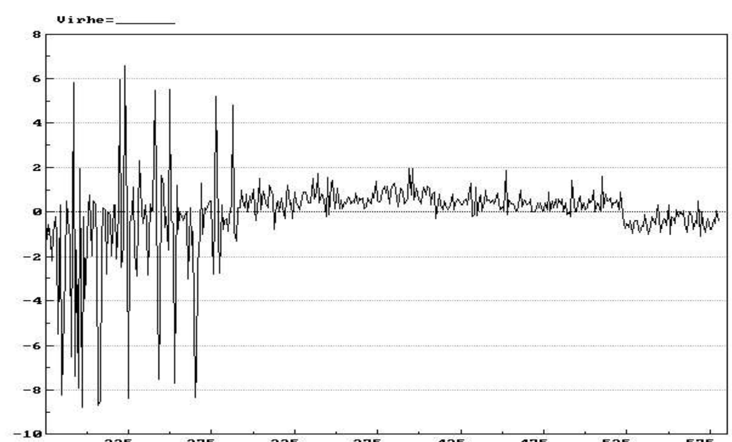

Figure 2 *The forecast error of the basic pigmeat price by observations*

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The forecasting error of the piglet price

The piglet price is influenced by the weight and quality of the piglet. According to the realisations of the piglet price expectations, the price formation is divided into two periods: The rounds 0–4 before Finland's EU membership and the rounds 5–9 during the membership. In the forecasts the producers seem to have taken into account the influences of the membership in the same way as in the forecasts of the pigmeat prices. Still a part of them in Southern Ostrobothnia thought that Finland's joining to the EU would influence on the prices rather strongly already in 1994, because the production costs of the pigmeat would have to adapt to the new situation in this respect, too.

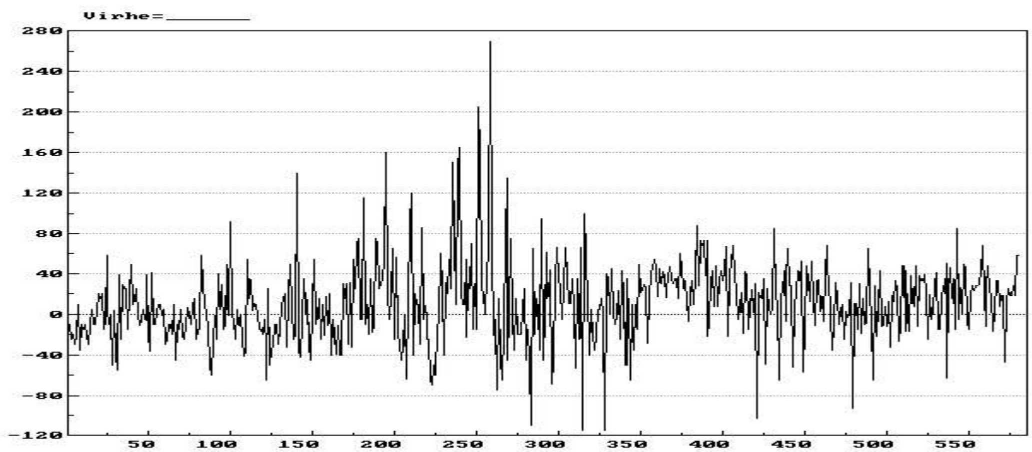

Figure 3 The forecast error of the piglet price (FIM/piglet) by observations

Results

Time series

Both monthly and quarterly series were tested from two periods: from the beginning of 1983 to the end of 1994 and from the beginning of 1983 to the end of March 1996. The properties of the series were linked to their aggregation and length. The quarterly series seemed less suitable for forecasting than the monthly ones.

The results of the unit root tests support the stationarity of the monthly producer price and production series, but it is obvious that the time series have not reached a sufficient stability during the short period of Finland's EU membership. The paired cointegration tests and study of the residuals used in these also show that the series as such are not very well suited for price forecasts or for supporting the forecasting process of the producers.

Empirical study

The accuracy as well as the weak and strong-form efficiency are tested in the cross-sectional and panel data as shown above. The regression equations were run by the PcGive 8.10 program, which produces the parameters. The White heteroscedastic t-values were also calculated, but they are not reported, because they do not differ from the results given later.

The analyses contained the pigmeat, basic pigmeat, and piglet prices. The tests of efficiency were run for the forecast errors as well as in their absolute and squared values. As to the basic pigmeat price the tests are run in the rounds 3–9 only, because the basic price is equal to the pigmeat price in the rounds 0–2. The results are reported according the 5% level of significance.

In order to follow the changes of the coefficients of the parameters over time, the examined periods of the panel data were shortened so that the shortest period contains the rounds 8 and 9. The changes of the background variables were measured by means of the coefficient of variation. The coefficients varied remarkably from one period to another in the panel data and from one round to another in the cross-sectional data.

The accuracy and weak and strong-form efficiency of the forecasts

The results of the accuracy regressions show that the forecasts of the pigmeat, basic pigmeat, and piglet prices were not unbiased in any round or period. In the case of the pigmeat price the requirement of weak-form efficiency was fulfilled in the cross-sectional data in the rounds 3, 5, and 9 and the squared value in the rounds 3 and 5. In the case of the basic pigmeat price, the requirement is fulfilled in the round 3, in the case of the absolute value in the rounds 3 and 5 and in the case of the squared values in the rounds 3, 5, and 9. As to the forecasting error of the piglet price, the requirement is fulfilled in the rounds 6 and 7, and in case of its absolute and squared values in the rounds 3, 6, and 9.

In the case of the pigmeat price the requirement of the weak-form efficiency is not fulfilled in any type of error in any periods of the panel data. As to the basic pigmeat price, the requirement is not fulfilled in the case of the forecast error, while the absolute values fulfil the requirement in the periods 5–9 and 8–9, the squared values in the period 5–9. In the case of the piglet price, the requirement is not fulfilled in any type of error of any period, the squared values in the period 5–9 not included.

The strong-form efficiency of the forecasts

As to the tests of the strong-form efficiency of the forecasts, the results concerning the forecasting errors in the cross-sectional data have been reported in Tables 1–3 and in the long periods 1–9, 2–9, and 3–9 of the panel data in Table 4. Because of the background variables, the coefficients of the lagged variables and their t-probabilities differ from the ones in the tests of weak-form efficiency. In the panel data the coefficients of the dummy variables representing the rounds of interviews are usually significant, but during a more peaceful period of the price formation only the first one of them may be found significant.

As to the pigmeat price (Table 1), the requirement of strong-form efficiency of the forecasting error is fulfilled in the rounds 4, 5, and 9, and the one of its absolute and squared values in the rounds 5 and 9. The results of the basic pigmeat price (Table 2) are reported from the rounds 3–9. The requirement of the forecasting error is fulfilled in the round 5, and in the round 5 and 9 of the absolute and squared values. As to the piglet price (Table 3), the requirement is fulfilled in the round 6 in the case of the forecasting error, in the rounds 7 and 9 of its absolute values and in the round 7 of its squared values.

In the panel data (Table 4) the requirement of strong-form efficiency of the pigmeat price is only fulfilled in the period 8–9 of the absolute value of the forecasting error. As to the basic pigmeat price, the requirement is fulfilled in the periods 7–9 and 8–9 of the absolute values. In the case of the piglet price, the requirement is not fulfilled in any rounds of any type of error.

In the tests of the pigmeat price, the following variables (Table 5) have the unstable coefficients: Other farmers, Places for pigs, and Second occupation. The least variations were found in the variables: EU, SH infoletters, Earliness, and Arable land. As to the basic pigmeat price, the largest variations were found in the variables: Region, Places of pigs, and Income from pigmeat, while the least variations were related to the variables: EU, Agricultural education, As entrepreneur, and Earliness. In the case of the piglet price, the unstable coefficients were related to the variables: As entrepreneur, Income from pigmeat, TV news, while the least variations were related to the variables: Second occupation, Other farmers, and Agricultural education.

Conclusions and discussion

The abrupt change of the economic environment of agriculture caused by Finland' joining to EU is clearly seen in the results of this study (cf. Ylätalo, Ryhänen & Sipiläinen, 1996). How the changes of the policy regime influenced on the pigmeat, piglet, and barley prices can be seen in Figure 4.

It was found that the nominal time series were less suitable for supporting the decision making of pigmeat producers. So the entrepreneurs could not utilise them for conducting their price forecasts by means of mathematical and statistical models. The results show that it was easier for the producers to forecast the physical quantities than the prices, because the change in the input-output ratio was smaller than the changes in the prices. If support is included in the pigmeat prices, the differences between respondents are smaller than in case of prices without support.

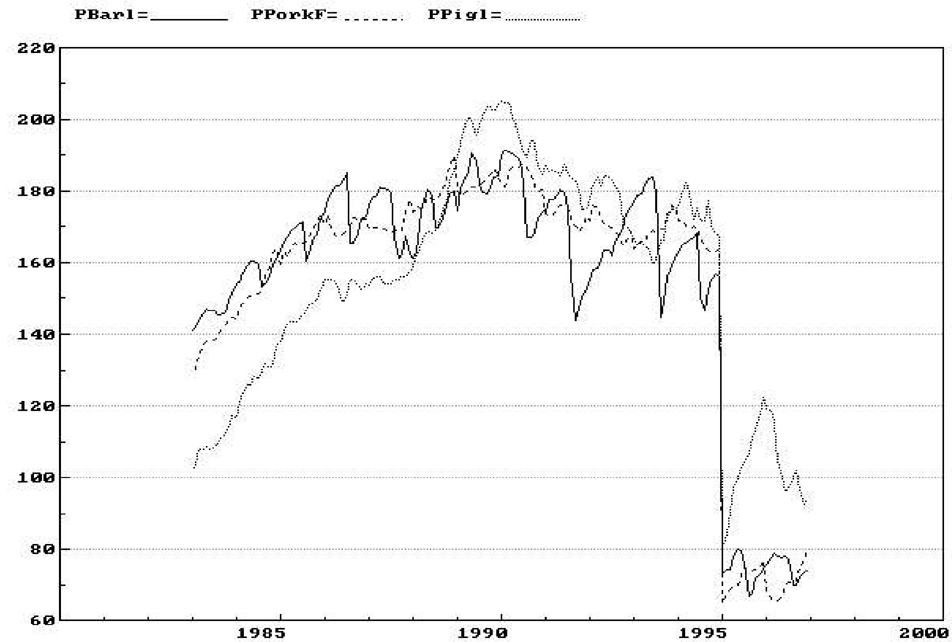

Figure 4 The prices (means and ranges matched) of fodder barley (PBarl), pigmeat (PPorkF), and piglets (PPigl) in the years 1983–1996

The accuracy of the forecasts depends on the period of time when the forecast was realised. Anticipating the real depth of the fall in the prices and the correct level of support proved very difficult, especially during the negotiations on the EU membership, and forecasting the prices of piglets seemed more difficult than in the case of pigmeat.

In the late summer and autumn of 1994 (rounds 3 and 4) there was no complete certainty about Finland's future EU membership nor any information about the pigmeat and piglet prices in the beginning of 1995, when the greatest forecasting errors are found. Neither was any information available concerning how joining to EU or staying outside of it would influence on the pigmeat prices (round 2) or the piglet prices (round 3) in the autumn of the year 1994. In December 1994 both prices were forecasted before the EU membership, though they realised during the membership (rounds 6 and 7). In the summer of 1995 there was no information about the future changes in the pigmeat subsidies, which were to occur in the beginning of 1996, neither about their influence on the piglet price (rounds 8 and 9).

The growth in the variances of the forecasts especially in the very beginning of the EU membership reflects the growing uncertainty as well as the differences in the opinions of the producers concerning the future policy choices in Finland and the future prospects of agriculture after the decisions are made. The unexpected and nervous reactions of the markets may be considered to have increased the errors in the forecasts for the pigmeat and piglet prices in the beginning of 1995, but the available data is not adequate to explain the effects of such reactions on the accuracy of the forecasts.

Due to the considerable variation between the forecasts of different producers, the ability of the tests to distinguish averages and variances remains weak, and this may be one reason, why the tests do not reveal the differences in the accuracy of the forecasts in relation to the background variables of the producers. Similar results were obtained in the tests concerning the differences between the producers in terms of the ability to learn to conduct more accurate forecasts during the EU membership of Finland. Considering the magnitude of the changes involved, the producers have still succeeded quite well in their forecasts in general, if measured by MSE, RMSE, MAD or MAPE.

The impact of risk and uncertainty can be seen in the development of the cumulative error of the gross margin or its deviation from the faultless value. It was positive only in Southern Ostrobothnia in the rounds 0–2, in other event negative. In both regions, the greatest loss calculated in this away was reached in the round 4. Thereafter the loss started to diminish in order to grow again in the last round.

The decline of the errors in 1995 can be considered an indication that the interviewees have begun to adopt the influences of the new pricing system on the formation of pigmeat and piglet prices, i.e. they have started to adapt to the EU membership. Instead of that, the increase of the errors in the last interview round indicates that adopting the new pricing system has not been enough to compensate lacking information about the future amount of subsidies. So, the increase of uncertainty is immediately seen in the errors (Siitonen, 1996 and 1999).

In the above situation one cannot outline the actually used information from other relevant information available for the entrepreneurs. Therefore the use of information has to be measured by indirect parameters discussed above. In spite of the problems, which are related to the way of measuring, the models seem to be suitable to measure the accuracy of the forecasts and produce logical results.

The tests concerning the rationality of the forecasts indicate that the forecasts were biased. The weak and strong-form efficiency varies according to the type of error. In the cross-sectional data the tests meeting the criteria are concentrated to the round and in the panel data to the periods involving the greatest uncertainty concerning the prices and/or support for pigmeat or the effects of these on the piglet prices. Strong-form efficiency occurs less frequently than weak-form efficiency, and both criteria are more rarely fulfilled in the panel data than in the cross-sectional data.

Because the first and second lags of the pigmeat price were not known by the entrepreneurs, when they were conducting their forecasts, the significance of the coefficients of these lags does not give as strong support to the irrationality of the price expectations as the significance of other lags, for the forecasting errors can be autocorrelated in these cases. This MA form autocorrelation of the error term, which is originating from the forecasting errors, is not a problem in the accuracy regressions run in the cross-sectional data, because they contain no time dimension. Instead of that the autocorrelation may influence that t-values are not consistent in the tests of rationality, though the OLS estimates are unbiased.

As to the piglet price, the autocorrelation of the forecasting errors would not seem to be any problem, because it is influencing in the beginning of the data only. In the case of the pigmeat price the problem may be more important. Therefore, the conclusions about the irrationality of the expectations of the pigmeat price cannot only be based on the significance of these coefficients. Because the t-probabilities in the accuracy regressions are 0.000, and because the results of the panel data seem very parallel with the ones of the cross-sectional data, the influence of the autocorrelation does not seem important. In the test of rationality the problem is automatically taken into account, because the former forecasting errors are explanatory variables in the regressions.[4]

The coefficients of the background variables are changing more often from a round to another in the cross-sectional data than from a period to another in the panel data. The sign may also be different in the same round or period depending on the type of error. In some cases the sign is in the beginning of the data different from the one at the end of the data, which can be considered an indication of the adjustment or maladjustment to the new policy regime or a reflection of the changes of the importance of different information sources. The results seem to give support to the opinion that the entrepreneur's qualities, which are positively correlated to the economic results of his or her enterprise in a stable period of time, do not necessarily behave in the same way under uncertainty.

According to the efficiency tests, the information sources used in working out the forecasts of the pigmeat and piglet prices differ from each other so that the regional information (regional newspapers and other farmers) and daily news matter (TV news) have been of more importance in forecasting piglet prices, while professional information (the magazine Käytännön Maamies) has been more valuable for forecasting pigmeat prices. The forecasting errors of all the three prices and the variation of the forecasting error of the piglet prices have been smaller, but the variation of the pigmeat prices larger in the forecasts of those respondents, who doubted Finland's EU membership.

In the case of the entrepreneurs doubting the EU membership, the smaller forecasting errors and their smaller variation under the greatest price uncertainty seem to refer to the direction that the forecasts were more accurate, if they were prudent and/or a continuum of the old system. On the other hand, the interviewees doubting the membership have divided their opinions so that a part of them continued the series on the previous basis, while the others decreased the price level toward the level in EU. The results of the different ways of thinking can be seen in the larger variation of the forecasts of the pigmeat prices.

From the point of view of an entrepreneur conducting forecasts, the uncertainty about the economic changes is an essential feature in the time period covered by this study. In the light of the results, it is easier to estimate future developments from the starting points of the market economy than to anticipate the unexpected

[4] The ML estimates run by PcFILM 8.10 later do not differ from the OLS ones run by PcGive 8.10.

political decisions. Still it is compulsory to get along with uncertainty today and in the future.

Though the study does not give cause for far-going conclusions about the influence of the entrepreneur's qualities to the utilisation of information and by that route further to the accuracy of the forecasts, the results of the efficiency tests still support the interpretation that agricultural education and experiences from other occupations would have been more beneficial for forecasting the pigmeat prices than the piglet prices, while the experience as an entrepreneur has been more beneficial in the case of the piglet prices. On the other hand, the size of the enterprise and the relative share of the income from pigmeat would not seem to have any influence on the utilisation of information or the accuracy of the forecasts.

According to the efficiency tests the interviewees did not necessarily fail to use under uncertainty any information, by means of which they could still have been able to improve their forecasts. Some test results support the opinion that the available information could not be interpreted unambiguously. This can be seen in larger forecasting errors and their larger variation during increasing uncertainty. The respondents have not adequately corrected their forecasts on the basis of the previous errors, or they have not had any chances to do that because of the great institutional changes during the period covered by the study.

Though the pigmeat producers' forecasts are not rational in the meaning presented by Muth (1961), it does not mean that their decisions would have been irrational. The large errors of the forecasts worked out under the greatest uncertainty before Finland's EU membership should be considered rather an implication of the lack of reliable information than a failure to utilise information.

On the basis of this study, the pigmeat producers' decision-making and activities cannot be considered irrational in the economic meaning, for they have rationally reacted to the changing prices e.g. by increasing the weight of pigs and adding more fodder grain in the feeding rations (cf. Romstad, 1996). The decrease of the forecasting errors with the progress of the interviews refers to the rational behaviour, too.

The results of the study give support to the opinion of the late Academician, Professor Nils Westermarck (1986) that there is no reason to underestimate the agricultural entrepreneur's ability to think and act after the principles of business economics, but the concept of scarcity is regulating his or her economic behaviour both on the level of knowledge and skills. The entrepreneurs have to learn to act in unstable markets and to react even to weak signals. Still there is a need for economic research in such fields of the discipline as developing tools for risk management and forecasting, as well as training and advising how to use them.

References

Andersson, H., Lund, M., Siitonen, M. & Romstad, E., 1995. The formation of farmers's expectations. In: *Nordiskt lantbruk i det nya Europa. Nordiska Jordbruksforskares Förening. Sektion IX: Landbrugsøkonomi,* pp. 5–22. In: Nordiskt lantbruk i det nya Europa. XX:e kongress Reykjavik 26–29 juni 1995. Föredrag, forskningsrapporter, abstracts. *Nordisk Jordbruksforskning* 77, 2 (1995), p. 229.

Box, E. P. G. & Jenkins, G. M., 1976. *Time Series Analysis: Forecasting and Control.* Revised Edition. Holden-Day. San Francisco.

Brandt, J. A. & Bessler, D. A., 1983. Price Forecasting and Evaluation: An Application in Agriculture. *Journal of Forecasting* 2 (1983), pp. 237–248.

Buhl, K., 1998. *The origins and consequences of price cycles. The influences of the international trade on the EU-pig meat market. Predictability and risks preparing to the market changes.*

Cho, D. W. & Hersch, P. L., 1998. Forecaster Characteristics and Forecast Outcomes. *Journal of Economics and Business* 50 (1998), pp. 39–48.

Colling, P. L., Irwin, S. H. & Zulauf, C. R., 1992. Weak- and Strong-Form Rationality Tests of Market Analyst' Expectations of USDA *Hogs and Pigs* Reports. *Review of Agricultural Economics* 14 (1992), pp. 263–270.

Diamantopoulos, A. & Winklhofer, H., 1999. The impact of firm and export characteristics on the accuracy of export sales forecasts: evidence from UK exporters. *International Journal of Forecasting* 15 (1999), pp. 67–81.

Honkapohja, S., 1984. Rationaaliset odotukset kansantaloustieteessä: johdanto kirjallisuuteen. *Kansantaloudellinen aikakauskirja* 80 (1984), pp. 362–382.

Ilmakunnas, P., 1989a. Tests of the Efficiency of some Finnish Macroeconomic Forecasts: An Analysis of Forecast Revisions. *Finnish Economic Papers* 2 (1989), pp. 137–146.

Ilmakunnas, P., 1989b. Survey Expectations vs. Rational Expectations in the Estimation of a Dynamic Model: Demand for Labour in Finnish Manufacturing. *Oxford Bulletin of Economics and Statistics* 51 (1989), pp. 297–314.

Leuthold, J. S., 1973. The Price Performance on the Futures Market of a Nonstorable Commodity: Live Beef Cattle. *American Journal of Agricultural Economics* 55 (1973), pp. 271–279.

Lovell, M. C., 1986. Tests of Rational Expectations Hypothesis. *American Economic Review* 76 (1986), pp. 110–124.

Muth, J. F., 1961. Rational Expectations and the Theory of Price Movements. *Econometrica* 29 (1961), pp. 315–335.

Parkin, M., 1996. *Economics.* Reading, Massachusetts.

Romstad, E. 1996. Hog Farmers' Price Expectations - A Panel Data Study. *Agricultural University of Norway. Department of Economics and Social Sciences. Discussion paper* D-27/1996.

Runkle, D. E., 1991. Are Farrowing Intentions Rational Forecasts? *American Journal of Agricultural Economics* 73 (1991), pp. 594–600.

Siitonen, M., 1996. Sikatalousyrittäjien hintaennusteiden osuvuus ennen ja jälkeen Suomen EU-jäsenyyden. In: Hartikainen H. (Ed.): *Sata vuotta yliopistollista maatalousopetusta. Helsingin yliopiston soveltavan kemian ja mikrobiologian laitos, taloustieteen laitos ja kasvintuotantotieteen laitos* (1996), pp. 84–93. Helsinki.

Siitonen, M., 1999. Sikatalousyrittäjien ennusteiden osuvuus muuttuvassa taloudellisessa ympäristössä. Summary: The accuracy of pig producers' forecasts in a changing economic environment. *Helsingin yliopisto. Taloustieteen laitos. Julkaisuja 26. Maatalousekonomia* (1999), pp. 1–142.

Tangermann, S., 1992. Agricultural trends in the EC. *Eurostat. Agriculture, forestry and fisheries. Studies and analyses. 5D.*

The Hog Cycle, 1995. Economic Research Service United States Department of Agriculture. *Agricultural Outlook.* March 1995: 13.

Wallius, S., 1992. *Korko-odotusten luonne. Erään asiantuntijaryhmän odotusten analyysi.*

Weckman, K. J., 1995. Lantbrukarnas beslutfattande under osäkerhet - ett samnordiskt forskningsprojekt. In: Nordiskt lantbruk i det nya Europa. XX:e kongress Reykjavik 26–29 juni 1995. Föredrag, forskningsrapporter, abstracts. *Nordisk Jordbruksforskning* 77, 2 (1995), p. 228.

Westermarck, N., 1966. The Role of Planning and Management on Family Farms. Part I. Interaction Between Farm Planning, Individual Advisory Services and the Farm Entrepreneur. *Acta Agriculturæ Scandinavica* 16 (1966), pp. 47–78.

Westermarck, N., 1986. Viljelijän liiketaloudellisessa ajattelussa tutkittavaa. *Maaseudun Tulevaisuus* 4.12.1986, p. 2.

Ylätalo, M., Ryhänen, M. & Sipiläinen, T., 1996. Yhteenveto ja johtopäätökset. In: Ylätalo, M. (Ed.): Maatalouden sopeutuminen EU:ssa vallitseviin hintasuhteisiin. Tuotanto- ja kustannusteoreettinen tarkastelu kasvinviljelyyn ja kotieläintuotantoon sovellettuna. Summary: The EU and Economic Adjustment of Finnish Agriculture - A Production and Cost-Theoretical Approach to Plant and Animal Production. *Helsingin yliopisto. Taloustieteen laitos. Julkaisuja 12. Maatalousekonomia* (1996), pp. 201–208.

Appendices

Table 1 The strong-form efficiency of the forecast error of the pigmeat price, cross-sectional data

Definition	The forecasting error of the pigmeat price								
	Round 1	Round 2	Round 3	Round 4	Round 5	Round 6	Round 7	Round 8	Round 9
Constant	0.556	0.279	-0.286	0.297	0.875	-0.078	0.005	0.056	-0.058
t-prob	*0.074*	*0.541*	*0.769*	*0.732*	*0.040*	*0.803*	*0.986*	*0.815*	*0.900*
Error_1	0.819	0.805	0.414	0.261	0.076	0.278	0.269	0.425	0.274
t-prob	*0.000*	*0.001*	*0.243*	*0.090*	*0.310*	*0.017*	*0.053*	*0.004*	*0.395*
Error_2		0.068	0.321	0.060	0.026	-0.044	0.200	0.142	0.238
t-prob		*0.773*	*0.560*	*0.857*	*0.720*	*0.416*	*0.059*	*0.264*	*0.422*
Error_3			-0.265	0.091	0.164	0.055	0.082	0.033	0.403
t-prob			*0.600*	*0.816*	*0.172*	*0.273*	*0.064*	*0.729*	*0.113*
Region	-0.208	-0.542	0.330	0.181	0.350	0.368	-0.117	0.087	-0.007
t-prob	*0.125*	*0.009*	*0.495*	*0.684*	*0.104*	*0.002*	*0.284*	*0.380*	*0.971*
Age	0.318	0.249	-1.076	-0.420	0.301	-0.067	0.009	0.194	-0.024
t-prob	*0.052*	*0.303*	*0.042*	*0.426*	*0.217*	*0.684*	*0.950*	*0.120*	*0.921*
Ag. education	0.122	0.001	-0.239	0.186	0.359	-0.028	0.072	0.207	-0.048
t-prob	*0.359*	*0.994*	*0.557*	*0.619*	*0.050*[1]	*0.833*	*0.528*	*0.048*	*0.820*
TV news	-0.048	0.011	-0.475	-0.046	-0.182	0.136	-0.007	-0.127	-0.102
t-prob	*0.723*	*0.954*	*0.255*	*0.908*	*0.329*	*0.299*	*0.949*	*0.206*	*0.613*
Reg. newspaper	-0.147	-0.122	0.081	-0.530	-0.129	0.084	0.239	-0.055	-0.218
t-prob	*0.277*	*0.533*	*0.845*	*0.181*	*0.501*	*0.539*	*0.048*	*0.607*	*0.296*
FU newspaper	0.022	-0.133	-0.069	-0.423	-0.233	0.132	0.107	0.061	-0.149
t-prob	*0.853*	*0.439*	*0.851*	*0.219*	*0.164*	*0.276*	*0.308*	*0.516*	*0.394*
Ag. magazine	-0.247	0.409	-0.275	-0.261	-0.002	0.218	0.267	0.085	0.188
t-prob	*0.115*	*0.079*	*0.587*	*0.578*	*0.991*	*0.157*	*0.050*[1]	*0.493*	*0.444*
SH infoletters	-0.037	-0.031	0.136	-0.302	-0.218	0.081	-0.135	-0.078	-0.195
t-prob	*0.797*	*0.881*	*0.760*	*0.467*	*0.274*	*0.567*	*0.269*	*0.486*	*0.381*
Other farmers	0.182	0.038	0.145	-0.245	-0.215	0.092	0.158	-0.083	-0.063
t-prob	*0.193*	*0.850*	*0.738*	*0.553*	*0.271*	*0.505*	*0.183*	*0.441*	*0.765*
Arable land	-0.080	-0.221	-0.031	-0.267	0.021	-0.033	-0.084	0.022	-0.078
t-prob	*0.518*	*0.221*	*0.937*	*0.465*	*0.906*	*0.789*	*0.426*	*0.813*	*0.682*
Places for pigs	-0.085	0.170	-0.328	0.105	-0.140	0.061	-0.117	0.121	0.131
t-prob	*0.418*	*0.264*	*0.330*	*0.740*	*0.347*	*0.563*	*0.193*	*0.143*	*0.435*
Sec. occupation	0.005	-0.016	-0.381	0.326	0.266	0.049	-0.034	-0.013	-0.064
t-prob	*0.964*	*0.925*	*0.291*	*0.367*	*0.122*	*0.692*	*0.743*	*0.890*	*0.722*
Income, p-meat	-0.030	0.190	0.259	-0.238	0.105	-0.111	-0.021	0.025	-0.142
t-prob	*0.790*	*0.242*	*0.459*	*0.487*	*0.512*	*0.335*	*0.827*	*0.773*	*0.405*
As entrepreneur	-0.314	-0.162	0.506	0.793	-0.368	0.052	-0.207	-0.230	0.037
t-prob	*0.051*	*0.496*	*0.320*	*0.100*	*0.116*	*0.756*	*0.154*	*0.070*	*0.886*
Earliness	-0.153	-0.141	0.261	0.189	-0.239	0.061	-0.029	-0.110	-0.210
t-prob	*0.254*	*0.468*	*0.530*	*0.630*	*0.208*	*0.652*	*0.805*	*0.288*	*0.309*
EU			-0.935	-1.753					
t-prob			*0.028*	*0.061*					
R^2	0.774	0.765	0.404	0.389	0.351	0.424	0.555	0.569	0.334
RSS	5.467	10.974	46.826	42.026	9.868	5.037	3.683	2.975	11.871
σ	0.365	0.524	1.110	1.052	0.503	0.359	0.307	0.276	0.552
Variables	17	18	20	20	19	19	19	19	19
Observations	58	58	58	58	58	58	58	58	58

[1] Rounded downwards

Table 2 The strong-form efficiency of the forecast error of the basic pigmeat price, cross-sectional data

Definition	The forecasting error of the basic pigmeat price						
	Round 3	Round 4	Round 5	Round 6	Round 7	Round 8	Round 9
Constant	0.322	2.200	0.869	-0.117	-0.045	0.056	-0.710
t-prob	*0.896*	*0.188*	*0.040*	*0.716*	*0.871*	*0.815*	*0.006*
Error_1	-0.911	0.463	-0.004	0.260	0.231	0.425	0.169
t-prob	*0.310*	*0.000*	*0.924*	*0.029*	*0.107*	*0.004*	*0.334*
Error_2	2.808	0.161	0.046	0.014	0.234	0.142	0.432
t-prob	*0.050*[1]	*0.792*	*0.140*	*0.611*	*0.030*	*0.264*	*0.010*
Error_3	-1.480	-0.717	0.167	0.004	0.019	0.033	0.253
t-prob	*0.252*	*0.351*	*0.130*	*0.856*	*0.304*	*0.729*	*0.067*
Region	0.659	-1.300	0.302	0.358	-0.095	0.087	-0.048
t-prob	*0.590*	*0.132*	*0.159*	*0.004*	*0.401*	*0.380*	*0.659*
Age	-1.477	0.647	0.288	-0.081	-0.036	0.194	0.140
t-prob	*0.263*	*0.504*	*0.212*	*0.621*	*0.798*	*0.120*	*0.294*
Ag. education	1.437	-1.157	0.278	-0.040	0.075	0.207	-0.061
t-prob	*0.168*	*0.127*	*0.139*	*0.776*	*0.522*	*0.048*	*0.591*
TV news	-1.715	0.749	-0.104	0.124	0.000	-0.127	0.005
t-prob	*0.108*	*0.343*	*0.580*	*0.361*	*1.000*	*0.206*	*0.963*
Reg. newspaper	-0.103	-1.413	-0.152	0.127	0.230	-0.055	-0.123
t-prob	*0.923*	*0.064*	*0.425*	*0.369*	*0.068*	*0.607*	*0.273*
FU newspaper	-1.538	0.079	-0.205	0.149	0.088	0.061	-0.031
t-prob	*0.104*	*0.906*	*0.210*	*0.223*	*0.413*	*0.516*	*0.740*
Ag. magazine	1.065	-1.287	-0.045	0.240	0.269	0.085	-0.020
t-prob	*0.407*	*0.152*	*0.833*	*0.131*	*0.060*	*0.493*	*0.880*
SH infoletters	-0.930	-0.804	-0.180	0.122	-0.117	-0.078	-0.006
t-prob	*0.411*	*0.321*	*0.361*	*0.402*	*0.363*	*0.486*	*0.957*
Other farmers	-0.657	0.298	-0.207	0.122	0.155	-0.083	-0.019
t-prob	*0.550*	*0.704*	*0.275*	*0.376*	*0.205*	*0.441*	*0.868*
Arable land	-1.725	0.179	0.051	-0.012	-0.102	0.022	0.084
t-prob	*0.089*	*0.799*	*0.765*	*0.925*	*0.347*	*0.813*	*0.418*
Places for pigs	0.757	-0.764	-0.150	0.050	-0.102	0.121	0.051
t-prob	*0.374*	*0.200*	*0.296*	*0.640*	*0.274*	*0.143*	*0.570*
Sec. occupation	1.817	0.495	0.207	-0.016	-0.040	-0.013	0.038
t-prob	*0.051*	*0.465*	*0.215*	*0.900*	*0.710*	*0.890*	*0.694*
Income, p-meat	0.761	0.082	0.057	-0.084	-0.052	0.025	-0.068
t-prob	*0.391*	*0.901*	*0.712*	*0.461*	*0.598*	*0.773*	*0.462*
As entrepreneur	0.704	0.576	-0.307	0.014	-0.150	-0.230	-0.099
t-prob	*0.584*	*0.519*	*0.163*	*0.931*	*0.297*	*0.070*	*0.476*
Earliness	-1.385	0.675	-0.151	0.059	-0.006	-0.110	-0.099
t-prob	*0.193*	*0.373*	*0.418*	*0.670*	*0.957*	*0.288*	*0.374*
EU	-4.154	-3.456					
t-prob	*0.000*	*0.079*					
R^2	0.535	0.624	0.383	0.413	0.527	0.569	0.519
RSS	300.930	152.400	9.382	5.127	3.918	2.975	3.467
σ	2.814	2.003	0.490	0.363	0.317	0.276	0.298
Variables	20	20	19	19	19	19	19
Observations	58	58	58	58	58	58	58

[1] Rounded upwards

Table 3 The strong-form efficiency of the forecast error of the piglet price, cross-sectional data

Definition	The forecasting error of the piglet price								
	Round 1	Round 2	Round 3	Round 4	Round 5	Round 6	Round 7	Round 8	Round 9
Constant	4.938	5.180	111.560	8.203	-12.130	17.278	-18.489	-10.399	8.097
t-prob	*0.768*	*0.841*	*0.001*	*0.870*	*0.741*	*0.408*	*0.460*	*0.554*	*0.631*
Error_1	0.618	0.451	0.191	0.376	-0.116	0.115	0.118	0.706	0.136
t-prob	*0.000*	*0.067*	*0.312*	*0.121*	*0.342*	*0.191*	*0.536*	*0.000*	*0.376*
Error_2		0.470	0.514	-0.025	0.091	0.002	0.093	-0.006	0.495
t-prob		*0.070*	*0.082*	*0.931*	*0.602*	*0.977*	*0.392*	*0.967*	*0.002*
Error_3			0.369	0.063	-0.583	0.174	0.077	0.050	0.014
t-prob			*0.231*	*0.885*	*0.007*	*0.069*	*0.372*	*0.508*	*0.913*
Region	-5.715	0.790	-47.529	-46.544	-35.211	11.787	2.577	10.363	0.178
t-prob	*0.356*	*0.934*	*0.000*	*0.021*	*0.025*	*0.224*	*0.822*	*0.144*	*0.978*
Age	1.536	-5.112	-15.323	-6.521	10.786	-6.749	4.117	-5.526	-6.271
t-prob	*0.851*	*0.685*	*0.297*	*0.779*	*0.532*	*0.511*	*0.746*	*0.538*	*0.462*
Ag. education	-7.146	17.937	-8.355	-23.406	-22.145	-4.822	-10.902	1.450	-10.664
t-prob	*0.300*	*0.098*	*0.512*	*0.244*	*0.145*	*0.597*	*0.335*	*0.852*	*0.148*
TV news	17.153	-4.493	-13.711	41.921	12.959	-1.785	-5.391	5.250	-4.984
t-prob	*0.020*	*0.701*	*0.316*	*0.056*	*0.404*	*0.843*	*0.629*	*0.474*	*0.479*
Reg. newspaper	-5.457	4.291	-17.374	-38.887	2.212	6.672	32.316	-12.191	-4.681
t-prob	*0.440*	*0.694*	*0.175*	*0.0597*	*0.890*	*0.481*	*0.008*	*0.145*	*0.564*
FU newspaper	-7.196	-12.420	10.962	-8.231	-4.794	4.635	14.972	-3.438	-7.569
t-tdn,	*0.236*	*0.192*	*0.325*	*0.636*	*0.715*	*0.539*	*0.114*	*0.610*	*0.244*
Ag. magazine	3.452	13.786	18.598	30.844	29.370	-13.712	-9.172	-9.001	14.377
t-prob	*0.672*	*0.276*	*0.212*	*0.191*	*0.108*	*0.206*	*0.485*	*0.311*	*0.094*
SH infoletters	-5.039	3.112	-13.289	12.288	4.059	-0.740	13.847	1.057	-1.984
t-prob	*0.501*	*0.787*	*0.322*	*0.557*	*0.799*	*0.937*	*0.230*	*0.897*	*0.800*
Other farmers	10.858	-18.227	-5.295	49.142	28.386	2.312	13.336	9.685	12.453
t-prob	*0.164*	*0.139*	*0.713*	*0.032*	*0.087*	*0.817*	*0.282*	*0.241*	*0.120*
Arable land	-4.625	-20.906	-24.629	-13.386	0.904	3.776	20.064	-3.708	-4.922
t-prob	*0.493*	*0.050*[1]	*0.058*	*0.480*	*0.949*	*0.650*	*0.054*	*0.615*	*0.485*
Places for pigs	-3.877	-3.012	-10.817	0.508	-13.605	12.639	-11.286	7.747	5.438
t-prob	*0.479*	*0.722*	*0.279*	*0.974*	*0.252*	*0.081*	*0.200*	*0.218*	*0.366*
Sec. occupation	3.657	3.959	-24.457	-30.068	1.580	0.111	-2.614	-11.736	-9.419
t-prob	*0.555*	*0.679*	*0.031*	*0.117*	*0.910*	*0.989*	*0.792*	*0.087*	*0.161*
Income, p-meat	1.971	2.036	10.203	24.964	7.792	-4.550	-3.955	-0.799	0.206
t-prob	*0.741*	*0.824*	*0.339*	*0.143*	*0.541*	*0.549*	*0.673*	*0.901*	*0.973*
As entrepreneur	-6.734	-0.952	0.069	27.980	-20.131	19.351	-8.805	10.004	-0.122
t-prob	*0.418*	*0.941*	*0.996*	*0.227*	*0.257*	*0.073*	*0.513*	*0.292*	*0.989*
Earliness	-15.376	-0.209	-32.164	-31.625	-7.678	1.813	-8.989	16.435	7.628
t-prob	*0.033*	*0.985*	*0.018*	*0.145*	*0.642*	*0.853*	*0.437*	*0.038*	*0.329*
EU			-26.025	-51.537					
t-prob			*0.037*	*0.247*					
R^2	0.641	0.433	0.677	0.627	0.385	0.304	0.457	0.638	0.620
RSS	15091	34743	43715	106578	62971	22155	33685	16685	15160
σ	19.185	29.471	33.917	52.959	40.183	23.834	29.389	20.684	19.716
Variables	17	18	20	20	19	19	19	19	19
Observations	58	58	58	58	58	58	58	58	58

[1] Rounded upwards

Table 4 **The strong-form efficiency of the forecast error of the pigmeat price, basic pigmeat price, and piglet price, panel data**

Definition	The forecasting error								
	Pigmeat price			Basic pigmeat price			Piglet price		
	1–9	2–9	3–9	1–9	2–9	3–9	1–9	2–9	3–9
Constant	0.125	0.306	-0.597	0.322	0.548	-0.153	-4.279	-6.723	18.566
t-prob	*0.523*	*0.145*	*0.007*	*0.396*	*0.191*	*0.747*	*0.695*	*0.574*	*0.155*
d_2	0.184			0.205			-3.209		
t-prob	*0.130*			*0.386*			*0.637*		
d_3	-0.749	-0.930		-0.562	-0.761		20.392	23.630	
t-prob	*0.000*	*0.000*		*0.025*	*0.004*		*0.005*	*0.002*	
d_4	-0.317	-0.610	0.251	-0.024	-0.237	0.501	24.703	28.316	4.717
t-prob	*0.011*	*0.000*	*0.073*	*0.920*	*0.356*	*0.077*	*0.000*	*0.000*	*0.531*
d_5	0.828	0.668	1.475	0.753	0.529	1.264	0.486	3.978	-19.563
t-prob	*0.000*	*0.000*	*0.000*	*0.002*	*0.037*	*0.000*	*0.944*	*0.582*	*0.012*
d_6	0.547	0.457	1.425	0.644	0.442	1.205	33.810	36.654	14.377
t-prob	*0.000*	*0.001*	*0.000*	*0.007*	*0.078*	*0.000*	*0.000*	*0.000*	*0.063*
d_7	0.205	-0.005	1.026	0.319	0.134	0.918	8.059	11.855	-9.049
t-prob	*0.110*	*0.972*	*0.000*	*0.182*	*0.595*	*0.001*	*0.248*	*0.104*	*0.253*
d_8	0.243	-0.005	0.942	0.325	0.139	0.924	3.524	6.419	-16.261
t-prob	*0.052*	*0.968*	*0.000*	*0.171*	*0.582*	*0.001*	*0.606*	*0.379*	*0.038*
d_9	-0.145	-0.368	0.551	-0.463	-0.654	0.127	19.169	22.220	1.492
t-prob	*0.246*	*0.004*	*0.000*	*0.051*	*0.009*	*0.648*	*0.005*	*0.002*	*0.848*
Error_1	0.345	0.269	0.203	0.234	0.224	0.206	0.264	0.243	0.225
t-prob	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
Error_2		0.103	0.051		-0.012	-0.025		0.019	0.011
t-prob		*0.023*	*0.286*		*0.770*	*0.578*		*0.698*	*0.831*
Error_3			0.057			-0.004			-0.081
t-prob			*0.208*			*0.935*			*0.117*
Region	-0.067	0.005	0.142	-0.090	-0.026	0.121	-10.947	-12.139	-16.543
t-prob	*0.323*	*0.943*	*0.070*	*0.496*	*0.858*	*0.464*	*0.004*	*0.005*	*0.001*
Age	0.055	-0.005	-0.082	0.078	0.029	-0.048	-1.855	-2.366	-2.365
t-prob	*0.555*	*0.961*	*0.434*	*0.663*	*0.887*	*0.829*	*0.720*	*0.679*	*0.704*
Ag. education	0.057	0.071	0.096	0.185	0.218	0.270	-11.260	-11.487	-16.316
t-prob	*0.456*	*0.394*	*0.268*	*0.213*	*0.190*	*0.147*	*0.009*	*0.017*	*0.002*
TV news	-0.039	-0.066	-0.105	-0.163	-0.212	-0.282	6.958	4.962	6.054
t-prob	*0.611*	*0.425*	*0.228*	*0.272*	*0.204*	*0.131*	*0.108*	*0.302*	*0.250*
Reg. newspaper	-0.090	-0.077	-0.067	-0.190	-0.203	-0.216	-0.925	-0.331	-1.687
t-prob	*0.257*	*0.374*	*0.463*	*0.220*	*0.243*	*0.269*	*0.836*	*0.947*	*0.754*
FU newspaper	-0.110	-0.097	-0.083	-0.225	-0.240	-0.246	0.658	1.728	3.886
t-prob	*0.107*	*0.196*	*0.289*	*0.091*	*0.107*	*0.141*	*0.863*	*0.681*	*0.396*
Ag. magazine	0.080	0.110	0.081	0.042	0.063	0.018	8.542	8.717	8.833
t-prob	*0.377*	*0.267*	*0.435*	*0.814*	*0.747*	*0.934*	*0.095*	*0.125*	*0.156*
SH infoletters	-0.046	-0.072	-0.102	-0.224	-0.278	-0.352	2.051	2.746	2.472
t-prob	*0.585*	*0.432*	*0.284*	*0.171*	*0.128*	*0.087*	*0.663*	*0.598*	*0.662*
Other farmers	0.063	0.029	0.004	0.046	0.014	-0.024	16.259	16.048	21.120
t-prob	*0.440*	*0.743*	*0.967*	*0.768*	*0.938*	*0.905*	*0.001*	*0.002*	*0.000*
Arable land	-0.101	-0.102	-0.089	-0.240	-0.268	-0.281	-0.500	-0.551	1.088
t-prob	*0.172*	*0.204*	*0.287*	*0.093*	*0.094*	*0.117*	*0.903*	*0.904*	*0.826*
Places for pigs	-0.025	-0.009	-0.032	-0.027	-0.020	-0.043	-3.944	-3.944	-4.542
t-prob	*0.684*	*0.898*	*0.653*	*0.820*	*0.883*	*0.776*	*0.256*	*0.306*	*0.279*
Sec. occupation	0.021	0.023	0.034	0.302	0.351	0.424	-7.659	-9.090	-11.880
t-prob	*0.765*	*0.762*	*0.666*	*0.028*	*0.023*	*0.015*	*0.052*	*0.037*	*0.013*
Income, p-meat	0.011	0.011	-0.011	0.105	0.122	0.119	2.537	2.921	3.974
t-prob	*0.868*	*0.876*	*0.882*	*0.418*	*0.397*	*0.463*	*0.496*	*0.479*	*0.376*
As entrepreneur	-0.071	-0.041	-0.005	-0.090	-0.063	-0.025	0.410	1.145	1.574
t-prob	*0.447*	*0.689*	*0.963*	*0.619*	*0.755*	*0.912*	*0.937*	*0.843*	*0.802*
Earliness	-0.083	-0.071	-0.051	-0.234	-0.247	-0.257	-10.625	-9.875	-12.484
t-prob	*0.291*	*0.409*	*0.568*	*0.128*	*0.150*	*0.181*	*0.018*	*0.048*	*0.023*
EU	-1.249	-1.266	-1.259	-4.532	-4.536	-4.517	-17.905	-18.340	-19.913
t-prob	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.102*	*0.109*	*0.088*
R^2	0.508	0.515	0.545	0.431	0.434	0.443	0.248	0.230	0.227
RSS	211.48	196.04	162.51	798.46	781.16	741.66	663462	636723	571658
σ	0.653	0.669	0.654	1.269	1.335	1.397	36.574	38.128	38.786
Variables	26	26	26	26	26	26	26	26	26
Observations	522	464	406	522	464	406	522	464	406

Table 5 Definitions of the variables

Variables	Definition
d_2	The dummy referring to the round of the interviews
Error_1	The first lag of the forecast error
Region	The home region of the entrepreneur (Southern Otrobothnia = 0, Varsinais-Suomi = 1)
Age	The age of the entrepreneur (younger = 0, older = 1)
Ag. education	The agricultural education of the entrepreneur (some education = 0, no education = 1)
TV news	The entrepreneur's opinion of the TV news as a source of information (important = 0, less important = 1)
Reg. newspaper	The entrepreneur's opinion of the regional newspaper as a source of information (important = 0, less important = 1
FU newspaper	The entrepreneur's opinion of the newspaper of the Farmers Union (Maaseudun Tulevaisuus) as a source of information (important = 0, less important = 1)
Ag. magazine	The entrepreneur's opinion of the agricultural magazine (Käytännön Maamies) as a source of information (important = 0, less important = 1)
SH infoletters	The entrepreneur's opinion of the infoletters of the slaughterhouses as a source of information (important = 0, less important = 1)
Other farmers	The entrepreneur's opinion of other farmers as a source of information (important = 0, less important = 1)
Arable land	The cultivated arable land hectares (more = 0, less = 1)
Places for pigs	The number of the places for pigs in the barns (more = 0, less = 1)
Sec. occupation	The entrepreneur's experience of the secondary occupation months (more = 0, less = 1)
Income, p-meat	The income from the pigmeat production FIM (more = 0, less = 1)
As entrepreneur	The entrepreneur's experience as an independent entrepreneur years short = 0, long = 1)
Earliness	The earliness of the entrepreneur's answer (early = 0, late = 1)
EU	The entrepreneur's opinion of the possible EU membership of Finland during the rounds 3 and 4 (will join = 0, will not join = 1)

The Significance of Financial Leverage in the Agricultural Sector

Søren Svendsen[a]

Abstract

The development in agriculture has caused still bigger farms and therefore more and more expensive farms. This has caused two fundamental consequences. The debt ratio has increased and it has become difficult to generational change the farms to younger generations.

The objective of the entire study has been to analyse these two fundamental problems in order to find some kind of solution. The project has been divided into four subprojects. The two of them have already been carried out, and we are dealing with the third.

In the first subproject 1200 accounts have been investigated in order to analyse the debt ratio. The study confirms, that it is impossible to optimise the debt ratio. On the other the study points out some inoptimal level. That is in the high end. The debt ratio is explained by several factors, of which the most important is age. The regression coefficient is –0.98, which means that for each year the farmer grows older his debt ratio decreases one percentage point. The correlation showed up to be 0.48, which is not convincing.

In the second subproject we have analysed 8 farms in a case study. We pinpointed two interesting generational change models, where it is possible to consolidate the farm by significant amounts. The first was a sliding generational change and the second was a production cooperation. We also calculated the financial risk and the business risk, like we demonstrated a very significant correlation between debt ratio and financial risk.

Keywords: Financial leverage, Debt ratio, Risk, Denmark

[a] Senior Research Fellow, Danish Research Institute of Food Economics. *svendsen@foi.dk*

Introduction

In order to analyze the possibility to optimize the debt ratio of a company the financial schools have established many theories. From these the most well known is the Modigliani and Miller (MM) theory (Brealey and Myers, 2000), which hypothesizes that the dept ratio has no influence on the evaluation of a company. Another fundamental financial theory is the leverage theory, which claims that profitability as well as the total risk, increase when debt ratio increases. Consequently it is not possible to establish an optimal debt ratio due to these two fundamental financial theories. In this study it will be demonstrated which factors influence the debt ratio. It will be tried empirically to identify the optimal debt ratio. And the coherence between the debt ratio and financial risk will be demonstrated.

Large debt ratio

Farm Accounting Statistics from all member states in the EU have been assembled in RICA (Resau d'Information Comptable Agricole). The key figures in Table 1 below are averages from 1998, and the absolute numbers are valued in Euro.

Table 1 Key figures of farms in EU countries

	DK	Sweden	Germany	GB	France	Holland	Finland	Average
Total Assets	480,000	310,000	563,000	767,000	250,000	736,000	157,000	
Debt Ratio	58%	31%	15%	13%	35%	35%	30%	31%
Net interests	27,000	11,000	10,000	15,000	11,000	21,000	4,000	14,000
Net Profit	17,000	5,000	23,000	27,000	29,000	42,000	19,000	23,000

The table clearly shows that the interest costs are by far the highest in Denmark and therefore the net profit is less than in most other EU countries. In most countries the net profit is much higher than net interests. But in Denmark it is the reverse due to the high debt ratio, which is almost twice the average. The numbers in the table are averages, however. It might well be the case, that the debt ratio is a problem to some farmers, whereas it is not to others.

The Danish Agricultural Associations (1995) state that it is a severe problem that interest expenses are a significant bigger burden to Danish agriculture than to the rest of EU. Furthermore: Report no. 1137, 1988 from the Ministry of Agriculture states: "Danish agriculture faces a substantially higher debt and interest burden than the rest of the EU countries". Finally Rasmussen (1998) writes that the debt ratio has increased significantly in the past 10–15 years and compared to the other countries in the EU the debt ratio is by far the highest. The development of the debt ratio in Danish agriculture is shown in Figure 1 below.

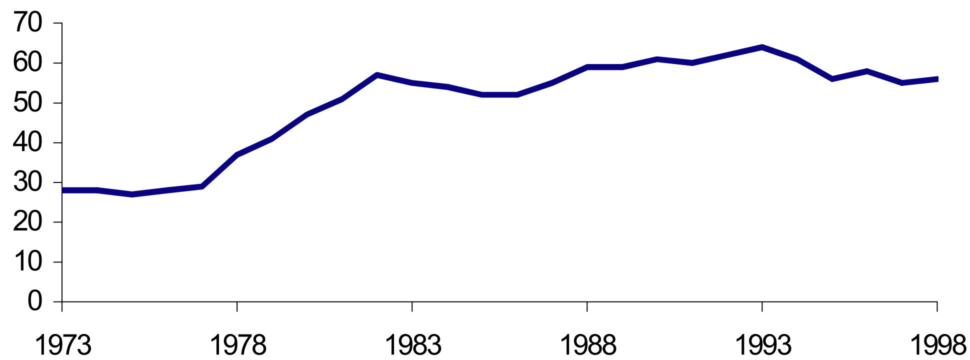

Figure 1 Development of the debt ratio

The shift of level from about 30% to about 60% in the period 1977–1982 is the most remarkable result in the figure. This development is due to the dramatic fall in interest rates in the beginning of the 80ies combined with high investments from the previous years, which were debt financed. When interest rates fall, bond prices rise, and accordingly the debt rises.

Thus, the above three references all agree upon the problems of the level of debt ratio in Danish agriculture. And according to Table 1 they are right: Interest payments are too high and net profit too low.

In the financial leverage theory the pivotal point is the debt ratio. The theory states that earnings as well as risk increase with the debt ratio. But empirical numbers has not yet demonstrated the coherence in the agricultural sector. This problem will be dealt with now.

Risk

In the portfolio theory risk is defined as the standard deviation of return in a certain period of time. The theory prescribes that both return and risk increase when the debt ratio increases. Five pork farms have been analysed and the relationship between debt ratio and financial risk will be demonstrated. Table 2 shows the debt ratio, total risk, business risk and financial risk of the five farms. Debt ratio is well known but: **What are financial risk, business risk and total risk?** And what should the level be? The latter is difficult to answer because the three variables have not yet been estimated explicitly in Denmark. The risk measures have been mentioned in theoretical terms but not really calculated, and therefore no references exist.

Total risk is measured as the standard deviation on the return on equity, ROE, over a certain period of time. The time period in question is six years. Business risk is the standard deviation on return on assets, ROA, because business risk must be independent of the way, the farm is financed. Finally financial risk is calculated as:

$$financial\ \ risk = \frac{1 + total\ \ risk}{1 + business\ \ risk} - 1$$

So financial risk is the added risk by using debt, and financial risk would be zero if debt ratio were zero. Financial risk increases as debt increases as is seen in Table 2.

Table 2 Connection between debt ratio and risk

Case	Debt ratio ultimo	Financial risk	Business risk	Total risk
1	66%	15.40%	6.17%	22.50%
3	69%	18.37%	3.79%	22.87%
2	72%	19.73%	14.82%	37.48%
5	75%	24.69%	5.66%	31.75%
4	81%	32.34%	6.63%	41.12%

The estimates from the table demonstrate an unambiguous connection between debt ratio and financial risk, which could be depicted as in Figure 2.

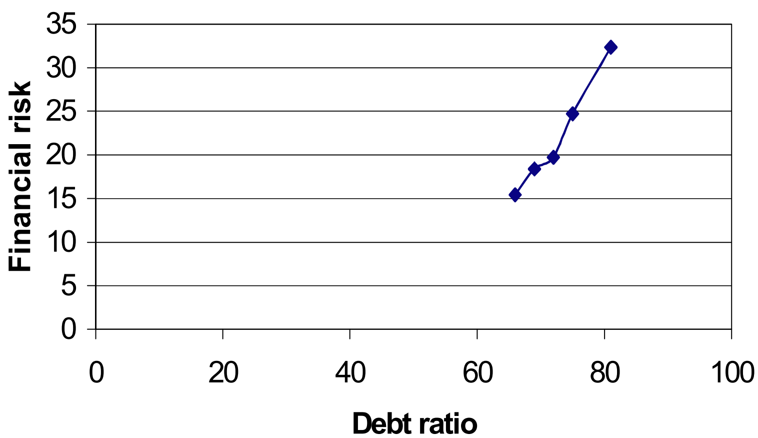

Figure 2 Debt ratio and financial risk, five Danish farms

The observations are almost lying on a straight line, and the correlation is as much as 98.84%. The linearity could be a coincidence. But it could be valid on the other hand, because the farms are much alike on the balance sheet and on the statement of income. Do remember that they are facing the same variances in prices all of them. And all of the farmers are younger and efficient farmers with high productivity. Of course five single farms are not enough to make sure there is linearity, but an unambiguous connection between the debt ratio and financial risk is demonstrated.

The levels of risk are difficult to interpret immediately, because it is new concepts to deal with in practice. However the levels of risk are comparable to the levels of the best performing Danish Investment Associations, whose five-year risks are between 18% and 21%. The same calculations have been conducted to dairy farms, and their total risks are between 10 and 15%, because milk prices are steadier than pork prices. This demonstrates differences between different sectors, which is according to the theory. It also demonstrates that the levels are sensible.

The analysis has just demonstrated that risk is proportional to debt ratio in line with the theory. If the farmer's ROA is higher than the interest rate and there is only little or no risk, it is a good idea borrowing money to adequate investments. But if the farmer's ROA is less than interest rate, the farmer is loosing money by increasing his debt ratio. From Table 1 it is obvious that Danish farmers on average pay too many interests and therefore earn too little. And from the discussion of risk it is obvious that risk increases when the debt ratio increases. Consequently a high debt ratio constitutes a problem to the farmer on average. However averages are not adequate to describe the problem of debt ratios for the agricultural sector, unless the debt ratios are uniformly distributed. The distribution of the debt ratio must be developed in order to locate the magnitude of the problem. And such a distribution has not yet been developed in Denmark.

The Danish Research Institute of Food Economics has analysed financial leverage in 1998 in Danish agriculture. The sample consists of 1200 financial statements of Danish farmers from the database of the above-mentioned Institute. The debt ratio is found and the distribution is shown in Figure 3 below. The debt ratio is shown on the horizontal axis and the number of farms on the vertical axis.

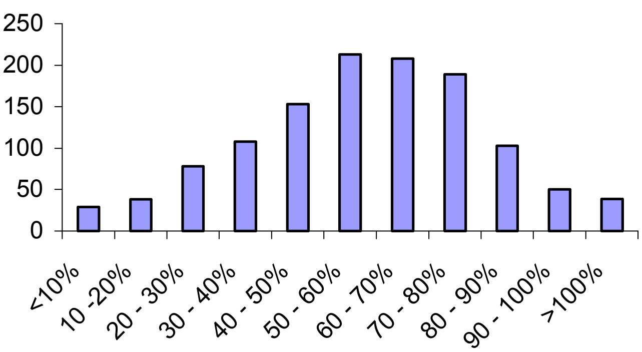

Figure 3 Debt ratio

The debt ratio is described by a normal distribution since 68% of the farms are within plus/minus one standard deviation and 95% within plus/minus two standard deviations. Few observed distributions are purely normal, far most of them are skew. The skewness of the distribution has been tested, and Pearson's coefficient of skewness turns out to be –0.120, which is very modest. Thus it is only a little left skewed. The debt ratio therefore might be characterized as a normal distribution with the parameters (μ, δ) = (58%, 23%) for practical purposes.

The problem of the debt ratio has now become more transparent. The farmers at the right hand side of the mean probably face a much bigger problem than the farmers at the left hand side. Or maybe the first category benefit from external financing, which is not the hypothesis though. The next part will deal with this question in an attempt of optimising debt ratio.

Demonstrating an optimal debt ratio?

In order to examine what happens to the relative earnings when growth is debt financed the financial theory relates the debt ratio to earnings per share, EPS. When leverage increases earnings as well as risk increase, and the result is that no optimal debt ratio can be demonstrated. In the extreme debt should be almost 100% in order to maximize EPS if there were no risk. Thus an unambiguously optimal debt ratio is not possible to achieve. In addition MM prescribe that a firm cannot change its total value by leverage (Van Horne, 1977).

However an interesting question arrives. Is it possible to empirically demonstrate an optimal debt ratio? In this study EPS is replaced by Return on Equity, ROE, because a farm is typically not a shareholder company and thus contains no stocks. ROE is equivalent to EPS as both key figures represent earnings related to equity.

In case it were possible to demonstrate a maximum ROE, this will turn out to be the optimal debt ratio found not mathematically but empirically. And this would in fact contradict to the MM theses. In the study 1,200 observations of debt ratio and ROE are plotted in a scatter diagram illustrated in Figure 4.

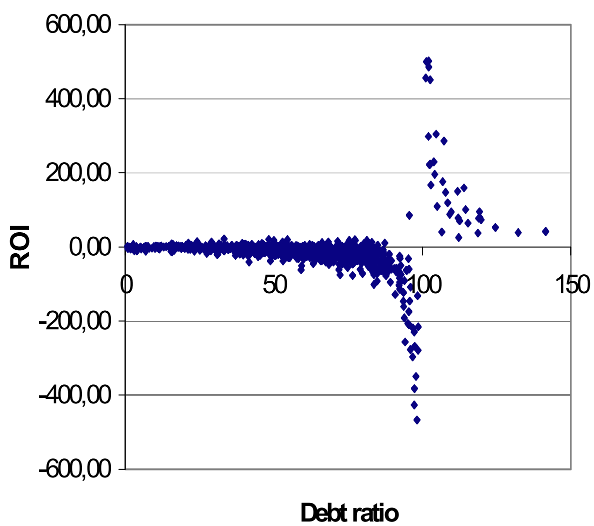

Figure 4 Debt ratio and return on equity (ROE), 1200 Danish farms

A debt ratio about 100%, which means an equity about zero, causes a significant variation, because equity enters into the denominator in the equation for ROE. Accordingly ROE $\rightarrow \pm \infty$, when debt ratio $\rightarrow$ 100%. Notice that the scatter diagram looks like a hyperbola with the centre (X, Y) = (100%, 0).

The farms on the right curve have a debt ratio over 100%, which means they are insolvent. Negative earnings divided with a negative equity cause a positive number. Consequently these farms all show negative earnings. Negative earnings on top of a negative equity are an extremely unfavourable combination.

The farms at the left curve all have a debt ratio less than 100%, which is of course the normal case. There is a top frontier and a bottom frontier. It is more difficult to interpret anything from the top frontier than the lower frontier. It is obvious to realize that ROE is decreasing exponentially at the lower frontier. Especially it falls heavily after the 50% level. And it becomes extremely negative as the debt ratio approaches 100%. The average debt ratio in Denmark is 58%. The figure illustrates that it is impossible to demonstrate an optimal debt ratio empirically, as no unambiguous top shows up. However it is easier to demonstrate an inoptimal level at the lower frontier. This is on the wrong side of the average level for a normal managed farm, as the lower frontier of the curve starts falling dramatically. That is due to the burden of interest expenses. This result is interesting because it pinpoints, that most farmers with high debt ratios should try to reduce their debt ratio substantially.

What can the farmer work out in order to decrease the debt ratio? The easy answer is: pay off his debt, but this is useless to the farmer, because he already knows. To give an adequate answer one must know what cause the debt ratio. This question will be dealt with in the next part.

Which factors influence the debt ratio?

In order to find out which factors influence the debt ratio, the 1200 financial statements of Danish farmers have been investigated. The hypothesis is, that the debt ratio is a function of seven independent variables:

$$DR = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7)$$

These variables are described below. In addition the hypothesis is linearity, and therefore the overall method has been a multiple regression analysis. And the analyses have been carried out in SAS (Statistical Analysis System).

Age

The regression analysis shows a slope of –0.98376 and a sample correlation coefficient of –0.4549 between age and debt ratio. That means when the farmer grows one year older, his debt ratio declines one percent on average. A correlation of -0.45 shows that the relationship is not overwhelming. However, the F-test

(Harnett 1977) points out to be more than 99.99% confident that there really is a relationship.

Consolidation

The long-term savings explain an amazingly modest part of the debt ratio, as the regression coefficient is only –0.0000177, and the correlation is 0.27. The explanation is, that much of the money is used for new investments. Particularly it is relevant to investigate if age and savings over the years in conjunction explain the debt ratio better. In fact they do as the correlation between the two and the debt ratio is 0.55.

Investments

It is a hypothesis that the earnings can be used for consolidation or investments. Therefore the correlation between investments and debt ratio should be significant. The correlation between investments and debt ratio is weaker than expected, as it is 0.2345, which is a surprising result. Part of the explanation is, that investments do not diminish the equity. Another explanation is that younger farmers invest most. And younger farmers have far the highest debt ratio. If one has a high debt ratio, a certain investment do not affect debt ratio as much, as if the debt ratio is low.

Region

Debt ratio is completely independent of region. The farmers in Jutland are not anymore cautious than farmers in Sealand. The correlation is zero.

Size

Size is not unambiguous. We have chosen to use total assets. The relationship between total assets and debt ratio is modest. The correlation is only 0.13, because the biggest debt ratios are in the middle.

Earnings

One of the most important hypotheses to test in the study is the relationship between inefficient management and poor financing. Management is measured by Return on Assets, ROA, which is an adequate measure of efficiency because ROA is independent of financing. And the adequate measure of controlling financing is debt ratio.

The regression analysis demonstrates a weak relationship between efficiency and debt ratio. The slope is –0.069 and the correlation is as modest as –0.025. The explanation is that many younger farmers have a high debt ratio as well as a high efficiency.

Two thirds of the insolvent farms have negative ROA, and the average ROA of these farms is –3.5%. In addition very high interest expenses arrive. This is a clear indication that poor management is strongly correlated to poor financing. Therefore the accounts payables must be cautious when they face extremely high debt ratios. This result is in accordance with the result from Figure 4, which showed a connection between bad management and a bad financial position.

All the parameters influence at the same time

When the regression analysis includes all the variables in aggregate the correlation coefficient is 0.5846. This is only 6% better than age in conjunction with consolidation solely. The debt ratio is a compound figure. Other parameters, such as management and market and economic conditions, influence too. So does the organization of the generational change. Such parameters are difficult to measure in a model, however.

Final remarks

An additional investigation (Svendsen, 2001) has asked farmers about their objectives and their strategy. This investigation points out that management and the objectives of the farmers are the most significant parameters in determining the debt ratio. Unfortunately it is impossible to segregate and scale these two parameters from the financial statements.

A Swedish investigation (Heshmati, 2001) has been conducted in much the same way on small business firms. This investigation confirms the coherence between several of the factors investigated above and the debt ratio. So the coherence is apparently not an isolated Danish phenomenon but is valid internationally.

Thus it is not an easy task for the farmer to reduce his debt ratio, if he is in the high end. Hard work and clever decisions are required. But the analysis confirms the importance of reducing it until he reaches the present average or a lower level. Farmers with high debt ratios usually face reduced earnings and increased risks.

References

Barry, P.J., Hopkin, J.A., and Baker, C.B., 1979. *Financial Management in Agriculture*.

Brealey, R.A. and Myers, S.C., 2000. *Principles of Corporate Finance*.

Report nr. 1137, 1988: *Relief of the Interest Burden of the Agriculture*, Agricultural Ministry, Denmark.

Coward, N., 1993. Financial Management and Probity. *Farm Management Journal* No. 5 Spring 1993.

The Danish Agricultural Association, Axelborg 1995: *Opportunities of Improvements Financing in Agriculture.*

FOI. *Statistics of Agricultural Financial Statements 1998/99.*

Franks, J.R. 1999. Financial Assessment of Farms Businesses, *Journal of International Farm Management* 2 (2).

Harnett, D.L., 1977. *Introduction to Statistical Methods*, California.

Heshmati, A., 2001. *The Dynamics of Capital Structure*. Working Paper, Stockholm School of Economics.

Levy, H. and Sarnat, M., 1999. *Capital Investment* & *Financial Decisions*, Prentice Hall, London.

Pedersen, F., 1999. *Finance Planing*, Systime, Århus.

Rasmussen, S., 1998. *Use of Income, and Financial Behaviour on Danish Agricultural Farms,* Working Paper, KVL. Copenhagen.

Svendsen, S., 1999. Forage Supply Corporatives. *Effective Agriculture* No. 16,

Svendsen, S., 2001. *Empirical Analysis of Generational Changes in Agriculture*. FOI Working Paper no. 20/2001.

Van Horne, J., 1977. *Financial Management and Policy*.

Ask LENNART: Integrating Heuristics and the Internet in a Decision Support System (DSS) for Field Management

Dennis Collentine[a], Martin Larsson[b], and Nils Hannerz[c]

Abstract

An analysis of participation by farmers in voluntary agri-environmental programs, leads to the conclusion that participation rates depend on the subjective estimation of the effect on farm income of program enrollment. Information transaction costs lead to the use of heuristics by farmers to reduce the complexity of the decisions, that is, to act as rationally bounded decision makers. Among the decision heuristics used by farmers, three are identified: representativeness, anchoring and availability. The paper describes how LENNART, a net-based decision support system (DSS), has been designed to exploit the use of these heuristics by providing low cost access to information. The model has been developed to evaluate the effects of agronomic measures on farm income and on the leaching of nutrients from a cultivated field. A subsidy program for catch crop cultivation in Southern Sweden, served as the basis for development of the DSS. This program is also used throughout the paper as an example of an agri-environmental program for purposes of illustration.

Keywords: Agri-environmental policy, Farm management, Linear cost model.

[a] Department of Economics, Swedish University of Agricultural Sciences, Box 7013, S-750 07 UPPSALA. *dennis.collentine@ekon.slu.se*

[b] Department of Soil Sciences, Swedish University of Agricultural Sciences, Box 7072, S-750 07 UPPSALA. *martin.larsson@mv.slu.se*

[c] Swedish Institute of Agricultural and Environmental Engineering - JTI
Box 7033, SE-750 07 UPPSALA. *Nils.Hannerz@jti.slu.se*

Introduction

Agronomic practices which contribute to nitrogen leaching are primarily connected with field cultivation practices. Changes in agronomic practices, best management practices (BMPs), have been identified which could substantially reduce the level of nitrogen leaching (Gustafson et al. 1998). Implementation of BMPs by farmers is generally assumed to be voluntary, encouraged by support from extension services or other government programs (Feather & Amacher, 1994; Norton, Phipps & Fletcher, 1994; Reichelderfer, 1989). Unfortunately, these programs have not achieved expected results (Collentine, 2002; Gustafson et al, 1998; Wolf, 1995; Setia & Magleby, 1987). For example, agri-environmental policy in Sweden established a program of subsidies for land use measures; creation of wetland areas, extensive pasture and buffer zones along watercourses, the use of catch crops, and long term pasture. However, after the first five years of the catch crop program only 20% of the area anticipated was enrolled in the program.[5]

The success of agri-environmental policy, and thus the cost effectiveness of these policies, will be enhanced through an understanding of the factors which determine how producers make choices with regard to BMP implementation (i.e. when to adopt and which measures to adopt).[6] If these factors are better understood, then information flows may be developed which support the decision of farmers to adopt specific measures as well as support authorities in the design, implementation and evaluation of agri-environmental policy. Henry Buller (1999) observed in a report on the implementation and effectiveness of agri-environmental schemes, that because "Agri-environmental policy occupies an ill-defined middle ground between regulatory approaches to environmental management … and more classic generalised market instruments … [that] agri-environmental policy critically needs to be placed at the level of the farmer and the farm". That is, successful programs begin with an understanding of how management choices are made by farmers on their farms.

The uncertainty with respect to costs that necessarily accompanies the adoption of new techniques, leads to a need for supporting information to analyze the economic effect of adoption on farm income. Farmers, like the rest of us, are limited by their capacity to store and process information. As decision makers, they operate in a realm of bounded rationality when faced with choices and rather than "optimizing" over the set of decision alternatives may instead "satisfice", (Simon, 1987; Hogarth, 1987).

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[5] Participation rules were then relaxed with respect to dates for sowing and plowing in the catch crop, in addition, complementary payments could be received for delayed cultivation (SOU, 1999). While these new rules have led to oversubscription in the program the factors which contributed first to the lower than expected participation rate and then to the greater than expected participation rate have yet to be understood. For a more complete description of the former program and an analysis of the low participation rate see Collentine, (2002).

[6] See Napier & Tucker (2001), Drake, Bergström & Svedsätter (1999) or Buller (1999) for studies of how farmers' attitudes may affect uptake in voluntary agri-environmental programs.

Decisions may be perceived as a series of sequential decisions, a set of decision nodes. At each node one of three actions is possible; accept (enroll in the program), reject unconditionally or reject and gather more information. The last of these three choices includes the expected costs of the additional information. Since these costs are positive and the revenues may be constant, this results in a paradox. If the value of the information gathered is lower than the cost of accessing and processing this information, the likelihood of participation is lower the more well informed the decision is. Thus, quick decisions based on simple decision rules may be effective.

The decision support system LENNART was designed to assist farmers with evaluation of the effects of implementing agronomic measures to reduce the leaching of nutrients from cultivated land. The principle idea is that each user can adjust the model to reflect local conditions based on user information. This allows for flexibility in use of the model and ensures that the user is in control of the results generated by the model by giving the user control over model inputs. LENNART thus provides a unique opportunity through the use of modern information techniques, to incorporate the use of decision heuristics by design into a decision support tool.

LENNART: Net-based interactive DSS and database

LENNART is designed to be used by individual farmers or farm advisers to explore results of modifications of farming practices, both the effect on the income of the farmer(s) as well as the effect on the leaching of nutrients. As noted above there are a series of factors which affect the decision of the farmer to implement a specific measure. These decision factors include:

- field specific qualities; soil type, previous crop, drainage
- farm specific qualities; crop rotation, agronomic practices, access to capital, access to information
- regional specific qualities; local weather
- the producer's perception of the costs and benefits of the alternatives (subjective probabilities)
- the individual risk profile of the producer and sectoral risk
- the dessimation of information
- the rate of adoption by other producers.

The model builds on the principles of decision making under uncertainty. Specifically, it is designed to take into account and support, user decision heuristics such as anchoring, availability and representativeness.

Decision heuristics

Decision heuristics are a collective term for behavior rules which serve to simplify choice. Because these rules apply to historic behavior patterns the information cost in applying them is low as the information used to generate the rule is already a sunk cost. Actual application is also possible at a relatively low cost since "One reason that heuristics work is that they can exploit structures of information in the environment" (Gigerenzer & Selten, 2001). This in turn, means that instead of processing information, the user of a heuristic needs only to look for a recognizable pattern in the flow of information. In the extensive work on heuristics pioneered by the psychologist team of Daniel Kahneman and Amos Tversky, three general types of decision heuristics were identified; representativeness, anchoring and availability (Kahneman, Slovic & Tversky, 1982). These decision heuristics are intuitively used by persons faced with complex decisions where there is uncertainty involved with respect to the outcome of the decision. They serve as a method for structuring subjective probabilities associated with the possible outcomes.

Through the analysis of how choices are framed by farmers with respect to participation in voluntary best management practices, the model development team studied the use of three types of heuristics as decision support: representativeness, anchoring and availability. The model LENNART was designed to support the use of these heuristics by decision makers. It does this by increasing the reliability of the information used to minimize the judgement errors due to bias, that may be associated with the use of these heuristics.

To support the use of the representativeness heuristic, LENNART has been designed to provide access to classes of users in the database and to support the user in determining whether the chosen classes are representative for the decision being considered. Each user logging on to LENNART provides basic information about the size of their farming operation, the type of farming operation and the geographical location of the farm. In addition, for each field entered for calculating the effect of a management option, information is entered on soil type and crop rotation. Furthermore, in the performance of the program calculations, the user enters additional economic and agronomic data such as, the selected discount rate, estimated tractor operation costs, etc (see Collentine, 2002).

The unique construction of LENNART makes it possible for the user to search the data base based on the class of data. For example, the user who wishes to compare their own estimate of labor costs with other users estimates will be able to search the data base and reproduce a summary of this information (see Figure 1). If the user believed that a more narrowly defined portion of the reference group more closely represented their own operation, say farms with more than 50 hectares in crops, then the data base in LENNART could be restricted and this limited data base made available to the user. The possibility of defining a specific reference group to use for comparative purposes, allows the user to search for subjectively defined similarities from a broadly defined population to use in comparing value estimates. In the absence of this possibility, the decision maker may be reduced to "looking over the neighbor's fence" as support for the use of the representative heuristic. The model expands the horizons of the user in a structured manner.

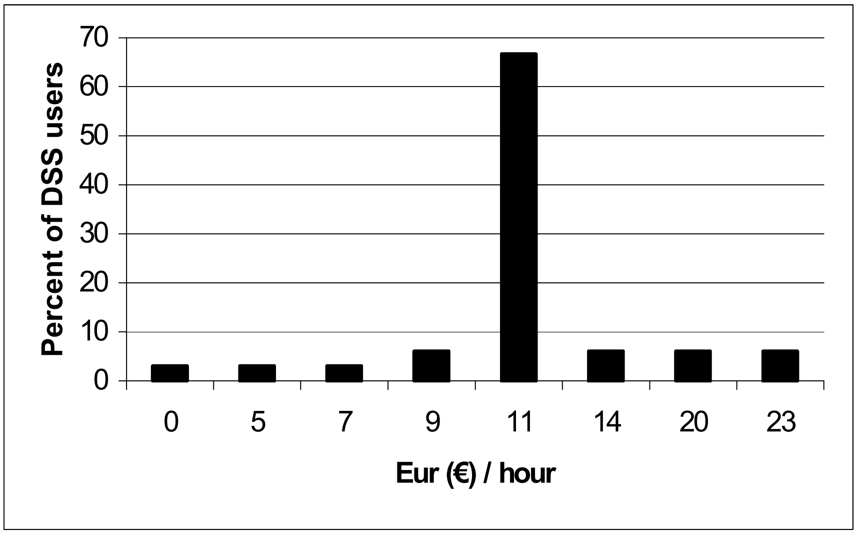

Figure 1 *Farm user estimation of labor cost per hour based on data from test-runs of LENNART.*

The default values provided by LENNART are designed to serve as values for instances where anchoring is a factor. Each BMP evaluated with the model is decomposed into the field level agronomic activities and effects associated with the measure. This permits independent estimation for each activity by the user. For example, the model decomposes the cultivation of catch crops into four separate activities/effects: seed costs, sowing method, harvest effect and weed control. Each of these in turn is broken down into the choice variables that need to be estimated by the user. To estimate the cost for sowing the catch crop, the user evaluates and compares two different sowing methods. In the dialogue box for estimating the cost of a separate seeder, the user selects values from two separate scrollable lists. The first is for the purchase price of the seeder which displays a default value and a scroll arrow. By clicking on the enter key the user accepts this default value for the cost estimation.[7] Clicking on the scroll arrow opens the list and the user can scroll up or down from the default value to select a different value which is then used to perform the estimate. The same process is followed for all of the fourteen choice values associated with the cultivation of catch crops. The default values displayed in LENNART serve as anchors for the user.

When moving through the dialogue boxes in LENNART, the individual user first sees the suggested default values (the anchor) in the area designated for choice values. The displayed default value gives a signal to the user of an appropriate choice for this variable. If this value is not acceptable then the user moves from this value to a new estimate that reflects additional user-based information. The net-based platform of LENNART (see below) allows the default levels to be adjusted on the server. This may be done in response to user driven information

[7] In the second prototype version of LENNART a standard value for depreciation and capital costs are used to calculate the entered purchase price as a present value.

(farm size for example) or for research purposes. The model supports the use of the anchoring heuristic by recognizing that the default values displayed are a low cost signal of information to the user.

Availability refers to access to information for making estimates of the frequency of events. LENNART is designed to provide access to other users' frequency estimates as well as expert estimates through the use of links to other sources of information. This heuristic shares similarities with the representative heuristic as they both refer to the reliability of a sample as representative of a larger population. However, availability refers primarily to the ability of the decision maker to access similar events. Users of the DSS LENNART may return to their own previous for comparative purposes. New estimates made by the farm user of the costs of implementation are easily compared to previous estimates as all the information is saved on the server in a database. The Internet platform also will enable the user to access other sources of information (research results, advising services etc.) as these become available, that may support frequency estimates. Lowering the cost of access to information has driven development of the Internet. By making LENNART available through the net, the cost of access is lowered and the availability of information to the user is increased.

A net-based dynamic DSS

The model is built on a relational database that is located on a web-server. Access to the system is performed via normal Internet browsers using plain HTML-code. The HTML-code is dynamically generated through server-side scripts. Both the system and sub-models of LENNART are maintained inside these scripts. When using the system the user sends a request to the web-server which processes the request and sends the result back as an HTML-page to the browser of the user.

On the server, LENNART computes the economic costs for adopting catch crops on each field and generates the resulting nitrogen loss reduction on that particular field. The economic model driving these cost estimations does not need any substantial amount of computational power. Therefore, the model is able to be run directly on the server when the user sends a request. Model responses are produced within seconds. This short response time is, however, not the case for the calculation of nitrogen reduction.

The basis for calculation of reductions in leaching losses of nitrogen is the physically based SOILNDB model, (Johnsson et al., 2002). Since rather extended demands are placed on the amount of data needed to run the model, the development team decided that these demands would be too cumbersome for LENNART. Instead, an extensive number of standardized runs were stored in a separate database. Nitrogen leaching for different soils, crop combinations and areas (climates) are kept in the database. Thereby nitrogen leaching data can be sent back to the LENNART user within seconds.

There are three primary factors which led to the choice of a server based web site accessed through the Internet for LENNART; access factors, development factors and data base factors. A server based program promotes access for a wide group of intended users. The site can be accessed by multiple users from individual computers, with the only personal computer software requirement being a standard web navigating program (Netscape or Explorer). Enabling access to the program through individual computer connections also allows the program to be demonstrated in a variety of environments. Farm advisers can demonstrate use of the program in consultations with farmers during farm visits. The program can also be demonstrated and used by groups in seminars.

Development of the model can be continuous over time as control over the version being used is determined through the server. This quality also means that no problems arise with versions being used which are out of date. Each time a user logs on, the version which becomes available is determined through commands on the server. This also allows for partitioning over time to test development of model components. For example, inclusion of a wizard format or tutorial can be tested by incorporating that component into the model made available to users on the server over for a specific period of time or a specified number of runs. Results from this partitioned model can be compared and choices made by model developers with respect to incorporation or development of the most favorable components.

The net-based format also allows for incorporation of changes in development of the independent natural science process based sub-model, SOILNDB. The server platform of LENNART allows changes to be made in the user available model as soon as new information becomes available which affects the results of the sub-model. The entire model doesn't need to be replaced, only those changes which are made to the model. This ensures that LENNART is able to make use of the best information available.

Figure 2 Comparative summary page in LENNART for farm users (in Swedish).

The location of the model on a server also means that the data base is developed as the model is used. This represents the dynamic aspect of the model. All of the data is located in one place and can be accessed from anywhere by designated users. As new data becomes available, i.e. every time the model is used, this data is directly available on the server. The immediacy of availability will be able to provide support for users that are interested in comparative data and for users that are interested in aggregate data for policy evaluation and design. Figure 2 illustrates one of the comparative summary pages in the second prototype of LENNART. This page compares the farm user's inputed cost estimates with the cost estimates used by the Swedish Agricultural Board for calculating the economic effect of cultivation of catch crops. It is also possible to use partitioning with respect to the database. Open access to the entire database through the Internet will make it possible for those users that are interested in the model to actively work with the database for this purpose. Figure 1 reproduces a diagram of LENNART user estimates of labor costs per hour. Statistical analysis of this kind of data is of interest for policy analysis and program evaluation.

The technical platform for LENNART is a Windows environment using an Access 2000 database, Active Server Pages (ASP) with server-side Visual Basic Script and a few client-side Java Scripts. The second prototype of the model (in Swedish) is available in the public domain at:
http://neptunus.md.slu.se/VASTRA/BAK/index.html.

Further development

The model currently allows users to evaluate the economic effect and the expected reduction in nitrogen leaching from a set of crop rotations in a specific area of Southern Sweden. Expansion is planned to cover both a larger geographic area as well as to include a greater number of soil types and crop rotations. In addition, the development team plans to improve the graphic interface through the use of focus group tests. Preliminary work is also underway to allow the evaluation of other field management measures in LENNART. New measures planned for development in extensions of the model include the reduction of fertilization intensity on fields and measures where timeliness is a factor such as the timing of cultivation in combination with other practices and the timing of fertilizer applications. Since measures where timeliness is a factor may have an effect on other farm activities beyond the individual field, a preliminary study of these types of measures is necessary before they may be included in LENNART.

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References

Buller, H., 1999. Evaluating participation in agri-environmental schemes. In Schramek, J., Biehl, D., Buller, H. and G. Wilson (Eds.), *Implementation and Effectiveness of Agri-environmental Schemes Established under Regulation 2078/92,* Project FAIR1 CT95-274, Final Consolidated Report, Frankfurt.

Collentine, D., 2002. Economic Modelling of Best Management Practices (BMPs) at farm level. In Steenvoorden, J., F. Claessen, and J. Willems (Eds.), *Agricultural Effects on Ground and Surface Waters*. IAHS Publication no. 273., Oxfordshire, UK.

Drake, L., P. Bergström, and H. Svedsäter, 1999. Farmers' attitudes and uptake. In Van Huylenbroeck, G. and M. Whitby (Eds.), *Countryside Stewardship: Farmers, Policies and Markets.* Elsevier Science Ltd, Oxford, UK.

Feather, P.M. and G. S. Amacher, 1994. Role of information in the adoption of best management practices for water quality improvement, *Agricultural Economics*, 11, 159–170.

Girgerenzer, G. and R. Selten, 2001. Rethinking Rationality. In:Girgerenzer, G. and R. Selten (Eds.). *Bounded Rationality: The Adaptive Toolbox.* MIT Press, Cambridge, MA

Gustafson, A., S. Fleischer, and A. Joelsson, 1998. Decreased leaching and increased retention potential co-operative measures to reduce diffuse nitrogen load on a watershed level, *Water Science Technology*, 38(10), 181–189.

Hogarth, R., 1987. *Judgement and Choice*. John Wiley & Sons, New York.

Johnsson, H., M. Larsson, K. Mårtensson and M. Hoffman, 2002. SOILNDB: a decision support tool for assessing nitrogen leaching losses from arable land, *Environmental Modelling* & *Software*, 17, 505–517.

Kahneman, D., P. Slovic, and A. Tversky (Eds.), 1982. *Judgment under uncertainty: Heuristics and biases*. Cambridge University Press, UK.

Napier, T. and M. Tucker, 2001. Use of Soil and Water Protection Practices Among Farmers in Three Midwest Watersheds. *Environmental Management*, 27(2), 269–279.

Norton, N., T. Phipps, and J. Fletcher, 1994. Role of voluntary programs in agricultural nonpoint pollution policy. *Contemporary Economic Policy*, 12, 113–121.

Reichelderfer, K. H., 1989. Externalities and the returns to agricultural-research – discussion. *American Journal of Agricultural Economics*, 71(2): 464–465.

Setia, P. and R. Magleby, 1987. An economic analysis of agricultural nonpoint pollution control alternatives. *Journal of Soil and Water Conservation*, November-December, 427–431.

Simon, H. A., 1956. Rational choice and the structure of the environment, *Psychological Review*, 63, 129–138.

Wolf, A.T., 1995. Rural nonpoint source pollution control in Wisconsin: The limits of a voluntary program, *Water Resources Bulletin*, 31(6), 1009–1022.

Implementation of Strategic Planning to Local Consultants—FarmStrat by DAAC

Torben Ulf Larsen[a]

Abstract

A Danish approach to the implementation of strategic consultancy to Danish economic consultants is presented. The implementation activities are carried out by two employees from DAAC. The different strategic tools have been tested in a number of farm cases by local consultants during the recent years. The main target for the FarmStrat project is to implement strategic advisory to the Danish Consultants. This will be done in two levels:

- All consultants dealing with farmers must have some knowledge in order to reach the business goals. They need a general knowledge of strategic tools and how they can be used in the daily working process with the farmers regarding tax, accounting, pig production etc.
- Some of the consultants need at training programme in order to perform top-level strategic advisory service to farmers. They have to be the specialists of the centres with great knowledge of strategic tools and marketing.

This means that the strategic advisory process will be carried out at two levels by accordingly generalists and specialists at the local centres. The training programmes of FarmStrat for the two groups are different, and the programmes will be described.

Keywords: Strategic consultancy, Processes, Training programme, Two levels of strategic advisory service, Behavioural test.

[a] Danish Agricultural Advisory Centre, Aarhus. *TUL@lr.dk*

Introduction

The article presents a new approach for implementation of strategic consultancy to farm consultants. The primary aim of the research and development activities carried out was to develop practising consultants' learning abilities so that their strategic competences can continually be improved. In an agricultural environment of increasing complexity and continuous changes, it is presumed that business consultants need lifelong, self-organized learning in order to help farmers solving their changing strategic problems. Therefore, although the following presentation is based on intentions of a Danish training programme, the emphasis will be put on revealed development principles that are generally applicable in the search for improved strategic consultancy in agriculture.

Background and objectives

During the last two decades we have in Denmark been working with the development of strategic consultancy to business farmers. The first strategic project was initiated in 1984 by the Danish Institute of Agricultural and Fisheries Economics (SJFI now FOI, The Danish Research Institute of Food Economy) and carried out in cooperation with a local agricultural consultancy centre at the Island of Bornholm. This project, called the Bornholmsproject, was mainly based on a traditional long-term planning approach.

In the late eighties the Danish Agricultural Advisory Centre (DAAC) started to develop its own strategic consultancy tools to family farms. The first project was Modular Strategic Planning that was build up by a number of modules whereas the majority were considered optional (Christensen et al., 1990). In the nineties Modular Strategic Planning has been fundamentally changed by DAAC and systematically marketed to local consultancy centres situated all over in Denmark. In the later revisions major emphasis have been put on how to include the vision and overall objectives of the farm family into the strategic consultancy process and how to promote collaborative strategic work among local consultants.

Then, in 1996 FOI and DAAC decided to initiate a joint project in order to improve the delivery of strategic decision support to Danish farm managers. Due to the increasing deregulation of the Danish farm economy and the more widespread introduction of user payments in agricultural consultancy organisations, the overall objective of the project was stated as the development of more market oriented strategic decision support to practical farm managers. The most important mean to achieve this end has been the adoption of an action research approach as explained in the following sections.

The main problem is that many consultants still act as bookkeepers and not as strategic consultants. The strategic tools have been developed and tested but the implementation to the consultants needs to be improved. A very small amount of the turnover in the Danish advisory service can be related to strategic planning. More than 80 percent of the total turnover comes from bookkeeping and accounting work. The aim of the FarmStrat project is in short terms to increase the turnover with regard to strategic advisory service to the Danish farmers. This will be done at two levels: All consultants in the advisory service need increased knowledge with regard to strategic planning especially strategic tools. Some of the consultants have to be specialist with a high degree of competences in the field. The basis of the strategic planning in FarmStrat is

- Business sector analysis (markets, technology, legalisation etc.)
- Farm analysis
- The management capability of the farmer and his family

Business sector analysis. The span of time will typically be 20 to 30 years in making building investments. By making a business sector analysis the farmer and his consultant can consider the strategic developments in e.g. technology, market outlets and law regulations. Perhaps it is not possible to predict with any certainty, but the farmer and his consultant might ask "What if" questions.

Farm Analysis is the traditional evaluation of the production and economy of the farm. How will the investment fit into the overall vision and mission of the farmer and his family? What is the desirable future of the family? And which requirements in the environment will the farmer fulfil through his business activities? Through dialogue with the farm family the consultant may help to create a mental picture of the future position and posture of the farm business and the preferred way of farming life. These mission and vision matters are important in order to give the farmer appropriate advices.

The quantitative analyses consist of traditional investment calculations, break-even analyses for critical parameters and pay-back period, preparations of financial budgets, analysis of labor demand for the investment and so on. In the qualitative analyses the consultant is supposed to compare the alternatives with the farmer's values and stated objectives. SWOT-analyses seem to be very useful in making these evaluations. The evaluation also includes judgments of e.g. the expected market situation, environment rules and other legislation of agriculture that may affect the farmer's strategic actions. Furthermore, the evaluation should include considerations of the management skills of the farmer. In order to do all these evaluations the consultant needs not only skills to deal with financial matters and quantitative calculations but should also have competences to include the more qualitative strategic aspects.

When the farmer reveals a need or opportunity for some strategic changes of his farm business, he is expected to contact his economic consultant in order to discuss the actual possibilities. At the first meeting between the farmer and the economic consultant, which is supposed to take place on the farm, it is important that the consultant is well prepared and e.g. knows the budget, the financial situation and the efficiency level in production. Furthermore, the consultant has to take time to listened to the farmer's ideas and objectives and ask questions like why and how. The main purpose is to reflect on the farmer's strategic opportunities—which as examples could be increases in the production by investments in buildings, equipment and so on or that of selling the farm to the next generation. The farmer's expectations concerning prices, agricultural laws, the markets and employees must also be revealed at this first meeting. Furthermore, the main assumptions required for the quantitative analyses should be decided by the farmer in collaboration with his consultant.

Management. Is the farmer capable to manage the greater production volume? Can he get the right working force? Therefore, the farmer has to discuss management issues like salary, working load, organisation, division of responsibilities and social culture with his consultant in order to attract and keep the right people. In this connection a new tool is used. The Discover test reveals the behavioural patterns of the farmer and employees.

These subjects are the main ingredients in the training programmes at the two levels with respect to implementation.

Participants in the project

The established team group consists of one researcher from FOI, two economic consultants from DAAC and business consultants. Between FOI, DAAC and the business consultants there are major differences in the tasks performed, methods adopted, leadership, shared culture and behavioural norms and in underlying paradigms on how to understand the world. The business consultants have tools and experiences which may be useful for the agricultural consultants.

FOI is a research institute under the Ministry of Food, Agriculture and Fisheries. The aim of the institute is to carry out research and give advice on agricultural and fisheries economics from a society as well as a firm business point of view.

DAAC belongs under the Danish Farmers' Union and the Danish Family Farmers' Association. The primary task of DAAC is to communicate professional know-how to the local consultancy centres that are working directly with individual farmers. The local consultancy centres are owned by local farmers' unions and/or family farmers' associations. By this organisational structure a close contact to the farmers should be ensured. The consulting services delivered to the individual farmers are handled by specialized consultants each covering one specific field, e.g. plant production, cattle husbandry, farm economics and management.

The reason for cooperating with business consultants outside the agricultural sector with competences in marketing, behavioural tests and implementation is to reveal some new aspects in these fields. Furthermore the business consultants have more skills and experiences with regard to marketing and management and how to implement to the organisation.

Implementation to all consultants

Regarding the implementation of the strategic way of thinking to all consultants in one consultancy unit (the Danish advisory system consists of two layers: A central staff organisation located in Aarhus with 500 employees and about 60 local advisory centres with between 25 to 250 employees who have the contact with farmers), DAAC cooperate in developing the training programme with a centre with a staff of 50 consultants. The programme has been made by the chief consultants and the participants mentioned earlier.

The process for the consultants consists of two modules the first lasting two days and the second one day. Between the two modules the consultants are committed to use the strategic concepts in the daily work in connection with at least two farmers and to make short report about their experiences. The goal for the whole organisation is that 75 percent of the farmers have to be contacted in 2003. During this contact the farmers have to formulate at least mission and vision for the farm and the family and maybe a SWOT-analysis. If the consultants estimate that there is a need for further strategic consultancy (investment, generational change etc.) at a high level he will contact one of the strategic specialist in the organization who then will deal with the farmer.

The content of the first module is as follows:

- Strategic theory
- Examples from non-agricultural branches
- Strategic tools especially developed to farmers
- Behavioural theory and praxis
- Decision making
- Marketing
- Question technique
- Guidelines for making two reports where the tools are used in the daily work during the training programme.

The content of the second modules is discussing the experiences and reports and formulating goals for the year 2003. The employees are committed to the goals through the year.

Implementation to specialized consultants

A small number of the consultants will be educated to specialized strategic consultants. This training programme will last 4 weeks in one year and consultants from different local centres are educated together. The first group of 8 consultants have started their education in Denmark. The education takes place at different locations in Denmark and for one week abroad.

The training programme consists of 5 modules as follows:

- The participating consultant and his chief consultant are invited to a meeting where the goals and the content of the programme are presented. Furthermore it is stressed that the expectations to the consultant are to increase the sale of strategic advisory service. This means that he has to have time and resources to market and carry through the processes during and after the programme.
- Strategic theory and praxis with emphasis on the branch analysis, the farm and the human resources. The Discover Test is used to reveal the consultants behav-

iour in a consultancy situation. The Discover test reveals four aspects of the consultants behaviour:

- Dominance
- Interpersonal capabilities
- Stability
- Competences

More about this test can be seen at www.discover-dk.com. This module also includes visits on different industrial firms in Denmark. It is carried through by an external business consultant.

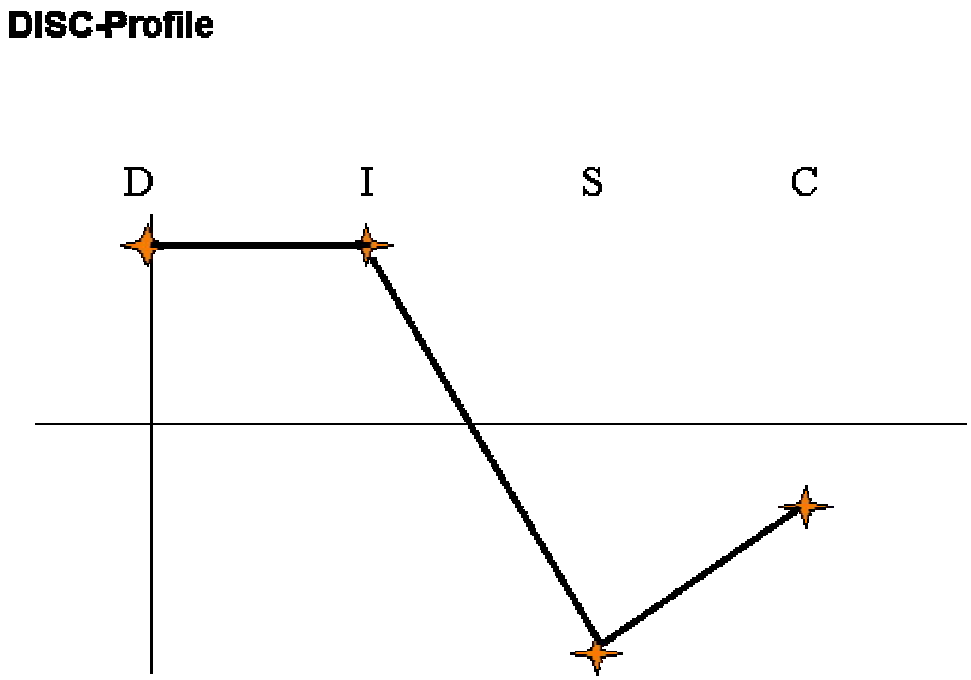

Figure 1 An example of a DISC-Profile

- The participants have to go abroad for one week to practise their skills in a foreign country in cooperation with native consultant. This module is supposed to give the consultants a broader view of the strategic way of thinking.
- Before this module the consultants have to find 3 farmers each who are willing to pay the normal price for a strategic plan for their farms. The farmers participate in the module and during this the consultants have to make strategic plans to the farmers including a Discover test of the farmers.
- In this module the consultants learn how to sell the strategic consultancy to farmers. An external business consultant does the programme. Furthermore they learn how to sell the strategic way of thinking to their colleges at home.

- The last module is a follow up course where experiences are shared with the other participants. Supervision will take place in order to improve the quality of the strategic consultancy.

Coaching of the chief consultant follows each module.

Conclusion and perspectives

During the recent years several strategic tools have been developed with regard to consultancy to farmers. Many of these are relevant to the practical strategic process. But still the strategic consultancy in Denmark is less than the estimated demand from the farmers. The implementation of the strategic way of thinking to the consultants and the agricultural organizations must be improved in order to satisfy the demand. In FarmStrat the implementation takes place in to levels. All consultants must have basic knowledge of strategy methods and processes. Some of the consultants must be trained so they can develop to professional strategic consultants who are capable to deal with all strategic aspects demanded by the farmers. This means a more intense training programme for these consultants. Furthermore in FarmStrat the behaviour as a manager is a part of the strategic planning involving a behavioural test of the farmer by using the Discover test.

One of the local centres will finish the process of implementing the strategy way of thinking to the whole organization at a general level late October 2002. 8 consultants have started to become high-level consultants with regard to strategy at the intensive programme the 16th of September.

References

Lund, M., 1999. *Rådgivning i strategisk planlægning inden for landbruget (Strategic Consultation in agriculture)*, report no. 94, Danish Institute of Agricultural and Fisheries Economics.

Lund, M. & T. U. Larsen, 2002. Development of strategic consultancy to farm managers: Experiences from an action research approach. *Farm Management Vol. 11 No. 6 pp.409–423.*

Pedersen, D. E. & B. H. Jacobsen, 2001. *Erfaringer med udvikling af strategiske beslutningsgrundlag til landmænd (Experiences with development of strategic decision support to farmers)*. Report published in cooperation between the Danish Institute of Agricultural and Fisheries Economics and The Danish Advisory Service.

At DAAC there will be an updated website (www.lr.dk/farmstrat) containing a complete description of the project and it's content. On this website it will also be possible to download all the developed strategic tools and written documents.

Supervision as a Tool for Developing the Competences of Farm Management Advisers

Morten Sejersen[a]

Abstract

In the presentation an overview of the in service training of farm management advisers in Denmark is given. The change from standard courses toward a more flexible competence development is described and discussed. Examples such as expert groups and supervision are presented in more detail. Examples from advisory sessions are demonstrated, the different tools used in the supervision process presented and the further development is discussed.

Keywords: Farm management advisors, Service training, Competence development, Supervision

[a] The Danish Agricultural Advisory Centre, Udkaersvej 15, Skejby, DK-8200 Aarhus N, *mos@lr.dk*

Framework for competence development

The advisory service in Denmark is organized by the farmers own organizations.

In total we have more than 600 farm management and tax advisers and technicians and more than 1,200 assistants or clerks in the advisory service. We make tax accounts for 45,000 farmers and farm accounts for 26,.000 farmers. We have more than 80% of the market in tax accounts for farmers.

The in service training is organized by the Danish Agricultural Advisory Centre (DAAC), the Departments of Farm Management and Accounting and the Department of Education.

History and quantity

The traditional in service training was carried out in courses of 3 to 5 days. The subjects were mainly professional such as information on new tax laws, budgeting etc.

The number of "participant days" meaning one person participating in competence development for one day totals more than 6,000 for advisers and technicians.

General trends

The general trends in the in service training can be summarized as follows:

- From one week courses towards shorter (1–3 days) courses or longer courses in modules
- From courses on the in service training centers toward local courses.
- More focus on advising methodology
- More focus on individual competence development planning,

These trends mirror the trends in the advisory service as such where the focus shifts from service (farm secretaries) and transfer of expert knowledge toward advice and sparring.

Expert groups

This year we have introduced the concept of expert groups. This concept urges the expert advisers to take responsibility for their own competence development. Advisers from DAAC participate in the groups, but have mainly a practical or secretarial function. The participant from DAAC is the national expert on the topic.

On the first meeting in the group, the participants plan the following steps answering questions like:

- Do we need a course at all?
- If we do, what should be the topics?
- When, where and for how long?
- Etc.

The experts also discuss other possible ways to develop their competences. It could be creating expert networks or a more committing cooperation.

So far we have started two expert groups.

Supervision as a tool for developing the competences of advisers

During the last four years supervision has systematically been introduced as a tool to develop the methodic and professional competences of Danish advisers. The results so far have been very positive.

Originally, the supervision was carried out by two advisers from the Danish Agricultural Advisory Centre (DAAC), the central advisory centre in Denmark, one from the Department of Education, one from the Department of Farm management (myself). We monitored local advisers (mainly farm management and tax advisers) in their advisory processes with farmers. The advisory processes were on presentation of farm and tax accounts to farmers, investment planning, service checks etc. We gave feedback to the local advisers and discussed the possible improvements and initiatives. The advisers, who are used to work alone almost always, in general responded very positive to the potentially very frightening experience of having an external person watching them on the job.

The conclusions are—put very broadly—that the advisers are always met with great confidence by the farmers, in general the advisers are professionally competent, but quite often they could improve their advisory methodology. In general, the advisers have (too) much focus on their expertise area and regularly loose the farmer´s attention in the advisory process.

Currently, supervision among colleagues is introduced. This enables many more advisers to have the benefits of supervision but also presents new problems: It is important that the supervisor has the trust and respect of his colleagues in order to implement supervision among colleagues on the advisory centres.

Defining supervision

Supervision is

- supporting and developing
- based on a contract
- aiming at professional and methodological development

- disturbing, intruding
- consisting of a contract, feedback and a new contract

The supervision process

The supervision process consists of:

- Agreeing on the contract
- Advisory session
- Feedback
- Discussing possible developments
- Agreeing on a new contract

Examples from advisory sessions

Finally I would like to give a few examples of our experiences. The examples are based on presentations of farm and tax accounts—the moment of truth.

It´s difficult to:

- prepare the session, analyze the account and find two-three key issues
- send an agenda to the farmer before the meeting
- ask the farmer, if he has issues for the agenda
- ask for acceptance of the agenda
- set up a detailed time framework and have acceptance from the farmer

It´s difficult to:

- concentrate on the key issues and refrain from going through the account from end to end
- listen to the farmer
- be direct on the issues
- make estimated calculations

It´s difficult to:

- keep the time framework
- conclude on the sessions
- evaluate the session

Conclusions

The change in competence development from standardized courses toward individual development with tools like supervision has increased the impact of improving particularly the methodological part of the advisory profession.

AGRIWISE—A Tool for Farmer Advisors and the University

Bo Öhlmér[a]

Abstract

In the current information age, data are entered into one system, printed out, included in new information material, and manually entered into another system. The aim is to develop a decision support system, named Agriwise; a database and connected decision support applications available at Internet, where different actors' sources of information are structured and labeled in such a way that data can be collected in an automated or semi-automated way, and output reports can be individually designed.

Such an organization has been developed including a database and two tools, enterprise budgets and a business plan. Users are (2001-12-31):

- LRF, i.e. the Farmer Federation, that links the product for free to its farmer members, of which 69 000 have Internet connections;
- LRF Konsult, i.e. the farmer consultancy company of LRF, that has 1 200 employees;
- Föreningssparbanken, a large Swedish bank with farmers as one of their target groups;
- SLU, the Swedish University of Agricultural Sciences;
- 25 additional organizations with a simpler form of subscription.

Using the product leads to a standardization of concepts and calculation methods, and to source labeling of the users' data. LRF aims at providing its farmer members a good decision support system. LRF Konsult aims at facilitating its consultancy service. Föreningssparbanken wants to standardize farmers' investment calculations included in loan applications, but also to facilitate its advisory service. SLU uses Agriwise as a tool for communicating research results to the agricultural sector and for teaching and research.

Keywords: Advisory, Decision Support System, IT, Research information

[a] Department of Economics, SLU, P.O. Box 7013, 750 07 UPPSALA, Sweden, *Bo.Ohlmer@ekon.slu.se*

Introduction

Background—the problem

In the current information age, data are entered into one system, printed out, included in new information material, and manually entered into another system. This means:

- Double the work and risk of typing errors, which leads to additional revising;
- Lacking current information in the latter part of the information chain, i.e. at the end user, which may lead to inferior decisions or teaching;
- The user has to collect data from many sources and synthesize them into an entirety, which takes time that may not be available.

For many years Swedish University of Agricultural Sciences (SLU) has produced a "Data book" for farm planning and regional enterprise budgets in agriculture in printed versions. The most recent printed version of the "data book" was produced in 1996 (Databok för driftsplanering, 1996). It was used for financial budgeting and planning in agriculture and for environmental management purposes. The data book includes data for prices, yields and costs within different production enterprises in agriculture, horticulture and forestry. Different sections treat issues regarding labor requirements, energy, machinery, capital and insurance. In addition there are sections on ecological production, storage and regulations as well as subsidies. The most recent data book includes 600 "tables" divided into 24 sections. Targeted users were:

- Farmers
- Advisors
- Insurance companies
- Analysts and researchers
- Authorities
- Schools

Regional enterprise budgets contain estimations of incomes, variable costs and the margin between them. The budgets are developed for various geographical regions, production processes, input-input combinations and intensity levels. These regional enterprise budgets are to a large extent built upon data in the data book for farm planning. The latest printed version of the regional enterprise budgets for agriculture was produced in 1995 (Områdeskalkyler för Jordbruk, 1995). LRF (National Farmers Association), some county agriculture units, some agricultural societies and the Meat Marketing Association produced similar budgets. These were also based, amongst other things, on the data book for farm planning. Regional enterprise budgets are used in part for production planning of farms, as well as for information on investments and yields in different production enterprises, and for approximate comparisons of profitability and resource use in different production options. The enterprise budgets are also used in teaching.

Computers are now used for financial budgeting and planning. Therefore the data for these calculations should be accessible via computer media rather than as a printed book and manual data entry. Similarly, the calculation models for enterprise budgets should be available directly to one's own personal computer without manual input. The use of computers in this regard also makes the collection of data to the database more efficient. Updating information could then be decentralized so that experts in different fields would be responsible for the tables within their respective fields.

Aim

The aim of the project described in this paper is to develop a common view and knowledge about the need and possibilities of developing a system for synthesizing and distributing information based on many sources. The aim is in more concrete terms to develop a database and connected decision support applications available at Internet, where different actors' sources of information are structured and labeled in such a way that data can be collected in an automated or semi-automated way, and output reports can be individually designed. This decision support system is named Agriwise.

Method

Close interactions with the users were established early in the development process in order to focus on the users, to facilitate to meet the users' needs, and to get the users to feel responsible for the end product and be committed and motivated to use it. A reference group for consultation on the content and presentation on the Internet was thus formed at the project start. The reference group consists of representatives of the users. A prototype was developed in the first project year and it has been in use since 1998.

Excel is a very well known spreadsheet program, which has become a standard. A user should easily be able to utilize the information from the database and calculation model from the enterprise budgets in Excel sheets. Data, explanatory text and calculation models are presented in Word and Excel. This is converted to HTML-coding and is available to users in HTML as well as in Word and Excel versions. A prototype for this has been developed. The prototype is accessible on the Internet.

In a first step the database has been restructured and updated. Following this, information was incorporated in the Internet version. Data was gathered from organizations that have contributed to the data book previously. These were departments within the Swedish University of Agricultural Sciences (SLU), agricultural cooperatives (ODAL, Farmek, SHS etc.), authorities (SJV), firms (Danisco, Svalöv-Weibull, etc.) and ARBIO.

Need of information in decision making—a literature review

Many scientists have categorized human behavior. Jung's typification in four psychological functions: feeling, intuition, thinking and sensation, and two main attitudes: extroversion and introversion (Sharp, 1994), is perhaps most famous. Öhlmér et al., (2001) have distinguished two categories of decision making processes, one analytical and one intuitive. The categories are not separate groups, but endpoints in an interval.

In the analytical process, the issue is decomposed into known and manageable parts. Each part is analyzed separately, and the conclusions of each part are summarized into a solution for the entire issue. Information like accounting data is most often transformed to key indicators, such as solidity, rentability, liquidity etc., before comparison to expectations. In the intuitive process, the entirety is judged. The decision maker recognizes similar situations from own or others' experiences and the differences are compared to his current situation. On this basis and with some additional information about the entirety, he judges how to solve the current issue (Öhlmér et al., 2001).

Decisions can be divided into unique and repetitive decisions. Unique decisions are made only once, concerning for instance a large investment. Öhlmér et al. (1998) define unique decisions as "those decisions, which have not been faced before by the decision maker; usually unique decisions are strategic, but they could be operational". The unique decisions often concern major considerations with substantial economic consequences. They are one-time decisions, which do not return. The problem situation is often new for the decision maker, which makes it difficult to find action alternatives, learn and evaluate the consequences. The long planning horizon also makes information more uncertain. The whole situation of the manager is affected, which makes it difficult to weight the consequences and value dimensions together to one measure. The level of probable deviation from the expected value is often very high and so is the outcome level. Since the decision is only made once, the outcome of the single decision becomes very important. The manager must be sure that the business can manage a not too unlikely negative deviation from expected value.

Repetitive decisions are decisions that are made several times, and consequently, have been faced before by the decision maker, probably concerning a smaller matter. For repetitive decisions the problem situation, alternatives and consequences are relatively well known, since the decisions are made recurrently. Only a few of the goals are affected and the consequences could usually be weighted to one measure, such as profit. The level of probable deviation from the expected value is mostly acceptable. Since the same decision is made recurrently during a longer period of time, it's more interesting to get as good result as possible for a series of decisions in a longer period, than in a single decision. For repetitive decisions the normative micro economic theory is applicable. This is, however, not the case for unique decisions.

Orasanu and Connolly (1993) claim that most research on decision making has focused on the decision event, not the process. Johnson (1987) argues that the concept of expected utility has been emphasized to the neglect of other aspects of optimization, such as problem definition, learning, analysis, other decision making rules, etc. (In this context, the concept of problem includes opportunities.) While the decision event is critical to good decisions, it is limited in scope. The full decision model also includes: assessment of the situation, context and nature of the problem; sequential evaluation of single options rather than a range of options; evaluation done through mental simulation of outcomes; and options accepted if they are found satisfactory rather than optimal (Orasanu and Connolly). Dynamic, real-time decision making is more accurately described as "a matter of directing and maintaining the continuous flow of behavior toward some set of goals rather than as a set of discrete episodes involving choice dilemmas" (Brehmer, 1990, p. 26).

Managers' decision making is mostly viewed as a series of linear steps. Johnson et al. (1961) identify six steps of decision making: problem definition, observation, analysis, decision, action and responsibility bearing. A standard section in most management texts is a list of five to eight decision making steps (Bradford and Johnson, 1953; Castle et al., 1972; Boehlje and Eidman, 1984; Castle et al., 1987; Kay and Edwards, 1994). The decision making process has been studied in more detail in a Swedish research program (Öhlmér, Brehmer and Olson, 1997; Öhlmér, Olson, and Brehmer, 1998; Öhlmér, 1998). They identified four separate functions (but not steps) of decision making (Table 1):

- Problem detection, resulting in detection of a problem or not;
- Problem definition, resulting in choice of options for further development;
- Analysis and choice, resulting in choice of one or more options;
- Implementation, resulting in output consequences and responsibility bearing.

Each function consists of four subprocesses:

- Searching information and paying attention to relevant information;
- Planning and forecasting consequences of the new information;
- Evaluating consequences and choosing alternative;
- Bearing responsibility of the choice.

At this level of detail we can see that search for and paying attention to information is included as a subprocess in all the functions. The information is used for estimating consequences and evaluating them. In problem detection, consequences of differences between expected and observed information are forecasted. In the other functions, consequences refer to broad consequences of option ideas, more detailed consequences of an option, and consequences of differences in planned and forecasted outcomes, respectively. The managers needed different information in the different functions of the decision making process.

Table 1 Conceptual model of the decision making process (Ohlmer et al., 1998)

Function	Subprocess Searching & paying attention	Planning & forecasting	Evaluating & choosing	Bearing responsi-bility
Problem detection	Information scanning; paying attention	Forecasting consequences	Consequence evaluation; problem?	Checking the choice
Problem definition	Information search; finding options	Forecasting consequences	Consequence evaluation; choice of option to study	Checking the choice
Analysis & choice	Information search	Planning & forecasting consequences	Consequence evaluation; choice of option	Checking the choice
Imple-mentation or action	Information search; Clues to outcomes	Forecasting outcomes and consequences	Consequence evaluation; choice of corrective action(s)	Bearing responsibility for final outcome; feed forward information

Johnson et al. (1961) studied farmers' information collecting, but they made no distinction between information collecting in different steps. Instead, observation was a step of its own. Furthermore, they did not distinguish between unique and repetitive decision making. They defined the following different knowledge situations (ibid p. 44–45, 52–53):

- Subjective certainty; present knowledge is considered as adequate for either a positive or negative decision.
- Risk action; present knowledge is considered as adequate for either a positive or negative decision, or the cost of additional information as equal to its value.
- Voluntary learning; present knowledge is considered as inadequate for a decision, and the cost of acquiring more information as less than its value.
- Involuntary learning; present knowledge is considered as inadequate for a decision, and the cost of acquiring more information as exceeding its value, but some outside force makes it necessary for the farmer to learn.
- Inaction; present knowledge is considered as inadequate for a decision, and the cost of additional information as exceeding its value.
- Forced action; present knowledge is considered as inadequate for a decision, but some outside force makes it necessary for the farmer to act.

In problem detection (see Table 1), the information collecting is a broad scanning procedure in which the farmer compares his perceptions about what is happening in the farm and the external environment with his expectations. The knowledge situations listed are not applicable until the farmer detects a problem, such as an opportunity to improve goal fulfillment by converting to organic production, or that an expected result is not achieved. So, these knowledge situations are applicable only in the analysis and choice phase of the decision making process. The value of additional observation may be increased by a more relevant content and design of the information, which may cause a farmer to move from inaction, or a negative choice, to voluntary learning or even positive risk action. Johnson et al. (1961, p. 57) studied farmers' information collecting in a machinery purchase decision. Such a decision is made several times and has the character of a repetitive decision affecting just a part of the farm. However, if it regards a major piece of machinery, such as a combine, it may have some similarities with a unique decision. They found that new information was obtained in at least 53% of the cases. Sixty percent of these obtained price information, 30 percent production information and 25 percent information about the human element. The primary sources of new information were neighbors or relatives other than the immediate family (46%) and dealers and salesmen (6%). The source of new information was not ascertained in about 40 percent of the cases. It is possible that mass media were the source of information in a large proportion of these latter cases (Johnson et al., 1961, p. 57).

Öhlmer et al. (1997) and Öhlmér (1998) studied farmers' problem detection and problem definition, respectively, in relation to deregulation of Swedish agricultural markets and EU-membership, which changed agricultural product prices 20–30% and the institutional environment. This was a unique problem not faced before and it affected the entire farm situation. Data collected with a retrospective questionnaire answered by 193 farmers (equal to 62% approved responses) were analyzed in systems of structural equations estimated with the aid of path analysis and the Maximum Likelihood estimator. They found that the problem detection process of analytical farmers was different from that of intuitive farmers. The analytical farmers had a logic, stepwise procedure, in which they: (1) paid attention to changes in relevant conditions, (2) estimated the consequences of the perceived changes, and (3) evaluated if the consequences would be a problem.

The intuitive farmers did not use these steps, but paid attention to information about the magnitude of the problem directly from the external information source. Information in mass media, advisory activities, management service and management tools were quantitative, and designed for a logic stepwise procedure of problem detection. Only 25% belonged to the analytical category of farmers that used this procedure. The intuitive farmers regarded quantifications and information about the intermediate steps as unnecessary details and theories without practical value. They needed information focusing on the evaluation of the problem and describing the changes in terms of directions from current conditions. The analytical farmers used mainly mass media and group activities as information sources, and the intuitive mainly group activities and individual advisory service. Mass media had a lot of information about the changes at an early stage.

The environment external to the farm was important for the intuitive farmers' problem detection. The environment was measured as the distance to the closest town. The consultants and the advisory service have their offices in towns. Farmers' suppliers and organizations have also their offices in towns. Workshops, seminars, demonstrations and similar activities are more often arranged in the towns than in areas more far from towns. It was easier to get individual advice in the towns or close to towns, and it was easier to establish a rich personal network closer to the towns. Analytical farmers seemed to be more independent of the distance.

Regarding problem definition, they found that providing farmers with more processed information in the form of, e.g., advisory service, induces them to find greater option consequences. However, more information did not seem to improve the creativity in the option generation. The level of creativity was dependent of problem magnitude, ability, degree of quantification and motivation. These factors were related to the ability to perceive and attend. These factors were, thus, more important than the amount of information for option generation.

Farmers' ability had a great influence on the problem detection as well as problem definition of both analytical and intuitive farmers. Avoidance had a great influence on both analytical and intuitive farmers' problem detection. A farmer, who had another problem such as a divorce or an economic problem, did not like to read about, listen to or discuss more problems.

Bergkvist et al. (2002) studied farmers' information search in strategic decision making, especially in the analysis and choice phase. Whether converting milk production to organic was used as a case to learn more about farmers' decision making and search of information. A questionnaire was sent to 868 organic and conventional producers. Data was analyzed descriptively and by bivariate regression with the aid of path analysis. They showed that the information about converting to organic farming received by the managers was not adapted to their special needs. The information was not always adequate to make the decision. Some of it could not be considered as information because it did not properly relate to the manager's knowledge. Most farmers used an intuitive process in strategic decision making, but the information was developed for the analytical process.

Farmers convert their milk production to organic production by either ideological or profitability reasons, or both. The profitability reason has become more common the last years, and they are now more important than ideological reasons at least among analytical farmers. Farmers need information about current and future profitability in organic production, apart from its effect on the environment. Analytical farmers are interested in direct economic factors such as future demand, rules, and support levels. Intuitive farmers are more interested in production factors that have an indirect effect on profitability such as production technology and delivery rules. Important sources are professional journals, advisors (individual service as well as courses), and neighbors. Mass media does not contain so much information about organic production, and consequently its ranking is low. (However, studies of other problems discussed in mass media show that also mass media can be an important source as noted above.) Analytical farmers need detailed information and figures about the various subprocesses, incomes and costs. Intuitive farmers need more qualitative information related to their current production or a model farm, such as change in production levels, input levels and profitability if they convert. Advisors could direct their efforts to analytical farmers to get early adopters who could serve as model farms. Advisors could refer to these model farms both in direct advisory service directed to intuitive farmers and when writing articles for professional journals.

Decision making situations or information search by an advisor or a farmer can be exemplified by the following (Öhlmér, 2002; Öhlmér and Nott, 1979):

1. Forecast the development of prices, support levels, and technology;
2. Find ideas about new market or production options;
3. Start a new production enterprise;
4. Increase or decrease production;
5. Investment (such as in acreage, buildings, machinery, other new technology etc.);
6. Performance control (e.g. bench marks) of both quality, quantity and profitability;
7. Budget forecast;
8. Valuation of entire farms, acreage, buildings or enterprises;
9. Financing;
10. Input-input and input-output choices, i.e. intensity, resource use, and input combination. Examples are fertilization, crop protection, machinery system, cropping system and the best use of excess capacity.

Interviews of Agriwise users (Öhlmér, Flodin and Karlsson, 2002, chapter 5 and appendix 2) show that the target group wants information specially developed for each decision making or information search situation and that this information should cover the entire information need in this situation. The users want a synthesis based on information from different disciplines, where the synthesis is developed for just this situation. If possible, a button for a specific situation, but they want also a search engine that is easy to use, and an option to produce information tables of their own. One example is deciding whether convert to organic milk production, where you need information about organic production of roughage, pasture, milk and heifers as well as the market and support information and budgets for the enterprise and the entire farm. The budgets are syntheses of the other listed information. The analytic farmers can do with information about the estimated incomes and costs in the new situation, but when advising intuitive farmers the advisor has to analyze also the current situation (i.e. the farmer's reference point) and discuss how it will change.

Every kind of situation 1–10 can be further divided in many specific use situations that together form all the farmers' decision making in the short and long run. Research results in most of the SLU's applied disciplines are involved.

Result – Agriwise

Business idea and target group

"We will communicate, through Internet, knowledge and experiences from research at SLU and its partners, and add other relevant information and application software, so our users perceive that they get a complete, current and correct basis for analysis and decision making in the short and long run within agriculture and supplementary businesses."

The concepts have the following meanings:

- *"Communicate knowledge and experiences"* means that we collect and structure information. We compile research results from different areas, i.e. synthesize, and simplify planning models and similar to models and methods relevant for practical use. Often, information had to be redesigned to be suitable for decision making in practice.
- *"From research at SLU and its partners"*. The SLU experts and their partners in various areas develop the information, in the first place. These experts have research of their own and follow the foreign research in their area.
- *"Add other relevant information and application software…(to) a complete …basis"*. To get a complete information basis, information is collected also from the market, e.g. prices. The user should only add what is specific for the planning situation.
- *"Current…basis"* means the most current information available. The production period is from a few months to several years, so time dependent information had to be valid for specific points of the production cycle. For example, the piglet has to be bought around four months before the fattening pig is slaughted, so the prices have to be valid for the corresponding points in time.
- *"Correct basis"* means information without errors.
- *"Basis"* means that the information is a basis for own planning and decision making. The information should be possible to use directly in the own computer.
- *"Application software"* means relevant tools for own planning and decision making.
- *"Our users"* are firms and other organizations that have farmers and similar as customers or suppliers. Our users' customers may use Agriwise on their own.
- *"Our users perceive"* means that it is important how our users perceive our services.
- *"Decision making in the short…run"*. Examples within crop production are fertilization, liming, choosing crops, choosing varieties, crop protection etc.

- *"Decision making in the…long run"*. Examples are investments in machinery, buildings, acreage and entire farms, or bigger changes in the output mix, production technology or farm organization.

The target group consists of firms and other organizations that have farmers, horticultural firms, foresters, sport horse owners and similar as customer, supplier or other business partner. The target group includes also organizations that use agricultural information in teaching, research development and investigations.

Agriwise's current supply of information

Agriwise has the following systems, application software and services:

- *Database for farm planning* (corresponds to the former Data book), which is a collection of agricultural data (around 600 tables) useful for farm planning and decision making.
- *Regional enterprise budgets*, which are models for estimating incomes, costs, and gross margins of farm enterprises in different geographical regions (around 600 budgets). Data from the database are used, but data describing the specific situation should be added if available.
- *Business plan*, which is a model that combines relevant enterprise budgets, adds common costs and develops a farm business plan including profit and loss statement, balance sheet, feed balance and balance of intermediate products and similar.
- *Courses and investigations*; Courses about farm planning can be given to the target group. The target group can engage Agriwise for investigations or development tasks within the subject.

Referring to the ten decision making or information search situations, exemplified previously, the database covers situation 2–9. The regional enterprise budgets are more tailor-made and cover situation 2–8. The farm business plan is still more tailor-made and covers situation 3–5 and 7–9. Agriwise doesn't cover situation 1, forecasting prices, support levels, and new technology where you need to scan the development in the surrounding world, nor situation 10, choice of intensity, resource use and input combination (e.g. feed planning) where you need more detailed biological and technical information.

Users' experiences

Users' experiences of Agriwise database and enterprise budgets have been investigated with a questionnaire sent out by Agriwise, and by interviews made by independent evaluators (Öhlmér et al., 2002). The users said it was technical and logical simple to use both the database and the enterprise budgets. It was a little easier logically to use the enterprise budgets. See Table 2. They regarded both the database and the enterprise budgets to be very useful, and that the enterprise budgets were the most useful.

Table 2 User experiences of Agriwise

	Database	Enterprise budgets
Logical difficulty in using	Easy	Easier
Technical difficulty in using	Easy	Easy
Type of content	Data	Data Calculations
Usefulness	Useful	More useful
Competing information sources	Journals Personal network	Journals Personal network

They said that using Agriwise was worth the cost for it. Some said that there was competing information and other that there was not. Competing information could be provided through journals and personal contacts. Answering a question about hindrances for using Agriwise, the users listed: data too old, irrelevant data, and technical difficulties.

The user experiences are collected from only seven users, so the conclusions can only be in the form of hypotheses for further testing.

Increasing managers' use of DSS means changing their behavior. Increasing the driving forces or reducing the restraining forces can bring about such change. The latter approach is often more fruitful and should have higher priority, because to increase driving forces without attention to restraining forces may increase pressure and tension between the users and the DSS suppliers (compare Kast and Rosenzweig, 1985, p. 637)

Data too old

The users indicated that the data and information should not be too old. However, each updating of data costs a lot, so the frequency of updating should be exactly what is needed, neither less nor more. Data used for analysis of problems within the year may need to be updated several times per year, but in long run decision making it may be enough with data describing the development over years, so such data could be updated just once a year.

Relevant data and information?

In a perfect world, researchers could foresee future information need and have relevant information available when needed. The world is not perfect so we need a system to catch the users' signals about information that is needed but not found.

Such a system means a channel from the users to the university that could affect the research.

Another aspect is that the data and information should be valid for the specific farm to be relevant, which means that they should be as local as possible, such as possible to adapt to local conditions in the form of soil type, climate, etc.

Which form of data and information?

The users regard the enterprise budgets as easier to use technically and logically than the database. It is easy to use one of the database tables, but the data is fragmentary meaning that you have to use many data tables to get the same information as from one enterprise budget. It is easier if all information needed in a specific situation is presented in one report. So, use situations should be identified, and information generators developed for each situation. The user should be offered a menu of use situations. The generator should produce a presentation of relevant information sorted out from the database, such as reference material for efficiency analysis of a fattening pig batch. It could also be more advanced processing of the database information, such as enterprise budgeting, investment calculation, farm organization planning or feed planning.

Which concepts for presenting data and information?

Given the limited processing ability of the human being, it is natural to define a reference (or anchoring) point and think in terms of differences from this reference point (Hogarth, 1987; Orasanu and Conolly, 1993). When analyzing a farm, the current conditions, organization, and achievements are the reference points. The Agriwise users evaluated the change actions in terms of comparing the forecasted consequences to the current achievements. So, such differences should be presented to the users, preferably in terms of fulfillment of relevant goals.

Taking enterprise budgets as an example, they should be calculated for both the current situation and the situation after the change action, which can be done with the existing application. Then these two situations should be compared and the differences presented, which could be done with a new application. A synthesis at this level is especially important if the advisor/consultant using Agriwise should present the information for an intuitive decision maker (Öhlmér, 2001).

The application for farm business planning is presenting the planned farm results in the form of a profit and loss statement, a financial statement and key indicators, which can be compared to corresponding information from the current business.

Users' experiences summarized

The users' experiences could be summarized in the following hypotheses:

- The frequency of updating the database should be exactly what is needed, neither less nor more;
- A system to catch user signals on lacking data and information should be included;

- The data should be as specific as possible, i.e., valid for a specific farm if possible.
- The most common use situations should be identified and information generators developed for each;
- Information about change actions should be presented as differences from current operations and achievements.

Technical solution

A prototype of the system was developed in the first half year of the project (1998) to be able to deliver information and services to users and by that get users to interact in the development process. The database prototype was based on static HTML-pages, and the enterprise budgets were generated manually. The farm business plan used the generated enterprise budgets, and they could be adjusted with local data. Data collecting and entering in the database was made manually. The prototype is not further described in this paper.

System structure

Figure 1 illustrates the system structure. The dotted lines mark the limits between Agriwise and the systems of the user and data provider. The information provider reuses the Servlet Generator, so it is represented in both the Agriwise and the information provider system.

The database

The database consists of around 600 tables, which is an unusually high number for a database. We are using an Oracle database system. The database is tested and the data stored in the prototype are currently being entered in the database. Eriksson and Martinsson (1999) have developed components for retrieval and validation of data (Servlet Generator and Servlet Parser, Figure 1).

Data are stored in a central database despite that it means storing the data in two locations. In a distributed solution, just the data providers store data. Our motives for the central database are that:

- Farm production processes use a long time period, which means that the dates of various input and output are related to each other, so the prices and quantities have to be valid for these dates. This is complex to handle in a distributed solution.
- When data collected from several sources are put together into an entirety, calculations may be needed, such as feed planning or optimizing machinery systems, and the user may ask questions about the entirety.
- The user wants to use the same data in repeated calculations, so announced updates are needed, with specific version numbers of each edition, rather than the most recent figure.
- The user wants an impartial quality control of data, so the data had to be checked and approved.

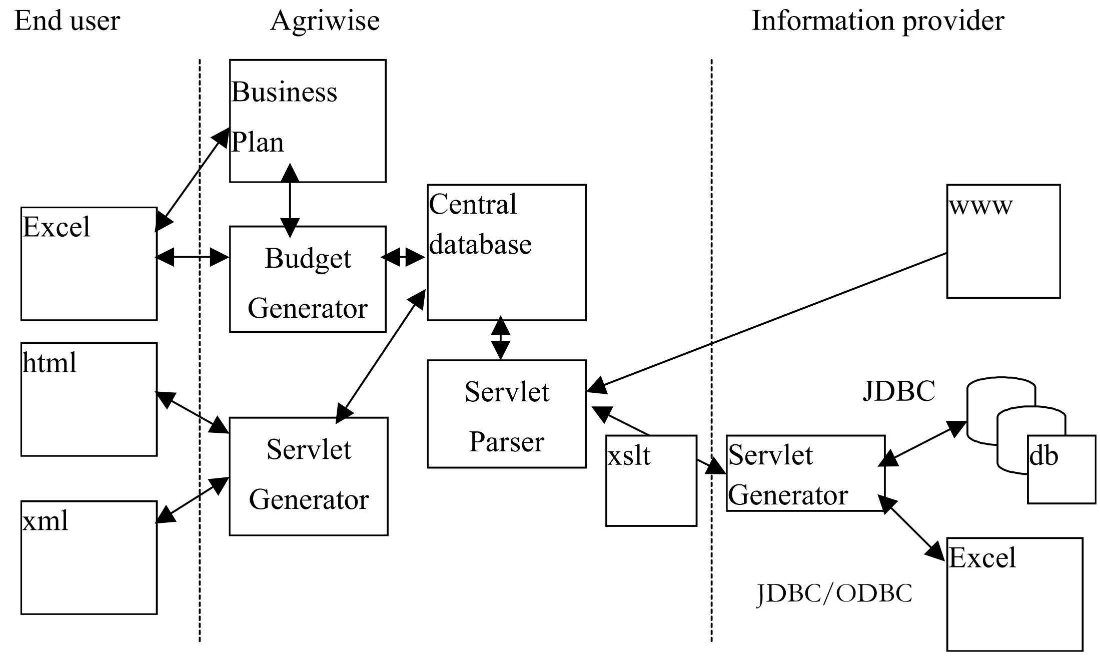

Figure 1 System structure

Data collecting

The options used to collect data are:

- Using XML to transfer data from various databases.
- Transferring data from Excel sheets.
- The data provider enters data via a web form.
- Agriwise staff collects data by telephone or from literature references and enters them via a web form.

The intention was to use XML to transfer data from the data providers to Agriwise. XML can be described as a database expressed in a text file, which simplifies communication between databases. Two java servlets are used to create the XML file with the data providers' data, Servlet Parser and Servlet Generator. Servlet Generator fetches data from the databases with SQL. The answer of the SQL-question is converted to XML. The XSLT style sheet, which is needed for converting from the information structure of the data provider to that of Agriwise, should be developed. Servlet Parser validates the data against the rules of XML. If data follow the rules of XML they are fed into Agriwise database with SQL. Unfortunately, no data provider delivers data in the XML format, so a semi-automated option is used in which data are transmitted from external databases in Excel sheets. The GUI-application converts data, entered with the web form, to XML format. So, if any data provider will use XML in the future, Agriwise is able to receive and process such a file.

Many data providers store and present data in Excel sheets. Examples are SCB's crop yield data and the Statistical Yearbook of forestry. It is possible to transfer Excel sheet data to a database, and such an application has been developed and tested.

Data can be entered via a web form with the aid of a GUI-application. The data are converted to XML and then validated by Servlet Parser and fed into the database. The GUI-application is developed in Visual Basic. In this application, test of data is important, and simpler calculation procedures are included in order to get unitary data concepts. Calculations may be needed to convert crop prices at a specific dry matter content to another dry matter content, or to summarize crop yield data of small statistical geographical areas to the larger production areas used in advisory service.

Output

The output has the following format:

- XML
- HTML
- Excel sheets.

A data provider may also be an end user. Such an end user may want the output in a validated XML file. The end user may want to convert the information to his data concepts, which is possible. Data in XML format could also be used as input to an application. The further processing of output data is the responsibility of the end user, but the Agriwise staff can assist. So far, no end user is using this option.

Output information will be generated in HTML via the Servlet Generator. As in the prototype, the database information is generated in HTML. The difference to the prototype is that the information is dynamic and that it is easier to update.

Excel sheets with enterprise budgets will be generated with a Budget Generator. It is an application that retrieves data from the database with SQL and develops an enterprise budget in one of five model types used in the prototype.

Excel sheets with the farm business plan are developed with a Business Plan Generator. It is an application in Visual Basic for Applications that uses enterprise budgets as input.

Discussion and conclusions

Organization

Agriwise users have got a common view and knowledge about the need and possibilities of developing a system for synthesizing and communication information based on many sources, and the users represent all important user categories. The discussion with other relevant organizations continues to develop this common view and knowledge further.

A prototype of the Agriwise system was in use within half a year from project start, and it has been improved continuously according to user responses. In that way, we have been able to develop the services to cover the user needs and also to make the system user friendly. One disadvantage of this method is that the users expect user-friendly services that cover their needs from the beginning. The Agriwise resources have been divided on the administration and further improvements of the prototype on one hand, and on the development of the more advanced "final" system on the other. More resources than planned have been used for the administration and further development of the prototype.

A weak point in the Agriwise organization is that some external data providers hesitate to give information about prices on farm products and inputs. Their competitors could take advantage of such information. So far, we have got the information but with sometimes considerable delay. An alternative is to collect price information from a sample of farmers.

The market

The Agriwise services have two different types of users. One type of user uses the Agriwise information in his business. We call him user or end user in this paper. The other type of user is the data provider. He uses Agriwise to communicate his data and information. The university's "third assignment" is to communicate new knowledge and information (i.e. own and others' research results) to practical use. Agriwise is a tool for this assignment that distributes new knowledge and information all the way into the advisors' and farmers' computers for practical use. Also market actors and institutional actors want to communicate their information about products or regulations, respectively.

The number of potential users of the first type is large. There are thousands of advisors, consultants, teachers, credit evaluators, property evaluators, damage evaluators, real estate agents, and institutional officers etc, who need this type of information in their business. The number of farmers with Internet was 69000 in 2001. We have chosen organizations, which have the potential users as employees, members, customers or suppliers, as the target group for subscription of the Agriwise services. One reason is that the costs of administration will be lower because the number of such organizations is much lower than the number of users. Another reason is that the user will feel more free to use the service to a larger extent.

The users' alternative information sources are own experiences, advisors, colleagues, journals, other literature and customers. An alternative for a big organization is to have a system of its own corresponding to Agriwise, but it is much more expensive to finance the system alone, the concepts and calculation methods may not be standardized, and the information will not be impartial.

The product

A decision support system has been developed including the structural components:

- Data and information
- Calculation methods
- System for delivering the services
- System for using the services

The *data* are (1) technical coefficients (including quantities) describing production functions, e.g. resource use and output at a given point of the function, (2) prices of products and production means, and (3) laws and regulations. These types of data and information have previously been presented in a printed version. The contribution of this project is more frequent updating, procedures of quality control, and that new areas have been added such as organic production, horticultural crops and special enterprises outside conventional agriculture. The information produced by the enterprise budgets have been available before in printed versions, but the business plan based on the enterprise budgets is a new contribution.

The *calculation methods* for enterprise budgeting and business planning is known previously and described well in the literature. The contribution of this project is to combine them to an entirety and adapt them to the system for using the services.

The *system for delivering the services* to the users consists of (1) collecting data, (2) delivering data and information, and (3) feedback from the users. The technical coefficients are mainly provided by SLU and to some extent Statistics Sweden. In some cases, optimizations or other calculations are needed to produce the coefficients, such feed plan optimization or simulating machinery systems. The market actors provide the main part of the prices. Institutions, such as Statens Jordbruksverk, provide information about laws and regulations. Data and information are delivered to users via Internet in XML-, HTML- or Excel-format. The users give feedback through the Agriwise homepage, email, telephone, the reference group or yearly questionnaires. One contribution of the project is the development of this delivery system, which is unique. The system combines data and information from various disciplines within SLU, the market and the institutions to an entirety delivered into the users' computers, and gives feedback about the usefulness and lacking information.

The *system for using* the services is based on HTML, Word and Excel, and knowledge in economic calculation. Information is data processed to a form that has a meaning for the user and is of value for ongoing or planned actions or decisions (Eisgruber, 1967; Davis, 1963; Bonnen, 1977; Everest, 1985 among others). The user should be able to understand the concepts and they had to fit the user's thinking processes. The user retrieves data and information from the Agriwise services, adapts them to the actual planning situation and processes them to become a basis for the decision or the analysis. This basis is produced in collaboration between the user and Agriwise, which put some knowledge demands on the user. One important contribution of this project is the ability to deliver data and information directly into the user's computer without manual data entry, which reduces the need of work and risk of errors. Another contribution is the standardization of concepts and calculation methods.

The Agriwise services provide information for planning and analysis of unique decisions, which have a strategic and long run character. The services are relevant for those who perform such tasks often enough to need the services, which mainly are advisors and other professionals serving farmers but also big farms. The Agriwise services include courses about the knowledge needed to use the services.

The conclusion is that we have developed a database and connected decision support applications available at Internet, where different actors' sources of information are structured in such a way that data can be collected in a semi-automated way, processed if needed and the output reports can be individually designed.

Corresponding products may be of interest in branches outside agriculture with a need to calculate, and with many small actors that cannot finance such systems of their own, such as branches where many small firms calculate bids and contracts. It may also be of interest in environmental management such as estimating environmental consequences, life cycle analysis, mineral balances etc.

The development process and the technical system

The steps in the development of the technical system have been:

- Specification of user demands and technical demands;
- Development of a prototype (including tests by users);
- Development of system components (including successive tests);
- Implementing the entire system (including tests by users).

The project started with specifying the demands that the system should meet. Concepts, structure, calculation models and other content needed regarding the database and enterprise budgets were well known both from the previous printed version and the literature. A business plan was not included previously, but various calculation models were well known from literature and teaching (Öhlmér, Göransson and Lunneryd, 2000; Karlsson, 1980; Nilsson, Liljegren and Söderberg, 1983; and Lantbruksstyrelsen, 1987). We chose a budgeting approach instead of profit maximization because the users demanded simplicity and transparency. A business planning model based on profit maximization may be added as a complement in the future.

The users had difficulties to read and discuss the specification of demands, so a prototype of the database and the enterprise budgets were developed in order to get user responses. The concepts and the calculation models were included and most of the users' demands were fulfilled, but there were no search engine and no advanced report generator. In the development we followed methods that have the user and his activities as a starting point, such as Task-Centered User Interface Design (Lewis and Rieman, 1993), User-Centered Design (Norman, 1993) and Action-

Centered Design (Denning and Dargan, 1996). The reference group has been very active in specifying user demands and discussing the prototype. Their influence on the content and design of the services has been very great. The organizations represented in the group are committed and feel responsibility for the Agriwise system.

However, the development has not been without difficulties. One example is reorganization of the IT activities of the university resulting in a loss of all IT-competence. Another is delayed implementation of new technology such as XML, which delayed the automated data collecting. A third is that we under-estimated the complexity of the database development due to special characteristics of this database. Normally, a database has few data categories and many observations of each category. Here, the database has many data categories and few observations of each category. The number of tables to generate is around 600 instead of a couple, which was time consuming. However, the biggest difficulty was the lack of a common information structure. Measurement concepts of the same events or factors differed between different disciplines, and even between different laws and regulations. So defining and structuring data was very time consuming, and a lot of calculations are needed before entering some of the data into the database. A consistent conceptual structure would facilitate collecting data from many sources, but currently a lot of concepts are not consistent. So far we have just paid attention to the problem. We have to use data as they are and make necessary calculations. This may be a generic problem that exists also in other branches.

Current information to farmers is analytically designed, but 2/3 of the farmers use an intuitive process in their unique decision making, where they focus on the entirety instead of analyzing subsystems in detail (Öhlmér, 2001). The advisors have to redesign the information before communicating with intuitive farmers. The consequences of a big investment or a big organizational change have to be related to the farmers anchoring or reference point and expressed as changes from this point. Usually, the anchoring point is the current operation or the operations of a model farm well known to the farmer. So this anchoring point has to be analyzed too, and the changes described. In the business plan, a regular profit and loss statement and financial statement as well as key indicators are estimated, which can be compared to the corresponding reports of the regular accounting systems.

Future development

The idea of this project is to present research results in the form of information basis for decision making that is tailor made for the user, and that this basis is available on Internet so it can be used directly in the user's computers. Agriwise as presented here is a start in the area of strategic decision making.

As a next step, Agriwise will be enlarged successively to other disciplines as well. The university's crop protection unit has a system where they present forecasts several times a week on the Internet. The unit for applied field research has started to develop a system for presentation of research results on Internet. These two systems will become *Agriwise – crop protection* and *Agriwise – crop production*, respectively. Agriwise as described in this paper will become *Agriwise – economics*. All these systems will be coordinated so they can exchange data with each other and have a common user interface. The faculty is responsible for the coordination, and each expert group works otherwise independently within its area. This will facilitate the interdisciplinary work as well as the combining of information from different sources to become a useful information basis for farmers' decision making in both the short and long run.

References

Bergkvist, L., Lunneryd, D., and Öhlmér, B., 2002. Value based design of information for strategic decision making - the case of Swedish milk farms' converting to organic production. Manuscript submitted to *European Review of Agricultural Economics*.

Boehlje, M.D., and Eidman, V.R., 1984. *Farm Management*. Wiley, New York.

Bonnen, J. T., 1977. Assessment of the current agricultural database: an information system approach. In: Judge, G. G. (ed.), *A survey of agricultural economics literature*, Vol. 2, University of Minnesota Press, Minneapolis.

Bradford, L.A., and Johnson, G.L., 1953. *Farm Management Analysis*. Wiley, New York.

Brehmer, B., 1990. Strategies in real-time dynamic decision making. In: Hogarth, R. (Ed.), *Insights in Decision Making: A Tribute to Hillel J. Einhorn*, pp. 262–279.

Castle, E.N., Becker, M.H., and Nelson, A.G., 1987. *Farm Business Management: The Decision Making Process*, 3rd ed. Macmillan, New York.

Castle, E.N., Becker, M.H., and Smith, F.J., 1972. *Farm Business Management*, 2nd ed. Macmillan, New York.

Databok för driftsplanering. *SLU, Speciella skrifter* 62. Uppsala 1996.

Davis, G. B., 1963. *Management information systems: conceptual foundations, structure and developments*. Chapter 1–4, McGraw-Hill, New York.

Denning, P. and Dargan, P., 1996. Action-Centered Design. In T Winograd (ed) *Bringing design to software.* Addison-Wesley, Reading, Massachusetts, pp. 105–120.

Eisgruber, L. M., 1967. Micro and macro analytic potential of agricultural Information Systems. *J. Farm. Econ.* 49 (1967), pp. 1541–52.

Eriksson, J. och Martinsson, D., 1999. *Automatisk datainhämtning med XML.* Examensarbete vid systemvetenskapliga institutionen, Uppsala Universitet.

Everest, G. C., 1985, *Database management: objectives, organization and system function*. McGraw-Hill, New York.

Hogarth, R., 1987. *Judgement and choice*. John Wiley, New York.

Johnson, G.L., 1987. A second perspective on Earl O. Heady's economics of agricultural production and resource use. *American J. of Ag. Econ.* 69, 707–711.

Johnson, G.L., Halter, A.M., Jensen, H.R., Thomas, D. (Eds.), 1961. *A Study of Managerial Processes of Midwestern Farmers*. Iowa State Press, Ames Iowa.

Kast, F.E., and Rosenzweig, J.E., 1985. *Organization and Management – A Systems and Contingency Approach.* McGraw-Hill International Editions, Singapore.
Kay, R.D., and Edwards, W.M., 1994. *Farm Management*, 3rd ed., McGraw-Hill, New York.
Karlsson, B., 1980. *Kompendium i driftsplanering.* Inst för ekonomi, SLU
Lantbruksstyrelsen, 1987. *Kalkylering inom lantbruket.* Jönköping
Lewis, C. and Rieman, J., 1993. *Task-Centered User Interface Design – A practical introduction*. University of Colorado, Boulder. Online: ftp.cs.colorado.edu/pub/cs/distribs/clewis/HCI-Design-Book (2000-03-10)
Nilsson, E., Liljegren, Y. och Söderberg, L., 1983. *Kompendium i bidragskalkylering.* Inst för ekonomi, SLU
Norman, D.A., 1993. *Toward Human-Centered Design*. Technology Review, July pp. 47–53
Öhlmér, B., 1998. Models of farmers' decision making. *Swedish J. Agric. Res.* 28, 17–27.
Öhlmér, B., 2001. Analytic and intuitive decision making - Swedish farmers' problem detection and option finding at institutional changes. *Proceedings of EFITA 2001*, Montpellier.
Öhlmér, B., 2002. *Behov av lantbruksekonomisk information och hur det kan tillgodoses.* Unpublished paper, Department of Economics, SLU, Uppsala
Öhlmér, B., Brehmer, B. and Olson, K. 1997. Decision making processes of Swedish farmers. In: *Advances in economic psychology* (eds. G. Antonides, W. Fred van Raaij & Shlomo Maital), 255–266. Chichester. John Wiley & Sons.
Öhlmér, B., Flodin, J., and Karlsson, T., 2002. *Agriwise – Databok för driftsplanering och områdeskalkyler.* Report 145, Department of economics, SLU, Uppsala.
Öhlmer, B., Göransson, B., och Lunneryd, D., 2000. *Business Management – with applications to farms and other businesses*, Småskrift 114, inst för ekonomi, SLU
Öhlmér, B., Lönnstedt, L., and Vikinge, B., 2001. *Design of Economic Information - Preliminary report from a pilot study of economic information in decision making processes*. Paper presented at a department seminar 2001-05-12, Department of Economics, Swedish University of Agricultural Sciences, Uppsala, Sweden. (Unpublished).
Öhlmér, B., and Nott, S.B., 1979. *The Need and Design of Computerized Farm Management Tools.* Report 155, Department of Economics, SLU, Uppsala
Öhlmér, B., Olson, K. & Brehmer, B., 1998. Understanding farmers' decision making processes and improving managerial assistance. *Agricultural Economics* 18, 273–290.
Områdeskalkyler för jordbruk. *SLU Info, Rapporter Allmänt* 188–195.
Orasanu, J., and Connolly, T., 1993. The reinvention of decision making. In: Klein, G.A., Orasanu, J., Calderwood, R., and Zsambok, C.E. (Eds.), *Decision Making in Action: Models and Methods*. Ablex Publishing Corp., Norwood, New Jersey.
Sharp, D., 1994. *Jungiansk typologi.* Sweden: CJP Centrum för Jungiansk Psykologi AB.

Optimisation of Feeding of Dairy Cows in the Long Term

Matti Ryhänen[a], Timo Sipiläinen[a], Risto Seppälä[a,b], Marketta Rinne[b], Pekka Huhtanen[b], Antti Suokannas[c]

Abstract

In Finland the choice of production technology and timing of harvest are challenging tasks when arranging silage production for the winter feeding of dairy cows. A linear programming model was constructed for assessing the effects of harvesting time and production technology on the long-term economic results. The maximised result was determined as the difference of milk return and feed cost. Silage production on the farms is assumed to equal the demand for silage on the farms. The optimal economic feeding system for dairy cows was determined taking into consideration the restrictions set by production technology and animal nutritional physiology.

According to the D-value[8], the optimal timing of harvest in the late spring and early summer varied from 67 to 71. Respectively, the optimal timing of the autumn harvest was at the end of the harvesting period. The results show that the timing of harvest affects the surplus per cow only slightly, when the spring harvest is delayed by one day. The harvesting technology affects the surplus more than the timing of harvest. In the long term, contractor operated round baling provides the best economic results on the farms with 15–60 cows when compared to the farm's own flail chopper and precision chopper chains.

Keywords: Grass silage, Primary and secondary growth, Quality, Linear programming

[a] University of Helsinki,Department of Economics and Management, P.O. Box 27, 00014 University of Helsinki, *firstname.surname@helsinki.fi*
[b] ARF/Animal Nutrition, 31600 Jokioinen, *firstname.surname@mtt.fi*
[c] ARF/Agricultural Engineering, 03400 Vihti, *firstname.surname@mtt.fi*

[8] The D-value indicates the quality of silage. It is defined as the proportion of digestible dry matter to total dry matter.

Introduction

The optimal choice of harvesting time and production technology of silage is a challenging task in the field of feeding the dairy cows (cf. Fagerberg and Torssell, 1990). Grass silage and grass fodder in general differs from other Finnish animal feed stuffs, since it is mainly produced on the farm where it is consumed, i.e. the silage market is small and irregular. It is not possible to observe a general market price for silage but the price can be determined by production costs. The unit cost of silage reflects the actual cost of silage in milk production in the same way as the market price of purchased concentrates. However, grass silage cannot be considered as a homogenous input or output, because the quality of grass varies considerably during the growing season making the quality of silage dependent on the timing of harvest. The preservation quality of silage may also vary a lot. Thus, the quality of silage has to be taken into account in choices concerning silage production. In addition, grass silage is typically harvested more than once per summer. We also have to consider the interrelation of sequential harvests. Because the quantity and quality of silage and the need for concentrates are related to the timing of harvest, silage production should be linked to the production of the end product, i.e. milk. In this way it is possible to study, how the solutions in silage production affect the economic result of milk production (cf. Rotz et al., 1989; Torssell and Fagerberg, 1990).

The economic environment of Finnish dairy farms has changed drastically because of EU-membership, which affects the decisions of dairy farmers. Before EU-accession milk production was largely based on grass silage since the price of cereals was high compared to milk price and the on farm produced silage of good quality was relatively competitive compared to concentrates. The output prices decreased drastically in 1995 when Finland joined the EU but milk prices decreased relatively less than the cereal prices, which suggests an increasing intensity in milk production. On the other hand, the relative decrease in cereal prices compared to input prices suggest lower intensity in crop production. Simultaneously to the fall in cereal prices, direct payments for crop production have increased. Direct payments also favoured cereal production instead of grass silage[9]. It has become profitable to substitute cereals for silage. The decrease in the price of concentrates also suggests that the value of the quality of silage has diminished.

In the short term a large share of costs on the farms are fixed. The changes in production are not instant but an adjustment process is needed. In this study we concentrate on the long term planning of dairy cattle feeding, which includes the organisation of grass silage production. In the long term it is essential to know answers to the following questions concerning milk production:

- what is the optimal cereal-grass silage ratio in milk production,
- what is the optimal harvesting and storage system for silage on the farm level and

[9] Finland was allowed to pay CAP support for grass silage since 2000, which partially removed unequal direct payments for different crops.

- what is the effect of the quantity and quality of silage on the economic result of milk production or what is the effect of the timing of harvest on the economic result under the Agenda regime.

These are the questions we are looking for the answer in this study.

Data and method

The quantity and quality of silage for each harvesting day (years 1998–2000) was determined on the basis of the observations of Rinne et al. (2000). However, trial yields are higher than the yields in practice. In order to improve the practical applicability of the trial results of Jokioinen (support region B), trial yields are proportioned to the median yields of Hila farms (Maaseutukeskusten liitto) in the same support region. In addition, earlier research results and norms are used when constructing harvesting chains. The calculations are made for the price and support level of the year 2001. It is assumed that the support can be fully utilised.

A calculation model was used in evaluating the influence of the harvesting chain and the timing of harvest on the economic result of specialised dairy farms. The ratio of areas under grass and cereals are assumed to be constant in such a way that the grass is renewed under the feed cereals. The area under grass includes both silage and pasture (3/4 of the total field area). The optimisation process determines the total field area. Concentrate supplementation is barley and turnip rape. There are three harvesting chain options: flail chopping, precision chopping and round baling. In flail and precision chopper chains grass is stored in flat silos. In the round baler chain bales are stored on the edge of the field, from where they are later transported to the cowshed. The calculations are made for farms of 15, 30 and 60 cows.

Production alternatives of silage are evaluated together with the result of milk production. The approach based on biological and physical relations is appropriate or even the only way to study the consequences when dramatic changes in production environment take place (e.g., Berentsen and Giesen, 1995; Ryhänen, 1996; DeLorenzo and Thomas, 1996). Feeding plans take into account the interrelation of daily intake, the quality of feed and milk production. The effect of the timing of calving on milk production and demand for feed is not taken into account. Grass silage production on the farm equals the demand for silage during the winter feeding period. This assumption is based on the fact that milk production cannot be based on purchased silage because of a lack of markets. Losses in harvesting, storage and feeding are taken into account.

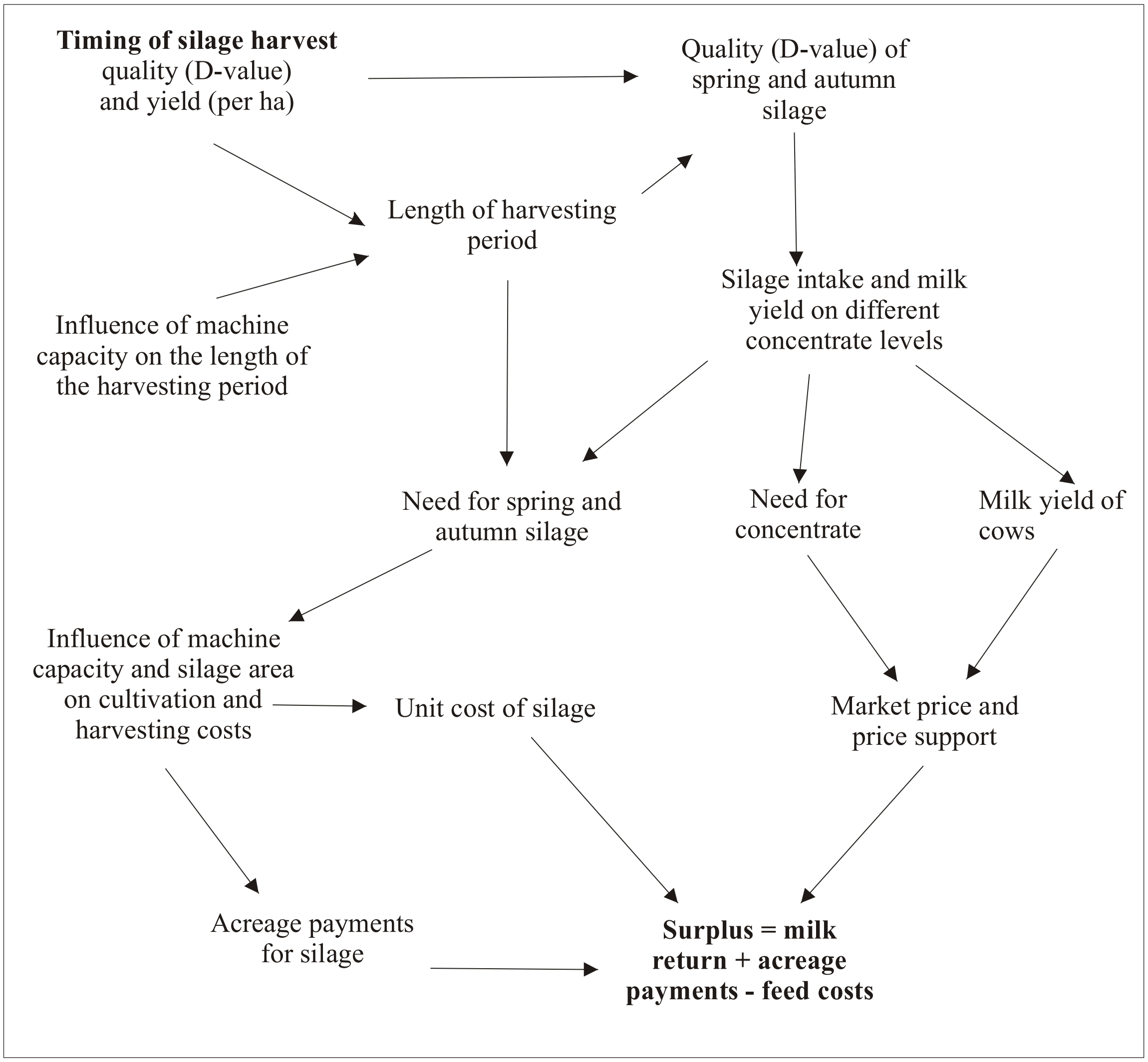

Figure 1 Determination of the economically optimal harvesting time for grass silage in the long term (the system of two harvests)

Figure 1 illustrates the connection between silage production, feeding of cows and milk production and the economic result of the farm in the case of two harvests when the planning horizon is long. Equation 1 presents the LP model, which maximises the surplus, i.e., the difference between milk return and feed cost. The feed cost includes all costs related to the feed acquisition.

$$\max z = p \sum_{i=a}^{t} x_i y_i + p \sum_{i=a}^{t} \sum_{j=1}^{r} x_{ij} y_{ij} + (A - R - w_v) \sum_{i=a}^{t} H_i^k - \sum_{i=a}^{t} w_i x_i$$
$$- \sum_{i=a}^{t} \sum_{j=1}^{r} w_j x_{ij} - w_c (x_c^k + x_c^s) - F - G - U \qquad (1)$$

subject to

1) $\sum_{i=a}^{t} \sum_{j=1}^{r} H_{ij}^{s} = \sum_{i=a}^{t} H_{i}^{k}$ 2) $\sum_{i=a}^{t} H_{i}^{k} + P = 3V$ 3) $H_{i}^{k} = \sum_{j=1}^{r} H_{ij}^{s}$ 4) $x_{i}l_{i} \le L_{d}$

5) $x_{ij}l_{ij} \le L_{d}$ 6) $\sum_{i=a}^{t} x_{ij}l_{ij} \le L_{d}$ 7) $x_{i} = nf_{i}D_{i}$

8) $x_{ij} = nf_{ij}D_{ij}$ 9) $x_{c}^{k} = n\sum_{i=a}^{t} x_{ci}^{d}D_{i}$ 10) $x_{c}^{s} = n\sum_{i=a}^{t} \sum_{j=1}^{r} x_{cj}^{d}D_{ij}$

11) $\sum_{i=a}^{t} D_{i} + \sum_{i=a}^{t} \sum_{j=1}^{r} D_{ij} = 205$

z = surplus, FIM[10]
p = milk price + price support, (FIM/kg)
x_i = yield of spring silage (the primary growth) on each harvesting day (kg DM); losses subtracted
y_i = milk yield per day produced by in advance fixed concentrate level (kg DM) on a specific D-value of spring silage (each harvesting day) (kg milk/kg DM of silage)
a = starting day of the spring harvest
t = finishing day of the spring harvest
x_{ij} = silage yield on the autumn harvest day (j), which corresponds to the spring harvest day (i) (kg DM)
y_{ij} = milk yield produced by in advance fixed quantity of concentrate (kg DM) and by autumn silage having a specific D-value (the silage harvested on an autumn harvesting day (j) corresponding to each spring harvesting day (i)) (kg of milk/kg DM of silage)
r = days of autumn harvest corresponding to each spring harvesting day
A = direct payments (FIM/ha)
P = pasture (ha)
V = cereals (ha)
H_i^k = area (ha) of silage harvested on a specific spring harvesting day; ($H_i^k = x_i$/yield per ha)
H_{ij}^s = area (ha) of silage harvested on an autumn harvesting day (j) corresponding to a specific spring harvesting day (i); ($H_{ij}^s = x_{ij}$/yield per ha)
w_i = variable unit costs depending on the quantity of produced silage in the spring silage (FIM/kg DM)
w_j = variable unit costs depending on the quantity of produced silage in the autumn silage (FIM/kg DM)
F = annual cost of silage machinery (FIM/farm)
G = labour cost of covering the silo (FIM)
U = annual cost of the silo building and plastic cost (FIM)
R = cost of arable land, FIM/ha (annual cost of subsurface drainage and interest of land (or the rent)
w_v = constant cost of renewing and fertilising the grass and the interest on working capital (FIM/ha)
w_c = price of concentrate (FIM/kg DM)
x_c^k = quantity of concentrate when feeding by spring silage (kg DM)
x_c^s = quantity of concentrate when feeding by autumn silage (kg DM)
l_i = labour input on a specific spring harvesting day (hours/kg DM)
l_{ij} = labour input on an autumn harvest day (j) corresponding to a specific spring harvesting day (i) (hours/kg DM)
L_d = available labour input per harvesting day (hours)
f_i = silage intake corresponding to silage of a specific spring harvesting day (kg DM/day/cow)
f_{ij} = silage intake corresponding to silage of an autumn harvesting day (j) corresponding to a specific spring harvesting day (i) (kg DM/day/cow)
D_i = feeding period of silage of a specific spring harvesting day (days)
D_{ij} = feeding period of silage of an autumn harvesting day (j) corresponding to a specific spring harvesting day (i) (days)
x_{ci}^d = concentrate intake on spring silage (kg DM/day/cow)
x_{cj}^d = concentrate intake on autumn silage (kg DM/day/cow)
n = number of cows

[10] We use FIM because the research period is before the Euro was introduced (1 Euro = 5.94573 FIM).

The LP-model was constructed assuming that the quantity and quality (D-value) of silage change from day to day but stay constant on each harvesting day. If the spring harvest is divided to several days it will take place continuously. The quantity and quality and unit cost of silage change with the harvesting period. The intake of silage and the respective milk yield are determined stepwise for each concentrate level. The intake of silage is adjusted to correspond to the need for each level of milk yield. The proportion of neutral detergent fibre (NDF) is used as a constraint for the diet. If the proportion of NDF from silage is less than 25 percent the concentrate level is not feasible.

In the model the yield of silage is linked to the timing of harvest and the capacity of harvest system. The location of pieces of land can be taken into account by introducing a variable describing the average distance between the fields and farm centre. The productivity of machines can be changed by additional turning and interruption times. In the model it is assumed that grass is grown on all plots following crop rotation.

The LP-model in formula 1 is an example for flail chopper technology (the time period for spring harvest and the concentrate level 5–14 kg/cow/day are set beforehand). The concentrate level is determined separately for spring and autumn silage, i.e. the levels may be different for spring and autumn silage. The changes in the D-value of silage (changes in the timing of harvest) influence the silage intake and the milk yield of the cow when a specific concentrate level is used. For example for the 1998 data 2700 LP-models are solved for a farm of 15 cows and flail chopper technology. When all LP-models have been solved the surplus maximising solution for each harvesting period is chosen from the group of optimal solutions.

Results and discussion

The optimal timing of harvest in the spring and early summer varied between 67–71, according to the average D-value (Figures 2a–2c). The results of optimisation show that the timing of harvest (D-value 63–72) affects the surplus per cow only slightly (4–17 FIM), when the harvest is delayed by one day. The harvesting method more affects the surplus than the timing of harvest. In the long term, round baling operated by a contractor provides the best economic result on the farms with 15–60 cows. Flail chopper and precision chopper chains cause 500–1500 FIM higher costs per cow than round baling operated by a contractor. Using a farm's own round baler chain does not become competitive compared to contractor operated round baling until a farm has 60 cows. Since the timing of silage harvest has relatively little influence on the surplus, the harvesting period can be extended, which makes it possible to reduce unit costs of silage for example by co-operation.

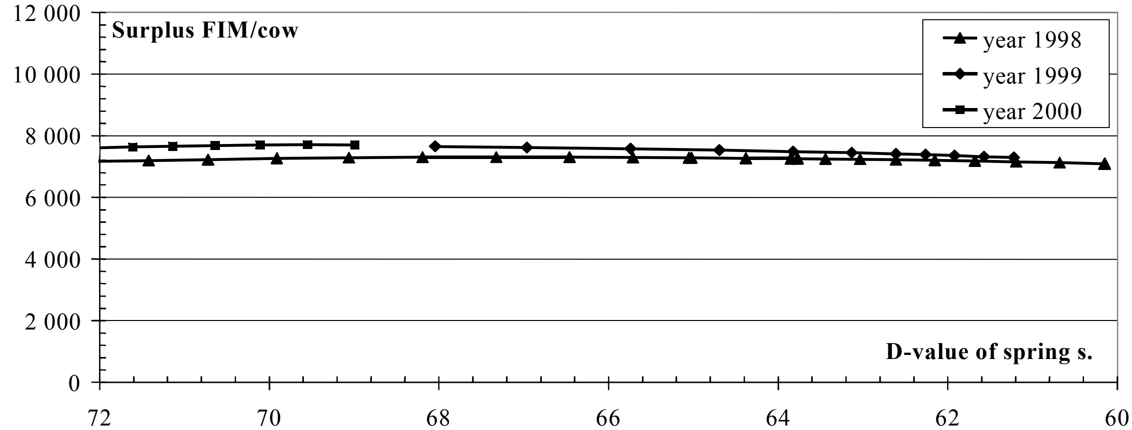

Figure 2a *Difference between milk return and feed cost on the farm of 30 cows on 2001 price and support level as a function of the D-value of spring silage (the flail chopper chain). Optimisation of autumn silage is included*

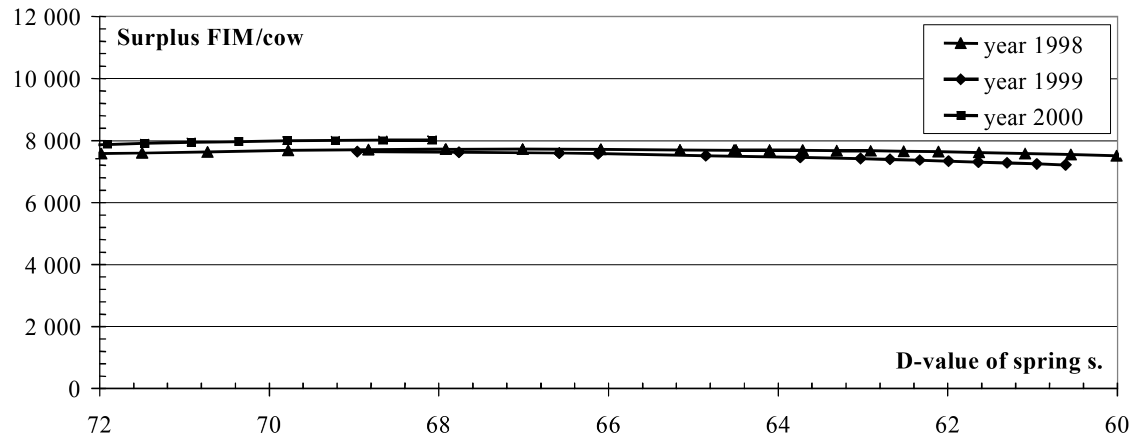

Figure 2b *As Figure 2a but for the precision chopper chain*

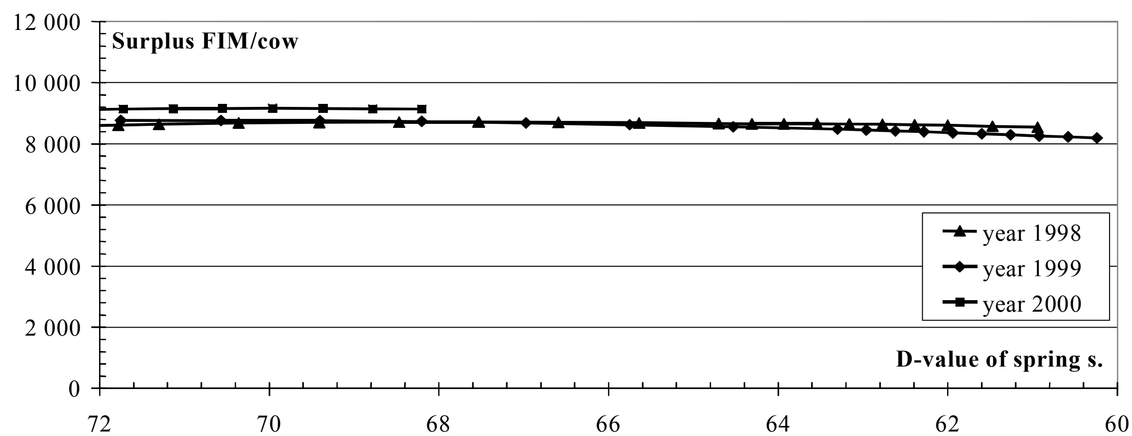

Figure 2c *As Figure 2a but for round baler chopper chain*

As a long term feeding strategy of dairy cows, the highest concentrate levels gave the best economic result in this study. Accordingly, it is profitable in the long run to convert the feeding of dairy cows from grass silage more to concentrates (cereals-turnip rape mixture). The increasing use of cereals and turnip rape mixture is largely based on their considerably lower price compared to the unit cost of silage. This will convert the feeding of cattle further away from their natural forage dominated diets.

Since high doses of concentrate disturb the functioning of rumen and endanger the health of the cow, concentrate doses higher than 14 kg per day (the maximum proportion of concentrate 57% of dry matter) were not feasible. According to the price and support assumptions of the year 2001, the optimal share of cereal turnip rape mixture in the diet is on the two highest concentrate levels of the study (13–14 kg/day). The proportion of cereal-turnip rape mixture of total dry matter intake is 51–57 percent. In the optimal solution the share of NDF varied between 25% and 29% of the portion's dry matter (DM). Practical experience has shown that even higher proportions of concentrate than in this study can be used for dairy cows without serious health problems. In this case farmers mainly use industrially produced concentrates that are more versatile but also more expensive than the home made mixtures of this study. The economic result of industrially produced concentrates could not be studied due to missing experimental data.

The effects of timing of the spring harvest

Figures 3–5 show, why the timing (D-value) of spring harvest relatively little affects the difference between milk return and feed cost i.e., the surplus. Figure 3 shows the changes in the quality (D-value) of autumn silage. When the spring silage was harvested at high D-value the D-value of the corresponding autumn silage was generally lower than the D-value of the autumn silage when the spring silage was harvested in a low D-value. The quality (D-value) of the spring and autumn silage develop in different directions thus compensating each other when the whole summer is taken into account. According to Figure 4, the variation of the D-value in the total silage yield was considerably smaller than the variation of the D-value in the spring silage. Thus a knowledge of the D-value in the spring silage is not sufficient for making recommendations concerning the timing of the spring harvest.

Figure 4 shows that the average D-value of the total silage yield varies approximately by one unit when the D-value of the spring silage yield varies by six units from 66 to 72. The average D-value of the total silage yield also varies yearly. In 1998 it varied by two units when it varied by five units in the extremely dry year of 1999.

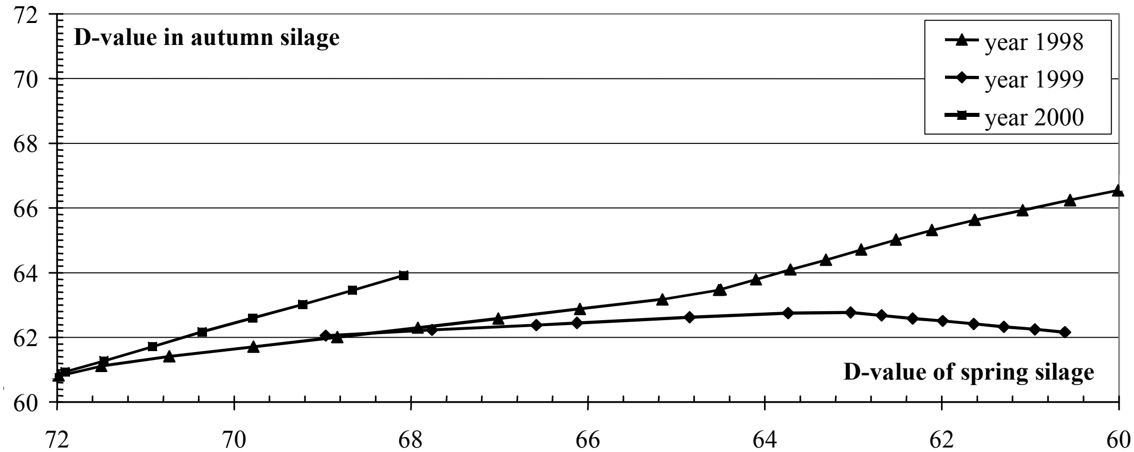

Figure 3 The D-value of autumn silage as the function of the D-value of the spring silage for a system of two harvest precision chopping when optimised on a farm of 30 cows (the silage area can be adapted according to the need for silage).

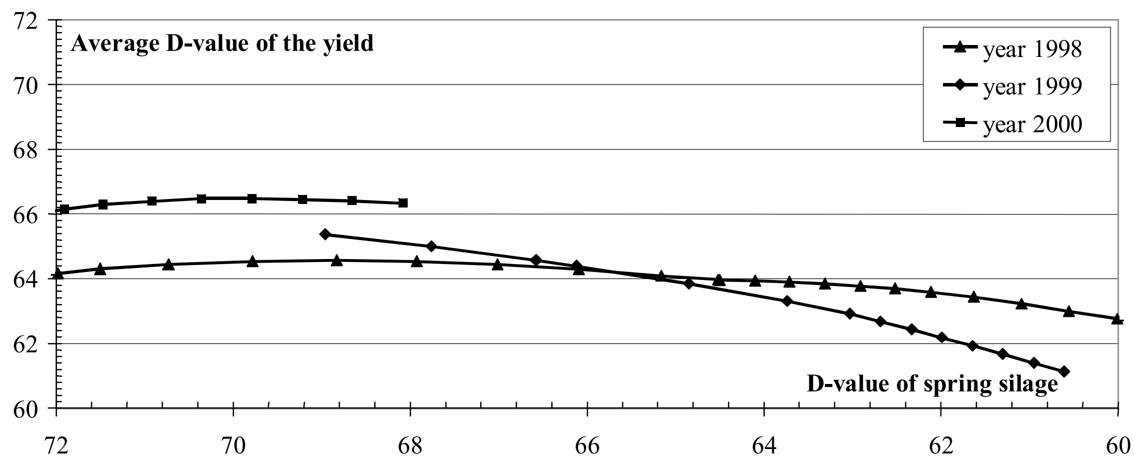

Figure 4 The average D-value of silage as the function of the D-value of the spring silage for a system of two harvest precision chopping when optimised on a farm of 30 cows (the silage area can be adapted according to the need for silage).

Figure 5 presents the total silage yield of the summer (in feed units) as the function of the D-value of the spring silage. When the spring silage was harvested at the high D-value (at early stage) the total yield of the summer in feed units was smaller than when the spring silage was harvested at low D-value (at later stage). In the former case the autumn yield was bigger than in the latter case but this difference was not large enough to compensate the losses in the spring silage. As Figure 5 shows the total silage yield of the summer was largest when the spring silage was harvested at the D-value of 60–65.

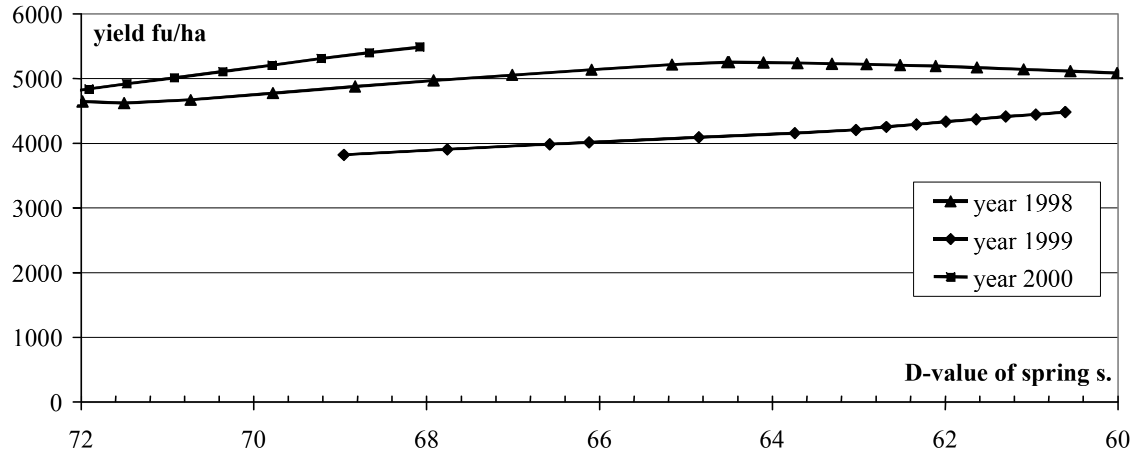

Figure 5 Average yield per hectare in feed units as the function of the system of two harvest precision chopping on the farm of 30 cows (the silage area can be adapted according to the need for silage).

The examination of the quality and quantity of spring silage and the harvesting decisions based on them is not adequate for economically optimal choices. In addition, we need information about the milk production response of feed. When the spring harvest is delayed the total feed unit yield of the summer increases but at the same time the average D-value decreases, which also reduces milk yields. The results show that the small variation of surpluses related to the timing of the spring harvest is related to the fact that the spring yield increases simultaneously with deteriorating quality and that the autumn silage partially compensates for the quality and quantity changes in the spring silage.

Optimal grass silage area

The optimal area of silage varies from year to year (Figure 6). According to the results it was reasonable to start harvesting the spring silage when the D-value was between 67 to 71. Figure 6 shows that in flail chopper technology the optimal harvest area of silage in 1998–2000 varied between 6.8 and 9.5 hectares on the farm of 15 cows. Thus the difference of required area was 40%. In different technologies and size classes area requirements varied by 25–40%.

The possibilities of the dairy farmer to adjust his/her silage area yearly are small. He/she has to decide beforehand how large an area will be reserved for silage production next summer. For example, years 1998 and 2000 suggest the silage area of 7.5 ha but in 1999 that area is too small, in spite of irrigation, if the spring silage is harvested at D-value of 67–71. In 1999, the need for forage can be covered by 7.5 ha if the spring harvest is delayed. In this case, the D-value will be low (62). This would result in a 5000 FIM/farm smaller surplus compared to years 1998 and 2000.

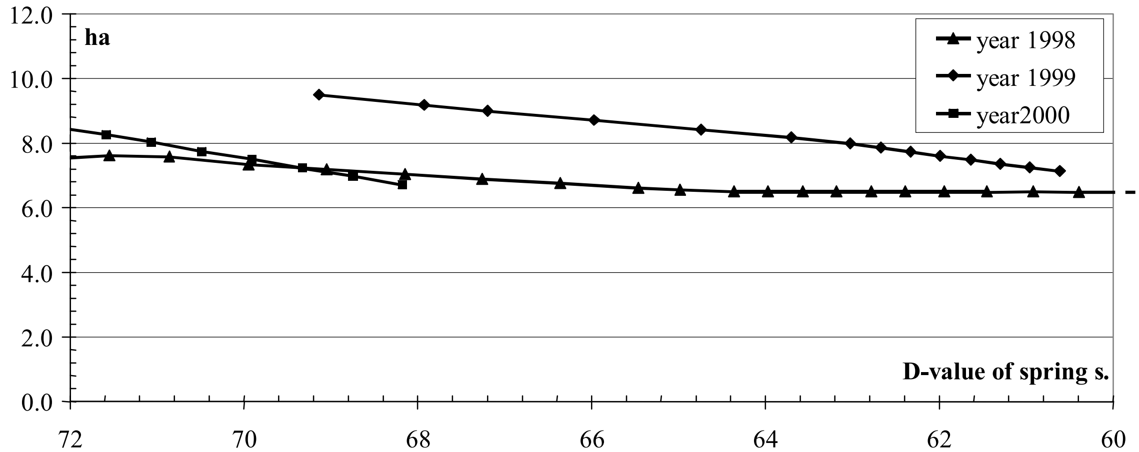

Figure 6 Optimal harvest area of silage on the farm of 15 cows (flail chopper technology)

The unit cost of silage

On a farm with 15 cows the unit cost of silage harvested by the flail chopper technology varied between 2.04–2.25 FIM/fu when the unit cost of contractor based round baling was 1.43–1.70 FIM/fu. The unit cost decreased with the farm size. For example, on a farm of 60 cows the unit cost of silage in the precision chopper technology varied 1.48–1.75 FIM/fu when the unit cost in round baling (contractor or own) was 1.30–1.63 FIM/fu. The minimum unit cost of grass silage was obtained at the low D-value of the spring silage (60–65) but the surplus was maximised at higher D-values (67–71). When the unit cost was calculated by a kilogram of dry matter the minimum was obtained at very low D-values. This shows that the unit cost of silage as the only decision criterion may lead to wrong solutions if the quality of silage is not properly taken into account.

Conclusions

The results show that the share of silage in the diet of the dairy cow decreases, which is mainly caused by a sharp decrease in the relative price of cereals and turnip rape mixture. At the same time the harvesting technique of silage and co-operation of farmers becomes more general, which makes it possible to cut the unit cost of silage. The longer economically rational harvesting period than before favours co-operation or the use of contractors. However, the unit cost of silage does not fall enough so that silage-dominated diets would prevail in the future. When the harvesting chains of silage develop rapidly it is reasonable to avoid expensive and long lasting investments especially if it is obvious that they cannot be written off during the planned period. The farmers seem have noticed the change. The sale for round balers has increased rapidly when at the same time the number of sold flail and precision choppers has decreased considerably.

In practice it should be noticed that dairy farming is an entirety that consists of the area, quality and availability of arable land, grazing possibilities and production potential of dairy cows, among many other things. These factors influence the farmers' choices. If it is not possible to use the results of this study to make farm-wise calculations they can be used as the basis of planning. To improve the applicability of the results requires a deeper knowledge of development of grass especially in the secondary growth in the main milk production regions like in Pohjanmaa and Pohjois-Savo.

It is important for milk producers to understand in their decision making the difference between the short and long term. In addition to long term planning, farmers continuously make short-term decisions. In the short term the price of silage is set to be equal to the variable unit cost of silage instead of the total unit cost, and fixed costs are considered as sunk costs. If there is no need for replacement of means of production and if the production is not extended, it is economically reasonable to keep the production methods unchanged in the short term.

In the study it was assumed that the effect of the D-value on milk output is similar both for spring and autumn silage. The production potential of the silage from secondary growth may be worse than that of primary growth. In this respect the confirmation of results requires trial experiments on dairy cows.

References

Berentsen, P.B.M. & Giesen, G.W.J., 1995. An environmental-economic model at farm level to analyse institutional and technical change in dairy farming. *Agricultural Systems 49*: 153–175.

DeLorenzo, M.A. & Thomas, C.V., 1996. Dairy records and models for economic and financial planning. *Journal of Dairy Science 79*: 337–345.

Fagerberg, B. & Torssell, B.W.R., 1990. Harvest time predictions in leys. 2. Economic consequences of harvest time at two contrasting feeding strategies. *Swedish Journal of Agricultural Research. 20*: 11–18.

Rinne, M., Hellämäki, M., Nousiainen, J., Aura, E. & Huhtanen, P., 2000. Kevätkorjuun optimoinnista koko kesän nurmisadon hallintaan. Maataloustieteen päivät 2000. Kotieläintiede. *Maaseutukeskusten liiton julkaisuja 952*: 126–129.

Rotz, C.A., Black, J.R., Mertens, D.R. & Buckmaster, D.R., 1989. DAFOSYM: A Model of the Dairy Forage Systems. *Journal of production agriculture 2*: 83–91.

Ryhänen, M., 1996. Maatalousyrittäjän päätöksenteko. Teoksessa Ylätalo M. (toim.) Maatalousyritysten sopeutuminen EU:ssa vallitseviin hintasuhteisiin. Tuotanto- ja kustannusteoreettinen tarkastelu kasvinviljelyyn ja kotieläintuotantoon sovellettuna. Helsingin yliopisto. *Taloustieteen laitos. Julkaisuja 12*: 9–23.

Torssell, B.W.R. & Fagerberg, B. 1990. Predicting economic optimum and nitrogen balance in the ley – ruminant system. Swedish University of Agricultural Sciences. Dept. of Crop Production Science. *Crop Production Science 10*: 1–45.

Van Soest, P.J. 1994. *Nutritional ecology of the ruminant*. 2nd. ed. New York. 476 p.

Forage Production and Feeding of Dairy Cows at Changing Economic Conditions in Norway

Ola Flaten[a]

Abstract

Norwegian dairy farmers are facing changes in the economic environment. Prices of products and concentrates are falling, while area and headage payments are increasing. The availability of grasslands has become more abundant. Impact of changes in economic conditions on production systems and profitability are examined. Linear programming models of dairy farms, with grain and beef as alternative enterprises, are designed to analyse the adjustments.

Optimal production systems are largely determined by a combination of economic factors associated with the various inputs, outputs and support schemes together with availability of farm resources. The "typical" Norwegian dairy farm has a small quota compared to other farm resources. Producing a fixed milk quota with moderate yielding cows is then most profitable (1999-conditions). Early cut silage offered ad libitum is most profitable.

Changes in the milk price have no effects on production as long as the quota is effective. If all of the land is utilised and grassland is the only possible land use, increased area payments have no production effects. If some grassland is not in use, area payments increase land utilisation as cows are fed less concentrate. If grain is also grown, increased grassland area payments result in more land allocated to grass. Forage and milk production become less intensive. By increasing headage payments, milk yield falls, as it is optimal to have more cows to produce the fixed quota output. This contributes to keep more grassland in production and in a more intensive forage production. Lower concentrate prices lead to increased use of concentrates and higher milk yields.

Keywords: Dairy farming; Optimal production systems; Policy instruments; Farm resources; Linear programming

[a] Norwegian Agricultural Economics Research Institute (NILF), P.O. Box 8024 Dep., NO-0030 Oslo, Norway. *ola.flaten@nilf.no*

Introduction

During the past 15–20 years, the economic conditions for Norwegian dairy farmers have changed considerably. In 1983 milk quotas were introduced. Many farms have the resources to increase milk production, but are limited by restrictive quotas, which actually have been reduced on many farms since 1983 (Giæver *et al.*, 1995). Farm gate prices have dropped during the past 10–15 years, whereas area and headage payments have increased.

The last 5–10 years availability of farmland has been less limited, because of the substantial decrease in the production of milk (Søyland *et al.*, 2002:43–44). This farmland trend is expected to continue and may influence dairy farm production systems.

Annual milk yields peaked in 1993 at 6350 kg energy corrected milk (ECM) per cow (TINE, 2002:73). By 2001, milk yields were down to 6115 kg ECM/cow. In the period 1993–2001 annual concentrate input was 1700–1750 feed unit milk (FUm) per cow but with a falling trend the last years. The annual genetic improvement in milk yield in the NRF (Norwegian Red Cattle) population of about 40 kg per cow (Sehested & Steine, 1999) has not been realised. This development suggests that changing economic conditions has influenced milk production systems.

New agricultural policy goals were decided upon in 1999 (Ministry of Agriculture, 1999). The farming sector has important roles in providing public goods (e.g., rural viability, landscape preservation, and food security). At the same time, prices, especially for grain, are to be further reduced, thus leading to cheaper concentrates and enabling further price reductions for meat and dairy products. The ensuing income losses are to be (partially) compensated for by changes in public support programmes.

In Norway approximately 80% of the variable and half of the total cost of milk production can be attributed to feed costs, emphasizing the needs for optimising forage production and feeding of dairy cows at various farming conditions.

Given this background, it is appropriate to investigate the impact of changing economic conditions on the use of inputs, outputs and economic results on Norwegian dairy farms. Important questions are: How do changing conditions affect the intensity in forage and livestock production? How are the chances of achieving agricultural policy goals influenced? Consequences of changes in prices, public subsidy schemes and availability of farm resources (farmland, milk quota, buildings etc.) will be examined. Management practices that are examined include grassland fertilisation, harvesting regimes, pasture management and dairy cows' feeding regimes. In addition, it is examined to what degree dairying ought to be combined with other farm enterprises.

Dairy farm models must jointly emphasis economics and biology, and the interaction between farming activities. In this paper models must be able to simulate farmers' behaviour outside historical observations. Linear programming (LP) has power and flexibility for this type of modelling (e.g., Pannell, 1996). Assuming profitability to be the major concern of farmers, the analysis uses LP models to establish optimum farming systems, as has been done in other farm level studies of dairying in a changing economic environment (e.g. Berentsen & Giesen, 1995; Ramsden *et al.*, 1999; Valencia & Anderson, 2000).

The paper is organised as follows. Section 2 gives an overview of the farm model structure. In section 3 model results for different economic conditions are presented. Section 4 concludes the paper and considers implications of the results for dairy farm management and the goal efficiency of farm policy instruments.

The farm model

A farm model system to analyse adjustments in Norwegian dairy farming have been designed. The LP model selects a profit-maximising set of farm activities from the modelled management options for a Norwegian dairy farm. The model includes about 60 activities and 40 constraints, having been kept at this moderate size by construction of a single year equilibrium model. A number of non-linear relationships are approximated by linear segmentation. Table 1 shows a simplified representation of the overall model structure. In the following subsections, different parts of the LP model will receive some further attention. Flaten (2002:117–140) gives a full description of the LP model.

The model's technical coefficients relating to crop and livestock production were partly obtained from various scientific studies. Not all of the published research is suitable for incorporation into modelling studies. There are also gaps in our knowledge where little work has been done. Because of these data problems, subjective assessments were needed to fill in some gaps.

In a farm level model it is impossible to fully represent all of the biological and human complexities in a decision problem. Most often programming models are an abstraction of reality. They are primarily used to put issues in perspectives and lead to insight, rather than to provide definitive numerical results, or as stated by Luenberger (1984:1): "*Optimization, then, should be regarded as a tool of conceptualization and analysis rather than as a principle yielding the philosophically correct solution*". The same philosophical position is taken here.

Farm resources

The farm resource situation is specified by the right-hand-side values for land, milk quota, livestock places and labour. The annual milk quota in the "typical" farm situation is 90.000 L (i.e., slightly above an average quota). No possibilities to acquire additional quota are assumed. Compared to the milk quota most dairy farms have many cow places. Based on Giæver *et al.* (1995) housing capacity limits the herd size to a maximum of 18 dairy cows and ten followers over eight months in the typical situation. Beef bulls can either use space allocated to dairy followers or empty cow places.

Table 1 Simplified model structure

	Activities								
	Forage production for on-farm use	Crop production for sale	Purchase of feeds	Animal production	Sell milk	Family labour	Hire labour	Subsidy schemes	Right-hand-side
Objective function	$-c_j$	c_j	$-c_j$	$+/-c_j$	c_j	$-c_j$	$-c_j$	c_j	MAX
Farmland	1	1							$\leq b_i$
Milk production				$-a_{ij}$	1				≤ 0
Milk quota					1				$\leq b_i$
Housing				a_{ij}					$\leq b_i$
Labour	a_{ij}	a_{ij}		a_{ij}		$-a_{ij}$	$-a_{ij}$		≤ 0
Supply of family labour						a_{ij}			$\leq b_i$
Feeding requirements	$-a_{ij}$	$-a_{ij}$	$-a_{ij}$	a_{ij}					≤ 0
Replacement control and birth balance				$+/-a_{ij}$					≤ 0
Crop rotations	$+/-a_{ij}$	$-a_{ij}$							≤ 0
Subsidy schemes	$-a_{ij}$	$-a_{ij}$		$-a_{ij}$	$-a_{ij}$			a_{ij}	≤ 0

Note: c_j is the expected gross margin of a unit of the *j*th activity, b_i is the amount of the *i*th resource available and a_{ij} is the technical coefficient that relates activity *j* to constraint *i*.

The model is adapted to farmers who can have a three cut harvesting system (i.e. many dairy regions of Southern Norway). In these areas the average forage area is slightly above 0.2 ha per 1000 litres of quota but varies from 0.1 to 0.4 ha among dairy farmers participating in NILFs farm accounting survey (Flaten, 2002:120). For a typical farm that can only grow forage farmland is set to 19 ha. Farmland is set to 22.5 ha if growing of grain is possible. The large dispersion in farmland resources and the anticipated "farmland-surplus" in Norway suggest that farm level adjustments at various land constraints should be examined.

The maximum farm-labour input by the farm family is 3500 hours per annum. The demand for labour is split into fixed and variable labour. Fixed labour input (2000 hours) is not explicitly priced in the models. The remaining 1500 variable hours are the limiting factor for own labour input. Additional labour can be hired.

Forage, crops and feeds

The land on the farm can be used for growing grass and possibly barley. Grass can be used for grazing or for silage making to be fed in the winter season. Grass for silage is direct-cut and conserved as silage and can be harvested two or three times per season. Separate models have been designed for each of the two harvesting regimes. Some farms can grow grain while many others cannot. Both situations are examined, and there are in total four basic models.

The two harvesting regimes are: 1) three cuts; the first just after heading starts, usually around June 10th, the others on July 25th and September 20th, and 2) two cuts, both in relatively late developmental stages, usually around June 25th and September 1st. Fewer cuts result in higher dry matter (DM) yields. However, digestibility is reduced (e.g., Beever *et al*., 2000). The difference in net energy yield between the two regimes is thus reduced. In Table 2, net yields and protein contents in the two harvesting regimes and with increasing nitrogen (N) fertilisation rates are shown. Protein contents are expressed as AAT (amino acids absorbed in the small intestine) and PBV (protein balance in rumen), according to the Nordic protein evaluation system. Grass yields and PBV-content in the grass yield respond to N-applications, but at a diminishing rate. More cuts increase the ability to utilise large N-applications. The PBV-content is higher at earlier stages of maturity.

Increasing the number of cuts leads to reduced winter survival and a thinner sward. The model for two (three) cuts is based on four (three) year grass leys duration (the sowing year excluded). Temporary grass is either sown without a cover crop or if possible with barley as cover crop.

Pasture yields should be high enough to cover the animals' forage requirements during the entire grazing period (May 20th to September 10th). Pasture can be temporary (re-established every 6th year) or permanent. Pasture yields are lower than silage yields. At fertiliser application rates on temporary pastures of 150 kg N/ha, 200 kg N/ha or 250 kg/ha net yields are 3410 kg DM/ha, 3710 kg DM/ha and 3860 kg DM/ha, respectively. On permanent pasture, fertilisation is low (50 kg N/ha) and so is also the yield (2000 kg/ha).

Table 2 Net grass yields and protein contents

	Kg DM/ha	FUm/ha	AAT, g/kg DM	PBV, g/kg DM
Two cuts:				
50 kg N/ha	4740	3410	70	-44
100 kg N/ha	5500	3960	70	-27
150 kg N/ha	5890	4240	70	-17
200 kg N/ha	6080	4380	70	-9
250 kg N/ha	6110	4400	70	-3
Three cuts:				
100 kg N/ha	3840	3230	73	-5
150 kg N/ha	4610	3870	73	12
200 kg N/ha	5120	4300	73	25
250 kg N/ha	5380	4520	73	36
300 kg N/ha	5440	4570	73	46

Barley is grown according to regional practices (only one activity is modelled). Expected yield is 3750 kg/ha. Feed grain cannot be mixed at the farm, and the entire barley crop is sold. Straw may be ammoniated and fed to the young cattle.

In the model forage cannot be sold or purchased, but concentrates are purchased. Feed mixtures (for dairy cows), prices and energy and protein contents are shown in Table 3.

Table 3 Concentrate mixtures for dairy cows

	Price-1999	Energy content	Protein contents	
	NOK/kg feed	FUm/kg feed	AAT, g/FUm	PBV, g/Fum
Ruminant feed 97 low	2.54	0.95	97	-15
Ruminant feed 97 high	2.77	0.95	97	20
Ruminant feed 200	4.21	0.93	200	100
Ruminant feed pasture	2.59	0.95	97	-30

Animal production

Farm livestock includes dairy cows, followers and beef bulls. The calving period is October. Each cow produces 1.00 calves per annum, with 50% of calves being male and 50% female. The annual culling rate for dairy cows is 40%. Heifers raised on the farm replace cows. Male calves can either be sold or retained for beef production. However, in the model no male calves can be purchased.

Milk yields during the winter period depend on the feed level, whereas the AAT/PBV system ensures the protein requirement. Silage can be offered *ad libitum* or in fixed (restricted) rations. Table 4 presents daily concentrate supplementation and silage intake (ad lib feeding) during lactation in the winter period at different performance levels and the two harvesting regimes. Higher concentrate supplementation increases milk yield, but at a diminishing rate. The addition of concentrates depresses silage intake but increases total DM-intake. Given the same amount of concentrates, DM-intake is assumed somewhat higher for direct late-cut silage, but milk yields are highest for earlier-cut silage. Higher concentrate supplementation increases body weight at turnout. Cows on low concentrate feeding compensate for, during the season at pasture, the weight deficit accumulated over the winter (e.g., Gordon, 1984; Coulon *et al.*, 1996). During the grazing period all cows receive the same amount of concentrate. The remaining feed requirement is covered by pasture grass.

Table 4 **Milk yield, supplementation of concentrates and intake of silage in the winter period. Silage offered ad libitum**

	Milk yield, kg/cow[a]				
	5500	6000	6500	7000	>7000[b]
Two cuts:					
Concentrate suppl., kg DM/day	3.20	4.90	7.00	9.90	11.70
Silage intake, kg DM/day	13.40	12.47	11.50	9.80	8.57
Three cuts:					
Concentrate suppl., kg DM/day	2.50	4.00	6.00	8.60	12.20
Silage intake, kg DM/day	12.75	12.02	11.01	9.63	7.63

[a] Milk yield for entire lactation period. Milk yields during winter feeding (235 days) are determined by subtracting milk yield on pasture (980 kg), independent of yield level.
[b] 7250 kg for two cuts and 7500 kg for three cuts.

In some feeding systems silage can also be rationed, but a minimum amount is necessary in order to maintain normal rumen functions. For each milk performance level, a scenario with minimal silage intake is also included. Within the upper and lower limits for silage intake one FUm silage replaces one FUm concentrate and vice versa.

Feed plans for young livestock is fixed. For heifers and steers one can choose between one feeding regime with, and one without ammoniated straw. However, the use of straw requires access to own farm-grown barley straw. Late-harvested silage gives lower daily weight gains of beef bulls. At two (three) cuts, the beef bulls are ready for slaughter at an age of 550 (450) days and a carcass weight of 300 (285) kg.

Economic aspects

Farm subsidy levels and prices from 1999 are used in the basic models (NILF, 1999). Area payments for grain (incl. sward establishment with barley as cover crop) are 3720 NOK[11]/ha. Area payments rates for forage crops are NOK 5050, NOK 2170 and NOK 1300 per ha for areas of 0–10, 10–25 ha and 25–40 ha, respectively. Annual headage payments for dairy cows in the intervals 1–8, 9–16 and 17–25 cows are NOK 3974, NOK 2300 and NOK 1650 per cow, respectively. For other cattle, the annual rates are NOK 715 and NOK 565 for 1–25 and 26–140

[11] €1 ≈ NOK 7.50.

heads of cattle, respectively. Structural income support in dairy production is NOK 2.00 per L for the first 30,000 litres delivered. Important prices are; milk 3.53 NOK/L, beef from bulls 36.05 NOK/kg, cow beef 30.55 NOK/kg, barley 1.92 NOK/kg and concentrates (see Table 3).

The opportunity cost of the family's labour input varies substantially between farm families. In the typical situation the cost of the family's variable labour is set to NOK 75 per hour. The same rate is used for hired labour.

The farm economic result (later called profit) in the models is revenues (included farm subsidies) minus variable costs (included variable family labour). The family's fixed labour input, interest and depreciation costs for fixed assets (except breeding cattle), maintenance of buildings, insurance, electricity, administration, etc. is not included.

Results and discussion

The typical farm situations

Table 5 illustrates the main features of the optimal farming systems in the typical farm situations (1999-conditions).

Ad lib silage feeding is most profitable. The dairy herd consists of moderately yieldng cows. Milk production per cow is highest at three cuts. In order to ensure a given milk performance level, more concentrates have to be fed at two cuts. Still, lower milk yield at two cuts may reduce supplementation of concentrates per cow. PBV is low in late-harvested grass (two cuts), necessitating use of expensive concenrates high in PBV. In the typical farm situations three cuts are more profitable than two cuts[12].

Barley is grown when possible. The marginal profit in barley production determines the shadow price of land. Grassland is preferably re-established with barley as cover crop. This is encouraged by the higher marginal area payments for grains, but cover crop would still be most profitable even if area payments were equal. Nitrogen fertilisation in grassland is moderate.

When possible, ammoniated straw is fed to yearlings. At three cuts, all bulls are fed to finish and there is still idle housing space. At two cuts, all housing space is utilised due to additional cows and replacement heifers, as well as a longer bull-fattening period. Some male calves are then sold.

[12] In almost all other estimated alternatives (included various resource mix and farm policy changes) a three cut harvesting system is most profitable. Subsequently, only results for three cuts will be presented. The supply of DM in silage gets more limited as farmland decreases. Because two cuts produce most DM per ha, profitability of three cuts is substantially smaller as farmland approaches 10 ha.

Table 5 Results in the typical farm situations

	Model[a]			
	3C-GB	2C-GB	3C-G	2C-G
Economic indicators				
Profit (NOK)	331,472	318,616	300,218	288,936
Area payments (NOK)	88,302	88,823	70,030	70,030
Headage payments (NOK)	62,170	62,361	62,170	63,428
Crop management				
Silage (ha)	9.3	8.8	9.0	8.9
Pasture (ha)	6.3	6.5	5.8	6.6
Permanent pasture (ha)	0	0	0	0
Sward establishment, no cover crop (ha)	0	0	4.2	3.5
Sward establishment, cover crop (ha)	4.4	3.5	-	-
Barley (ha)	2.5	3.7	-	-
Fertiliser, silage (kg N/ha)	200	155	200	194
Fertiliser, pasture (kg N/ha)	150	150	195	200
Livestock management				
Cows (number)[b]	14.70	14.93	14.70	16.00
Heifers (annual)	5.88	5.97	5.88	6.40
Beef bulls (fat stock/year)	7.35	5.56	7.35	3.73
Sold calves (number/year)	1.47	3.40	1.47	5.87
Yield (kg milk/cow)	6603	6500	6603	6073
Intake of concentrates (kg/cow)	1943	2089	1943	1598
Ruminant feed 97 low	1873	0	1873	269
Ruminant feed 97 high	0	2022	0	1262
Ruminant feed 200	3	0	3	0
Ruminant feed pasture	67	67	67	67
Labour input (hours)	3353	3345	3375	3367
Shadow prices				
Land (NOK/ha)	4710	4710	4800	4800
Milk quota (NOK/L)	1.37	0.74	1.19	0.85
Housing, cow places (NOK/place)	0	1572	0	528
Housing, young stock places (NOK/place)	0	1572	0	528

[a] 3C-GB, three cuts, barley; 2C-GB, two cuts, barley; 3C-G, three cuts, no barley; 2C-G, two cuts, no barley.

[b] *Ad lib* feeding of silage is profitable in all alternatives.

The farm resource situation

Availability of farm resources and profitability of alternative enterprises may affect the optimal production system. Many different resource situations may be analysed. Effects of farmland, milk quota, housing capacity and labour costs are examined in this paper.

Utilisation of farmland only suitable for growing forage crops is particularly interesting[13], as the "surplus" of grassland in Norway is increasing. Alternative *A* in Table 6 shows the optimal system in the most extreme situation, land as a free good. Utilisation of more land (27.8 ha) with lower fertilisation (113 kg N/ha for silage) and lower grass yields are profitable. Permanent pasture replaces temporary pasture. Cow places become scarce. Their shadow price is substantial. Milk yield diminishes only a little (-223 kg per cow).

Alternative *B* in table 6 shows the optimal solution if both grassland and housing capacity are abundant. The forage area increases to 35.1 ha. Land is cultivated as extensive as the model permits. Concentrate supplementation to dairy cows are low—and *ad libitum* intake of silage high. Milk yield per cow is the lowest possible in the model.

The model has a short term planning horizon. In a point in the future, setting up of a new farm building has to be considered. If a constant milk quota is assumed, the model can be used to examine optimal housing capacity adjustments. Even if strategic decisions, as a milk output expansion, are excluded, insight is gained into optimal adjustments. Based on NILF (1999:98) annual housing costs is NOK 5175 per marginal cow (replacement heifers included) and NOK 1600 per marginal bull.

Alternative *C* and *D* show the optimal solutions at respectively 19 ha grassland and grassland in abundance. A new building increases costs per kg milk. Thus, in alternative *C* producing the quota on fewer but higher yielding cows than in Table 5 is profitable. Production of forage becomes more extensive, especially as some land is put into permanent pasture. Alternative *D* may be compared to alternative *B*. Less farmland is utilised, but still at low N-applications. More concentrate is supplemented per cow. Fewer but higher yielding cows produce the quota. High building costs result in a somewhat less extensive milk production, even if grassland resources are abundant.

Alternative *E* shows the optimal farm plan for the 19 ha farm if the quota does not restrict milk output (or the quota system is abolished and the milk price remains the same). All of the cow places are utilised to dairy cows. No quota limitations increases milk yield to 7232 kg per cow (+ 629 kg). Total milk delivery is 120,900 L (+ 34%). Less farmland is utilised to silage production and more to lower-fertilised pasture. Abundant grassland leading to relatively low-cost forage in alternative *F* result in lower milk yield per cow (6603 kg), but a somewhat higher milk yield than in alternative *A* with quota limitations (6380 kg).

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[13] If alternative crops can be grown, additional land may be allocated to non-forage crops. Vice versa, as the land base decreases, less land is allocated to non-forage crops. Model calculations show that grassland and milk production then gradually becomes more intensive.

Table 6 Optimal adjustment at various fixed resource mixes. Model without barley production, three cuts (3C-G), 1999-conditions

Alternative	*A*	*B*	*C*	*D*	*E*	*F*
Farmland (ha)	Abundant	Abundant	19	Abundant	19	Abundant
Cow places (number of cows)	18	Abundant	New	New	18	18
Milk quota (L)	90,000	90,000	90,000	90,000	Abundant	Abundant
Economic indicators						
Profit (NOK)	328,939	342,676	214,442	240,014	318,954	345,287
Area payments (NOK)	86,665	96,148	70,030	91,230	70,030	87,534
Headage payments (NOK)	63,897	70,996	59,360	67,024	64,205	64,205
Crop management						
Silage (ha)	12.4	16.3	8.1	14.3	7.7	11.5
Pasture (ha)	0	0	3.4	0	7.3	0
Permanent pasture (ha)	11.3	13.4	4.1	12.2	0	13.2
Sward establishment (ha)	4.1	5.4	3.4	4.8	4.0	3.8
Total farmland (ha)	27.8	35.1	19.0	31.3	19.0	28.5
Fertiliser, silage (kg N/ha)	113	100	200	100	200	126
Fertiliser, pasture (kg N/ha)	-	-	150	-	150	-
Livestock management						
Cows (number)[a]	15.22	17.70	13.85	16.20	18.00	18.00
Heifers (annual)	6.09	7.08	5.54	6.48	7.20	7.20
Beef bulls (fat stock/year)	7.61	8.85	6.93	8.09	0.47	0.47
Sold calves (number/year)	1.52	1.77	1.39	1.62	10.33	10.33
Yield (kg milk/cow)	6380	5500	7000	6000	7232	6603
Intake of conc. (kg/cow)	1670	897	2502	1259	2953	1943
Total milk deliveries, L	90,000	90,000	90,000	90,000	120,900	110,225
Labour input (hours)	3431	3649	3297	3520	3492	3506
Shadow prices						
Land (NOK/ha)	0	0	3730	0	4030	0
Milk quota (NOK/L)	0.93	2.27	0.46	1.17	0	0
Housing of cows (NOK/place)	4342	0	x	x	5795	9263

[a] *Ad lib* feeding of silage is profitable in all alternatives.

In the models fewer but higher yielding cows fill the quota as labour costs increases. Forage production costs increases. N-applications in grassland are adjusted downward.

To sum up, the farm resource situation clearly influence optimal forage and milk production systems. The results suggest that under certain conditions with abundant grassland, low yielding forage and milk production systems are most profitable. But such a production system presupposes free cow places (or very cheap buildings) to a larger herd. With higher building costs milk production becomes more intensive. Grasslands are still utilised in a low-input way, but farmland in operation diminish.

Effects of milk price support, area payments and headage payments

Model calculations (not presented here) show that additional milk price support does not affect the use of inputs and production, because production over the quota is unprofitable. However, as profitability increases directly, price support may be a targeted instrument to improve dairy farm incomes. The milk price only influences production if the price drop is larger than the shadow price of the milk quota. Typical farms have capacity to increase milk production, and profitability of alternative enterprises is relatively low. Milk quota shadow prices are high (e.g. above NOK 1.00 per litre milk in Table 5). The milk price must fall significantly before the milk quota are not fully utilised.

Table 7 shows optimal adjustments in the typical farm situations if area payments and/or headage payments are withdrawn. The reduced profit demonstrates the importance of these payments for the viability of dairy farms but income may also be transferred in ways that do not influence production (e.g., milk price support).

If only forage crops can be grown, the shadow price of land decreases correspondingly to the decrease of the area payment (Alternative I). The internal price of forages does not change. The choice of production strategy is not influenced. The (lack of) adjustment presupposes that it is profitable to utilise all of the farmland, i.e. a positive shadow price of land after removal of the area payment. However, if some grassland is not in use, increased area payments encourage utilisation of more grassland as cheaper silage result in lower yielding cows fed less concentrates (per kg milk).

If grain crops are also grown, no grassland area payments result in more land allocated to barley (Alternative III). Net forage costs increase if grassland area payments are removed. Grassland fertilisation and milk production becomes more intensive. If feasible, the high price of silage relative to concentrates makes it profitable to restrict silage rations. If area payments for grain are also withdrawn (Alternative IV) the competitive position turn, because grain had the highest marginal area payment rate. Grain production becomes unprofitable. Grassland utilisation is less intensive. Milk yield per cow is lower than at the basic assumptions in Table 5.

By decreasing headage payments per cow, milk yield rise, as it is optimal to have fewer cows to produce the same quota output (Alternative II and Alternative V). More concentrate is supplemented per cow and per kg milk produced. This contributes to less need for forage and a more extensive grassland utilisation. Reduced headage payments decrease the shadow price of both farmland and milk quota. (If cow places are limited, their shadow price may also be influenced.)

Table 7 Optimal adjustments if area payments and/or headage payments are withdrawn. The typical farm situations, three cuts at 1999-conditions

Alternative	I	II	III	IV	V
Model	3C-G	3C-G	3C-GB	3C-GB	3C-GB
Area payments, forage	Withdrawn	Withdrawn	Withdrawn	Withdrawn	Withdrawn
Area payments, grain	-	-	As in basis	Withdrawn	Withdrawn
Headage payments	As in basis	Withdrawn	As in basis	As in basis	Withdrawn
Economic indicators					
Profit (NOK)	230,188	168,364	271,795	245,047	182,153
Area payments (NOK)	0	0	41,938	0	0
Headage payments (NOK)	62,170	0	59,360	63,586	0
Crop management					
Silage (ha)	9.0	8.7	5.9	11.0	10.4
Pasture (ha)	5.8	6.2	5.3	6.6	4.2
Permanent pasture (ha)	0	0	0	0	3.5
Sward est., no cover crop (ha)	4.2	4.1	0	0	0
Sward est., cover crop (ha)	-	-	3.0	5.0	4.3
Barley (ha)	-	-	8.2	0	0
Fertiliser, silage (kg N/ha)	200	200	200	150	150
Fertiliser, pasture (kg N/ha)	195	150	200	150	150
Livestock management					
Cows (number)	14.70	14.50	13.85	15.12	14.70
Of this *ad lib* access to silage	14.70	14.50	0	15.12	14.70
Heifers (annual)	5.88	5.80	5.54	6.05	5.88
Beef bulls (fat stock/year)	7.35	7.25	6.93	7.57	7.35
Sold calves (number/year)	1.47	1.45	1.39	1.51	1.47
Yield (kg milk/cow)	6603	6693	7000	6419	6603
Intake of conc. (kg/cow)	1943	2071	3215	1712	1943
Labour input (hours)	3375	3359	3261	3368	3331
Shadow prices					
Land (NOK/ha)	2630	1910	4710	1470	1150
Milk quota (NOK/L)	1.19	0.80	1.03	1.54	1.07
Housing of cows (NOK/place)	0	0	0	0	0

Significant changes in prices and subsidies

Farm policy changes in the same direction as described by the Ministry of Agriculture (1999) are examined. We look at the following scenario, with significant price and support changes (compared to 1999-conditions): the price of barley is reduced by 25% (0.48 NOK/kg) to 1.44 NOK/kg. The price of seed grain and concentrates is reduced accordingly. The price drop is partially made up for by raising the area payment for grain by 1280 NOK/ha to 5000 NOK/ha. Milk and beef prices are reduced by 15%. The area payment, after levelling-out its structural profile, is 4500 NOK/ha forage area in the interval 0–25 ha and 3000 NOK/ha in the interval 25–40 ha. For dairy cows, headage payment now amounts to 3750 and 2750 NOK/cow for the intervals 1–16 and 17–25 cows, respectively. Payment for young cattle is changed to NOK 900 per head. The changes are greater than actually implemented in 2000.

Table 8 shows the results in the typical farm situations at three cuts[14]. Optimal solutions when silage must be offered *ad libitum* are also presented because *ad lib* feeding is necessary in several feeding systems.

First, we consider results when silage rations may be restricted. Concentrates are no longer more costly than silage, making rationing of silage most profitable. In model 3C-G, cows are just offered the minimum amount of silage. Concentrate supplementation are high. The image of milk as a natural grass-based product may then be questioned.

Lower concentrate prices *ceteris paribus* result in increased use of concentrates and a higher yielding milk production system. Nevertheless, when silage can be rationed, milk yields in Table 8 tends to be lower than at the 1999-conditions. Levelling-out of the structural profile and accordingly higher marginal area and headage payments cause much of this effect. Further, weakened profitability in barley production encourages lower yielding milk production systems. In fact, barley production on the typical mixed dairy farm is not profitable. More abundant land resources characterise the farm situation. Land use becomes extensive, included significant use of permanent pasture. Farmland remains in operation, but in a low input-output manner. Compared to the 1999-conditions, profits are reduced by NOK 13,000–23,500. The farm income deduction of NOK 14,000 partially compensates for this.

The difference in profit between silage offered restricted and *ad libitum* is small (Table 8). The way of offering silage does however influence the production system significantly. Milk yield per cow is somewhat higher if silage is offered *ad libitum* (and higher than at the 1999-conditions). In model 3C-G cows are supplemented 0.31 kg concentrate/kg milk if silage is offered *ad libitum*. Restricted silage supply increase the concentrate supplementation to 0.46 kg per kg milk. Land allocated to permanent pasture is reduced if silage is offered *ad libitum*.

[14] The difference in profit between a three and a two cut system is NOK 4000–5000 smaller than at the 1999-conditions. Gains of three cuts are still considerable.

Table 8 Results in the case of significant changes in prices and subsidies. The typical farm situations at three cuts

	Grass and barley (3C-GB)		Only grass (3C-G)	
	Silage may be rationed	Silage must be offered *ad lib*	Silage may be rationed	Silage must be offered *ad lib*
Economic indicators				
Profit (NOK)	307,943	307,794	282,375	281,210
Area payments (NOK)	103,210	103,408	85,500	85,500
Headage payments (NOK)	75,149	73,963	75,149	72,947
Crop management				
Silage (ha)	9.8	10.4	6.6	8.7
Pasture (ha)	3.2	4.2	1.6	6.2
Permanent pasture (ha)	5.6	3.5	8.3	0
Sward est., no cover crop (ha)	0	0	2.5	4.1
Sward est., cover crop (ha)	3.9	4.3	-	-
Barley (ha)	0	0	-	-
Fertiliser, silage (kg N/ha)	150	150	200	200
Fertiliser, pasture (kg N/ha)	150	150	150	150
Livestock management				
Cows (number)	14.93	14.70	14.93	14.50
Of this *ad lib* access to silage	10.57	14.70	0	14.50
Heifers (annual)	5.97	5.55	5.97	5.80
Beef bulls (fat stock/year)	7.47	7.35	7.47	7.25
Sold calves (number/year)	1.49	1.47	1.49	1.45
Yield (kg milk/cow)	6500	6603	6500	6693
Intake of conc. (kg/cow)	2140	1943	2966	2071
Labour input (hours)	3318	3330	3266	3359
Shadow prices				
Land (NOK/ha)	5800	5800	6050	6720
Milk quota (NOK/L)	1.30	1.30	1.19	1.04
Housing of cows (NOK/place)	0	0	0	0

Not presented model calculations indicate that more of abundant grassland resources are put into production at the significant policy changes. This seems a bit surprising, since lower concentrate prices work in the opposite direction and farmland use was more extensive in the typical farm situation. Levelling-out of subsidy rates leading to substantially higher payment rates for farmland over 25 ha and more than 16 cows causes this adjustment. On land-abundant farms, the high input of land and cows to produce the quota result in increased profit as farm policy changes.

Conclusions and some farm policy implications

LP models have been designed to examine optimal short-run adjustment on Norwegian dairy farms. Important biological relationships and interactions in forage, crop and livestock production are represented but much are also simplified or excluded. The main purpose of the optimisations is insight in adjustments rather than precise, numerical results.

Optimal production systems are largely determined by a combination of economic factors associated with the various inputs, outputs and support schemes together with availability of farm resources. The typical Norwegian dairy farm has a small quota compared to other farm resources. At 1999-conditions producing a fixed milk quota with moderate yielding cows was most profitable. Under certain conditions with abundant grassland, low yielding forage and milk production systems are profitable. But such a production system presupposes free building places (or very cheap buildings) to a larger herd and relatively low costs in forage production. In cases with high opportunity costs on fixed resources high yielding milk production systems are encouraged.

With a fixed quota, additional milk price support does not affect production. The milk price only influence production if a price drop is larger than the quotas' shadow price.

What happens if area payments for forage crops increases? If all of the farmland is utilised and grassland is the only possible land use, no changes in production occur. If some grassland is not in use, area payments may increase grassland utilisation as cows are fed less concentrate. If grain crops are also grown, increased grassland area payments result in more land allocated to grass. Forage and milk production becomes more extensive.

By increasing headage payments, milk yield falls, as it is optimal to have more cows to produce the same quota output. This contributes to keep more grassland in production and in a more intensive forage production.

What happens when reduced prices are to be compensated for by taxable farm income deductions and a levelling-out of the subsidy's structural profile? Concentrates may no longer be more costly than silage, making rationing of silage (if possible) most profitable. Lower concentrate prices *ceteris paribus* result in increased milk yields, but combined with levelling out of headage and area payments the change in milk yield is small. Forage production becomes more extensive, especially if silage is rationed and cows are fed large rations of concentrates.

In the 1990s price support should be reduced, e.g. in order to decrease food production (surpluses) and lower production intensity. Area and headage payments were regarded as less "production-distorting" income compensation schemes. However, within a milk quota system, milk price support may be a targeted instrument to improve dairy farm incomes. On the other hand, area and headage payments have effects on production. More grassland is kept in production and is cultivated in a less extensive way, as lower yielding cows require more forage per kg milk. In Norwegian agriculture, this may encourage production of public goods (e.g., rural viability, agricultural landscapes, food security). Cheaper concentrates reduce costs of production, but may make it harder to keep grassland in production. Obviously, representation of milk quotas and the biology of milk production systems yield valuable information about farm level adjustments to policy changes.

More decision problems on dairy farms at changing economic conditions could be examined, e.g. the dynamic and tactical features of sequential farm decision-making under risk (forage production, feeding, quota "fit", etc.), time of calving, culling strategies, choice of grass harvesting technology and other strategic decisions (e.g., evaluation of expansion and conversion to organic farming). Econometric studies may allow insight into how farmers actually have adjusted—but dual methods lack biological details that accompany e.g. optimisation models (e.g., Just & Pope, 2001:633). Conclusions from normative farm model studies may be challenged and complemented by results from real farm case studies in which more of the real situation can be included (Malcolm, 2001). From a policy point of view more knowledge is needed about the relationship between farming systems and production of externalities and public goods. Thus, there remain many options for further dairy farm research at changing economic conditions.

References

Beever, D.E., N. Offer & M. Gill, 2000. The feeding value of grass and grass products. In: Hopkins, A. (Ed.), *Grass: its production and utilization, 3rd ed.* Blackwell Science, London, pp. 140–195.

Berentsen, P.B.M. & G.W.J. Giesen, 1995. An environmental-economic model at the farm level to analyse institutional and technical change in dairy farming. *Agricultural Systems* 49, 153–175.

Coulon, J.B., P.D. Hour, J.P. Garel & M. Petit, 1996. Long-term effect of level and pattern of winter concentrate allocation in dairy cows. *Annales de Zootechnie* 45, 233–251.

Flaten, O., 2002. *Økonomiske analyser av tilpassinger i norsk mjølkeproduksjon*. Doctor Scientiarum Theses 2001:1. Institutt for økonomi og samfunnsfag, Norges landbrukshøgskole, Ås.

Giæver, H., O. Flaten, A.M. Jervell & A. Hegrenes, 1995. *Kostnader og omstillingsmuligheter på norske mjølkeproduksjonsbruk*. NILF-rapport 1995:3. Norsk institutt for landbruksøkonomisk forskning, Oslo.

Gordon, F.J., 1984. The effect of level of concentrate supplementation given with grass silage during the winter on the total lactation performance of autumn-calving dairy cows. *Journal of Agricultural Science, Cambridge* 102, 163–179.

Just, R.E. & R.D. Pope, 2001. The agricultural producer: theory and statistical measurement. In: Gardner, B.L. & G.C. Rausser (Eds.), *Handbook of agricultural economics, volume 1A Agricultural production*. Elsevier, Amsterdam, pp. 629–741.

Luenberger, D.G., 1984. *Linear and nonlinear programming, 2nd ed.* Addison-Wesley Publishing Company, Reading, Massachusetts.

Malcolm, B., 2001. *Farm management economic analysis: a few disciplines, a few perspectives, a few figuring, a few futures.* Invited paper at the annual conference of Australian Agricultural and Resource Economics Society, Sydney. http://www.agribusiness.asn.au/Review/Perspectives/Malcolm_2001_1.htm

Ministry of Agriculture, 1999. *St.meld. nr. 19 (1999-2000). Om norsk landbruk og mat-produksjon.* Det kongelige landbruksdepartement, Oslo.

NILF, 1999. *Handbok for driftsplanlegging 1999/2000*. Norsk institutt for landbruks-økonomisk forskning, Oslo.

Pannell, D.J., 1996. Lessons from a decade of whole-farm modelling in Western Australia. *Review of Agricultural Economics* 18, 373–383.

Ramsden, S., J. Gibbons & P. Wilson, 1999. Impacts of changing relative prices on farm level dairy production in the UK. *Agricultural Systems* 62, 201–215.

Sehested, E. & T. Steine, 1999. Effects of different breeding goals in the Norwegian cattle population. *Nordisk Jordbrugsforskning*, 81(3), 267–272.

Søyland, V., L. Forsell & N.K. Nersten, 2002. *FOLA 2002: Landbrukspolitikk – forenkling og målretting*. NILF-rapport 2002–1. Norsk institutt for landbruks-økonomisk forskning, Oslo.

TINE, 2002. *Årsrapport 2001. Organisasjonsavdelingen TINE Norske Meierier.* TINE Norske Meierier, Oslo.

Valencia, V. & D. Anderson, 2000. Choosing optimal milk production systems in a changing economic environment. *Farm Management* 10, 618–630.

Characterizing Efficient Dairy Farms and Farmers

Bjørn Gunnar Hansen[a], Agnar Hegrenes[b], and Grete Stokstad[c]

Abstract

At present there are nearly 20 000 milk producers in Norway, and approximately 10 per cent of them are members of the Norwegian Dairy Financial Recording (NDFR). The NDFR is an important basis for production and financial advice given by the dairies.

There is a great interest among milk producers and advisors in comparing results from different farms to find out why some are doing well and some are doing not so well, and to learn from those doing well. Gross margin (GM) per litre of milk produced is the traditional indicator for efficiency. This data, as other data on milk production, indicate that there is a wide variation in gross margin per litre of milk between farms with seemingly similar conditions for producing milk. This is interpreted as a potential for improving the efficiency of many producers.

However, for many reasons gross margin per litre of milk is not an ideal indicator. A new version of the NDFR contains more information, for instance information on fixed costs of roughages produced on the farm. It is hoped that the new version of the NDFR makes it a better tool for improving the profitability of milk production.

In an ongoing project we try to use the NDFR to analyse who are doing well and why. We use a combination of Data Envelopment Analysis (DEA) and statistical analysis. For each farm we produce an efficiency index, and then we apply statistical methods to find factors that can explain the index. So far we have only very preliminary results.

Management factors are important, but the NDFR data-base have very little information on management factors. It is planned to collect such data for a sample of farmers and include that in the study at a later stage.

Keywords: Milk production, Efficiency indicators, Data envelopment analysis, Statistical methods

[a] TINE, Norwegian Dairies Association. *bjorn.gunnar.hansen@tine.no*

[b] Norwegian Agricultural Economics Research Institute

[c] Agricultural University of Norway, Departement of Economics and Social Sciences

Introduction and background

At present there are nearly 20 000 milk producers in Norway. More than 90 per cent of them are members of the Norwegian Dairy Herd Recording System (NDHRS). This system contains mainly production data (data on feeding, milk yield, quality of milk, health status and veterinary treatments of every cow etc., and herd data). A little more than 2000 milk producers are also members of the Norwegian Dairy Financial Recording (NDFR). This is a combination of NDHRS data and information from the farm accounts. However, data on other enterprises than milk production and related activities are excluded. The NDFR is an important basis for production and financial advice given by the dairies, especially advice concerning short run decisions.

There is a great interest among farmers and advisors in comparing results from different farms to find out why some are doing well and some are doing not so well, and to learn from those doing well. Gross margin (GM) per litre of milk produced is the traditional indicator for efficiency. This data, as other data on milk production, indicate that there is a wide variation in gross margin per litre of milk between farms with seemingly similar conditions for producing milk. This is often interpreted as a potential for improving the efficiency of many producers.

In Norway, production of beef most commonly takes place in dairy herds, with great differences in quantity of meat produced per herd and per cow. Earlier studies have shown that comparisons of GM per litre among farms tend to favour farms with large acreage and large cowsheds and thus large meat production per cow. Therefore, comparisons of GM do not provide a ground for "fair" comparison. Creating a better basis for comparing results among dairy farms is therefore an important part of this project.

This article is based on a research project which started in June last year and ends in June 2003. The project has five participants, Norwegian Agricultural University, Norwegian School of Veterinary Science, Norwegian Agricultural Economics Research Institute, Geno (breeding organization) and TINE, with TINE as project owner. When the project is finished we intend to be able to describe the efficient farm/farmer through a set of variables from farm accounts, production records, and leadership information.

The article is organised as follows: After this short presentation of the background for the project, we present some theoretical considerations and give more details concerning the data and method. Thereafter, we present some preliminary results. In the final section we discuss the preliminary results and draw some conclusions.

Theory

In the traditional leadership-performance debate leaders are viewed as having a significant impact on the organizations they head. A crucial question is therefore how much of the variance in organizational performance can be attributed to the person in the leadership role. Further, many authors have criticised the "economic man"-approach in performance studies for being too narrow. The critics suggest that one need to include knowledge from other disciplines, i.e. psychology, in order to be able to understand and explain man's behaviour.

Several models to explain behaviour have been developed, some of them also related to farmers. In our work we build partly on a large study conducted among Scottish farmers in the late nineties (Willock et al., 1999). One important aim of that study was to detect attitudes, goals and values among farmers, and to use these findings as explanatory variables for predicting behaviour. Behaviour was determined in many ways related to how the farmers ran their farm. Built on this model and other relevant literature we have developed a model which shows the connection between the different subjects involved in our attempt to explain economic efficiency. The model is shown in Figure 1.

Comparative analysis has a long tradition in agriculture. Many have questioned the usefulness of comparing different farms, but we believe that such comparisons, in one form or another, provide useful information on best practise and can give farmers hints on possible ways of improving their financial results. However, the financial result of a farm depends on many factors that are not measured in enterprise records. We have tried to take these factors into account when designing this project.

Comparative analysis based on NDFR data is previously based on explaining gross margin per litre of milk. In this work we have chosen to use the efficiency of the farm/farmer to generate gross margin as the measurement stick rather than gross margin per litre of milk directly.

Efficiency is generally measured using either parametric or non-parametric methods. Parametric methods include deterministic frontier production functions, stochastic frontier methods, and panel data models (Battese, 1992). Non-parametric models involve mathematical programming. Data Envelopment Analysis (DEA) is a common non-parametric method. One of the advantages of DEA is that one does not need to specify a distributional form for the production function and the inefficiency term. In our project we are studying farms at a micro level, and the functional form for the production function is not well known. One aim with this work is to improve the toolbox for advisers or farmers within dairy production. DEA is extensively used in practice to compare firms that are different. Thus we think that DEA has a bigger potential than the parametric method as a practical measurement stick for comparisons between farms. This was the main reason for selecting the DEA-method. Some disadvantages compared to stochastic frontier methods are that DEA does not account for noise, and that it cannot be used to conduct conventional tests of hypotheses.

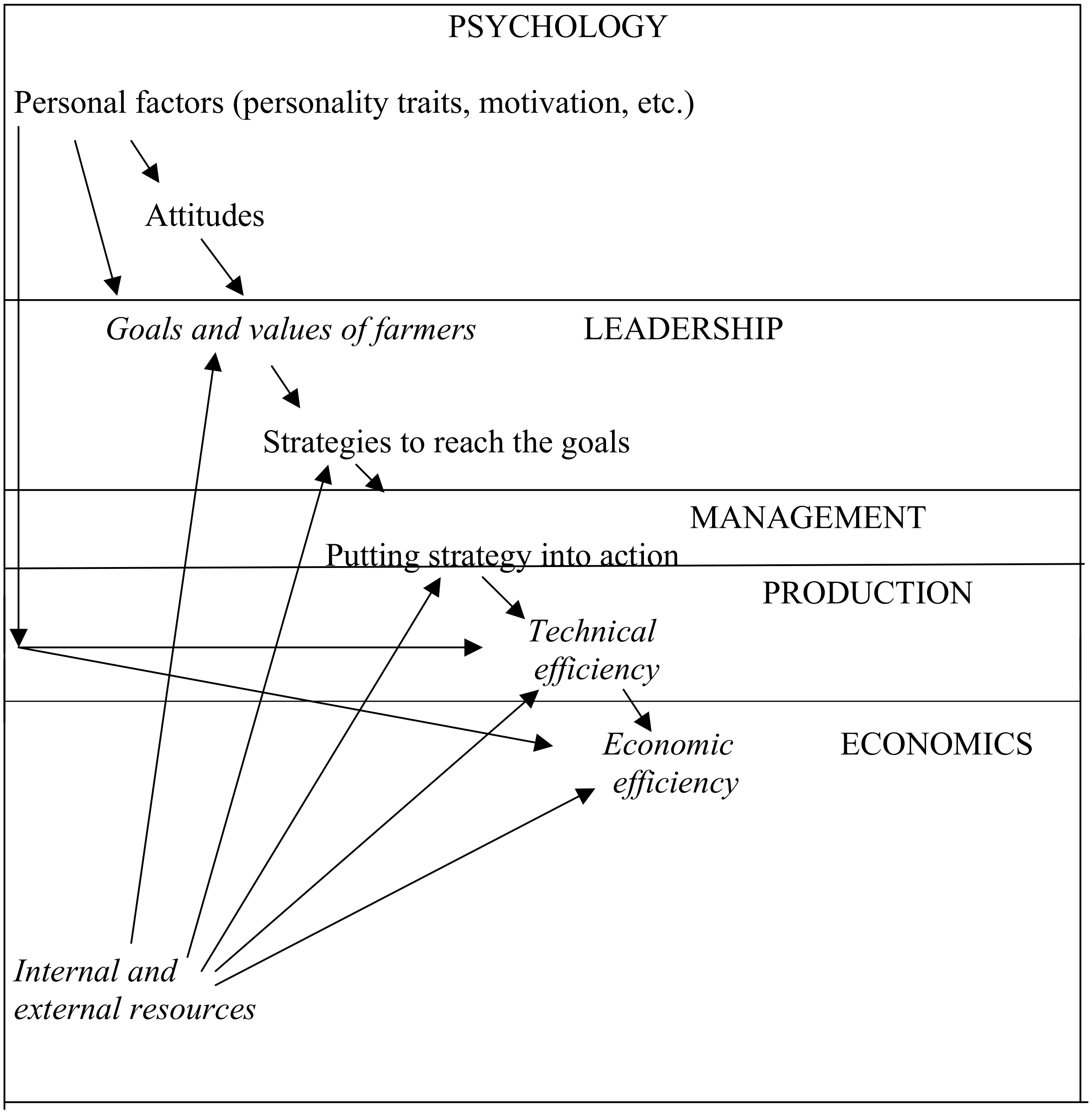

Figure 1 Model to explain the farmers' economic behaviour (Based on ideas from e.g. Willock et al., 1999)

According to Farrell (1957) efficiency can be divided in two components, technical efficiency and allocative efficiency. The first reflects the ability of a firm to obtain maximal output from a given set of inputs, and the latter the ability to use the inputs in optimal proportions, given their respective prices and the production technology. These two measures are then combined to provide a measure of total economic efficiency. In principle there are two ways of expressing efficiency, either input-oriented measures or output-oriented. With input orientation the question is

"By how much can input quantities be proportionally reduced without changing the output quantities produced?" Alternatively, by an output oriented approach one can ask "By how much can output quantities be proportionally expanded without altering the input quantities used?"

These two concepts are illustrated in Figure 2. In the figure we have assumed a constant returns to scale technology represented by *f(x)*. According to Farrell (1957) the farms in point A and C lie one the efficiency front, and hence are fully efficient with efficiency index 1. Farm B has output-oriented efficiency index *XB/XA*. The input oriented efficiency index is *OY/OX*. The efficiency index thus takes a number between zero and one. DEA has been used in a number of analysis and also as a basis for advice to farmers, for instance Lund & Ørum (1997) and Gerber & Franks (2001).

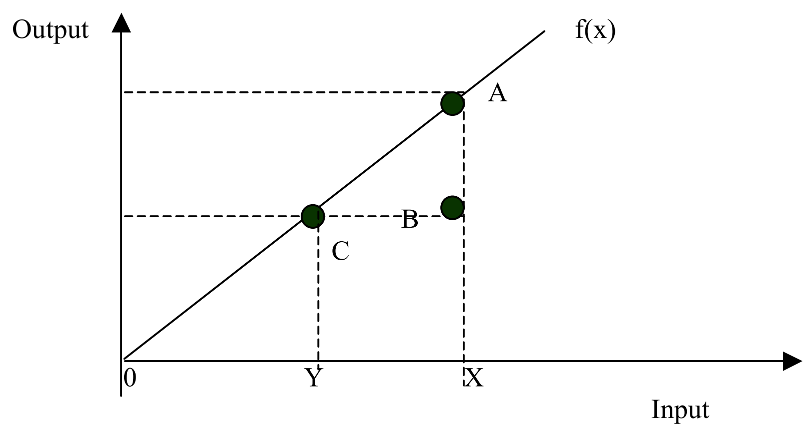

Figure 2 DEA-model

Material and method

The reference population in this study is all dairy farmers who are members of the National Dairy Herd Recording System. The study population is the 1915 farmers who are members of both the Norwegian Dairy Herd Recording System (NDHRS) and the Norwegian Dairy Financial Recording (NDFR) in 2000 and 2001. A check of representativity shows that the study population has slightly larger herds and less veterinary treatments than the reference population, but the differences are so small that the study population is considered representative of the reference population. This project is divided into two studies as described below.

Study I

Defining and measuring efficiency is a key question in study one. The next step is do explain the efficiency score as far as possible with data from the NDFR data.

DEA-analysis

Our goal is to measure economic efficiency. Among the many possible output measure, we choose two: gross margin without any subsidies except price-subsidies (GM1), and gross margin including subsidies and minus fixed roughage costs (GM2). GM2 is closer to the net income from agriculture than GM1. One part of the project is to study the correlation between these two GM indicators.

Many factors are fixed or quasi-fixed in the short run. Our efficiency measure addresses the question: "By how much can gross margin be expanded without increasing the fixed input factors?" All farms have a milk quota, it is expensive to change the cowshed, and the agricultural land is not easily increased. Available labour force might in many cases be regarded as relatively fixed in the short and medium run. An efficient farm can be defined as a farm that gets a high GM compared with the quantity of quasi-fixed factors.

The NDHRS have information on milk quota and area for forage production, i.e. roughage production. There are no information on other quasi-fixed factors. However, we have calculated the square metres necessary to house the existing average herd size, and used this as a proxy for cowshed capacity.

DEA involves the use of linear programming methods to construct a piece-wise surface over the data. Efficiency measures are then calculated relative to this surface. To calculate productivity increasing efficiency index for farm k out of n farms assuming variable return to scale we have used the linear programming model below, equation 1.

Maximize $1/E_k$ [1]

With respect to:

$\sum_{j=1}^{n} z_{kj} y_j \geq \frac{1}{E_{Vk}} y_k$ where y is gross margin [1a]

$\sum_{j=1}^{n} z_{kj} x_{ij} \leq x_{ik}$ where *i* =quota, area and building capacity [1b]

$\sum_{j=1}^{n} z_{kj} = 1$ [1c]

$z_{kj} \geq 0$ $j=1,..,n$ [1d]

With use of this model we have computed $1/E_k$ for all n firms. The efficiency measure (E_k) is greater than 0 and less than or equal to 1. Constraint 1c is omitted when we have computed the efficiency measure assuming constraint return to scale.

The constant return to scale assumption is only appropriate when all firms are operating at an optimal scale. We make this assumption in our model when gross margin exclusive of subsidies is concerned because the data shows little difference between the two methods. Farms may then be "benchmarked" against substantially larger or smaller farms. We refer to this measure when we use the notation E1. When subsidies and fixed costs are included our data shows a decreasing return to scale, partly due to the subsidy scheme. Another reason might be that smaller farms substitute machinery with labour, which is not included in our model. We therefore include constraint 1c in our model to account for variable returns to scale when gross margin inclusive of subsidies minus fixed roughage costs is concerned. The model above illustrates this calculation (E2).

Statistical analysis

First we use DEA to rank the farms by the economic efficiency index (two alternatives E1 and E2). Then the farms are divided into quartiles due to efficiency and analysed statistically with GLM, agreement and regression analysis. By combining two quite different methods we hope to get the best from each. The main objective of the statistical analysis is to detect the causes for the obtained differences in efficiency, and to compare the different measures. The analysis has the following five aims:

1. Compare two measures; Economic efficiency index computed with DEA (E-DEA) and Gross Margin per litre milk delivered (GM) to express the overall profitability of a dairy farm.
2. Express the overall farm E-DEA by a set of production and leadership variables.
3. Express the E-DEA for three different parts of the herd, namely milk production, heifer raising, and beef-production by a set of production variables.
4. To study repeatability in ranking of dairy farms on economic efficiency over two years.
5. Study the correlation between the two dependent variables on individual farms.

Dependent variables:
As dependent variables in this analysis we will use two different profitability measures:

- E-DEA exclusive subsidies except price-subsidies (E1)
- E-DEA inclusive subsidies minus fixed roughage costs (E2).

Independent variables:
These variables are divided in the following categories:

- ➢ Variables related to production
- ➢ Variables related to leadership

In the first analysis of the material, only variables related to production will be available. Leadership variables will be collected through a survey. Due to the number of variables available compared to the number of farms included, it is necessary to divide the production data for the farm as a whole into item related categories. These are as follows:

- ➢ Animal health
- ➢ Fertility
- ➢ Breeding
- ➢ Milk quality
- ➢ Feeding
- ➢ Meat production

- Roughage production
- Production strategy
- Variable and fixed costs
- Incomes

Study II

Study will be conducted after the analysis of the 2000-data is finished. It therefore gives us the opportunity to collect supplementary information on different subjects which need further examination. The other main purpose is to include some leadership variables to increase the explanatory power of the study. In the traditional leadership-performance debate leaders are viewed as having a significant impact on the organizations they head. A crucial question is therefore how much of the variance in organizational performance can be attributed to the person in the leadership role. Further there are many authors which criticise the "economic man"-approach in performance studies for being too narrow. The critics suggest that one need to apply knowledge from other disciplines, i.e. psychology, to be able to understand and explain mans behaviour.

In the model one notices that leadership factors such as farmers goals and values lie close to explaining behaviour. Goals and values among dairy farmers in Norway have been paid little attention, both in recent research and in the extension service. From the figure one also notices that management variables such as those included in the decision making process lies even closer to behaviour. Therefore it could also be of interest to include those in the study. However, we have chosen not to do so. The main reason for this is that studying i.e. the decision making process requires a case-study approach, and due to limited financial and time resources, such an approach is not possible in this study. We therefore restrict ourselves to focusing on goals and values as explanatory variables. Leadership factors and supplementary information will be collected through an interview with 180 farmers during winter 2003.

Results so far

At present the DEA-analysis of the 2000-data is completed, and so is the comparison between the different dependent variables. The rest of the analysis remains. Here only some preliminary results are presented. First some results comparing the efficiency indexes with the respective gross margins.

Figure 3 shows that as GM1 grows the deviation in E1 increases, at least up to some point. In average GM1 explains 65% of the total variation in E1. In the case of a perfect fit the observations would cluster along a 45° line through origo. The figure shows that there is a tendency that GM1 underestimates the efficiency especially for large numbers of GM1. Figure 4 illustrates this. As we can see the mean of the difference lies to the right of zero. This indicates that in general farms are more efficient than can be read directly from the GM1.

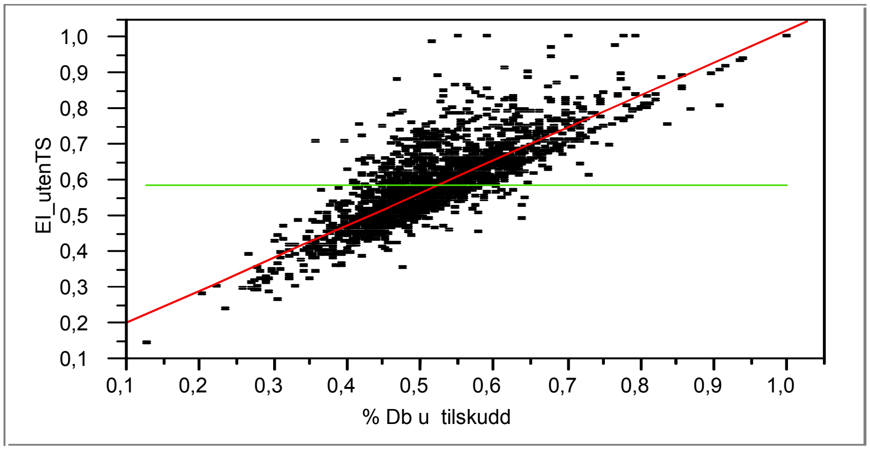

Figure 3 E1(vertical axis) as a function of GM1(horizontal axis). GM1 is rescaled to lie between 0 and. The horizontal line indicates the mean of E1 and the other sloped line is a linear regression of GM1 on E1

A farm may have a high GM1 per litre of milk, due to a large meat production. However, compared to the use of building capacity and land in addition to milk production, the farm do not perform as good as the GM1 measure indicate. The few data points where the scaled measure for GM1 is less than the efficiency score can be due to two causes: The farmers do not produce his quota, thus the fixed factor quota is larger than amount of litre of milk used to calculate GM1 per litre. The other cause may be that the milk quota is not a binding constraint in the calculation of the efficiency score.

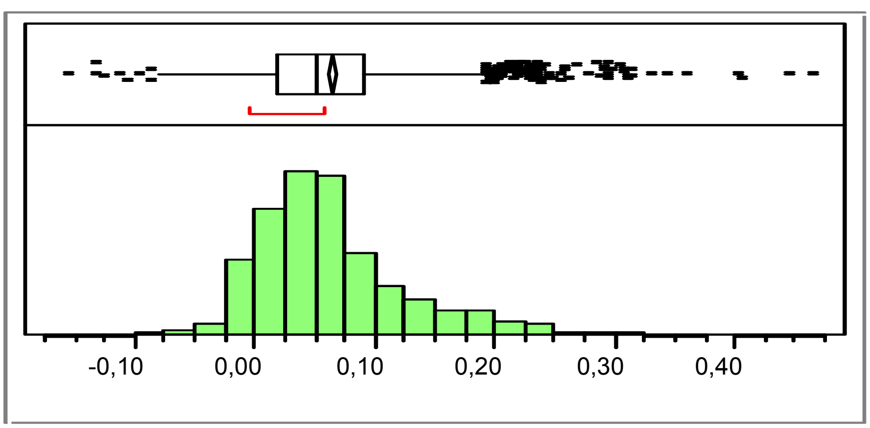

Figure 4 Distribution of the difference E1 minus GM1. Both measures are rescaled to lie between 0 and 1

We now turn to E2 and GM2. Figure 5 shows the same main pattern as Figure 3, but the deviation in E2 when GM2 increases is perhaps even larger. The explanation may be the same as above. On average GM2 explains 66% of the total variation in E2.

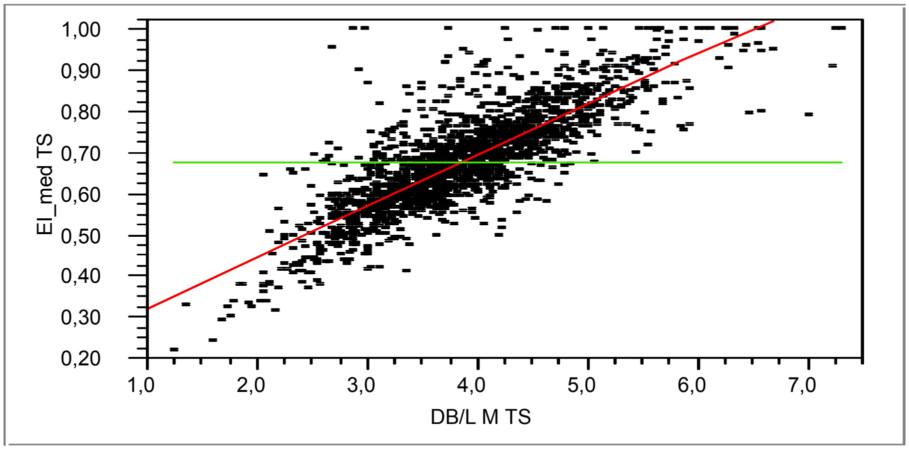

Figure 5 *E2 (vertical axis) as a function of GM2 (horizontal axis). GM2 is not rescaled.* *The horizontal line indicates the mean of E2 and the sloped line is a linear regression of GM2 on E2*

The efficiency measures provide rankings of farms that are adjusted for variations in gross margins that is due to different use of the quasi fixed factors quota, area and buildings, thus the variation declines.

One important difference between GM2 and GM1 is the acreage subsidy, which will depend on location and size of the farm. Thus we would expect some differences between the measures GM1 and GM2. GM2 explains about 42% of the variation in GM1. When we compare E1 and E2, we find the same pattern, and E2 explains also about 42 percent of the variation is E1. The means of the measures that are indicated in Figure 3 and 4 are not directly comparable. E2 is calculated assuming variable return to scale and that will give scores that are equal to or higher than a calculation assuming constant return even if it where a perfect fit between GM1 and GM2.

We have ranked the farms according to E1 and E2 alternatively, and then grouped into four groups; lowest ¼, next lowest ¼, next highest ¼ and highest ¼. Table 1 and Table 2 show some average figures for each group.

Calving index is the number of calvings in the month with highest number of calvings divided by the total number of calvings, i.e. it expresses how concentrated the calvings are to one month/period of the year.

Fertility-status (FO-number) is an index that increases when there are fewer problems associated with getting all cows-in-calf).

To summarize, the most efficient farms when ranked by E1 seem to be characterized by:

- high milk price
- high income from beef
- low miscellaneous costs
- high roughage crop yield
- highest dairy deliverance and quota filling

- accurate concentrate feeding
- high beef production per cow
- low concentrate costs in spite of high beef production per cow

When measuring efficiency, both which input factors and economic parameter to choose are of great importance. These factors have a great influence on the efficiency ranking. In this study the results so far indicate that differences in the three input factors among farms can explain approximately 1/3 of the total variation in Gross Margin without subsidies (GM1). This finding illustrates that directly comparison of GM between farms can be misleading. The efficiency index thus seems to create a better ground for comparing results among farms than does Gross Margin without any correction.

As one can see, list of factors in Table 2 differs from those in Table 1. This is partly in accordance with the findings of Giæver (1996).

To summarize, the most efficient farms when ranked by E2 seem to be characterized by:

- Low roughage cost
- High beef production per cow
- High income from beef
- Low miscellaneous costs
- More concentrated calving.

Table 1 Mean values for each quartile of E1. Only variables where significant differences between quartiles occur are mentioned[1,2]

	Highest ¼	Next highest ¼	Next lowest ¼	Lowest ¼
Variables in NDFR:				
GM1, kr pr l	3.43	2.86	2.57	2.15
Milk income minus feed costs, kr pr l *	2.20	2.03	1.94	1.77
Beef price minus feed costs, kr pr kg produced *	14.50	13.63	13.04	11.17
Milk price, kr/l *	**3.33**	**3.22**	**3.18**	**3.13**
Income from beef, kr/l	**1.48**	**1.24**	**1.22**	**1.07**
District subsidies, kr/l	0.64	0.60	0.53	0.48
Livestock subsidies, kr/l *	**1.49**	**1.51**	**1.57**	**1.72**
Concentrate, kr/l	1.30	1.29	1.35	1.41
Vet/medicine, kr/l	0.096	0.099	0.106	0.114
Miscellaneous, kr/l *	**0.117**	**0.131**	**0.141**	**0.172**
Roughage costs, kr/FEm[3] *	1.85	1.92	1.91	2.13
Diff. between used and reported concentrate in % *	-0.3	3.2	4.1	6.1
Roughage crop, FEm/ha *	**4760**	**4400**	**4120**	**3740**
Kg beef produced pr cow *	**322**	**286**	**273**	**249**
Variables in NDHRS:				
Total milk produced, kg *	116 001	108 410	102 047	90 581
Milk delivered, litres *	**102 979**	**95 919**	**89 636**	**78 979**
No cows *	18.1	17.1	16.3	14.8
Kg milk per cow	6 427	6 367	6 309	6 110
% of quota delivered	99.65	99.35	98.80	97.49
Fertility status (FS-no)	71.0	67.1	62.6	60.6
Calculated loss due to mastitis, kr pr l	0.162	0.170	0.179	0.202
Other feedstuffs, FEm/l	0.036	0.027	0.021	0.019
Growth rate young bulls, gram/day	416	393	395	354
Extra milk quality payment, kr pr l	0.174	0.167	0.165	0.158

1 Income and costs are divided by litres of milk delivered

2 Variables with fat types seem the most important so far

3 Roughage costs include both variable and fixed costs exclusive farmers own labour

* Marks a difference between all four groups. Otherwise maximum two groups may be identical.

Table 2 Mean values for each quartile of E2. Only variables where significant differences among quartiles occur are mentioned[1,2]

	Highest ¼	Next highest ¼	Next lowest ¼	Lowest ¼
Variables in NDFR:				
GM2, kr/l	4.75	4.10	3.70	3.09
Milk income minus feed costs, kr/l *	2.11	2.02	1.92	1.88
Milk price, kr/l	3.28	3.21	3.19	3.18
Income from beef, kr/l *	1.39	1.29	1.20	1.11
District subsidies, kr/l	0.66	0.57	0.55	0.47
Acreage subsidies, kr/l	0.86	0.78	0.73	0.71
Livestock subsidies, kr/l	1.67	1.58	1.53	1.51
Miscellaneous costs , kr/l *	0.12	0.13	0.14	0.16
Roughage crop, FEm/ha	4450	4300	4180	4090
Roughage total, FEm/l	0.95	0.91	0.88	0.88
Other feedstuffs, FEm/l	0.034	0.03	0.022	0.019
Kg beef produced pr cow *	306	292	273	258
Diff. between used and reported concentrate, %	2.5	3.0	4.1	5.5
Roughage costs, kr/FEm[3]*	**1.59**	**1.80**	**2.01**	**2.42**
Variables in NDHRS:				
% of quota delivered	99.3	99.6	98.8	97.6
Fertility status (FS-no)	69.3	67.2	64.7	60.2
Calving index *	36.3	34.9	32.5	30.7
Slaughter weight young cow, kg	180	195	191	204

[1] Income and costs are divided by litres of milk delivered

[2] Variables with fat types seem the most important so far

[3] Roughage costs include both variable and fixed costs exclusive farmers own labour

* Marks a difference between all four groups. Otherwise maximum two groups may be identical

Preliminary conclusions

As mentioned above the results so far are preliminary. When calculating economic efficiency the result differs both with what input factors and what economic measure are being used. The efficiency index calculated with DEA seems to give a better basis for comparing results among farms than Gross Margin alone, but the method is vulnerable to inaccurate data. However it is a small number of farms that makes up the measurement stick for the total population, thus it is possible to check this data more thoroughly for measurement errors than what is possible fore the total data set. GM1 and GM2 seem to explain almost 2/3 of the variation in corresponding efficiency, and the explanation rate is lowest for high values of GM. There seems to be one set of figures characterizing those farms being most efficient in production, and a slightly different one characterizing those who are most efficient when subsidies and fixed roughage costs are taken into consideration. A list of parameters which might be the most important to describe efficient farms, independent of what economic measure is concerned, might look like this:

- Milk income minus feed costs

- Beef production per cow, kg
- Slaughter income, kr/l
- Miscellaneous, kr/l
- Roughage cost, kr/ FEm

Another group which also seems important is:
- Roughage crop, FEm/ha
- Fertility status in the herd (FS-no)
- Milk deliverance in % of quota
- Accuracy in reporting concentrate
- Milk price, kr/l
- District subsidies (regionally differentiated price subsidies), kr/l
- Concentrate cost pr cow, kr

If a farm belongs to the best half within these subjects, or perhaps even to the best quartile, this might be an indicator of the farm being economically efficient.

Acknowledgement

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References

Battese, G.E., 1992. Frontier production functions and technical efficiency: a survey of empirical applications in agricultural economics. *Agricultural Economics* 7: 185–208.

Farrell, M.J., 1957. The measurement of productive efficiency. *Journal of the Royal Statistical Society*, series A, CXX, Part 3, 253–290.

Gerber, J. & J. Franks, 2001. Technical efficiency and benchmarking in dairy enterprises. *Farm Management* 10(12): 715–728

Giæver, H., 1996. Er "dekningsbidrag" et nyttig begrep? *Landbruksøkonomisk forum* 13 (2): 67–70.

Hansen, B.G., S. Larsen and A. Aastveit, 2000. Økonomi i mjølk- og storfekjøtproduksjonen. *Bondevennen*, november 2000.

Lund, M. and J.E. Ørum, 1997. Computerised efficiency analysis in farm business advice. *Farm Management* 9(10): 507–514.

Willock, J., I.J. Deary, G. Edwards-Jones, G. J. Gibson, M. J. McGregor, A. Sutherland, J. B. Dent, O. Morgan, and R. Grieve, 1999. The Role of Attitudes and Objectives in Farmer Decision Making: Business and Environmentally-Oriented Behaviour in Scotland. *Journal of Agricultural Economics* 50(2): 286–303.

Stochastic Dynamic Optimisation: An Analysis of Surface Grading of Peat Soils in Northern Norway

Gudbrand Lien[a], Agnar Hegrenes[b], and J. Brian Hardaker[c]

Abstract

Farmers in northern Norway have experienced severe winter damage on grassland rather frequently, especially on flat areas and peat soils in regions with an unstable winter climate around zero degrees Celsius. Traditional drainage with drainpipes is normally not sufficient to prevent such damage in these areas. During the past two decades the use of open ditches and surface grading has become the main method of reclaiming and draining peat land. A new heuristic stochastic dynamic analysis method for problems like this, combining simulation and optimisation, is used to explore the profitability of surface grading of peat soils. This analysis indicates that the year in which a ley should be reseeded depends on stage in the growth curve when eventually the winter damage happens as well as on the severity of the damage. Given the present acreage subsidy payment, surface grading is normally profitable from a farmer's point of view.

Keywords: Stochastic simulation, Dynamic optimisation, Perennial grasslands, Optimal replacement, Genetic algorithm

[a] Researcher, Norwegian Agricultural Economics Research Institute, *gudbrand.lien@nilf.no*.
[b] Researcher, Norwegian Agricultural Economics Research Institute, *agnar.hegrenes@nilf.no*.
[c] Emeritus professor, University of New England, Australia, *hardaker@northnet.com.au*.

Introduction

Grass production is the main agricultural land use in many parts of Norway. In northern Norway, i.e. the three counties of Nordland, Troms and Finnmark (Fig. 1), as much as 94 per cent (89 644 ha) of agricultural land in use was under grass in 1999 (Statistics Norway, 2001). The profitability of grassland is strongly correlated with the length of the ley period (Hegrenes, 1991). Winter damage is the main reason why leys have to be reseeded. In the years 1975, 1978, 1985, 1995, and 1998 grass leys were severely damaged on many farms in northern Norway. Andersen (1960) reported a relatively high frequency of winter damage in some northern locations in the period 1922–59. Clearly, winter damage to grassland is a significant hazard in this area. The frequency of winter damage is highest on flat areas and peat soils in regions with an unstable winter climate with episodes of thaw while average temperature is below zero degrees Celsius.

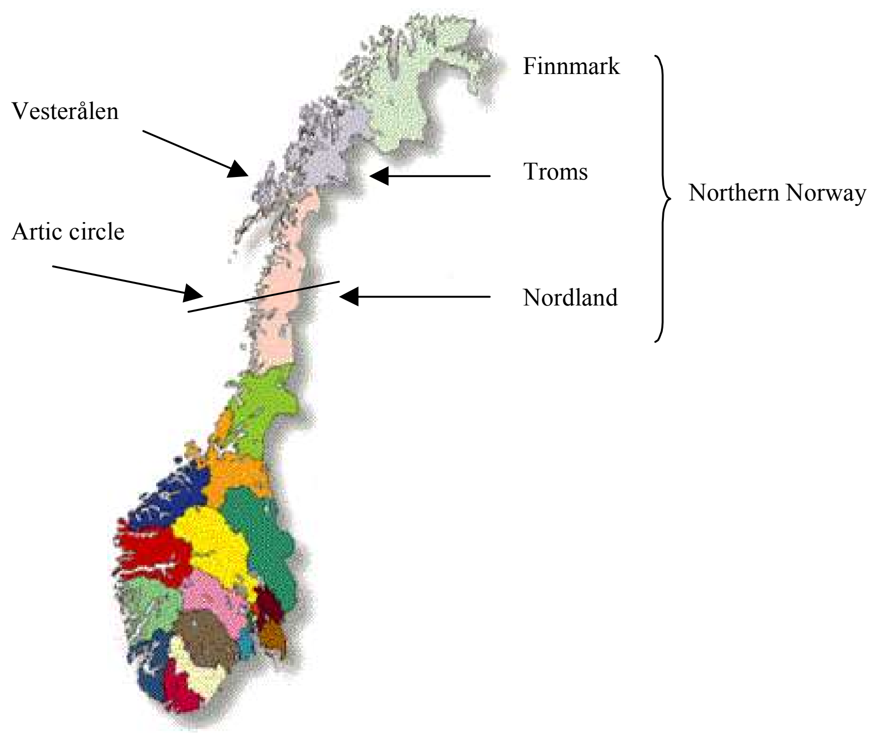

Fig. 1. Map of Norway.

Frequent winter damage of the leys leads to unstable and low average yields. This in turn leads to unstable farm incomes. It is of interest both to the farmers and to the government to evaluate methods of reducing the problems connected with winter damage of grassland. The aim in this article is to describe and evaluate such methods, mainly from a farmer's point of view. Hegrenes *et al.* (2001) used a deterministic investment rule to analyse the profitability in surface grading. The results indicate that surface grading is profitable for farmers, but the conclusions are sensitive to changes in crop yields and the value of the production. Lien *et al.* (1999) showed that winter damage and length of the ley periods highly influenced the profitability of cultivating peat soils, and indicated that surface grading is profitable for farmers. To our knowledge, no other studies of the economics of surface grading have been published.

The article is organised as follows. After this introduction we describe the problem of winter damage in more detail and present some ways that farmers might reduce the problem. From this description we conclude that surface grading seems promising. We thereafter provide an applied investment analysis of surface grading combining simulation and optimisation. To our knowledge, no one has used this analysis approach before to solve problems of this nature. The article ends with a discussion of the results and the method.

The problem

The problem of winter damage of grassland is most common on flat areas and peat soils in regions where winter temperatures vary around freezing point. Periods with temperatures below freezing point and no or thin snow cover cause the soil to freeze. Frozen peat soils have low water permeability and surface water caused by cycles of cold and mild periods will not infiltrate into the soil and underground drainage system. Surface water freezes when a mild, rainy period is followed by cold weather. An ice cover is likely to damage the ley, and the damage risk increases with the duration of the period with ice cover. In addition, most peat soils in northern Norway have low water permeability even in summertime, especially if the soil is worked by heavy agricultural machinery. There might be ponding on the surface after rainfall. Such fields are difficult to harvest for silage due to low load-bearing capacity. The combination of a variable winter climate, flat areas and peat soils is rather common in northern Norway, for instance in the Vesterålen region in Nordland county. A farmer having fields with the characteristics described above is faced with three alternatives:

1. To drain the field with underground agricultural drainpipes (traditional drainage)
2. To use open ditches and to surface grade the field between the ditches
3. To stop harvesting of the field and take it out of use.

Open ditches and grading of the surface of peat soils have been commonly used for cultivation and reclamation in northern Norway over the past two decades. The distance between the open parallel ditches is normally 40–50 metres, and the ditches are about one metre deep. The area between the open ditches is graded so as to create a slope of 4–5 per cent towards the open ditches. The surplus water is thereby drained off the surface. Net area is reduced because of the open ditches. For simplicity this method is subsequently referred to as "surface grading" in this article.

Surface grading has been found appropriate for reclaiming peatlands in areas with high precipitation that have been out of use for agricultural purposes because of poor drainage (Haraldsen *et al.*, 1993). The method has also given high yields of grass on peat soils in areas with moderate to little precipitation in northern Norway (Haraldsen *et al.*, 1995). Grading the surface of the peat soils reduces the problems of surface ponding that, in turn, has resulted in less winter damage on grassland and has increased the possible length of the ley periods. Aandahl *et al.* (1999) found that approximately 75 per cent of surface graded fields with peat soils in the Vesterålen region had leys 7 years or more old. Many of them had reached ages of 10 years or more without reseeding. These leys had survived years when there has been severe winter damage of nearby leys on other flat, peat soil fields drained with agriculture drainpipes.

Practical experience and estimates by local advisers (Ryeng, 1996) indicate that the investment costs are at least as high for traditional drainage as for surface grading. Because of low water permeability, traditional drainage with agricultural drainpipes does not provide efficient drainage of such fields, either during winter or in summer. Preliminary estimates indicate that traditional drainage is not profitable in such situations as described in this article. The main alternatives are therefore surface grading or not using the land.

We assume that no yield can be harvested in the year of surface grading, and that the graded area is then sown to green crop (e.g. forage rape) for the first year before the grass ley is sown. Thenceforth we assume a rotation of grass can be cultivated, and be replaced with grass. Some maintenance work of the surface graded fields has to be carried out from time to time.

We do not know a priori the optimal interval between the reseeding of grasses after grading, which in any case will depend on the uncertain events, mainly the incidence of winter damage. Yet the optimal replacement strategy must be known to do the analysis of the initial investment decision.

Young leys normally have higher yields than older leys (Nesheim, 1986). Further, the yield is reduced immediately after winter damage but there is normally a partial recovery in yield in the subsequent years (Haraldsen *et al.*, 1995). In addition to winter damage, yields are also affected by seasonal conditions, which vary unpredictably from year to year. Product prices and costs are also uncertain variables in the investment analysis. All these mentioned stochastic factors imply that a farmer's net revenue is uncertain and "jumpy". The size of the downward jumps, the age of the leys when the winter damage happens, product prices, reseeding costs, and especially the recovery phase after a winter damage event are factors which influence the decision on whether or not to reseed. The challenge is to find the optimal replacement strategy of the leys under these circumstances, for use in the investment analysis.

The model

Conceptual framework

A tool that accounts for both uncertainty and several options is stochastic dynamic programming (SDP) (see, e.g., Kennedy, 1986; Taylor, 1993). When a SDP model includes many stochastic variables with many events for each variable, a common problem is a "bushy mess" (Hardaker *et al.*, 1997), also known as "the curse of dimensionality" (Bellman and Dreyfus, 1962). Dimensionality problems make convergence slow or impossible and in some cases may be overcome only with unacceptably coarse grids for "discretised" variables. Hierarchic Markov Programming (Kristensen, 1988; Kristensen, 1994) is an approach for reducing these difficulties that we plan to explore in future work. While our problem can be formulated as an SDP model, preliminary work shows that we do encounter severe dimensionality difficulties.

In this article, a heuristic "simulation optimisation" approach is used as an alternative to SDP. Oriade and Dillon (1997) give a review of simulation models in agricultural economics research and Mayer *et al.* (1998) give a review of simulation optimisation techniques in the field of agricultural systems. Stochastic simulation via Monte Carlo sampling allows a good representation of the uncertainty inherent in the problem. Simulation optimisation avoids any need to "discretise" the distributions as is normally necessary for SDP. We chose to do the stochastic simulation in Palisade's @Risk add-in software for Excel. Stochastic simulation means that we can evaluate a given replacement strategy with any required degree of precision simply by setting the appropriate simulation sample size. We used a sample size of 50 000 to get good estimates of the distribution of the chosen objective variable for any specified strategy. The disadvantage of simulation is that direct optimisation is then not possible, e.g., we cannot apply Bellman's principle of optimality (Bellman and Dreyfus, 1962). So we have to use a search procedure in conjunction with the stochastic simulation model to find the optimal replacement strategy. The search procedure used is a genetic search algorithm provided by Palisade's RiskOptimizer software package.[15] Mayer *et al.* (2001) found evolutionary algorithms (including genetic algorithms) superior to other search methods for optimisation of simulation models of agricultural systems. Genetic optimisation algorithms mimic Darwinian principles of natural selection by creating an environment where hundreds of possible solutions to a problem can compete with another, and only the "fittest" survive. Just as in biological evolution, each solution can pass along its good "genes" through "offspring" solutions so that the entire population of solutions will continue to evolve into better solutions. The random generator used in the simulation process is seeded to ensure that the same set of random samples is sampled for each experiment. The algorithm runs until some

[15] In the optimisation we used the recipe solving method, a crossover rate on 0.5, a mutation rate on 0.1, and a population size of 200.

specified stopping rule, controlled by the user, is satisfied. In this article RiskOptimizer ran the optimisation over 48 hours on a Pentium III 1133 MHz computer.

Generally, the optimal replacement rule of the leys is when the marginal net revenue is equal to the (initially unknown) highest average net revenue per year. But when jumps (winter damage) are observed, the replacement depends on the stage in the growth curve when the fall in production happens. This is illustrated in Fig. 2.

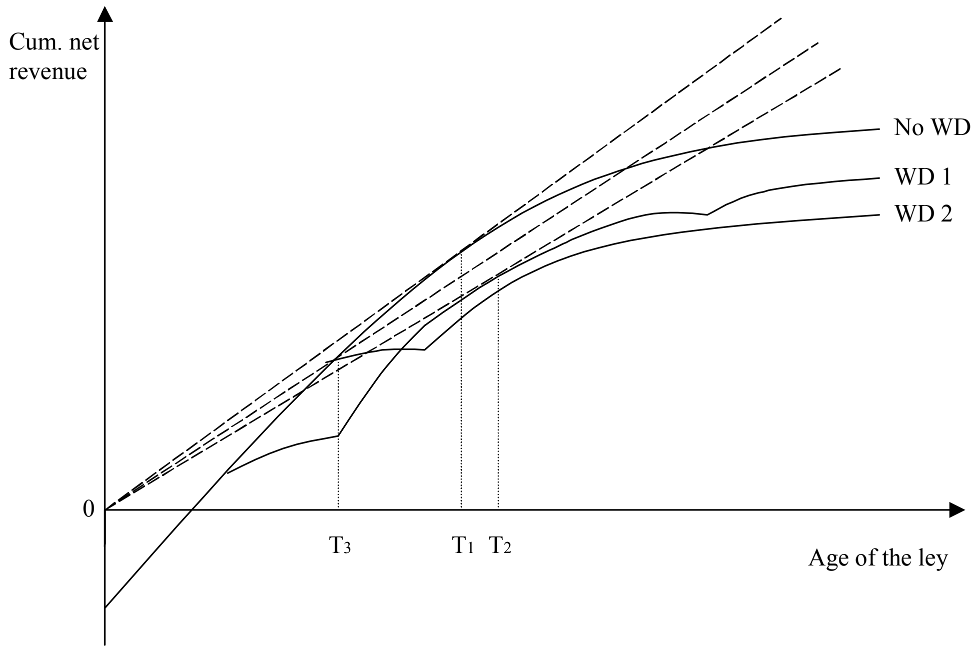

Fig. 2. Outline of optimal replacement strategy for different scenarios

In the simple example in Fig. 2 we assume, for simplicity, zero interest rate. Converting the interest rate to one that is positive changes nothing in the logic. We also ignore the cost of investment in surface grading in this example—it is only the logic of optimal replacement of the leys that is illustrated. Further, in this example and in our model the replacement decision variable is net revenue per hectare. Of course it is yield that jumps, but we use net revenue as the decision variable, since yield and net revenue do not have perfect positive correlation.

Given no winter damage the curve for total (cumulative) net revenue ("no WD" in Fig. 2) against time starts below the origin of the vertical axis (due to establishment costs) and becomes positive, perhaps with initially increasing gradient followed by generally decreasing gradient. The line from the origin to the curve is the equivalent annuity (given zero interest rate). The optimal replacement time, T_1, is found by maximising the gradient of this line, which means finding the point of tangency between the curve and the line from the origin (Dillon and Anderson, 1990).

Each time winter damage occurs there will be a downward yield jump and normally a downward net revenue jump (depends on the correlation between yield and net revenue). After each step down there will be a section of increased and increasing gradient followed by normal decreasing gradient, reflecting the recovery phase. In this case maximal equivalent annuity will either occur when replacing immediately after winter damage (as in case "WD 2" in Fig. 2) to avoid experiencing the low production that follows, or on one of the segment between jumps ("WD 1"). In the last case it is not profitable to replace during any post-damage period in which the gradient is increasing. Moreover, it would only pay to keep the leys after the winter damage if eventually the gradient of the tangent from the origin rose above what it was at the point of winter damage.

With no winter damage it is reasonable to search for the optimal replacement time on the basis of the net revenue alone. The trigger if winter damage is observed depends on the stage in the growth curve when the fall in production happens. Early in the life of the ley it is more likely that the recovery after damage will be sufficient to later raise the average net revenue above the average to that point. But later in the life, when marginal productivity is less or even declining, that will not happen. So, we need a different decision variable after winter damage than post damage productivity alone to be the basis for a search for optimality. One option, which we use in this article, is to have two decision variables in this case: age and post damage net revenue. In cases with winter damage, the decision rule becomes to replace when net revenue falls to a given level conditional on the age of the ley.

So far in this description only winter damage incidence has been treated as stochastic. In our model the yearly nature of yields and output prices are also treated stochastically. Consequently, the objective is to maximise expected equivalent annuity, subject to the same rules as for the deterministic case. This objective is appropriate provided there is no risk aversion.

The decisions to replace or keep the ley are assumed to continue sufficiently far into the future to justify an assumption of an infinite time horizon. Formally, we seek to maximise farmer's expected profit per year, represented by the expected value of the equivalent annuity. In the simulation, this is the average annuity over a large number of Monte Carlo sampled life histories of leys from investment year to time of replacement, computed for the replacement rule described. Each expected annual equivalent is found using the annuity formula

$$Ea = E\left[\frac{1}{S}\left\{\begin{array}{l}\sum_{S}\left(Inv + NPV_G^s + NPV_M^s\right)*r + \\ \max_{l_j} \frac{1}{\sum_{I_j^s} I_j^s}\left(\sum_{I_j^s}\left(\left(NPV_{L_j}^s\left(l_j\right)*\frac{r(1+r)^{N_{l_j}^s}}{(1+r)^{N_{l_j}^s}-1}\right)*I_j^s\right)\right)\end{array}\right\}\right] \tag{1}$$

where Ea is the expected value of equivalent annuity, E is the expectation operator, s is Monte Carlo sample $s\,(s=1,\ldots,S)$, Inv is assumed deterministic investment cost of surface grading, NPV_G^s is the stochastic net present value of the green crop in the first year after surface grading in sample s, NPV_M^s is deterministic net present value of maintenance cost of the surface graded fields in sample s, r is the discount rate.

The last component of equation 1 includes the search for the optimal replacement strategy of the leys. l_j is the net revenue limit for each replacement case j, where $j = 0$ is no winter damage (no WD) regardless of age of the ley, $j = 1$ is winter damage in the first year after replacement (WD 1), $j = 2$ is winter damage in the second year after replacement (WD 2) (note, this can be the first winter damage on the ley, or the second (i.e. that there was also winter damage in year 1)), $\ldots$, $j = 20$ is winter damage in year twenty after replacement (WD 20). We use a genetic optimisation algorithm to find the "optimal" solution for each l_j. I_j^s is an indicator variable specified as

$$I_j^s = \begin{cases} 1 & \text{if } j = 0 \text{ (no WD)}, j = 1 \text{ (WD 1)}, j = 2, \ldots, j = 20, \text{respectively in Monte Carlo sample } s \\ 0 & \text{else in sample } s \end{cases}$$

The net present value of the stochastic annual cash flows is

$$NPV_{L_j}^s(l_j) = \sum_{N_{l_j}^s} \frac{y_t^s p_t^s - c_t^s}{(1+r)^{N_{l_j}^s}} - R_0^s \tag{2}$$

where y_t^s is stochastic (inclusive of jumps) yield of a ley of age $t\ (t = 1,\ldots,20)$ in sample s, p_t^s is stochastic output price of a ley of age t in sample s, c_t^s is variable cost assumed proportional, or close to proportional to expected yield of a ley of age t in sample s, and R_0^s is the stochastic net value of the yield in the re-establishing year 0 in sample s. $N_{l_j}^s$ is the age of the ley at the net revenue limit l for replacement case j in sample s. $N_{l_j}^s$ is in the interval $t = 1,\ldots,20$. $\left(r(1+r)^{N_{l_j}^s} / (1+r)^{N_{l_j}^s} - 1\right)$ is the annuity factor. This specification requires that we search for an optimal expected annuity over possible replacement rule setting specified as expected net revenue in the next year for the cases no winter damage and winter damage where the setting for the trigger level of net revenue varies according to the age of the ley.

With this approach we assume no risk aversion, i.e., we maximise the expected equivalent annuity. We assume this investment decision does not affect a large part of a farm, and so does not represent a large part of a farmer's income. Then, following Pannell *et al.* (2000) and Lien and Hardaker (2001), we predict that the extra value of recommendations derived from a model that represents risk aversion, compared to a model based on risk neutrality, would be small.

Specification of the model

Investment in surface grading

Based on Hegrenes *et al.* (2001), we assume that one hectare can be surface graded at a total cost of approximately NOK (Norwegian kroner) 30 000 (approximately EUR 3 900). This cost is assumed deterministic, since the farmer can invite tenders.

It is common practice to have one year with green crop before the grass is seeded. Based on Hegrenes and Lien (1999) we assumed the yield per hectare of green crop in year one to be truncated normal distributed with mean 5000 kilograms dry matter/hectare (kg DM/ha) and standard deviation (SD) 1000 kg DM/ha.

In northern Norway, most of the grass is made into silage or used for pasture. We assume that the yield is made into silage. The output price of the green crop was assumed triangular distributed with minimum, mode, and maximum at NOK 1.02, 1.65, and 2.18 per kg DM, respectively. This distribution was based on observed market prices of purchases and sales of coarse fodder in northern Norway between 1996 and 1998 (NILF, 1997a–1999a).

Because weather conditions tend to be the same in relatively large regions, many farms might simultaneously experience winter damage or high or low yields in the same year. This could have an influence on the market for silage. Therefore, it could be expected that the market value of the crops varies and is high when yields are small and low when yields are large (Johnson, 1997). On the other hand, the local market for fodder is not isolated from the national market. Since the correlation between crop yield and price of the yield is uncertain, is not expected to be very high, and for simplicity, we ignore this correlation in our analysis.

Again for simplicity, we have assumed some maintenance work of the surface graded fields to be carried out every twenty years, regardless of the rotation pattern. The maintenance cost was set to NOK 7000 per ha.

To find the expected equivalent annuity of the investment cost, green crop income the first year after investment and regular maintenance costs we multiplied the NPV of these items (over the infinite horizon) by the interest rate. The interest rate was assumed to be 5 per cent per annum, approximately equal to the average real interest rate on Government bonds with 10 years maturity.

Annual cash flows for surface graded fields

In spring two years after the surface grading, grasses are seeded with barley as a cover crop. We assume that the method and cost of re-establishing the ley are the same regardless of the reason why the field was reseeded. Very good growing conditions for the cover crop may reduce the grass yield the following years. Normally, farmers reduce use of fertiliser in the reseeding year. We have therefore assumed the yield is triangular distributed with minimum, mode and maximum at 1000, 4000 and 6000 kg DM/ha, respectively. The same distribution was used for the price of the output as for the green crop in year one.

Peat soils are normally naturally acidic, and acidic precipitation and use of chemical fertilisers exacerbate soil acidity. Therefore, lime is commonly applied in the year of reseeding grassland, for instance 5 tons per ha if the grass is reseeded every five years. However, in this analysis we cannot assume any fixed reseeding pattern ex ante. Therefore, we have assumed that 1 ton of lime per hectare is applied annually.

For the annual cash flow for each year after the reseeding year we treat yields and grass prices as stochastic, as described. In constructing the yield process, historical data might have been used. However, the required historical data for leys over many years are not available. In addition, historical data could be irrelevant if there has been technical or climatic change. Another problem with estimation from historical yield data is that the data represent a situation in which some fields have an old grass ley because of the yield level has remained high, while fields with more rapidly falling yield curve have been reseeded at an earlier age and so are not represented in the data for later ages. We used expert advice (soil and crop researchers) to estimate the expected yield curve without any winter damage (WD)—see curve "no WD" in Fig. 3.

Results given by Nesheim (1986) indicate higher yields from grass leys aged one to five years compared with older leys. This is also in accordance with results from the "Grassland Survey in Norway" described in Haraldsen and Waag (1991). The maximum possible age of ley is assumed to be 20 years, i.e., any ley that reaches 20 years is assumed to be reseeded the following year.

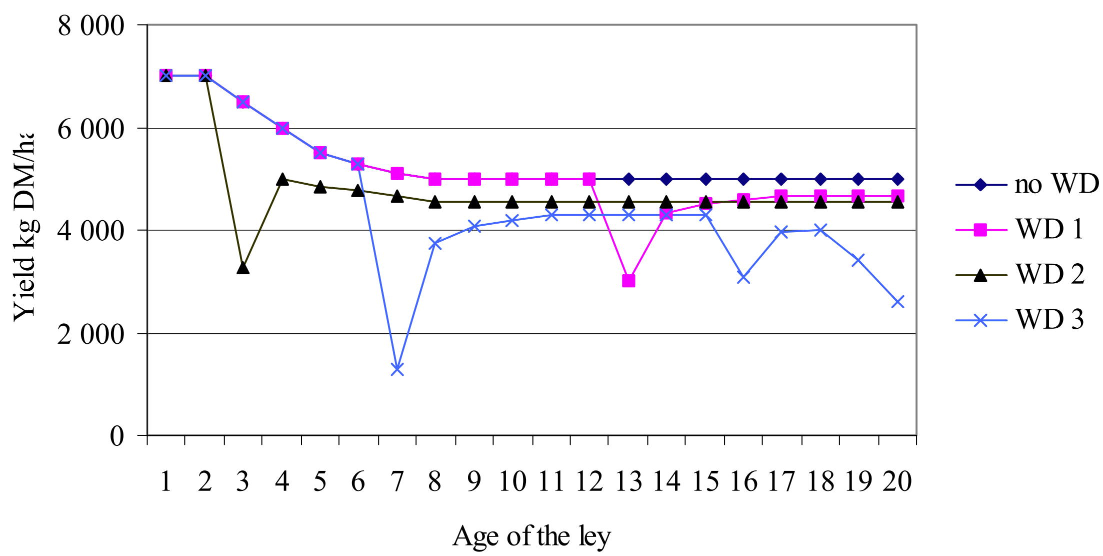

Fig. 3. Some possible expected yield processes of the leys

To account for the risk of winter damage, we added discrete downward jump processes to the "no WD" yield process. Experience suggests that there are rather few problems with winter damage on surface graded fields (Aandahl *et al.*, 1999).

The probability for winter damage was assumed to follow a discrete distribution, stochastically independent of other stochastic variables in the model. Based on expert advice, we specified six discrete events, no WD, 20%, 30%, 40%, 50% and 75% winter damage, with probability 0.85, 0.06, 0.05, 0.02, 0.01 and 0.01, respectively, where the percentages are the decline in yield of "no WD" yield on the field. In other words, it is assumed that there is a probability of 15 per cent that some winter damage will occur each year with a complementary probability of 85 per cent of no damage. In the years when damage occurs, it is more likely to be slight than severe. We assumed that the expected value of the yield is reduced by the specified proportions immediately after winter damage but there is normally a partial recovery in yield in the subsequent years (Haraldsen *et al*., 1995). In this analysis it was assumed, again based on expert advice, that the step down in yield following damage is reduced by 2/3 in the year following the year with winter damage due to a partial recovery of the damaged leys. In the second and third years after the year with winter damage it was assumed the yield on the winter damaged field will further approach the yield curve with "no WD" by 1/3 of the difference between yield on fields with winter damage and the "no WD" curve. As an example of the yield process before the yearly stochastic nature of yields are accounted for (see below) let us say we get a 50% reduction in expected yield in a given year. In the following year the expected yield goes to 1/3 of 50% = 16.7% below "no WD". Two years after the winter damage, the yield depression on is further reduced by 1/3 from 16.7% to 11.1%, in year three to 7.4% below "no WD". From year four this yield curve will be 7.4% below "no WD"-curve until the ley is reseeded or until a new winter damage occur.

In the model, as in practice, it is also possible that there may be a further incident of winter damage of a ley that has already suffered winter damage in an earlier year. In Fig. 3 some possible yield processes are sketched (without accounting for yearly stochastic nature of yields, see below). The expected yield curve for, e.g., WD 3 in this figure shows incidences of repeated winter damage in years 7, 16, 19 and 20.

Yields vary for many other reasons than winter damage, so to reflect the yearly stochastic nature of yields, we assumed the yield is (truncated) normal distributed with constant SD independent of yield level and age of the ley. Distributions other than the normal could have been used, but the normal was used for simplicity. Historical data from the Norwegian Farm Business Survey (NILF, 1994a–2000a) for farms in northern Norway over the period 1993 to 1999 was used to estimate the SD of the yield process. The calculated SD for this period was 705 kg DM/ha/year within farms.

The relation of yields between years can be treated as an empirical question. From the grassland survey we found the average correlation of grass yield from one year to the next to be 0.44. This implies that the expected yield curve from any stage onwards will be conditional on the current year's yield. In our model the replacement of the leys is based on the conditional expected yield next year, given current yield.

The same distribution for the per unit value of output was applied as for the output of green crop. The correlation of grass price between years was calculated as 0.36 (NILF, 1990b–2000b). This stochastic dependency relationship was also included in the model during the simulation and optimisation.

The assumed variable costs take account of inputs of fertiliser, preservatives, fuel, other variable machinery costs and labour input. These costs were assumed to be proportional, or close to proportional, to yield. Costs were calculated dependent on expected yield level based on Handbook in Farm Business Planning (NILF, 2000b).

Because of the open ditches, net area is reduced compared with a field with no ditches. The reduction was assumed to be 7 per cent. The cash flows are adjusted accordingly.

Results

Since our model is complex, the combination of optimisation and simulation is time consuming. We therefore chose to simplify the replacement rule in this empirical part. Based on preliminary results, we observed that the optimal trigger value changed most the first few years after the re-establishment but then remained rather stable. Hence we made a fine grid for the trigger over the early years after re-establishment and a coarser grid for later years. We estimated optimal trigger net revenues for the following cases: no winter damage at all (no WD), winter damage in the first, second, and third year after re-establishing (WD 1, WD 2, WD 3), winter damage in the fourth or fifth years (WD 4–5), winter damage between six to eight years after replacement (WD 6–8), winter damage between nine and twelve years (WD 9–12), between thirteen to sixteen (WD 13–16), and between seventeen and twenty years after replacement (WD 17–20). Based on our approximated trigger values for particular years/ranges of years we interpolated year-by-year vales by smoothing a curve (with cubic splines methodology (Craven and Wahba, 1979)) through the values for midpoints of the ranges.

Under this simplifying assumption, the optimal trigger net revenues for different estimated replacement cases are shown in Table 1.

If no winter damage is experienced, the model indicates that it is best to replace the ley when expected net revenue falls below NOK 463 per ha. If there is winter damage of the ley in the first year after re-establishment, the trigger net revenue is NOK –283 per ha. The trigger net revenue from winter damaged leys rises as the ley ages (Table 1). In other words, farmers should require a (somewhat) higher level of productivity from an older ley if it is to be retained than from a younger ley, since the latter has more future potential.

We can now examine the question of whether it will be profitable for a farmer to surface grade a field and follow the optimal replacement strategy compared to the alternative of not using the peat land. The alternative of not using the field will give zero profit from production in all circumstances. The estimated distribution of total equivalent annuity of surface grading and following the optimal replacement strategy is given in Fig. 4.

Table 1 Estimated optimal replacement strategy for different replacement cases

Replacement case	Trigger net revenue per ha, NOK
No WD	463
WD 1	-283
WD 2	-103
WD 3	67
WD 4	196
WD 5	279
WD 6	327
WD 7	355
WD 8	378
WD 9	396
WD 10	411
WD 11	421
WD 12	426
WD 13–20	429

The expected value of the equivalent annuity of surface grading (without subsidies) is NOK 503 per ha, implying that on average the surface grading is profitable for farmers. But as Fig. 4 indicates, the annuity is very uncertain. In 90 per cent of the cases the annuity is between NOK -1533 and NOK 1966 per ha. Fig. 4 shows that there is about a 20 per cent chance that the surface grading will be unprofitable (negative annuity value). Based on sensitivity analysis of the simulation results, we found that the factors that most strongly affect the profitability are the jump size and jump frequency and output prices in the first years after reseeding.

The distribution in Fig. 4 is calculated before subsidies are taken into account. In most of northern Norway the acreage payment for grassland in year 2001 was NOK 4400 per ha per year for less than 20 ha per holding, and NOK 2200 per ha for 20–40 ha per holding. The average farm size in northern Norway is 14.6 ha (Statistics Norway, 2001). The subsidies would shift the cumulative distribution function shown in Fig. 4 to the right by an amount equal to the amount of the subsidy per hectare, therefore making surface grading profitable with very little chance of a negative annuity.

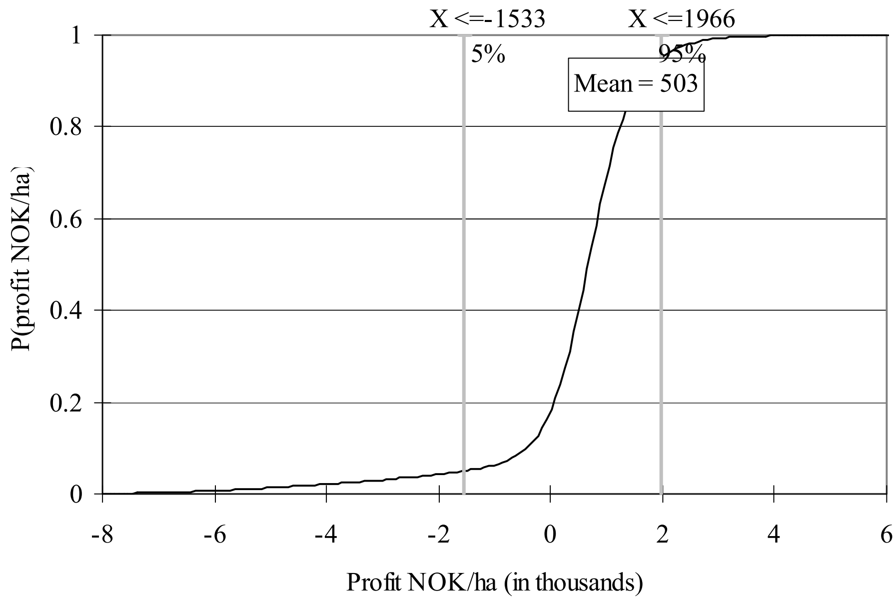

Fig. 4. Cumulative distribution of total equivalent annuity of surface grading the field and follow the optimal replacement strategy.

Fig. 5 illustrates what happen if the mode of the output price decrease 20 per cent, from NOK 1.65 per kg/DM to NOK 1.32 per kg/DM, ceteris paribus.

Fig. 5 shows that the chance surface grading will be unprofitable increases from about 20 to 50 per cent when the mode output price is reduced by 20 per cent, ceteris paribus.

Fig. 6 illustrates the average age at which the leys should be reseeded if the optimal replacement strategy from Table 1 is followed.

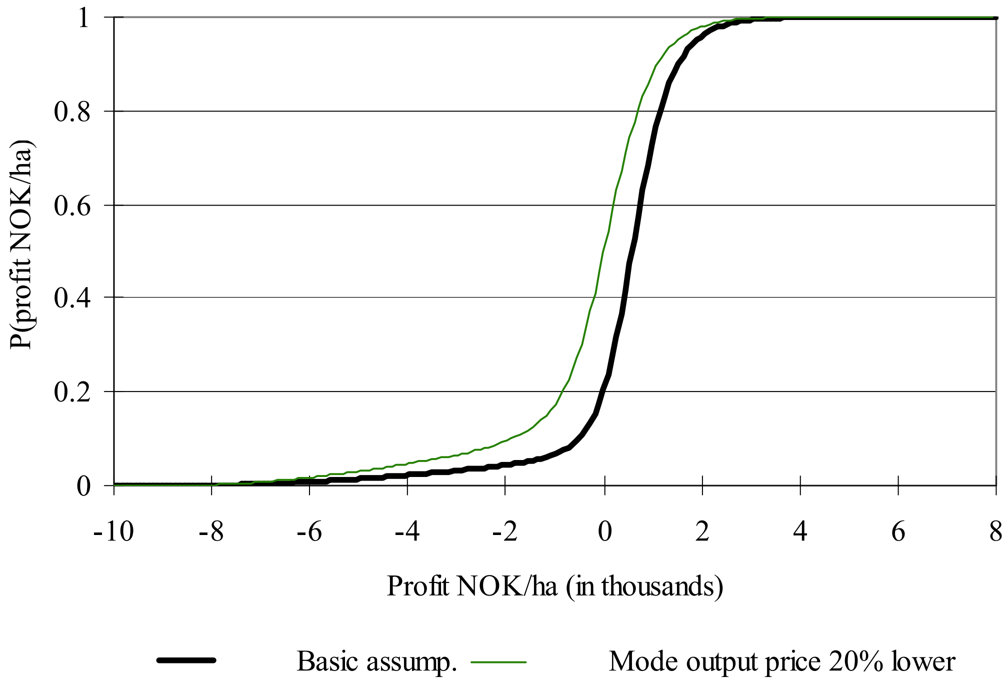

Fig. 5. Cumulative distribution of total equivalent annuity of surface grading given the basic assumption and when the mode output price is reduced by 20 per cent, ceteris paribus, respectively.

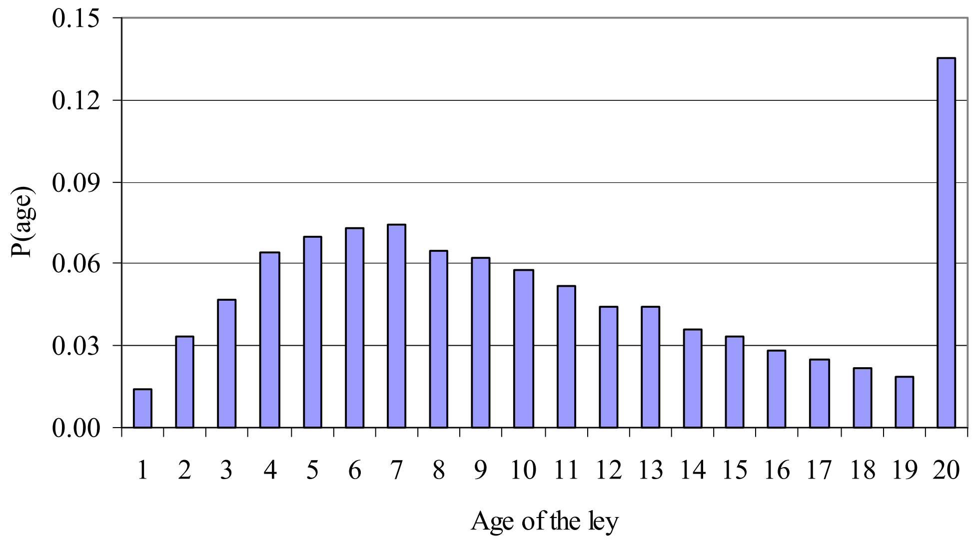

Fig. 6. Distribution for optimal year to replace the ley follows the optimal replacement strategy.

There is about an 86 per cent chance that the leys should be replaced before the maximum age in the model, which is 20 years. Earlier replacement of leys before 20 years typically happen when the leys is about 5 to 8 years old (Fig. 6).

Discussion

The method used, a heuristic simulation optimisation approach, emerges as an interesting alternative to stochastic dynamic programming. It largely overcomes the "bushy mess" problem of SDP and so permits the use of much finer grid of discrete values of state and decision variable. As a result, the method should give more accurate results. Simulation optimisation is also more flexible and easier to implement than SDP. The drawback is that searching for reasonably stable optima with such a model is very time consuming.

The results of the analysis indicate that surface grading normally is profitable for farmers, given the present agricultural policy. These results are in accordance with earlier investigations (Hegrenes *et al.*, 2001; Lien *et al.* 1999). However, the conclusion should be qualified by some limitations of the analysis. The assumption of a normal distributed yield may or may not be appropriate (Just and Weninger, 1999). However, we do not believe that the results in this analysis are much affected by this assumption. Perhaps more important is the fact that, in our model, only incidents of winter damage and the yearly stochastic nature of yields are included in the yield risk. In any further development of the model other significant sources of yield risk such as probability for damage caused of work with heavy machinery could be included if such risks could be quantified. The partial recovery of the yield after winter damage may be larger on old than young grassland. This aspect is not included in our analysis. Environmental aspects of surface grading, which may be important in some cases, have also not been included in our analysis.

In this paper we maximise farmer's expected profit per year as represented by the expected value of the equivalent annuity. If the investment in surface grading affects a large part of a farm, and so a large part of farmer's income, it may be that farmer's risk attitude should have been included in the investment/replacement analysis. One possibility for future research is to include risk aversion in the model by doing a moment-based utility evaluation of the equivalent annuity, i.e., to convert each equivalent annuity into a utility value and then optimise expected utility.

The public crop disaster programme that includes several schemes reduces the costs to farmers of winter damage of their grass leys. These grants were not included when estimating costs of winter damage in this analysis. The main reason is that the analysis was done on a per hectare basis while the crop disaster schemes are on a whole farm basis. The omission of these grants means that the farmers' net costs of winter damage used in our analysis are over-estimated.

The analysis and results are specific for conditions prevailing on particular soil types in northern Norway. However, the results may be relevant to other regions where soil and climatic conditions and prices are similar to those described here.

Therefore, it is not surprising to notice an increasing interest in the use of open ditches and land grading in other parts of Norway. Further, the method of analysis could readily be applied to similar problems in other countries where yields, prices and subsidies are different. Our model could also easy be applied to other replacement problems.

If a field is surface graded, the cost of grading can be regarded as a sunk cost. Also, if the farmer stops harvesting the field, he would loose the acreage payment. Therefore, only if economic conditions were to worsen considerably would it be sensible to take land that had been surface graded out of use.

References

Aandahl, T.-J., T.K. Haraldsen & A. Johansen, 1999. Langtidsvirkninger av profilering. Oppfølgingsundersøkelser i Vesterålen. *Norden* 103, pp. 4–6. (In Norwegian)

Andersen, I.L., 1960. Investigation on the Wintering of Meadow Plant on Northern Norway. *Research in Norwegian Agriculture* 11, pp. 635–660. (In Norwegian)

Bellman, R.E. & S.E. Dreyfus, 1962. *Applied Dynamic Programming*. Princeton University Press, Princeton.

Craven, P. & G. Wahba, 1979. Smoothing noisy data with spline functions. *Numerische Mathematik* 31, pp. 377–403.

Dillon, J.L. & J.R. Anderson, 1990. *The Analysis of Response in Crop and Livestock Production*, 3rd ed. Pergamon. Oxford.

Haraldsen, T.K., H. Bakke, T.E. Sveistrup & K. Lindberg, 1993. Grading the surface of peat soils in Vesterålen, northern Norway. *Norsk landbruksforsking* 7, pp. 217–233.

Haraldsen, T.K., T.E. Sveistrup, K. Lindberg & T.J. Johansen, 1995. Soil compaction and drainage systems of peat soils in northern Norway. Effects on yields and botanical composition in leys. *Norsk landbruksforsking* 9, pp. 11–28.

Haraldsen, T.K. & T. Waag, 1991. Grassland survey in Norway, a database for yield, soil information and climate. *Norsk landbruksforsking* 5, pp. 279–304.

Hardaker, J.B., R.B.M. Huirne & J.R. Anderson, 1997. *Coping with Risk in Agriculture*. CAB International, Wallingford.

Hegrenes, A., 1991. Sammenligning av kort- og langvarig eng ut fra økonomiske hensyn. *Nordiske Jordbrugsforskeres Forening* (NJF) Seminar 196, 11.–13. mars 1991, Kolbotn, Norway. (In Norwegian)

Hegrenes, A. & G. Lien, 1999. *Vurdering av risiko for avlings- og inntektsvariasjon innen bruk i Nord-Norge*. Norwegian Agricultural Economics Research Institute. Notat 1999:13. (In Norwegian)

Hegrenes, A., G. Lien, T.K. Haraldsen & T.E. Sveistrup, 2001. *The economics of surface grading of peat soils in northern Norway*. Norwegian Agricultural Economics Research Institute. Working paper 2001:20.

Johnson, G.L., 1997. Work on Asset Fixity or Investment/Disinvestment Theory. In: Schmid, A.A. (Ed.): *Beyond Agriculture and Economics*. Michigan State University Press, East Lansing, pp. 91–120.

Just, R.E. & Q. Weninger, 1999. Are crop yields normally distributed? *American Journal of Agricultural Economics* 81, pp. 287–304.

Kennedy, J.O.S., 1986. *Dynamic Programming. Applications to Agricultural and Natural Resources*. Elsevier. London.

Kristensen, A.R., 1988. Hierarchic Markov processes and their applications in replacement models. *European Journal of Operational Research* 35, pp. 207–215.

Kristensen, A.R., 1994. A survey of Markov decision programming techniques applied to the animal replacement problem. *European Review of Agricultural Economics* 21, pp. 73–93.

Lien, G. & J.B. Hardaker, 2001. Whole-farm planning under uncertainty: impacts of subsidy scheme and utility function on portfolio choice in Norwegian agriculture. *European Review of Agricultural Economics* 28, pp. 17–36.

Lien, G., A. Hegrenes, L.J. Asheim, T.-J. Aandahl & T.K. Haraldsen, 1999. Økonomisk analyse av profilering i Vesterålen: Avkastning på linje med aksjeinvestinger. *Norden* 103, pp. 4–7. (In Norwegian)

Mayer, D.G., J.A. Belward & K. Burrage, 1998. Optimizing simulation models of agricultural systems. *Annals of Operations Research* 82, pp. 219–231.

Mayer, D.G., J.A. Belward & K. Burrage, 2001. Robust parameter settings of evolutionary algorithms for the optimisation of agricultural systems models. *Agricultural Systems* 69, pp. 199–213.

Nesheim, L., 1986. A grassland survey in Nordland, North Norway III. Feed quality parameters and yield. *Scientific Reports of the Agricultural University of Norway*. 65(20).

NILF, 1994a–2000a. Account results in agriculture and forestry. Results for 1993–1999. Norwegian Agricultural Economics Research Institute. Annual publication. (In Norwegian)

NILF, 1990b–2000b. Handbook in farm business planning. Norwegian Agricultural Economics Research Institute. Annual publication. (In Norwegian)

Oriade, C.A. & C.R. Dillon, 1997. Developments in biophysical and bioeconomic simulation of agricultural systems: a review. *Agricultural Economics* 17, pp. 45–58.

Pannell, D.J., B. Malcolm & R.S. Kingwell, 2000. Are we risking too much? Perspectives on risk in farm modelling. *Agricultural Economics* 23, pp. 69–78.

Ryeng, V., 1996. Lønner det seg å grøfte? *Norden* 100: pp. 22–23. (In Norwegian)

Statistics Norway, 2001. Jordbrukstelling 1999. Tabell 2 Jordbruksareal i drift, etter bruken av arealet og fylke. 1969, 1979, 1989 og 1999. Dekar. Available at http://www.ssb.no/emner/10/04/10/jt1999/tab-2001-04-03-02.html. Cited 2 July, 2001.

Taylor, C.R. (ed.), 1993. *Applications of Dynamic Programming to Agricultural Decision Problems*. Westview. Boulder.

A Farm Level Decision Tool to Determine Optimal Slaughtering Time of Lambs

Grete Stokstad[a]

Abstract

Several factors influence the value of a lamb carcass throughout the slaughtering season, and therefore have implications for the optimal slaughtering time of lambs. The expected price of the carcass varies through the season due to:

- Variations in the weight of the lambs, and the growth through the season.
- The classification of the carcass, i.e., the price per kg changes as the lambs grow.
- The prices of the various quality changes throughout the season.

The quality of the grazing fields limits the possible weight gain and influences the classification of lams. The grazing resources are in general limited, and will affect the possibility of fattening lambs in the fall. The objective with this study is to come up with a tool to help in determining when to slaughter which lambs in the fall when resources are limited.

In order to make good decisions, the first step is to calculate the profitability of various slaughtering decisions. I use known characteristics of the lambs as weight, sex etc. to determine expected value of the carcass if slaughtered at various point in time in the future. In order to determine expected quality for the carcasses I have used a multinomial ordered probit regression model to determine the probability for obtaining a particular classification.

A linear programming model is used to choose the best alternatives given limited grassing resources. The model can be used to determine optimal slaughtering decisions given a particular group of lambs and resources. By limiting the possible choices in the model, the model user may also investigate the losses associated with alternative slaughtering schemes.

In this paper I describe the forecasting models for determining the value of the carcass, I describe the general linear programming model and show some results from running the model.

Keywords: Decision making, Linear programming, Sheep farming.

[a] Department of Economics and Social Sciences, Agricultural University of Norway, PO Box 5033, NO-1432 Ås, Norway, *grete.stokstad@ios.nlh.no*

Background

Several studies look at the relationship between lamb characteristics, feeding of the lambs, type of breeds and it impact on eating quality (Arsenos et al., 2001) or meat quality (Dias et al., 2001). Others have studied carcass characteristics and consumer ratings in order to design a quality grading system for lamb meat (Jeremiah, 1998).

The meat grading system "EUROP" is used to differentiate price of meat of different qualities. (In addition to measurement of fatness and type of animal.) Thus, the actual classification of the carcass influences the profitability for the farmer.
The price of different qualities of lamb meat varies for several reasons.

- Prices of various qualities are used to reflect the market situation. The price represents the value consumers put on different qualities directly or indirectly since quality signals what type of product the carcass can be used for. The total supply, for example periodic market surpluses, may also affect the price level.
- The price differentials of various qualities can also reflect the slaughter possibility to utilise the various qualities due to peak – non-peak season or consumer demand.
- The price level or differences between levels may also be used to even out the natural peak season of lamb slaughtering. Thus the farmer may sell the lambs before it reaches it quality potential or to postpone slaughtering in order to avoid the peak season and low prices.

The objective of this paper is to present a tool to help determining optimal decisions regarding slaughtering of lambs. This is particularly interesting since the optimal decision may vary between years due to:

- various amount of resources at the farm level, and
- changes in the price scheme between years.

General rules of thumb are often used in determining which lambs to slaughter. Their usefulness depend on the particular price scheme and resource situation. A model is a much more general tool, which may be used under different price scenarios and resource situations. In addition, the possibility to sign up for a contract regarding slaughtering early in the season and receive a higher price, also make it interesting to use a model to help verify whether that is an interesting alternative.

The model is constructed to determine the optimal slaughtering of a particular stock. In order to run the model one need needs data for a herd of lambs (N-animals) to forecast weight and classifications of their carcasses.

The model consists of two main parts:

- Calculation of the coefficients in the optimisation model, among them the expected value of lamb n given that it is slaughtered at time t and feed alternative m, ($V_{n,m,t}$).
- A linear programming model (LP) that determines the optimal slaughtering plan given the available resources.

The optimisation problem can be formulated as a simple LP model. However, the model may have many activities/decision variables. The size of the model will depends on site-specific constraints (the number of lambs, slaughtering times and resources) and possible new extensions to the model (as fixed factors). Thus the size, number of activities and constraints varies with the application.

An important aspect with the total model is that the linear programming model is automatically written out and run when the user have supplied the necessary farm specific information. Thus running alternative versions of the model do not require that the user manipulate the LP-model directly[16].

In the next section I first describe the linear programming model since the model also identifies what type of information that is needed. Then I describe data requirement and the calculation of the values of lamb carcasses. Finally, I describe the data that the example runs are based on and discuss the results.

The optimisation model

The model is particularly useful in a situation with limited resources and/or cost associated with purchasing additional resources. It determines which animals to slaughter at the possible slaughtering weeks (dates) that the user specify. Alternatively the model may be used to compare alternative slaughtering schemes by varying the possible dates and minimum quantities slaughtered at certain dates.

The objective with the model is to maximize the return. There are two types of decision variables:

- Activity x_{nmt} represent a slaughtering of a given lamb (n) which is fed with a particular diet (m) at a particular slaughtering time (t). With a total of N lambs, M alternative feeding strategise and T possible slaughtering dates the model will have $N*M*T$ decision variables of this type to chose among.
- Activity r_k is the amount of purchased fattening resources k. The number of such decision variables is likely to be a small number.

The objective function consists of two parts.

- The sum of the possible activity levels (x_{nmt}) multiplied with their corresponding carcass value (V_{nmt}).
- The costs of providing additional resources;. the sum of price per unit of additional resources (c_k) multiplied with the amount purchased r_k.

[16]The present version of the model is programmed in SAS. Depending on the data input—the program writes out the LP model and runs it. Alternative the model may be programmed in Excel where one may use macros to write and run the particular LP program given the data provided. On other alternative is to place the model on a server, where several users may use it through Internet. The LP-problem may be large, thus it is also useful with a program/macro that summarize the result from the model so the user do not need to interpret the result from a large LP model, but rather get a summary of relevant information.

$$Max\sum_{n=1}^{N}\sum_{m=1}^{M}\sum_{t=1}^{T}V_{nmt}\,x_{nm}-\sum_{k=1}^{K}c_k r_k$$

It is maximized with respect to three types of restrictions:

1 $\sum_{m=1}^{M}\sum_{t=1}^{T}x_{nmt}\le 1$ for n=1...N. As long as V_{nmt} is greater than zero we may use this inequality sign.

2 $\sum_{n=1}^{N}\sum_{m=1}^{M}\sum_{t=1}^{T}a_{mtk}\,x_{nmt}-r_k\le b_k$ for k=1...K resources.

3 $\sum_{n=1}^{N}\sum_{m=1}^{M}x_{nmt}\ge c_t$ for t=1...T if $c_t > 0$. c_t is the minimum number of lambs to slaughter at particular times, and the constraint is omitted if c_t is zero.

Constraint type 1 consists of N equations that make sure that each lamb only is slaughtered once. The value of the activity level is thus maximum 1. Without these constraints the problem is unbounded. This formulation allows for fractional carcasses. However this will at the most apply for one animal in each time period. It is possible to make it a binary variable 0 or 1 and avoid this problem, at the cost of running an mixed inter programming problem in stead of a LP model. However the fixed resources in constraint type 2 is the "source" of the fractional lamb. The precision of these values will in most cases be somewhat uncertain, therefore adjusting these resources is probably another way to avoid fractional lambs.

Constraint type 2 limits the available fattening resources that are available for no additional costs, b_k and accounts for use of resources that needs to be purchased, r_k. Activity r_k may be omitted from the constraint; there by not making it possible to purchase more of this resource. For example in a situation where b_k represents the acres of a particular green fodder. Alternatively the resource b_k may be purchased feed (concentrate), then b_k would be set to zero and r_k is the amount of concentrate one has to purchase. The amount of the resource used by on lam n feed m slaughtered at time t is given by a_{nmt}. The activity r_k may also be limited by setting a limit to these values (directly or adding a constraint).

Type 3 constraints can be used in order to force a minimum slaughtering at certain times. Alternatively one may use a maximum constraint by changing the inequality sign.

In a linear programming model the weight gain per day may not be a function of the number of lambs in the field. Therefore, one must use constraints as equation 2 to make sure that one have enough grassing fields to produce the particular quality assumed in the model.

Several alternative models may also be considered. One alternative is to include fixed cost in he model. Fixed cost by slaughtering lambs in a particular point in time may be included in the model by using a binary model.[17]

Data to run the model

To use the model, we need values for the coefficients in the optimisation model. They are determined based on the information the model user provides

The following information must be provided or calculated to run the model: The model user specifies:

- In which weeks one may consider to slaughter lambs, thereby determines t=1 ... T.
- Data for the individual N lambs. This data are used to calculate the value of a carcass of animal n, fed alternative r and slaughtered at time t, denoted $V_{n,m,t}$. This is further discussed in the next section.
- Price and subsidy per kg of various qualities of lamb meat over time.
- Possible minimum quantities to be slaughtered at certain times y_t.
- Available fattening resources:
  - Resources at the farm, for b_k used in fattening the lamb, for example grassing fields.
  - Whether additional amount of resource k can be purchased, if so specify the cost of c_k.
  - The resource use of each lamb slaughtered at a particular day, a_{mtk}.

Resource use a_{mtk} is assumed to be independent of individual n, but may depend on time t, and growth/feed assumptions r. The general requirement is that use of the resource per animal can be formulated as a function that depends on t, m and k.

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[17] In a model with fixed costs we add maximum T new activities y_t. The binary variables y_t is zero when one not slaughter lambs at time t and one when one slaughter lambs at that point in time. In the objective function one adds the following term:

$$-\sum_{t=1}^{T} k_t y_t$$

where k_t is the fixed cost. In addition to constraints type 1, 2 and 3 we have a new type of constraint,

$$\sum_{n=1}^{N} x_{nt} - M * y_t \leq 0 \qquad \text{for all } t = 1...T$$

where coefficient M is a large number, at least N.

Forecasting the value of a carcass slaughtered at a particular time

An overview

The value of a carcass will depend on three factors that all may vary over time:

– the prices (and price subsidies) at the time of slaughtering,
– classification of the carcass
– carcass weight

The dark-grey box in Figure 1 represents the data input about the herd of sheep. This is information which farmers that are member of the "efficiency control" or use a data program for storing data about individual sheep, already have recorded, with one exception "fatness"/ or year specific fatness of the herd.

Both carcass weight in the future and the probability for a particular classification will depend on this information. This is indicated in Figure 1.

To work as a forecasting model under varying price scenarios, it is important that the value of the carcass is built on these three separate factors. Classification of a particular type of carcass will probably be quite stable while prices may change over time and the carcass weight as well as expected classification will change over time depending on time and the particular feeding of the lamb.

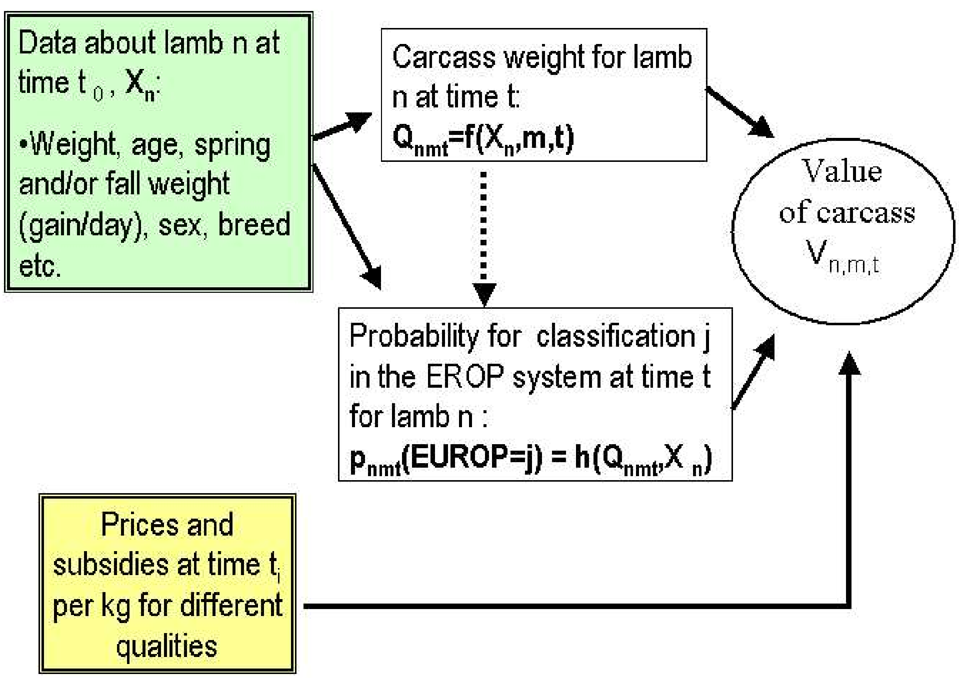

Figure 1 An overview of the calculation of the value of a carcass. The grey boxes show data that may be changed between different applications

The grey boxes represent input data to the model. Expected weight of carcasses (Q_{nmt}) is calculated based on information about the individual lambs X_n, time of slaughtering and possibly the feed strategy. This is further discussed below.

The probability for obtaining classification j for a carcass (n,m,t) is denoted p_{nmt}(classification=j), where $j = P, O$ and R. The probability of a given classification at time t depends on known information about the particular lamb, in addition to t and possibly m. Estimation of these probabilities are discussed below. Price information, probabilities for classifications and expected carcass weight are combined to calculate the value of all carcass possibilities, V_{nmt}.

The value of a carcass

Expected price per kg of the lamb is calculated as a price at time t for classification j ($Price_{jt}$) weighted with the probability that the lamb will reach the different classifications. In addition the subsidy per kg is added. This sum is multiplied by the weight of the carcass Q_{nmt} to determine the total value of the carcass:

$$V_{nmt} = (\textstyle\sum_j (p_{nmt}(classification=j)*Price_{j,t}) + \ Subsidy_{mt} * Q_{tnmt}$$

There is uncertainty both regarding the future carcass weight and classification. However the price step between quality P and O is much larger than the difference between O and R or other weight dependent pricing rules. Thus I find it interesting to treat this uncertainty in a different way than uncertainty regarding weight.

The subsidy per kg ($Subsidy_{nnt}$) may vary over time and depends to some extent on the on the slaughtering weight. When Q_{nmt} is above a certain level (currently 13 kg) you get the subsidy[18]. When the carcass weight is above 23 kg the subsidy per kg is decreased. Expected market prices and price subsides over time are usually published in the beginning of the slaughtering season.

Carcass weight

Carcass weight is forecasted for the possible slaughtering dates. It must be expressed as a function of available data. In the present model these forecast are based on initial weight, expected weight gain per day, time of slaughtering, and the dressage percentage. However this part of the model needs to be further refined. Several factors may be included. Skar (1991) who studied the economics of alternative fattening schemes of lambs concluded that: Small lambs had the greatest weight gain. The weight gain diminished as the weight of the lamb increased. The shorter the fattening period, the greater the weight gain per day per animal. However, with use of concentrate it was possible to maintain weight gain during the fattening period. Thus, there are several factors that potentially could be included in the forecasting estimates.

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[18] Alternatively we could have calculated the probability that the slaughtering weight would be above this level and used this information when calculating expected price per kg.

Skar (1991) used the following relationship between stipulated weight of the animal before slaughtering and carcass weight as:

Carcass %= (0.099024 stipulated weight) + 35.175359*

However the carcass percent is slightly lower today due to removal of kidney stem from the carcasses. In the example present version of the model only one alternative feeding strategy is available and weight is calculated[19]:

$Q_{nt} = -5.81256 + 0.48041\ (fall\text{-}weight_{nt} + (weeks(t-t_0) * growth\ per\ week_{nt}))$

Classification of carcasses

Classification of meat depends on the shape of the muscles on the carcass. This is determined with both genetic differences as well as the environment (feed). In general, heavier lambs are better classified than small lambs.

The classification of a lamb is not a continuous variables, it represent discrete choices. In such cases we need to use a categorical model to forecast classification results. The observed occurrence of a choice is considered to be an indicator of an underlying, unobservable continuous variable. This variable is the propensity to be classified as a given alternative.

Such variables are characterised by the existence of thresholds, crossing a thresholds means switching from one alternative to another. To deal with this type of data, I estimate the unobserved variable, the propensity to end up in a particular discrete choice (see Green, 1985 or Kmenta, 1986). These estimated probabilities are used in the calculation of the expected price the farmer receives for the lamb.

It is at least three different classes the carcass may be classified in. These different classifications have a natural order poor (P), better (O) the best (R). Thus, I use a multinomial-ordered choice model.

The probability for obtaining a better classification increases as the carcass weight increases. Other factors that also may influence the classification are sex and breed. For example are Texel lambs known for being ready for slaughtering earlier than the typical Norwegian breeds.

Candidates for probability distributions are s-shaped curves bounded in the interval (0, 1) such that the value is 0 when $X_i \rightarrow -\infty$ and 1 when $X_i \rightarrow +\infty$. The multinomial ordered probit model is based on the assumptions of the existence of a relationship

$$Y_i^* = X_i'\beta + \varepsilon_i$$

Where β is a vector of parameter estimate and X is a vector of independent variables. Y_i^* is an unobserved variable, $\varepsilon_i \sim N(0,1)$, and $\varepsilon_I\ (i \neq j)$ are independent. It is assumed that Y_i^* is related to the observable alternative categories of choice as follows:

[19] This is based on own data. The carcass percent may be underestimated due to an overestimate of growth per day.

$$
\begin{aligned}
Y_i &= P \text{ if } Y_i^* < 0 \\
&= O \text{ if } 0 \leq Y_i^* \geq A \\
&= R \text{ if } A \leq Y_i^*
\end{aligned}
$$

Let $F(\cdot)$ be the cumulative distribution function of a standard normal variable. Then we can specify the probabilities:

$P(Y_i=P)=F(X'b)$

$P(Y_i=O)=F(A+X'b) - F(X'b)$

$P(Y_i=R)=1-F(A+X'b)$

In the model I use the estimated values for an unobserved variable Y^* as a function of carcass weight, a dummy variable for sex (ram) and one dummy variable for breed (dala).

With use of the probit model I have estimated A and the coefficients in equation Y_1 below

$$Y_1 = X'b = 7.89 + 0.83\, D_{ram} - 0.64\, D_{dala} - 0.58\, carcass,kg$$

$$Y_2 = A + Y_1 = 4.84 + X'b$$

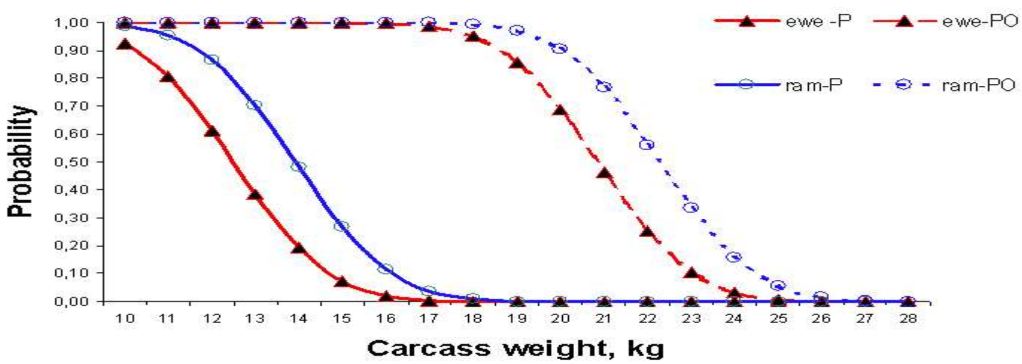

Figure 2 Probability that a lamb (a ewe or a ram) of a heavy breed, will be classified given the carcass weight. The probability that the lamb will be classified as P is shown with a solid line, while the stipulated lines show the probability the lamb is classified as either P or O. Circle indicate rams, while triangle show ewes

In the future other specifications of Y_1 may be considered. For example, should the fatness of the lamb or the general quality of the grassing area be considered? Instead of using carcass weight directly, we could use other indicators as weight gain per day, age of the animal or additional factors. However, at present, to utilize the data I have, I choose to use carcass weight as an explanatory variable in order to estimate expected classification. This point needs to be further investigated.

Price data

Figure 3 shows prices and Figure 4 shows price subsidies for different qualities of sheep meat. Lamb carcasses less than 13 kg do not get any price subsidy. It is further assumed that carcasses less than 13 kg receives kr 1.50 less per kg than the weight group 13–23 kg, Figure 3. While heavier lambs, more than 23 kg, receive 0.70 kr/kg less than this group.

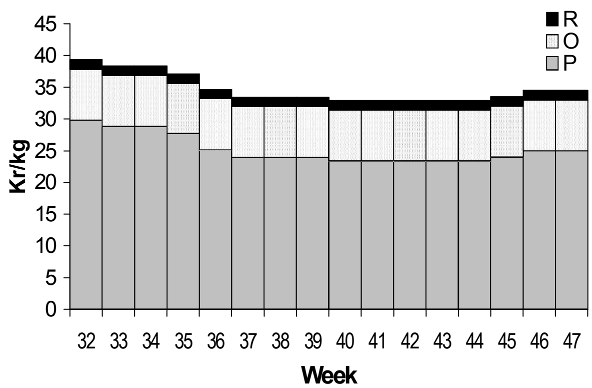

Figure 3 Price per kg lamb meat for quality R, O *and* P *per week of carcasses 13–23 kg*

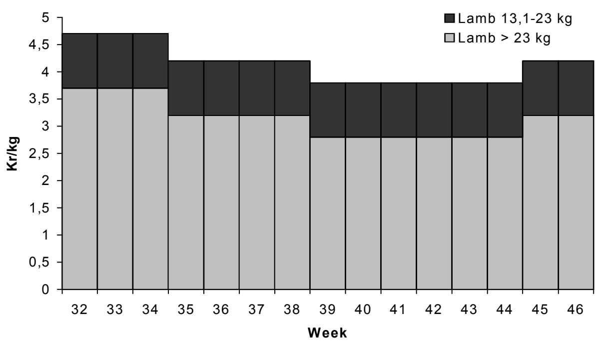

Figure 4 Subsidy per kg lamb meat for two weigh groups

A taste of the model

To demonstrate the use of the model I have run the model for a small group of lambs. The distribution of the weight of the lambs at the first possible time of slaughtering 3. of September (week 36) is illustrated in Figure 5. Possible slaughtering week numbers are set to 36, 38, 40 and 42.

These data are constructed. However, the distribution of weights is based on the distribution of my flock. It is the same number of rams and eves, and they are evenly distributed.

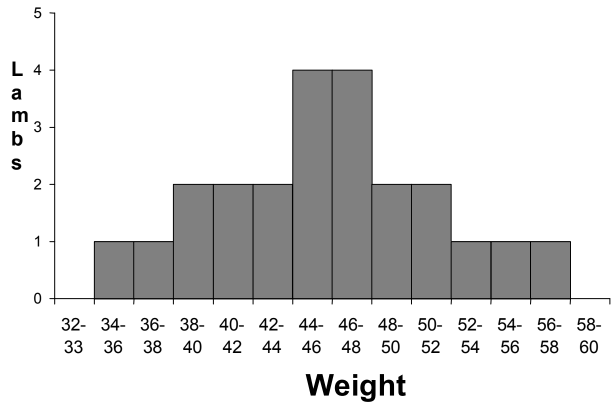

Figure 5 Number of lambs in different weight groups

I have assumed only one feeding strategy (m=1), Thus, the only discussion is when should one slaughter lambs. I have run the model with two different assumptions with respect to weight increase per day. Table 1 shows the average value of the carcass and slaughter weight at time of slaughter when lambs gain 250 g per day. Six different slaughtering alternatives are considered.

The four first alternatives do not require any run of the linear programming model, since all lambs are slaughtered at a certain time. Table 1 also shows the total number of weeks with feed which is used following these strategies. Later time of slaughtering results in higher average weight but also an increase in value per carcass. Alternative 5 is based on use of the model, where the objective is to maximize the income from carcasses. There is no variable cost associated with keeping the lambs. The result is that one chooses to slaughter lambs that are about to pass the limit of 23 kg. The average weight decrease compared to alternative 4, but the average value of the carcass increases. The column "grazing weeks" shows total number of weeks with lambs. It indicates use of grassing resources and show that this decrease in spite of increased income. The last alternative is constructed to be relatively similar to alternative 2 with respect to use of grassing resources. In this case it is better to slaughter lambs twice, to avoid slaughtering of very small lambs.

These recommendations are based on a growth per day of 250 gram. If one assumes a lower growth per day, for example 100 g/day, or variable costs associated by keeping lambs alive, the model suggest that a larger share of the relatively heavy lambs should be slaughtered early even they are not in danger of passing the weight limit of 23 kg. These examples illustrate that it is important to come up with good estimates for the costs and weight increase over time.

Table 1 Slaughtering alternatives, slaughtering time, relative value, average value and weight of carcasses, total use of grass (grassing weeks)

Slaughter decisions:	Number of lambs slaughtered in week #: 36	38	40	42	Relative value	Average value per carcass, Nkr	Total grassing weeks	Average carcass weight, kg
1 All lambs in week 36	23				1.00	566	0	15.3
2 All lambs in week 38		23			1.08	611	46	18.7
3 All lambs in week 40			23		1.14	643	92	20.4
4 All lambs in week 42				23	1.19	671	138	22.1
5 Maximize income	2	5	4	12	1.23	698	98	20.4
6 Total number of grassing weeks limited to 48 weeks	15			8	1.12	635	48	17.1

Discussion and results

With the present parameterisation the model performs as expected. As grazing resources becomes scarcer the model suggests to slaughter the heavier lambs first, particularly those that will pass the 23 kg limit. The model does not punish keeping old lambs too long, since I not have included reduced price due to fat lambs or classification "ram/young sheep" late in the fall. This can be included in the model in the future. At present the biggest flaw with the parameterisation of the model is that the data is from a herd where I have slaughtered heavy lambs early in the season and the data for the breed "Dala" is quite limited. Thus I do not have too fat lambs or "rams" in the dataset. My experience is also that there are differences with respect to years, but maybe these differences can be explained by different grassing conditions during the summer and fall.

To improve the parameterisation of the model, one could design new slaughtering experiments or analyse data from previous studies in a different way. For example use of probit or logit model to estimate probabilities for various classification, rather than reporting the change in values of carcasses directly.

If we can model the relationship between carcass weight/quality and the particular treatment and starting point of a lamb, then we can improve the quality of the lambs delivered to slaughter, given that farmers find it profitable. The model can also be a tool to give advice on the design of price schemes to give economic incentives to produce quality carcasses.

Sheep fattening is not a big business. However the general model concept can be applied to other productions. Such situations are when price depends on categorical and non-categorical information about a product, and there are several possible marketing dates. One example is fattening of cattle. There are also similar "problems" in salmon production. Thus this model concept may be used in a wider setting.

References

Arsenos, G., G. Banos, P. Fortomaris, N. Katsaounis, C. Stamataris, L. Tsaras, and D. Zygoyiannis, 2001. Eating quality of lamb meat: Effects of breed, sex, degree of maturity and nutritional management. *Meat Science*, Vol 60. pp. 379–387.

Días, M.T., S. Velasco, V. Cañeque, S. Lauzurica, F. Ruiz de Huidobro, C. Pérez, J. González and C. Manzanares, 2001. Use of consentrate or pasture for fattening lambs and its effect on carcass and meat quality. *Small Ruminant Research*. Vol. 43 pp. 257–268.

Green, W. H., 1993. *Econometric analysis*. 2nd ed. Macmillian Publishing Company.

Jeremiah, L-E., 1998. Development of a Quality Classification System for Lamb Carcasses. *Meat Science*, Vol 48 , pp. 211–223.

Kmenta, J., 1986. *Elements of Econometrics*. 2nd ed. Macmillian Publishing Company.

Skar, R., 1991. *Høstfeiting av slaktelam*. Forskningsmelding A-014-91, Norsk institutt for landbruksøkonomisk forskning.

Risk and Risk Management in Organic Farming—Presentation of a Research Project

Matthias Koesling[a], Gudbrand Lien[b], Ola Flaten[c], Martha Ebbesvik[d], and Paul S. Valle[e]

Abstract

The Norwegian Ministry of Agriculture (1999) has announced its goal of converting 10% of the total agricultural area to organic farming methods by the year 2009. Considerations of profitability and risk will be especially important, when the conversion of a farm is planned. Studies of risk and risk management in organic farming have been lacking in Norway. Only very few such studies have been carried out internationally, thus showing that there is a definite need for more risk and risk management research in organic farming.

The project aims to increase knowledge about risks and risk management in organic farming systems. It is a co-operation between NILF, NORSØK, and NVH. Both biological and economic aspects of risk will be taken into consideration. We wish to test and apply acknowledged statistical and risk analysis theories and methods on issues related to organic farming. The project will deal with the extent of risk in organic farming, strategies used by organic farmers to handle risk and whole-farm models to analyse optimal economic solutions under uncertainty in organic farming. The project will cover farms that are still in conversion and completely converted farms. Results from the project will directly benefit farmers and farm advisers. Politicians and public administrators will receive access to significant information for the design of future policies.

Keywords: Risk; Risk management; Organic farming

[a] The Norwegian Centre for Ecological Agriculture, NORSØK. *matthias.koesling@norsok.no*
[b] The Norwegian Agricultural Economics Research Institute, NILF. *gudbrand.lien@nilf.no*
[c] The Norwegian Agricultural Economics Research Institute, NILF. *ola.flaten@nilf.no*
[d] The Norwegian Centre for Ecological Agriculture, NORSØK. *martha.ebbesvik@norsok.no*
[e] The Norwegian School of Veterinary Science, NVH. *paul.s.valle@veths.no*

Introduction[20]

In July 2002 the Norwegian Agricultural Economics Research Institute (NILF), the Norwegian Centre for Ecological Agriculture (NORSØK) and the Norwegian School of Veterinary Science (NVH) started on a three-years project named "Risk and Risk Management in Organic Farming".

In this article we will present the project. First a brief background for the research need on risk and risk management in organic farming is given. Then the project's objective and utility value is presented. Further, the project methodology and design is more thoroughly described, and finally the last section contains the project's framework.

Background

During the past few years, there have been intensive efforts to increase the scope of organic farming in Norway. The number of enterprises inspected by Debio (the Norwegian inspection body) increased from 423 in 1991 to 1,840 in 2000 (Debio, 2001). In the same period, the acreage of organically certified farmland and land in conversion increased from 2,443 ha to 20,522 ha. In 2000, the total organic acreage amounted to 2% of the total agricultural area in Norway.

Consumers are interested in organically produced food and are willing to pay higher prices (e.g., Huang, 1996). In many western countries, sales of organic products have recently increased by 25–30% per year, compared to a 3–5% increase for food in general (Lohr, 1998). Based on both domestic and international market trends, the Norwegian Ministry of Agriculture (1999) has announced its goal of converting 10% of the total agricultural area to organic farming methods by the year 2009. This requires that a considerable number of farmers convert to organic production, and that the market demand for these products increases accordingly.

This focus on organic farming is based on its potential for helping to achieve farm policy objectives and developing a more sustainable agriculture (Norwegian Ministry of Agriculture, 1999). Organic agriculture is said to contribute to food safety, greater product diversity, increased use of local resources, environmental benefits and increased income potential. Another argument is that increased expertise on environmentally sound farming methods can benefit the entire agricultural sector.

Farmers have many different reasons for converting to organic production methods. The pioneers in the field were primarily concerned with ideological issues

[20] This article is based on the project description "Risiko og risikohandtering i økologisk jordbruksproduksjon (Risk and Risk Management in Organic Farming)" submitted to the Research Council of Norway, 15 January 2002.

and the problems resulting from intensive agriculture, whereas environmental and economic concerns have played a greater role for those that have converted in the past few years (Padel, 2001). Thus, in order to promote the conversion to organic farming methods, considerations of profitability and risk[21] will be especially important.

Internationally, there have been many studies about economic issues related to organic farming (Lampkin and Padel, 1994). Offermann and Nieberg (2000) reviewed the profitability in organic farming in several European countries, including the factors that affect profitability in the transition from conventional to organic farming. The analyses showed that organic farming is an interesting alternative in many countries, even though yields are lower. This was due to higher producer prices and specific subsidies for organic farms. Organic premiums were highest for vegetable products.

In Norway, the profitability of organic dairy farms was analysed by Vittersø (1995 and 1997). The results showed lower variable costs, but higher total costs per kg milk on the organic farms. However, if higher prices could be obtained for organic milk and specific subsidies were paid, profitability could be equal to or better than the conventional dairy farms, depending on yield levels, the percentage of purchased feed and the additional labour requirements.

Repstad and Eltun (1997) used data from farming systems research at Planteforsk, Apelsvoll from 1990–96 in their analysis of economic return of different farming systems. Data from the trials were used to simulate production on farms with about 30 ha farmland. There were treatments with crops (cereals and potatoes) with no livestock, and treatments with forage and field crops with livestock. For each treatment, a conventional, an integrated and an organic farming system was tested, i.e., a total of six different systems. Yields were relatively high in the organic field crop system, and profitability (measured as return to labour and management per hour) was highest in the organic system. However, the profitability of the organic farming system was significantly reduced if prices and subsidies were kept at the same level as in the conventional farming system. For the models that included livestock, profitability was about the same (including premium prices and organic subsidies).

The mentioned studies primarily evaluated profitability. However, it is not sufficient to only focus on profitability without considering risk, since the long-term stability of output and farm incomes can also be important. Organic farm production can be subject to a different exposure of risk and require different risk management practice due to restrictions in pesticide use, mineral fertilizer, synthetic medicines, purchase of feeds and breeding animals, etc. Subsidies account for a larger share of the production income on organic farms, thus resulting in greater income stability, whereas the price development for organic products is uncertain.

[21] Hardaker *et al.* (1997:5) define *uncertainty* as imperfect knowledge and *risk* as uncertain consequences, particularly exposure to unfavourable consequences. To take a risk, then, is to impose oneself to a significant chance of injury or loss.

Finally, institutional risks related to policy development (rules and regulations, subsidies, etc.) may be different in organic agriculture.

Studies of risk management in organic farming

Numerous articles have been published internationally on agricultural risk management. Studies of risk and risk management in organic farming have been lacking in Norway, and we only found a few foreign studies on the issue. Hirschi (2000) developed a mathematical programming model that maximizes the net present value of certainty equivalents. The model was used to study portfolios of conventional and organic crop rotations in the Midwest of the USA at varying degrees of risk aversion. Net return varied the most in the organic farming system, but organic farming was part of an optimal portfolio for farmers with low levels of risk aversion. Land use changed to conventional production as risk aversion increased.

Mahoney *et al*. (2001) evaluated the profitability and risk (stochastic dominance) for conventional and organic crop rotations in field trials on rich soil in Minnesota. Yields and costs were lowest in the organic crop rotations, which were most profitable, even without an organic premium. When including organic premiums, the organic system was clearly the dominant strategy. In contrast to Hirschi (2000), no additional risk was observed in organic farming.

Waibel *et al*. (2001) evaluated profitability in the transition from conventional to organic apple growing in Germany. Traditional investment analysis showed best profitability after converting to organic growing methods. Risk assessment using stochastic simulation confirmed the conclusion under certainty. In organic apple growing, the choice of variety is important for the control of pests and achieving high prices. The effect of variety diversification on expected income and income variance was tested with a MOTAD approach. It often made sense to grow several different varieties.

The Economic Research Service (US Department of Agriculture) has initiated a research project on "Risk Management in Organic Farming", but written reports has not yet been published (Dismukes, 2001). Only very few such studies have been carried out internationally, thus showing that there is a definite need for more risk management research in organic farming. This applies especially to livestock husbandry and mixed farming systems combining livestock husbandry and crop production, for which no relevant studies were found at all.

The project's objectives and utility value

The project's major objective is to increase knowledge about risks and risk management in organic farming. The project includes the following sub-goals:

1. Assess the extent of risk, especially risks related to crop yields, livestock performance, animal health, prices and income on organic farms.
2. Assess the risk management strategies used by organic farmers/producers.

3. Develop whole-farm planning models to analyse the economically optimal adjustments under uncertainty in organic farming.

Results from the project will directly benefit farmers and farm advisers. Politicians and public administrators will get access to significant information for the design of future policies and the organization of organic agricultural production. Experience from data collection and treatment, project results and developed models will be useful for further research and risk management in organic farming. The results will also benefit conventional farming.

Project methodology and design

The project's sub-goals require different types of data and research methods. These are presented in the following.

Sub-goal 1: The extent of risk in organic agricultural production

Farmers must take a number of risk factors into consideration (Hardaker *et al.*, 1997; Harwood *et al.*, 1999): production risk[22], price risk, political risk, personal risk and financial risk. We know little about the annual variations of yields, performance, animal health, prices, economic results, etc. on Norwegian organic farms, and about the degree of covariation between the factors. More knowledge about these factors will improve the basis for assessing risk management strategies on organic farms. The analyses in the project will be based on historical data and be limited to production risk and price/income risk (economic risk).

The project's main focus will be the study of risks associated with organic farming, but we will also make comparisons with conventional farming. We also plan to compare the extent of risk in Norwegian and Dutch organic agriculture.

Due to such factors as the restrictions on the use of pesticides and soluble mineral fertilizers, it is often assumed that yield variations are more pronounced in organic than in conventional farming (Tvedegaard, 2000:36). In conventional farming, the uncertainties arising from pest attacks can be reduced by using pesticides, whereas uncertainties regarding price and yields can also lead to a risk-increasing effect of pesticide use (Pannell, 1991). The nitrogen supply from nitrogen-fixing legumes and mineralization of farmyard manure are major yield-determining factors in organic crop production. Both of these processes are weather dependent, and thus associated with a certain degree of risk.

According to Sundrum (1998), there are hardly any fundamental differences with regard to the animal health status in organic and conventional farming. However, the data material for this literature review was limited. In any case, the "farm manager" factor is important for animal health. Organic farms are often more diversified, and thus may have less time and resources available for animal health

[22] Production risk (biological risk) includes the uncertainty regarding crop yields and livestock performance due to such factors as unpredictable weather, pests and diseases.

issues. As a result, there may be an increased risk of disease. Because of restrictions on purchased feedstuffs and insufficient, unbalanced feeding—especially after years with poor fodder yields—there may also be an increased risk of certain feed-related diseases and deficiencies, and livestock performance can show greater annual variations. On the other hand, stringent regulations regarding livestock housing and open-air runs may help to prevent animal diseases. Restrictions on the use of feed additives, including antibiotics, may lead to different health management strategies.

There have been some studies of animal health in organic livestock husbandry in Norway (Strøm and Olesen, 1997; Reksen *et al.*, 1999; Hardeng and Edge, 2001), but none of these studied the long-term disease variations. This project aims to study the general animal health conditions in organic livestock husbandry, i.e., to survey the total animal health risk associated with organic animal husbandry on completely converted farms and those still in conversion. The disease frequency measured as registered veterinary treatments does not necessarily reflect the actual health status. We will also examine possible treatment differences (alternative health management) between organic and conventional livestock husbandry. In-depth studies of specific issues that may arise, and that could be of interest for explaining causality, will have to be dealt with in follow-up studies.

In the short term, subsidies are a reliable source of income, and the rates are highest for organic farming. This may thus contribute to a stable income situation on organic farms. On the other hand, prices can be more variable than in conventional farming.

It is therefore not obvious whether the production and price (market) risks are greatest in organic or conventional farming.

Methods

It is desirable to collect data from several farms for several consecutive years. The data can then be treated and analysed as panel data in order to calculate expected values, variance and correlation for a number of agronomic and economic parameters. Panel data methods were used by Hegrenes and Lien (1999) in their statistical analysis of yield and income variations on farms in northern Norway and by Hegrenes *et al.* (2001a) in their study of income variations on Norwegian farms. Rasmussen (1997) used fixed-effect models to estimate yield and price risks for different farming systems in Denmark.

More recent analytical methods, such as multi-level analysis (Goldstein, 1995), improve the ability to study the causes of variations of animal health at various levels (lactation, herd, region, etc.). This also applies to long-term studies.

Data sources

In order to obtain insight into price (market) and production (yield) risks, we will utilize several sources of data. In the farm surveys ("Account Statistics"), agronomic and economic data are annually collected from about 1,000 farms, divided between different regions, farm size classes and types of farms. In 2000, 82 of these farms received organic farm support (including conversion subsidy), many of which were dairy farms. For most of these farms, we will also receive data in 2001. Until the year 2000, 39 of the survey farms have received organic subsidies for two years or more. The farm surveys are especially suited for the assessment of business and financial risk on both organic and conventional farms.

The Norwegian Centre for Organic Agriculture (NORSØK) has annually collected agronomic and economic data on organic farms from 1989–96 via the two projects "30 bruks-prosjektet" (Løes and Schmidt, 1993) and "Gardsstudie-prosjektet" (GSP) (Ebbesvik, 1997). The farms in the projects were either converted or in conversion to organic farming methods. The agronomic data covered crop production (land-use, fertilization, yields, etc.) and livestock husbandry (herd size, feeding, pasture management, performance, health, etc.). The analysis of economic return by Vittersø (1995, 1997) is based on these sources.

Animal health and performance data will be taken from the health recording scheme (Østerås and Spanne, 1999), a part of the Norwegian animal production and dairy herd recording schemes. These schemes represent an extensive, historical database covering about 95% of the Norwegian dairy herds. Most organic dairy farmers also participate in the recording scheme. These data can be linked with other databases, thus enabling significant insights into various areas without expensive field trials and/or data collection. The health status in organic livestock husbandry will be described in absolute terms and in relation to conventional animal husbandry.

Production risk will also be analysed by using data from crop production field trials and systems research. Data are available from numerous field trials with different crops, including cereals. Field trials enable the quantification of annual variation, but many of these are single series of trials. In systems research, several crops are included in a crop rotation, thus making it easier to estimate yield correlations. In cooperation with Planteforsk (commissioning R&D services), the project will analyse data from systems research at the research stations Apelsvoll and Kvithamar. These trials were initiated in 1990, and are still in progress.

Limitations

In order to limit the scope of the project, the analyses have to be limited to certain farm enterprises and farming systems. The main type of organic production in Norway is dairy farming. In the future, the cultivation of organic feed grain and protein crops for crimping or milling will gain increasing importance, since all feed in organic livestock operations must be grown organically by the year 2005 (EF Tidende, 1999). For that reason, it is important that more feed grains and protein crops are grown on livestock as well as on specialized crop farms. In the project, we will thus focus on dairy farming, dairy farming combined with on-farm production of feed concentrates, and pure crop production (cereals and potatoes).

Sub-goal 2: Risk management strategies used by organic farmers

In other countries, there have been studies of what conventional farmers consider being the major risk factors and of which risk-management strategies they use.

According to Harwood *et al.* (1999), US farmers focus mainly on price, production and political risks. The use of derivative and insurance markets are the most popular risk-management strategies. In the Netherlands, Huirne *et al.* (2000) found that farmers considered price and production risks to be most important. Insurance was the most common risk-reducing strategy. We could not find any comparable studies of organic farms. In Norway, no such studies have been conducted on either conventional or organic farms.

Based on a survey, we thus wish to study important risk factors and management strategies (including product diversification) among organic and conventional farmers in Norway. The motivations for converting and continuing to farm organically vary among farmers (Padel, 2001). It would thus also be interesting to examine if farmers with different motives for converting to organic farming have different risk conceptions and use different risk management strategies.

It is presumed that the risks are especially high in the *conversion period*, during which farmers often have little knowledge of organic farming methods, lack necessary experience and are prone to yield reductions, and therewith have less feed for their livestock (Løes, 1992). Farmers in the conversion period will be included in the survey.

The survey will be conducted among a selection of about 500 farms (selected from Debio's farm register) and a similar number of conventional farms as a reference group (selected from the Norwegian Agricultural Authority's database).

Sub-goal 3: Optimised economic adjustments under uncertainty in organic farming

Whole-farm planning model for the analysis of organic production during conversion

When converting to organic farming methods, farmers usually have insufficient knowledge about and experience from organic production. The possibilities of supplementing low yields with purchased, conventionally grown feed are limited, and the restrictions will be even more stringent in the future (EF Tidende, 1999). There is often uncertainty with regard to what prices one can expect to obtain, and which marketing channels to use. It may be necessary to invest in new equipment and additional land. At the time of conversion, it is often uncertain what the future labour requirements will be.

Organic producers receive subsidies as one-time conversion payments, but it is doubtful if the payments are substantial enough to secure satisfactory liquidity in the conversion period. Ebbesvik (2001) developed software to assist farm advisers and farmers in the calculation of conventional and organic gross margins. For significant farm expansions or conversions, it is common to formulate deterministic whole-farm plans for a period of 5–6 years in advance in order to evaluate the economic result and liquidity. For the analysis of strategies for a farmer considering converting to organic production, stochastic whole-farm plans give more detailed and relevant information.

Stochastic budget models, which directly include uncertain variables, have been developed for whole-farm planning by Lien (2002), among others. The model is based on a deterministic dynamic farm plan. The most uncertain factors are specified by probability distributions, and the dependency between stochastic variables is specified. Dynamic stochastic budgeting is used, in which the model simulates 6 years in advance, and stochastic dominance analysis is used to rank investment and production strategies. Other similar stochastic models are described by Richardson & Nixon (1986) and Milham *et al.* (1993). By adapting such models to Norwegian conditions on conventional and organic farms, farm-level, informative analyses of the economic development in the medium run can be conducted. An alternative extension of Lien's model is to combine stochastic budgeting and optimisation. This approach was used in the analysis of the profitability of surface grading of peat soils in northern Norway (Lien *et al.*, 2002), and would be interesting to test in the analysis of farms considering the conversion to organic production. The project will also evaluate alternatives to stochastic budgeting for analyses of adaptations in the conversion period.

The stochastic budgeting model will be used on case farms to analyse relevant investment and production strategies associated with organic production.

Whole-farm planning model for the analysis of organic production after completion of the conversion period

A mathematical programming model for the analysis of optimal adjustments under uncertainty on completely converted organic farms will be developed. The analysis model is discrete stochastic sequential programming, which optimises product combinations (portfolio selections), allows production and price risks, enables decisions to be taken several times throughout the production process (sequential decision making), and takes the entire farm's resource limitations and operational system into consideration. The model maximizes expected utility for different risk attitudes by the farmers.

The model will be a modification and extension of the model described by Lien & Hardaker (2001) and Hardaker *et al.* (1997:196–203). The model will also be based on studies conducted by, among others, Kaiser & Apland (1989), Ekman (2000) and Flaten (2001). It is important to take into consideration characteristic biological and institutional aspects of organic production. This requires in-depth agronomic expertise of organic farming, and important contributions in this respect will be made by NORSØK. We have found few organic farm models for the analysis of optimal adjustments. DeBuck *et al.* (1999) describe a mathematical programming model for studies of organic, integrated and conventional farming systems in Dutch crop production, but without using any empirical data. Hirschi (2000) developed a type of mathematical programming model that maximized the net present value of certainty equivalents and was used to study portfolios for varying degrees of risk aversion.

The model will be based on, among others, data and results from other parts of the project (see sub-goals 1 and 2). We will thus develop models including dairy production (combined with on-farm production of feed concentrates) and specialized crop production (cereals and potatoes).

Several aspects can be analysed and studied with the model, such as:

- Optimising the portfolio of organic products
- Tactical decisions for the management of possible feed shortages (selling/buying feed or animals throughout the year, crop portfolios assuring yield stability, less intensive feeding, etc.)
- Consequences of not being able to use conventional feed (concentrates and roughage) in organic dairy production, and potential for increasing feed self-sufficiency (including grain crimping)
- Effects of farm cooperation (joint operation, machinery cooperation, exchange of farmland, etc.)
- Effects of various subsidy schemes for organic farms and policy-related risks for the farmer
- Importance of the farmer's risk attitude for optimal adjustment

As the project progresses, we will determine which of these (and other) aspects to analyse in detail.

References

Debio, 2001. http://www.debio.no/diverse/debstat1.htm, as of 11.01.02.

DeBuck, A.J., E.M.T. Hendrix & H.B. Schoorlemmer, 1999. Analysing production and environmental risks in arable farming systems: A mathematical approach. *European Journal of Operational Research* 119: 416–426.

Dismukes, R., 2001. Agricultural economist in ERS-USDA. Personal communication.

Ebbesvik, M., 1997. *Nøkkeltall fra 13 gårder med økologisk drift. Resultater og kommentarer*. Norsk senter for økologisk landbruk, Tingvoll.

Ebbesvik, M., 2001. *Planleggingsprogram for økologisk landbruk – brukerveiledning*. Norsk senter for økologisk landbruk, Tingvoll.

EF Tidende, 1999. EU's forordning om økologisk husdyrproduksjon. *De Europeiske Fællesskabers Tidende*, 24. august 1999. ftp://ftp.ecoweb.dk/eu-forordning/eu-husdyr.pdf, as of 11.01.02.

Ekman, S., 2000. Tillage system selection: a mathematical programming model incorporating weather variability. *Journal of Agricultural Engineering Research*, 77(3): 267–276.

Flaten, O., 2001. *Gardsmodeller for å analysere produksjonstilpasning i norsk mjølkeproduksjon*. Notat 2001–12. Norsk institutt for landbruksøkonomisk forskning, Oslo.

Goldstein, H., 1995. *Multilevel statistical models, 2nd ed.* Arnold, London.

Hardaker, J.B., R.B.M. Huirne & J.R. Anderson, 1997. *Coping with risk in agriculture*. CAB International, Wallingford, Oxon.

Hardeng, F. & V. Edge, 2001. Mastitis, ketosis and milk fever in 31 organic and 93 conventional Norwegian dairy herds. *Journal of Dairy Science* 84: 2673–2679.

Harwood, J., R. Heifner, K. Coble, J. Perry & A. Somwaru, 1999. *Managing Risk in Farming: Concepts, Research, and Analysis*. Agricultural Economics Report No. 774. U.S. Department of Agriculture, Washington.

Hegrenes, A., B. Hill, & G. Lien, 2001a. Income instability among farm households – evidence from Norway. *Farm Management* 11: 37–48.

Hegrenes, A. & G. Lien, 1999. *Vurdering av risk for avlings- and inntektsvariasjon innen bruk i Nord-Norge*. Notat 1999:13. Norsk institutt for landbruksøkonomisk forskning, Oslo.

Hirschi, R.L., 2000. *Organic row crops in a diversified farm portfolio*. Paper presented at the Western Agricultural Economics Association Annual Meetings, Vancouver, June 29–July 1, 2000.

Huang, C.L., 1996. Consumer preferences and attitudes towards organically grown produce. *European Review of Agricultural Economics* 23: 331–342.

Huirne, R.B.M, M.P.B. Meuwissen, J.B. Hardaker & J.R. Anderson, 2000. Risk and risk management in agriculture: an overview. *Int. Journal of Risk Assessment and Management* 1: 125–136.

Kaiser, H.M. & J. Apland, 1989. DSSP: a model of production and marketing decisions on a midwestern crop farm. *North Central Journal of Agricultural Economics* 11: 157–170.

Lampkin, N. H. & S. Padel, 1994. *The Economics of Organic Farming, An International Perspective.* CAB International, Wallingford, Oxon.

Lien, G., 2002. Assisting whole-farm decision-making through stochastic budgeting. Forthcoming *Agricultural Systems.*

Lien, G. & J.B. Hardaker, 2001. Whole-farm planning under uncertainty: impacts of subsidy scheme and utility function on portfolio choice in Norwegian agriculture. *European Review of Agricultural Economics* 28: 17–36.

Lien, G., A. Hegrenes, J.B. Hardaker, T.E. Sveistrup & T.K. Haraldsen, 2002. *Profitability of surface grading of peat soils in northern Norway – A new heuristic analysis alternative to stochastic dynamic programming*. NILF. Unpublished paper, submitted to Agricultural Systems.

Lohr, L., 1998. Implications of organic certification for market structure and trade. *American Journal of Agricultural Economics* 80: 1125–1129.

Løes, A.K., 1992. *Aktuelle omleggingsproblemer – en spørreundersøkelse*. Norsk senter for økologisk landbruk, Tingvoll.

Løes, A.K. & K. Schmidt, 1993. *Hva var 30 bruks-prosjektet? En beskrivelse av prosjektforløp og resultater*. Norsk senter for økologisk landbruk, Tingvoll.

Mahoney, P.R., K.D. Olson, P.M. Porter, D.R. Huggins, C.A. Perrilo & K. Crookston, 2001. *Risk analysis of organic cropping systems in Minnesota.* Paper presented at the American Agricultural Economics Association Meeting, Chicago, August 5–8, 2001.

Milham, N., J.B. Hardaker & R. Powell, 1993. *RISKFARM: a pc-based stochastic whole-farm budgeting system*. Centre for Agriculture and Resource Economics, University of New England, Armidale (unpublished paper).

Norwegian Ministry of Agriculture, 1999. *St.meld. nr. 19 (1999-2000) Om norsk landbruk and matproduksjon*. Det kongelige landbruksdepartement, Oslo.

Offermann, F. & H. Nieberg, 2000. *Economic performance of organic farms in Europe. Organic farming in Europe: Economics and policy. Volume 5*. Universität Hohenheim, Stuttgart.

Padel, S., 2001. Conversion to organic farming: A typical example of the diffusion of an innovation. *Sociologica Ruralis* 41: 40–61.

Pannell, D.J., 1991. Pests and pesticides, risk and risk aversion. *Agricultural Economics* 5: 361–383.

Rasmussen, S., 1997. Yield and price variability in Danish agriculture: an empirical analysis. In: Huirne, R.B.M, J.B. Hardaker, & A.A. Dijkhuizen (eds.), *Risk Management Strategies in Agriculture – State of the Art and Future Perspectives*. Backhuys Publishers, Leden, The Netherlands, pp. 37–44.

Reksen, O., Aa. Tverdal & E. Ropstad, 1999. A comparative study of reproductive performance in organic and conventional dairy husbandry. *Journal of Dairy Science* 82: 2605–2610.

Repstad, K. & R. Eltun, 1997. *Economic return with conventional, integrated and organic farming* (In Norwegian). NILF-rapport 1997:3. Norsk institutt for landbruksøkonomisk forskning, Oslo and Planteforsk, Norsk institutt for planteforskning, Kapp.

Richardson, J.W. & C.J. Nixon, 1986. *Description of FLIPSIM V: a general firm level policy simulation model*. Texas Agricultural Experiment Station. Bulletin B-1528.

Strøm T. & I. Olesen, 1997. *Mjølkekvalitet, helse and holdbarhet på kyrne ved omlegging til økologisk husdyrproduksjon*. Norsk senter for økologisk landbruk, Tingvoll.

Sundrum, A., 2001. Organic livestock farming: A critical review. *Livestock Production Science* 67: 207–215.

Tvedegaard, N., 2000. *Omlægning til økologisk planteavl – analyse af de økonomiske konsekvenser på udvalgte planteavlsbedrifter*. Working paper no. 2/2000. Statens Jordbrugs- og Fiskeriøkonomiske Institut, København.

Vittersø, H., 1995. *Foretaksøkonomiske tilpasninger i økologisk melkeproduksjon*. NILF-rapport 1995:8. Norsk institutt for landbruksøkonomisk forskning, Oslo.

Vittersø, H., 1997. *Økonomien ved omlegging til økologisk melkeproduksjon på ni garder*. NILF-rapport 1997:1. Norsk institutt for landbruksøkonomisk forskning, Oslo and Norsk senter for økologisk landbruk, Tingvoll.

Waibel, H, H. Garming & K. Zander, 2001. Die Umstellung auf ökologischen Apfelanbau als riskbehaftete Investition. *Agrarwirtschaft* 50: 439–450.

Østerås, O. & T. Spanne, 1999. Helsekortordninga 1998. *Norsk Veterinærtidsskrift* 111: 321–332.

Farm Boards

Morten Juhl Lassen[a]

Abstract

The increasing complexity of farms rising from the structural changes in farm size and specialisation of production means that the need for farm management on individual farms is increasing. Analysis of farm accounts data show great variation in the economic results due to management skills.

Farm councils or farm boards can be a valuable tool for the farmer in managing the farm. The farmer's objectives with the farm board can be divided into the following two:

1. Objectives concerning professional problems (operational level).
2. Objectives concerning strategic farm plans (strategic level).

The number of farm board members and the demands for their qualifications depend on the objective of the board. Thus the farmer must define and describe the objective of the farm board prior to the recruiting of board members.

The aim of this paper is to discuss the idea and the concept of farm boards and how a further implementation of the concept of farm boards among Danish farmers can be made.

Key words: Farm Boards, Farm Councils, Management, Strategy.

[a] Danish Agricultural Advisory Centre, The National Department of Farm Accounting and Management of The Danish Farmers´ Unions, Udkaersvej 15, Skejby, DK-8200 Århus N. *mjl@lr.dk*

Background

The increasing complexity of farms due to the structural changes in farm size and specialisation of production means that the need for farm management on the farm level is increasing. Moreover, the rising demands from the surroundings on agriculture have resulted in the fact that many farmers now consider hiring some kind of overall professional sparring partners to provide advice on the farm management and operation. Analysis of farm accounts data show great variation in economic results due to management skills.

Together with the directors the board of a joint-stock company or a private limited company make up the management of the given company. The internal division of labour is as follows: the manager attends to the day-to-day management of the company while the board of directors attend to the overall management of the company. These rules are specified in the legislation. Thus, the board of directors of joint-stock companies and private limited companies is by means of the legislation assigned a real responsibility and they have the authority to e.g. employ and dismiss the manager of the company.

As a principal rule the board members of personally owned companies, e.g. farm councils, are not responsible and they do not have real authority. A private company that wishes to have a board must be voluntary and without interference from the law-making body make this decision. It is thus the owner of the company who decides whether real responsibility and competence should be conferred on the board. If the views of this board are not considered, it is likely that it is dissolved, as no one wishes to waste their time. Otherwise it develops into a social association—and this has nothing to do with farm boards.

As the companies are managed by the owners, the decisions made by the farm board can only be consultative. However, it is evident, that if the decisions of the board are not complied with/carried out in practice, the purpose and the commitment of the work of the board will disappear.

Why farm boards?

Farm councils or farm boards can be valuable to farmers both with respect to the operational and the strategic management level.

By establishing a farm board the farmer and his family attaches one or several persons to the farm, which by means of the special agreement receive some of the responsibility of the farm (operation). In many cases it is sufficient for farmers to receive services and consultancy from advisers in the traditional sense. However, in some cases there may be a need for other types of sparring partners. Here, the farm board concept may be an excellent supplement/solution.

A farm board is not the same as participating in experience exchange groups. The participants of such a group bring the different farms into focus one by one and the individual participant has no real "responsibility" for the other's farms. By establishing a farm board, the farmer and his family manage to put focus solely on their own farm. Moreover, they receive ideas and feedbacks accustomed specifically to their needs concerning the plans and decisions they face.

In order for the farm board to be successful, the farmer must be willing to question the way in which he runs the farm. He must be open, honest and ready to give and receive criticism. Almost the same requirements apply to the board members. In addition they must of course possess the relevant qualifications to fulfil the expectations of the farmer. Finally, all board members must be able to respect each other and the tasks at hand.

The farm board concept

Objectives

In order to obtain benefits from the work of farm boards it is important (prior to the establishment) to describe what the objectives are and what is expected from the farmer himself, the board members and the output/benefit, respectively. In the paragraphs below we have attempted to divide the objectives into groups. The list of objectives is not exhaustive, but it merely states examples of the tasks that a farm board may face.

1. Objectives concerning professional problems

Typically these tasks cover concrete problems, of which the farmer e.g. wishes the board members to form a correct estimate:

- A concrete operational plan
- A piece of advise from an external adviser
- "How should I design the housing system?"
- Organising of the farm work
- Requirements for employee profile
- "How can I improve…?"

A joint feature is that the problems presuppose professional insight.

2. Objectives concerning strategic farm plans

The whole instead of the details is brought into focus. This may e.g. be:

- Conversion from one management method to another
- Large technological changes
- Expansion plans
- Can the farm property be used for production in the future?
- Liquidation/reduction of the farm

- Generational succession
- Image care
- Examination of trends, ethics and morality of the surrounding world
- Overall advice on economy, available funds and financial risk
- Possibilities of attracting and keeping of qualified labour in the long term
- “Ensuring” the family by letting other know the farm in general.

The joint features are that the strategic problems are so broad and general that many other matters must be assessed at the same time. In this way it is important that the board members are able to survey and estimate complex problems on general grounds. Thus, many different inputs and experiences from other trades may be valuable.

Recruiting of board members

A farm board is only of interest to those who are willing to develop and change their farms and those who do not wish to be autocratic. The farmer must be prepared to share the management of the farm with other professionals and he must be willing to get involved in the board tasks. Moreover, he must be open, honest and able to outline objectives as well as to give and receive constructive criticism.

The number of farm board members and their qualifications depend on the objective of the board. Thus, the farmer must define and describe the objective of the farm board prior to the recruiting of board members.

If the primary objective of the farm board is to obtain advice concerning professional problems of the day-to-day management, the farm board will only have to consist of one external member. However, the professional knowledge of this person must at least be at the level of the farmer himself. This means that the external person should typically have the same education as the farmer and preferably also run a similar farm. In this case the member is able to share his own experiences with the farmer.

However, if the main purpose of the farm board is to receive ideas and feedback concerning overall and strategic problems, the number of bard members should be 2–6 persons dependent on the farm’s complexity, production, size, etc. One or more of the members may very well be colleagues, but they must be able to keep the matters in “a large perspective”. It may be useful if other members come from totally different business sectors as long as they possess other competences, which differ from the competences of a good farm manager.

Besides possessing competences that are relevant to the objective, the board members must in general be open and honest and they should be able to back out if they don’t feel they get anything from the board work. Moreover, they must respect the task at hand and each other and be able to give and receive constructive criticism. Finally, the members must allocate time for meetings, including preparing themselves for the meetings. Each board member is e.g. paid DKK 5,000 per year and mileage expenses for participating in four meetings.

The farmer himself chooses the members of his farm board. It is of great importance for the future work of the farm board that the farmer chooses the board members carefully and that the persons work well as a team. The board members may be people whom the farmer knows already and/or people who have been recommended to him. He should always consider carefully whether it is an advantage or disadvantage that one or more board members live close to him. If the farmer employees people on his farm, he should also consider whether one of them should be a member of the farm board.

Organisation of the board work

If the board counts 2–6 members, it is natural to try to establish a simple work organisation. Due to the fact that the farm board will probably only meet up to four times per year, it is important to ensure a documentation that will minimise "the start-up" every time the farm board members meet.

Farm board portfolio

From experience it is a good idea to provide each single board member with a simple tool in the form of a farm board portfolio as well as structured and ready-made minutes of meetings. The farm board portfolio includes:

1. Annual plan
2. Summons to ordinary and extraordinary board meetings as well as names and addresses/phone numbers of all board members
3. Notes concerning future board meetings
4. Minutes
5. Procedures and regulations
6. The farm board agreement

The annual plan is normative for the work, which the chairman of the board wishes to be carried out and which the board has promised to carry out during the coming year. As part of the concept The Danish Advisory Centre (DAC) have developed a farm board manual, which is also accessible on the DAC web site: Landbrugsinfo on the address: http://www.lr.dk. The "Farm Board Manual" functions as assistance and inspiration for farmers and advisers that wish to establish a farm board. Among other things the manual contains concrete suggestions/templates for: Agendas, minutes, procedures, farm board agreements, and annual plans.

Annual evaluation

An annual evaluation of the farm board achievements should contribute to maintaining the dynamism in the farm board work.

It is important that the farm board is continuously made up of members, who may ensure the farm future in the best possible way and that the board functions professionally. Normally, it is not possible for farm boards to upgrade its members by means of in-service training, which is the case in large companies. Thus, the farmer must choose board members with the right profile and replace the members, gradually, when they do not contribute anymore.

Typically board members are recruited for a period of two years. Experiences show that it is important to exchange board members on a continuous basis in order to maintain the dynamism of the farm board.

From the farmers point of view one year of board work should have provided a usefulness, which correspond to the contribution of time and money. Similarly, each board member must ask himself whether it has been worthwhile to spend time and energy on the board work.

Experiences until now

In April 1996 there was a workshop where farmers and local advisers in cattle production and economics were invited to specify the ideas of farm boards. The result of the workshop was a booklet in starting farm boards, and the start of a minor number of farm boards.

In December 2001 there has been a review of the booklet. There was made a handbook on the basis of interviews of farmers and advisors, who had experiences with farm boards. The objectives of the handbook were to collect knowledge and experiences from farm boards, and to give inspiration to establish and use farm boards.

Furthermore, there was a seminar in November 2001 where there was more than 100 interested farmers and advisors. We plan another seminar in the winter season 2002/2003. The objectives of this seminar are to share the knowledge with interested farmers and advisors and to promote further implementation of the concept of farm boards.

References

Pedersen, D. E. & B. H. Jacobsen, 2001. *Erfaringer med udvikling af strategiske beslutningsgrundlag til landmænd (Experiences with development of strategic decision support to farmers)*. Report published in cooperation between the Danish Institute of Agricultural and Fisheries Economics and The Danish Advisory Service.

Sørensen, B., Rasmussen, H. H., and Munk, A., 2001. *"Håndbog til gårdbestyrelser" ("Handbook of Farm Boards")*. Report published from The Danish Advisory Service, December 2001.

At DAAC there will be an updated website (www.lr.dk, gårdbestyrelser) containing a complete description of the concept. On this website it will also be possible to download all the developed tools and written documents.

The Balanced Scorecard (BSC) for Danish Farms—Vague Framework or Functional Instrument?

Christian Noell[a] and Mogens Lund[b]

Abstract

Nowadays agricultural firms are more often than in the past decades forced to adapt operations, plans, strategies etc. to changes and uncertainties in their legal and business environment. The Balanced Scorecard (BSC) as an approach to strategic controlling in agriculture is discussed as an answer to the growing management demands in Danish farms. A brief description of the BSC-concept, its development process as well as principle potentials and limitations is given. In a case example on a dairy farm the current Danish strategic planning framework and the BSC are compared. The need for a stricter orientation of strategic planning to external demands (customers, stakeholders) is emphasised. Necessary prerequisites for the implementation of the BSC-concept into practical farming are discussed. Finally five critical success factors to the BSC adoption by Danish farmers are identified.

Keywords: Balanced Scorecard, Strategic Management, Management Accounting, Consulting

[a] Department of Economics and Natural Resources, Royal Veterinary and Agricultural University (KVL, Rolighedsvej 23, DK-1958 Frederiksberg/Copenhagen.), *cno@kvl.dk*

[b] Danish Research Institute of Food Economics (FØI), Ministry of Food, Agriculture and Fisheries, Rolighedsvej 25, DK-1958 Frederiksberg/Copenhagen. *mogens@foi.dk*

Introduction

Today's agricultural firms are more often than in the past decades forced to adapt operations, plans, strategies etc. to changes and uncertainties in their legal and business environment (see e.g. Noell, 1995 & 1998; Woodburn et al., 1995). New demands to product quality, food safety and sustainable agricultural production have further motivated the interest in new management accounting approaches for the farm level. Despite many strategic management research projects carried through for Danish agriculture (see e.g. Pedersen, 1986; Jeppesen, 1990; Jensen et al., 1993; Lund and Larsen, 2002), there is still a lack of substantial knowledge on how to implement strategic management and strategic consulting on real farms. The problems related to the insufficient implementation can be realised in many ways: there is no systematic relationship between long-term and short-term plans, no coherent investment planning is ensured, no feed-back is provided to farmers, who have developed a strategic plan, and there is only a weak link between the competitive business environment and the internal farm structure.

Main purpose of the development and introduction of new management accounting methods and principles like Activity Based Costing, Target Costing, Economic Value Added, Benchmarking, and Balanced Scorecard was the general finding that after the introduction of Strategic Planning in the 1970s and Strategic Management in the 1980s a lack of co-ordination between the level of strategic decision making in a firm and operational level became more and more visible. The Balanced Scorecard (BSC), developed by Kaplan and Norton (Kaplan and Norton, 1992, 1996) found widespread acceptance as a major contribution to overcome "implementation gaps" that result from a lack of internal co-ordination. The implementation gap can be understood as an incomplete implementation (and development) of a firm's strategy into its business operations; that is insufficient links and feed-backs between the strategic and operational level of the firm, between short-term and long-term perspectives as well as between financial and non-financial performance measures and between stakeholder demands and internal business processes.

In the course of a stronger business orientation of the primary food production farmers, advisors, and researchers are becoming aware of similar needs for improved co-ordination of the traditional management functions. While it might look in the first glance as if farms were not suitable for the application of the BSC-concept or other new management accounting methods, it turns out that currently particularly small and medium sized firms like corporate or family farms have to make large efforts to overcome their specific "implementation gaps". Increased contract production, environmental regulations, food safety demands and a general increase in business and financial risks are asking for a more professional handling of the farming business.

What is the Balanced Scorecard (BSC)?

Basic concept

In Kaplan und Norton's (1992, 1996) original concept the BSC is intended to fill the gap between the development of a strategy and its realisation. As definition and specification of strategy serves Porter's (1998 & 1980, 1985) concept of competitive strategy. The BSC-framework supports and links four "critical" management processes, that is (1) clarify and translate vision and strategy, (2) communicate and link strategic objectives and measures, (3) plan, set targets, and align strategic initiatives and (4) enhance strategic feedback and learning. Furthermore, the business dimension of the strategy formulation is composed of external perspectives (shareholder and customer) and internal perspectives (internal processes and learning/development/growth). The "balanced" consideration of critical issues in the management and business dimension is (at least theoretically) assured by its combination with a controlling (=feed-forward control) dimension, that covers (a) financial and non-financial performance indicators, (b) short-term and long-term indicators and (c) lagging and leading indicators. Finally, Kaplan and Norton emphasise the strict hierarchical order of the selected performance measures, the existence of causal relationships among them as well as their measurability and relevance. The main intention of the BSC is to overcome the shortcomings of purely financial and economic performance measures, not to overcome the final goal of profit maximisation. The maximal sustainable profit is in the long-term objective of the application of the BSC-concept, and the relevance of all other measures and perspectives is determined by their direct and indirect relation to the firms profitability.

Figure 1 illustrates the basic properties of a BSC in Kaplan and Norton's original concept. The bold arrows indicate a typical unidirectional cause-effect chain across the variables of different hierarchical levels. For operational use the network of strategic goals had to be translated into a network of measurable indicators. Again, the network of goals (and subsequently measures) had to be derived from the overall firm's strategy.

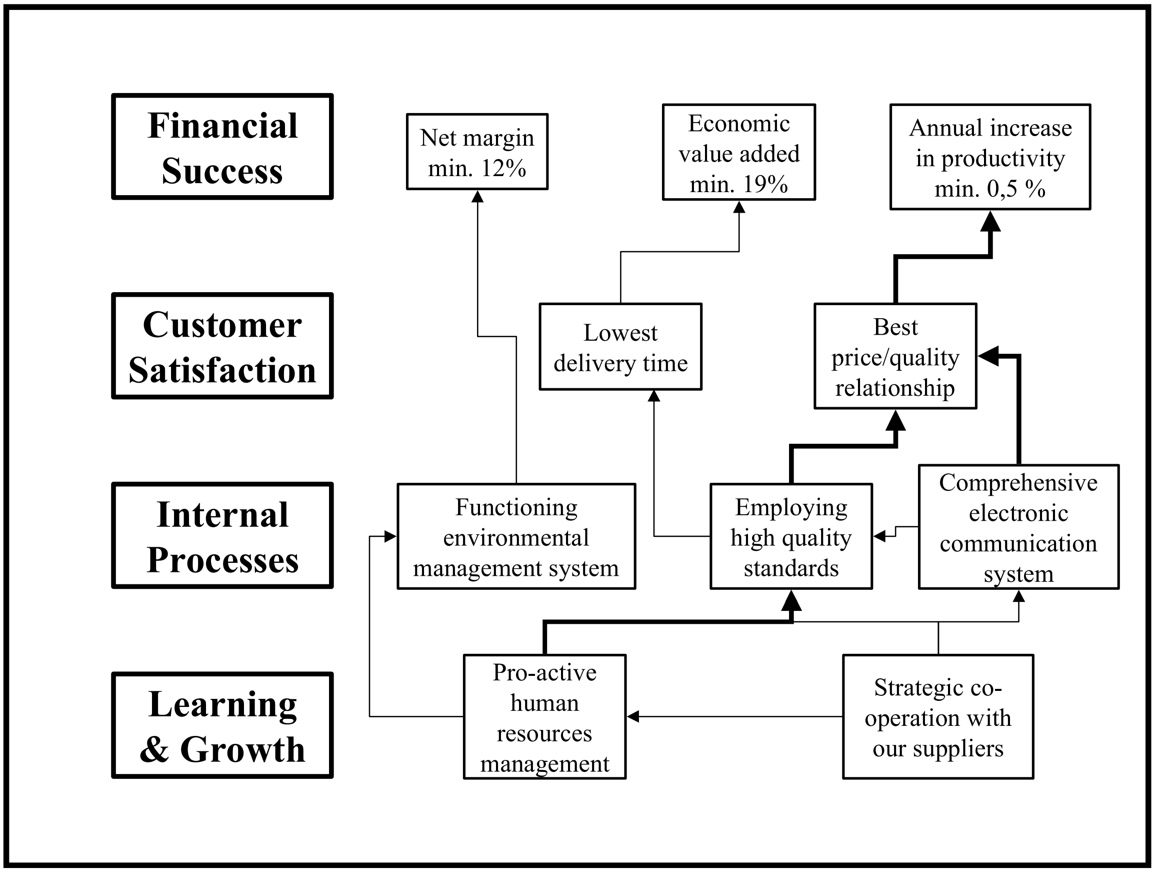

Figure 1 Hierarchical system of strategic goals in the BSC (following Ahn, 2001, p. 448; Sim and Koh, 2001, p. 21)

Steps in the development of a BSC

As the BSC-concept is intended to bridge the gap between a firm's strategy and its daily operations, the development of a BSC has to be rooted in the strategic management area and has to result in a practically usable management tool. Ahn (2001) describes the phases of the development process as he has applied it in the development of a BSC for ABB industries as follows:

1. **Starting the development process:** *Identifying strategic goals*. Kaplan and Norton's four perspectives (financial, customer, internal processes, learning and growth) are applied to the process of goal identification or classification, respectively.
2. **Structuring the BSC:** *Modelling chains of cause and effect*. Identification of causal links between the previously identified strategic goals. This phase results in a BSC in an intermediate stage as presented in Figure 1.
3. **The qualitative BSC:** *Defining measures for quantifying achievement of goals*. Those measures should quantify the benefit of goal achievement, have a motivating effect and cover various aspects of a goal.

4. **The quantitative BSC**: *Setting milestones and targets for the measures.* Here the target is to describe the final goal level to be achieved within the given strategic planning rhythm (3 years in the case of ABB), and from this milestones (=stage levels) for each year have to be derived. The analysis of a considerable amount of data will be necessary in this phase.
5. **Implementing the BSC:** *Developing strategic programs for achieving the goals.* For each set of goals one or several strategic programs should be developed.

Step by step the qualitative, long-term and broad scopes of the strategic management level are turned into a quantitative, short-term and narrow system of performance measures. Each development step actually produces a BSC with a different degree of specification. Much of the controversy about the BSC can be traced back to a misunderstanding of its multi-layered structure. In many cases the first time specification of a BSC will be based on an already existing strategic management framework. Then the first two or even three steps of the development will for practical reasons be substituted by an intermediate development step. In this step the existing strategic management structure has to be translated into the perspectives of the Balanced Scorecard (see e.g. Figure 2).

Potentials and limitations of the BSC-concept

The BSC is by far not an easy-to-develop management accounting tool. A number of authors and even the original proposers of the concept have pointed out that the BSC needs significant adaptations and modifications for its successful use in the business reality. Frequently repeated points of criticism (Nörreklit 2001) are the following:

- The assumption of *cause-effect relationships* across the four major perspectives is problematic. More often the relationships among the performance variables are ambivalent (e.g. the relation between customer satisfaction and financial success), statistical (covariance, but no causal relationships), purely logical (e.g. relationships developed from neoclassical reasonning) or simlpy not existing.
- The assumption of a *hierarchical relationships* among the four major perspectives is questioned. For example might management development lead to increased profits, but sufficient profits are needed to finance management development. Consequentially, instead *interdependent* rather then *unidirectional* relationships among the measurement variables are suggested.
- The *time-dimension* is neglected in the BSC due to the assumption of hierarchical cause-effect relationships. The original approach is often considered static instead of dynamic and as such unsuitable for strategic management.
- The strict focus of the BSC on Porter's (1980, 1985) concept of competitive strategy, where the *firm's environment determines the choice of strategy* (cost leadership or differentiation) and the firm adapts its core competence to the strategy is generally rejected. The BSC is assumed to be as well applicable to a strategy development that takes the core competence of a firm as starting point. This fact is

particularly important for agricultural firms, because they are generally quite restricted in utilisation and transformation of their resources.

- The restriction to a number of *four* in the BSC's *perspectives* as well as to their *scope* is regularly criticised. It should be taken into account that finally the purpose of the BSC is to satisfy all relevant stakeholders of a firm in a "balanced" way. Thus e.g. the "financial" perspective takes into account the ownership side of a firm, the "customer" perspective takes demands to product/service quality into account and so on. If necessary and reasonable the type of stakeholder and thus the customer perspectives should be adapted accordingly.

The above list could be further continued. For a comprehensive discussion of the strengths and weaknesses of the BSC-concept, see among others Olve and Sjöstrand (2002), Jones and Sasser (1995). Nevertheless it should also be mentioned that the criticism is partially misleading. On the one hand, performance and scope of the original BSC-concept are often overtaxed and on the other hand it is not taken into account that any BSC applied to a real firm is an "intermediate" or "end-product" of a comprehensive and repeated process of strategy-development, -implementation and -controlling. Furthermore, the different conceptual levels of the BSC are often neglected, that is the basic concept is described as vague and unclear, while the nature of an implemented BSC as an management accounting tool is not considered and vice versa. Recent findings of more empirically oriented papers like those from Olve and Sjöstrand (2002), Andersson (2002), Ahn (2001), Kaplan and Norton (2001), Sim and Koh (2001), Hoque and James (2000) a.o. indicate that the process of development of a BSC and its embedded in the strategic management process.

Strategic planning and the Balanced Scorecard in Danish agriculture

Current strategic planning framework

As a starting point for the construction of a BSC for a farm the Danish strategic planning approach for agricultural firms has been chosen. This approach was originally developed in the eighties as described in Pedersen (1987) and has since then been further developed, see e.g. Jensen et al. (1993) and Lund and Larsen (2002). The approach consists of five basic elements. The **vision** is a qualitative statement describing the kind of life the farm family wishes to realize, while the **mission** should describe the needs demanded by the society that the agricultural firm is expected to fulfil. The first sub-strategy is the **financial strategy**, where some generic objectives of the strategy could be consolidation, use of own capital for consumption, taxation policy and self-financing contra external borrowing of new investments. Another sub-strategy is the **activity strategy**, where some typically generic objectives in farming are specialization or diversification. Economics of scale and cost minimisation are the normal economic drivers behind a specialisation strategy, whereas adaptation of non-farm activities such as tourism or aquaculture could be agricultural examples of diversification. The third sub-strategy constitutes of the **capacity strategy**, where the generic objectives of the strategy typically are depreciation, maintenance or expansion. Usually young farmers wish to expand, while older farmers often decide to depreciate their production capacity. The fourth sub-strategy is the **organisational strategy**, where the generic objectives are related to the choice of organisation of the firm, including the delegation of tasks and responsibilities, choice of information systems and human resource development.

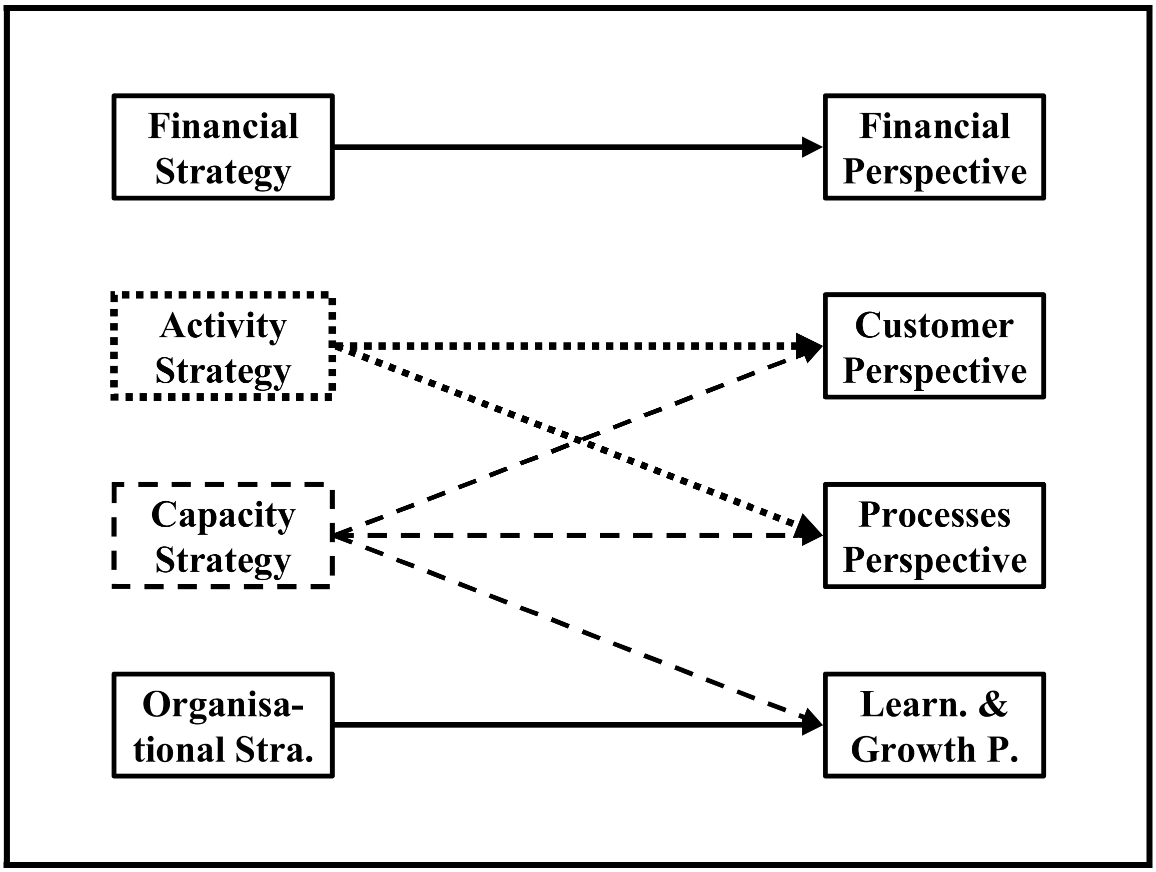

Figure 2 Links between the idealised Danish strategic planning model for farms and the perspectives of the Balanced Scorecard concept

The main challenge of the development of the BSC is to translate the system of these four sub-strategies into a set of interrelated measures, targets and initiatives in the context of the four perspectives of the BSC as indicated in Figure 2. In the following chapter this transformation will be illustrated by the use of a case example from dairy production. As there is no practical experiences with the development of Balanced Scorecards in Danish agriculture yet, and as the autors have not available any realistic agricultural examples from other countries, the case example will necessarily be a hypothetical one. Thus, the example will serve the purpose of demonstrating the basic properties of BSCs for farms.

Linking a farm strategy and BSC: the (hypothetical) case of a dairy farm

The dairy farm used as a case is assumed to be owned by a younger, married farmer. The farmer and his wife have not yet any children and the wife is working outside the farm. About 80 per cent of the farm income comes from milk production and the herd size is assumed to be 145 milking cows. The breed is Holstein and the milk yield is 7,500 kg milk per cow. The land size is 130 ha of medium soil quality, which is mainly used for cereals, grazing and forage. There are modern machines, whereas the buildings and the milking equipment are rather old and thus labour consuming. A 21 years old man is employed full-time as farm worker. Debt ratio is 95 per cent as there in the last two years have been seriously disease problems in the herd.

The vision and mission statement of the farm family's business was formulated by the farmer and his wife before they bought their farm three years ago. The **vision** (see e.g. Noell, 1994) of the family includes a farm business with employees, good conditions for family life, children, the wife being involved in the management of the farm and time for involvement in the local community. The **mission** of the business is to deliver healthy and high quality products, to carry out environmental sound production, creating job opportunities for the local community and to guarantee attractive payments to all "share- and bondholders". Based on a recently performed **SWOT-analysis** a number of strategic issues where identified: (1) clarification of the future development of the farm in light of the vision and mission, opportunities and threats in the environment and the strong and weak points in the business, (2) increased productivity and flexibility in relation to uncertainty and changes in external factors, (3) development of a better investment planning and improved capacity utilization, (4) a sufficient self-financing of investments and a more sustainable economy, (5) development of the farmer's competences as a farm business manager.

Regarding the **economic performance** the following three main problems were identified (1) a benchmarking revealed that the current productivity in milk production was to low compared to similar dairy producers, and (2) no targets for the profitability and priorities of new investments have been formulated, and finally (3) there are no systematic links between short-run and long-run financial planning. In the process of developing a new strategy for the farm emphasises was especially put on the relationship between short-term and long-term financial goals and their relationships to the sub-strategies in order to improve the future income generation.

Relating the structured strategic plan to the BSC-concept

Figure 3 shows a simplified version of the result of these efforts. In order to increase the productivity three important processes have been identified in the activity strategy: 1) The cow replacement policy; 2) feed utilisation; and 3) the yield of milk. Intensive work was carried out to reveal the cause-and-effects relations between these and other strategic issues. For instances, there are a close causal relationships between the choice of replacement policy, i.e. replacement of old cows with heifers, and the expected milk yield. As another example there are causal links between the utilisation of feed and the facilities and equipment for storage of forage, which are part of the capacity strategy. In formulating the capacity strategy a distinction between existing investments and new investments have been made. The main problems with existing investments are the lack of utilisation, whereas the instalment of improved planning routines was seen as most important with respect to new investments. The preparation of investment plans, capital budgeting and systematic feedback procedures were seen as necessary parts of the future investment planning on the farm.

The fulfilment of the objectives in the activity and capacity strategies require specific organisational changes in order to increase the future farm income. As shown in Figure 3 these initiatives include 1) employment of higher skilled labour, 2) adaptation of better information systems and 3) supplementary education in financial management. It is here hypothesized that a higher skilled labour force together with access to better and more timely information will increase labour productivity. At the same time it is expected that a new information system might provide the relevant information for investment planning, which the farmer should learn to appreciate by further education in financial management.

Farming is characterized with a rather long production time, because there is a long time span from operational decisions are taken until the financial results will be shown. For instance is there more than two years from a heifer calf is born and it can start to produce milk, and when it comes to investments in new building facilities the time span could be 20 years or more. Under such circumstances it is especially important that a strategic plan as shown in Figure 3 is supplemented with a mixture of leading and lagging measures to evaluate the business performance and motivate the staff employed in the farm. Table 1 summarises the leading and lagging indicators for our farm case example.

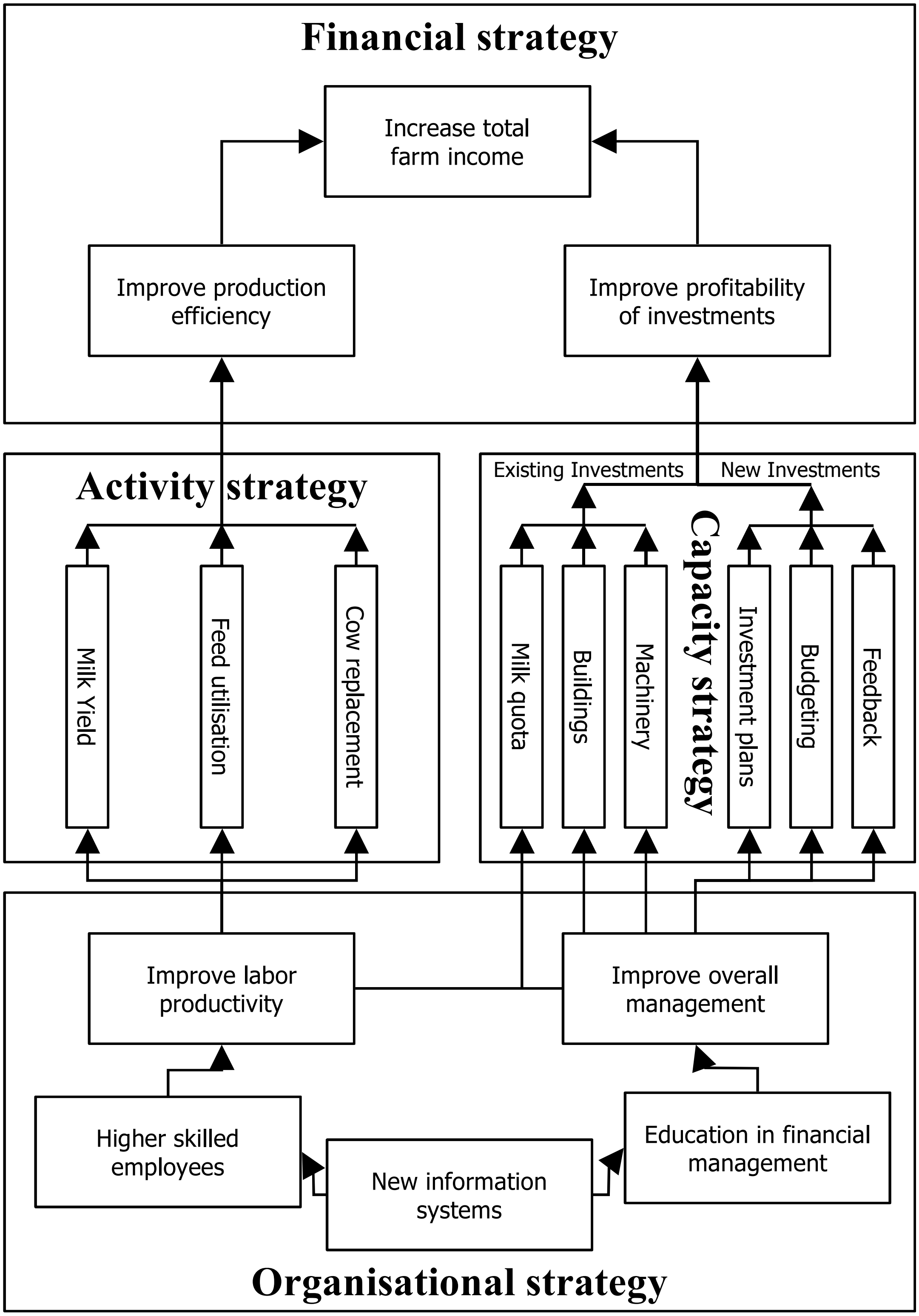

Figure 3 The structured strategic plan for the hypothetical Danish dairy farm

Table 1 Sub-strategies, strategic objectives, indicators and their correspondence to the perspectives of the Balanced Scorecard concept

Sub-Strategies and Strategic Objectives	Measures		Corresponding Perspective of BSC-Concept
	Lag-indicators	Lead indicators	
Financial			
F1: Increase total income	Income statement	Cost drivers	*Financial*
F2: Improve production efficiency	Gross margin per cow		*Financial*
F3: Improve profitability of investments	ROI	Investment portfolio	*Financial*
Activities			
A1: Better health status	Replacement rate	Number of farm visits of dairy advisors	*Customer*
A2: Improve milk yield	Milk yield per cow	Hygiene and sanitary standards	*Internal Processes*
A3: Improve utilization of feed	Feed units per cow		*Internal Processes*
A4: Higher yield of forage	Feed units per ha	Crop rotation	*Internal Processes*
A5: Less storage loss of forage		Investments in new storage facilities	*Internal Processes*
Capacity			
C1: Better utilization of milk quota	Gross margin per kg quota	Replacement of dairy stock	*Internal Processes*
C2: Improve utilization of buildings	Percent of stalls idle	Purchase of more milk quota	*Internal Processes*
C3: Better utilization of machinery	Machinery costs per Ha	Machinery contracting work	*Internal Processes*
C4: Reduce the use of labour	Hours per milking cow	Investments in labour saving installations	*Internal Processes*
Organisation			
O1: Hiring of a more skilled herd manager	Gross margin per Wage dollar	Targets for practical and theoretical education	*Learning & Growth*
O2: Use of better information systems	Costs to bookkeeping and production control	Sharing of information	*Learning & Growth*
O3: Development of managerial competences	Numbers of course days	Available time for overall management	*Learning & Growth*

The adopted lagging measures such as i.e. the income statement, the gross margin per cow and per kg, machinery costs per ha and hours used per cow are often generic in the sense that they are the same for many agricultural producers. Many of these can be found in traditional production and accounting reports. The leading indicators, or the performance drivers, are however often unique for the individual firms as it is these indicators that should drive the firm towards excellent results. In farming most of the performance drivers will be located in the activity, capacity and/or organisational strategy. Examples of assumed leading indicators in our case example are use of cost drivers, the implementation of new hygiene and sanitary standards and sharing of information.

Compatibility of strategic plan with BSC

The results from Table 1 indicate some important similarities and distinctions between the existing strategic planning model for Danish agriculture and Kaplan and Norton's Balanced Scorecard concept:

- "Financial strategy" and "financial perspective" largely match each other. The long tradition of financial performance measurement in agriculture would make any other result quite surprising.
- "Activity strategy" partially corresponds to the "customer perspective", but mainly to the "internal processes perspective". With a strict focus on production the activity strategy assumes a relatively narrow perspective of short-term operations.
- On the one hand "capacity strategy" fully corresponds to the "internal processes perspective", but on the other hand it almost exclusively refers to investment activities in production.
- While "organisation strategy" and "learning and growth" perspective largely match each other the organisation strategy in this example covers a much shorter time horizon than the learning and growth perspective in the original BSC-concept would suggest.
- The cause effect relationships in the structured strategic plan (see Figure 3) could only partially be transferred to a Balanced Scorecard, mainly because an extension of the "customer perspective" would imply new relations among existing indicators and possibly make the introduction of new indicators necessary.

Seen from a BSC standpoint the "customer perspective" is only implicitly taken into consideration in the existing strategic planning concept. The much discussed development of agriculture from *production driven markets* to *market driven production* has obviously not yet had a fundamental impact on the farms' management structure. The focus is mainly on the "internal processes perspective". Furthermore, the "learning and growth perspective" is undervalued. These results are not unexpected because agriculture traditionally has a very strong orientation of all its structure towards production, while the market or general outside orientation is much weaker. Not at least for this reason the results show that the implementation of the (original) BSC concept into Danish agriculture has to be accompanied by a general shift in the business orientation. Finally, it must be concluded that the differences between the traditional strategic management framework of Danish agriculture are much bigger than their technical similarities seem to indicate initially.

Implementation of the BSC into Danish agriculture: The role of research and consulting

Importance of cooperation among institutions

Previous research projects (Henneberg et al. 1991, Henneberg 1995) have confirmed that there is a need for a more holistic consulting approach to improve the efficiency and long-run profitability of Danish dairy firms. Although many initiatives have been taken during the last decades, holistic consulting methods are still not generally implemented in the Danish advisory service. In order to introduce business consulting based on the principles of BSC's to farmers, there is a need to develop:

- general *procedures and methods*, that is interactive tools for the construction of BSC's, whereby the individual farmer's vision, mission and strategy can be transformed into objectives, measures and initiatives that may guide the future decision-making and action-taken in the specific firm,
- *feedback processes*, where performance data is collected about the strategy that makes it possible to test the hypotheses about the relationships between strategic objectives, initiatives and actions, and
- *consulting processes* that promote learning from the performance data and makes it possible to adjust the strategy to new questions and conditions that may emerge.

Furthermore university and research institutions could enhance the economic efficiency of the BSC-implementation by developing **Standard-BSCs** for different types and sizes of farms and different lifecycle-stages of farmers. Those standardised BSCs could than be further specified and customised to the needs of practical farmers by the advisory service and subsequently adapted to single farms by local advisors. To fulfil the above requirements there is a need for a close cooperation between university, research institutions and the advisory service. One important reason is that consultants in the existing advisory service do not have the necessary competences and methods to give farmers' feedback on their strategy and to help them test the assumptions and expectations that their strategy is based on.

Importance of double-loop learning

Most consultants have only been trained in single-loop learning, where realised results are compared and evaluated according to some a priori formulated plans. This feedback method is functioning well as long as the farmer and/or his consultants have complete information about the objectives and the required actions to reach the objectives. It is a single-loop feedback process, where the objectives is already determined and will not be changed. Deviations from the planned results are not making the farmer ask, whether the planned results are still wanted. Furthermore, by this method the farmer is not asking, whether the adopted strategy to realize the planned objectives are still suitable. Deviations from the planned path are regarded as random errors and all energy is focused on getting the firm back to the planned course. However, overall farm strategies cannot any more be regarded as stabile or linear in such a way. Today, the farmer needs feedbacks on more complicated strategies and more turbulent environments. A given farm strategy may—although it is developed by the best intentions and by use of the best available information—no longer be suitable or valid under the existing conditions. Consultants should therefore have the ability to promote double-loop learning, which is the learning that happens when farm managers are questioning the underlying assumptions and make reflections if the adopted strategy is still in line with the evidence, observations and experiences that they have today. Sometimes, farmers need to formulate new strategies to utilize the opportunities and avoid threats that could not be predicted at the time the original strategy was formulated. It should be the responsibility of research institutions (Lund, 1997 & 1998). For the implementation of the BSC it can be directly concluded, that BSCs suitable for practical purposes have to be flexible and adaptable. Consequentially the Balanced Scorecards for Danish farms should have to consist of two parts: a less specified **development part** that allows and stimulates double-loop learning and a highly specified **operational part** that is derived annually from the development part and allows single loop learning.

Importance of participation

Furthermore, past experience indicates that it has been difficult to implement integrated solutions, when different consultants from the advisory organisation are involved at the same time. If consultants assist in the development and implementation of BSCs to practical farmers, there will be a need for teambuilding and new organisations of cooperative consultancy activities. Jointed activities between research and advisory organisations with respect to teambuilding and the process of strategic consultancy have already been carried out during the recent years in Denmark. Experiences obtained from these activities, which are summarized in Lund & Larsen (2002), show that Action Research is an efficient approach to stimulate teambuilding and the development of strategic consultancy processes. In order to utilize economics of scale, marketing of BSCs to practical farmers could be promoted by the development of consulting packages. To be successful, one requirement is that different consulting packages should be customised to different types of farmers and different farm enterprises. An important requirement is that consultants specialized in BSC activities have received the skills to identify the **unique resources, competences and opportunities** in the individual farm in a dialogue with the farmer and other important stakeholders in the firm.

Perspectives of the BSC for Danish agriculture

Is the Balanced Scorecard applicable to practical agriculture?

In this article we discussed the relevance of applying the BSC concept to the Danish primary agricultural sector. As for most other commercial companies the BSC for farms should also include the four perspectives "financial", "customer", "internal processes" and "learning and growth". However, once a farmer in Denmark has decided to be a crop, dairy or pig producer he cannot change his specialisation or his business strategy easily. Even his choice of production technologies is largely restricted by legal regulations. Neither can he choose freely to sell his products to whom and at a price he wants. The majority of agricultural producers are selling their products to big processing and packing companies and are also buying most of their input factors from big suppliers. The primary agricultural sector is also characterised by low market power of individual farms. Altogether the typical Danish farm is a *highly integrated small business with low strategic flexibility*. Do these facts make any of the typical perspectives of the BSC invalid for the farm business? Is strategic management possibly not applicable to farms at all? In the authors' opinion the answer to both questions is clearly "no". The reason for that simply is, that size, scope and flexibility of a firm certainly determine its possibilities to shape the business environment and to play a dominant role in the markets, but these characteristics do not effect the general need for a firm to optimally adapt to its legal and business environment (see e.g. Noell 1995, Noell and Diers, 1994). Thus, the perspectives of the BSC and the rules of strategic management are basically the same for any size and type of business—and are certainly as valid for farming as for any other small business. To some extent traditional farms are even better suited for the application of strategic tools than corporate firms: e.g. entrepreneurial visions need to be tied to individual persons rather than to a (management) group for long-term effectivity (Noell, 1994).

Does the "customer perspective" apply to farms?

The innovation and development of new customer value packages are normally seen as a typical part of the "customer perspective" in the BSC concept, but generally individual farms are too small to carry out independent innovation and development activities e.g. in breeding or production technologies. Those activities are usually carried out by universities and public research institutions. The results are regularly disseminated by consultants of the advisory service. Does this have any implication for the "customer perspective" not being applicable to a farm's business environment? The opposite is true: a farm's profit is essentially depending on its ability to match the demands made by the already mentioned big firm's that are mainly buying its products. It is true that product and service innovations are not important to a farm that (as the overwhelming majority of all farms) follows a strategy of "cost leadership" (Noell, 2002), but the farm has to meet certain quality and food safety demands of its customers (dairy firms, slaughterhouses etc.) in production with corresponding consequences for "internal processes" and the other strategic areas. A dairy farm for example has to meet high hygienic standards or target values for fat or protein content of the milk delivered. If a farm is following a "focus strategy" or a strategy of "product differentiation an active consideration of customer satisfaction is a necessary core competence (Noell et al., 2001). The explicit consideration of the "customer-perspective" is and will always be important. For the farm firm the customer-perspective is aside from the buyers of their products also including the different representatives of agricultural policy that pay subsidies and make transfer payments to agriculture. The "customer perspective" might be further extended to a (multiple-) "stakeholder-perspective" to take into account the special strategic situation of farming. Strategic management would than be well suited to the current and future demands to agricultural "multifunctionality".

Conclusions

For a successful implementation of the Balanced Scorecard for farms in Denmark five major issues should be considered:

- *First*, shifting from a more or less static strategic planning framework to a more dynamic and comprehensive strategic management practice.
- *Second*, shifting the main strategic focus from "internal processes" to "customer"-perspective and establishing of close links between those two perspectives.
- *Third*, developing a "stakeholder-perspective" and focussing the entire strategic management process on it.
- *Fourth*, because of the peculiarities of the farming sector, the primary starting point of all strategic thinking should be (and remain) the area of resources, capabilities and other potentials of a given farm, while market and product opportunities should be chosen accordingly.
- *Fifth*, the farm accounting practice should be adapted to the needs of strategic management and the Balanced Scorecard. The orientation of agricultural accounting towards processes, products and services should be further strengthened e.g. by the introduction of Activity Based Costing, Target Costing and profitability measurements adjusted for cost of capital (EVA).

Those demands can only be met in close cooperation between research, the advisory system and the farmers themselves. Only in this case the Balanced Scorecard—or any customized derivative for farms—can be used as a functional instrument in agriculture.

References

Ahn, H., 2001. Applying the Balanced Scorecard Concept: An Experience Report. In: *Long Range Planning*, vol. 34, pp. 441–461.

Andersson, P., 2002. Competence Development Program for the Farmer with Respect to Life as well as Business. In: *Proceedings from the 13th International IFMA Congress,* Arnhem.

Henneberg, U., 1995. Identification Of Weak And Strong Elements In Management and Production Systems In Dairy Farming. In: Christensen et al.: *Managing Long-Term Developments of the farm Firm*. Wissenschaftsverlag Vauk Kiel KG.

Henneberg, U.; V. Østergaard; A. Hedetoft; J. Skærlund and Christensen, J., 1991. Kvægbedriftens hamonisering – fremgangsmåde, resultater og perspektiver for ledelse og rådgivning (Development of harmonious and economic dairy farms. Methods, results and perspectives for management and advisory work). Beretning nr. 691 fra Statens Husdyrbrugsforsøg. Landbrugsministeriet.

Hoque, Z. and James, G., 2000. Linking Balanced Scorecard Measures to Size and Market Factors: Impact on Organisational Performance. In: *Journal of Management Accounting Research*, vol. 12, pp. 1–17.

Jensen, C.; J. Morgensen; G. Sigaard & J. O. Thøgersen, 1993. Action Research in Strategic Whole Farm Planning. In: *Proceedings of the 11th European Seminar on Extension Education*, Århus.

Jeppesen, H. A., 1990. Modular strategic planning. In: Christensen, J.; S. Rasmussen; P. E. Stryg and Pedersen, D. E. (1990). *Managing Long-Term developments of the farm Firm*. Wissenschaftsverlag Vauk, Kiel.

Kaplan, R.S. and Norton, D.P. 1992. The Balanced Scorecard as a strategic management system. In: *Harvard Business Review*, Jan.–Feb., pp. 61–66.

Kaplan, R. S. & D. P. Norton, 1996. Using the Balanced Scorecard as a strategic Management System. In: *Harvard Business Review*, January–February.

Kaplan, R.S. and Norton, D.P., 1996. The Balanced Scorecard, Harvard Business School Press, Boston, MA.

Kaplan, R.S. and Norton, D.P., 2001. Transforming the Balanced Scorecard from Performance Measurement to Strategic Management: Part II. In: *Accounting Horizons*, vol 15, 2, june, pp. 147–160.

Lund, M., 1997. Learning approaches in Strategic Management. In: B. Öhlmer and Lunneryd, D. (eds.) 1997: *Learning in Farmers' Decision Making. Report no*. 116. Dept. of Economics, Swedish University of Agricultural Science, Uppsala.

Lund, M., 1998. Rådgivning i strategisk planlægning inden for landbruget (Strategic consultation in agriculture). Danish Research Institute of Food Economics, Copenhagen.

Lund, M. and Larsen, T. U., 2002. Development of Strategic Consultancy to Farm Managers. In: *Farm Management*, vol. 11, 6 pp. 409–423.

Noell, Chr., 1994. Entrepreneurial Vision and Strategic Thinking on Family Farms, In: Jacobsen et al. (eds.) *Farmers Decision Making - A Descriptive Approach in Copenhagen*, Denmark, pp. 121–133.

Noell, Chr., 1995. Processes of Adaptation and Adoption in Agricultural Management as Elements of Successful Adaptation Behaviour in a Turbulent Environment. (Adaptions- und Adoptionsvorgänge in der landwirtschaftlichen Unternehmensführung als Elemente erfolgreichen Anpassungsverhaltens in einer veränderlichen Umwelt) Kiel: University of Kiel, 193 pp.

Noell, Chr., 1998. Recycling in Agriculture – A Business Opportunity with a Future? (Landbewirtschaftung und Recycling - eine Einkommenskombination mit Zukunft?). In: *Schriften der Landwirtschaftlichen Rentenbank*, 12, 1998, pp. 139–182.

Noell, Chr., 2002. Strategies for Sustainability and Sustainable Development in Agriculture_(Nachhaltigkeitsstrategien der Landwirtschaft aus ökonomischer Sicht). Bonn: ILU, 109 pp.

Noell, Chr. and Diers, I., 1994. Cost of Adaptation and Learning - a relevant Part of Change Costs in Agribusiness Firms, (Anpassungs- und Lernkosten: ein entscheidungsrelevanter Teil betrieblicher Umstellungskosten). In: *Agrarwirtschaft*, 43, March 1994, pp.101–108.

Noell, Chr.; Spilke, J.; Wendt, K.; Koestler, W., 2001. Direct Marketing in the Internet – Organisation and Technical Layout. (Ein Hofladen im Internet - Überlegungen zu seiner betrieblichen Konzeption & technischen Realisierung). In: *Zeitschrift für Agrarinformatik*, 2, pp. 34 –45.

Nörreklit, H., 2000. The balance of the balanced scorecard – a critical analysis of some of ist assumptions. In: *Management Accounting Research*, vol. 11, pp. 65–88.

Olve, N.-G. and Sjöstrand, A., 2002. The Balanced Scorecard, Capstone Publishing: Oxford (UK).

Pedersen, D. E., 1986. Implementation Of Farm Management Information Systems – The Bornholm Project. In: Christensen, J.; A. H. Nielsen & D. E. Pedersen (eds.) (1986): *Implementation of Farm Management Information Systems*. Wissenschaftsverlag Vauk, Kiel.

Pedersen, D. E., 1987. Strategic Planning On farms – Implementation and Experiences. In: *Proceedings (working group B9 papers) from the V European Congress of Agricultural Economists*, Balantonszeplak, Hungary.

Porter, M.E., 1980. *Competitive Strategy: Techniques for Analysing Industries and Competitors*, New York, Free Press.

Porter, M.E., 1985. *Competitive Advantage: Creating and Sustaining Superior Performance*, New York, Free Press.

Sim, K.L. and Koh, H.C., 2001. Balanced Scorecard: A Rising Trend in Strategic Performance Measurement. *Measuring Business Excellence*, vol. 5, 2, pp. 18–26.

Stacey, R. D., 1993. Strategic Management and Organisational Dynamics, Pitman Publishing, London.

Woodburn, M.R., Ortmann, G.F., Noell, Chr., Levin, J.B., 1995. Farm- and Decision-specific Information Preferences of Market-Oriented Farms in Natal (South Africa) (Betriebs- und entscheidungsspezifische Informationspräferenzen marktorientierter landwirtschaftlicher Betriebe in Natal (Südafrika)). In: *Berichte über Landwirtschaft*, June 1995, pp. 240–258.

A Pilot Study of Accounting Information in Decision Making Processes

Bo Öhlmér[a] and Lars Lönnstedt[b]

Abstract

Most research and teaching has been in how farmers should make decisions and not in how farmers make decisions. Lack of knowledge about how decisions are actually made may be one of the reasons why management services and tools are not used to the expected extent. Previously a conceptual model of how farmers make strategic decisions has been developed. When testing the model one finding was that many farmers used an intuitive decision making process. The research question is if accounting information would be more useful for farmers' problem detection if it is designed to fit the type of decision making process used, intuitive versus analytic. The result presented in this paper is based on a limited sample of milk producing farmers in Uppsala county. The results support the hypothesis, that farmers using an intuitive decision making process have a higher probability to detect a farm problem if the information is designed to fit the intuitive process. However, they didn't reach the same level as the farmers using the analytic process, so the information has to be further developed to fit the intuitive process better. The results did not support the hypothesis, that farmers using an analytic decision making process have a higher probability to detect a farm problem if the accounting information is designed to fit the analytic process, at least not with the design of intuitive and analytic information used in this pilot study.

Keywords: Accounting, Financial statements, Profit and loss statement, Farmers, Problem detection.

[a] Department of economics, SLU, P.O. Box 7013, 750 07 UPPSALA, Sweden, *Bo.Ohlmer@ekon.slu.se*

[b] Department of economics, SLU, P.O. Box 7013, 750 07 UPPSALA, Sweden, *Lars.Lonnstedt@ekon.slu.se*

Background

A comparison of accounting data from similar farms shows a big variation in profitability between the farms. Furthermore most farms have a much lower profitability than they could have (Wennberg, 1998). Often, managers do not detect economic options and problems at an early stage. The managers are, of course, interested in financial support. However, they are not so interested in the offered courses, workshops, information material etc (Larsson 1989; Johannisson, 1992). It is the same in other countries, such as in Great Britain, where the demand of advisory service has been studied (Chaston, 1992). Many computerized information systems and other management tools are offered, but they are not used to the expected extent neither by managers of small general firms (Westberg, 1983; Davis et al., 1989) nor by farmers (Batte et al., 1990; Putler et al., 1988). It does not matter whether the information systems or other management tools are developed by the universities or by the advisory system. Most research and teaching has been in how farmers *should* make decisions and not in *how* farmers actually make decisions. Johnson (1987) argues that the concept of expected utility is emphasized to the neglect of other aspects of optimization, such as problem definition, learning, analysis, other decision making rules, etc. This lack of knowledge about *how* farmers make decisions may be one of the reasons that management services and tools are not used to the expected extent.

How farmers make decisions has been studied in a research program at the Department of Economics, SLU, in collaboration with Department of Psychology, Uppsala University, and Department of Applied Economics, University of Minnesota (Öhlmér, Brehmer, and Olson, 1997; Öhlmér, Olson, and Brehmer, 1998; Öhlmér, 1998). With the aid of a literature review and case studies a conceptual model of how farmers make strategic decisions has been developed. The model was tested and further developed through statistical analysis of data collected with a questionnaire to randomly selected farmers. The questionnaire was about how the farmers adapted their farms first to deregulation and then to EU-membership. One finding was that many farmers used an intuitive decision making process, while management information, services and tools are developed for the analytic decision making process, which may explain farmers' low interest in the information services and tools.

With this background, and as a preparation for a complete research project, a pilot study was conducted in 2001. It is a continuation of the research program described above. The results of the pilot study are presented in this report.

Aim

The research question is if accounting information would be more useful for farmers' problem detection if it is designed to fit the decision making process used. Two hypotheses are investigated:

1. Farmers using an analytic decision making process have a higher probability to detect a farm problem if the accounting information is designed to fit the analytic process
2. Farmers using an intuitive decision making process have a higher probability to detect a farm problem if the information is designed to fit the intuitive process

The result of the complete research project is expected to be recommendations that accounting information from advisory and accounting service offices should be developed in two versions, one for decision makers using the analytic process and another one for decision makers using the intuitive. Knowledge about the analytic process is well developed already, but the knowledge about the intuitive process has to be further developed, so we learn to design information that fit the concepts and models used in this process. The economic benefits at both the firm and society level may be considerable if the information basis is improved and, by that, also the results and quality of the decision making processes. The research has also a considerable scientific value by increasing the knowledge about decision making processes and especially the sub process of scanning internal economic information.

Literature review

Farmers' decision making is mostly viewed as a series of linear steps. Johnson et al. (1961) identify six steps of decision making: problem definition, observation, analysis, decision, action and responsibility bearing. A standard section in most farm management texts is a list of five to eight decision making steps (Bradford and Johnson, 1953; Castle et al., 1972; Boehlje and Eidman, 1984; Castle et al., 1987; Kay and Edwards, 1994). Steps listed in the texts but not listed explicitly by Johnson et al. include setting goals, monitoring, and evaluating results. Simon (1965) describes the decision process as a trichotomy: intelligence, design, and choice. Mintzberg et al. (1976) initially describe a similar trichotomy; identification, development, and selection and then develop a list of 12 routines within the strategic decision process: decision recognition, diagnosis, search, design, screen, evaluation-choice, authorization, decision control, decision communication, and political. The farm management texts either state explicitly, or seem to imply, that the steps should be followed in a linear order for every decision, but researchers have found that decision makers do not follow the process linearly. Witte (1972) found that the phases of problem recognition, information gathering, development and evaluation of alternatives and choice were not followed linearly by either his whole sample of data processing equipment decisions or even the sub sample of what he called the most efficient decisions. Nor were the phases followed in the smaller sub decisions that Witte found within the entire decision. Mintzberg et al. describe decision making as a "groping, cyclical process" (p. 265). They did not find a linear process, nor did all of their studied decisions include every one of the 12 basic routines. They identify six factors that can create havoc with any idea of a straight, simple decision process: interrupt, scheduling delays, timing delays and speedups, feedback delays, comprehension cycles, and failure recycles. Johnson (1976, 1986, 1994) also notes these loops and non-sequential decision making process.

In Table 1 four separate functions of decision making are identified. **Each function consists of four sub processes.**

Table 1 Conceptual model of the decision making process (Ohlmer et al., 1998)

	Sub process			
Function	**Searching & paying attention**	**Planning & forecasting**	**Evaluating & choosing**	**Bearing responsibility**
Problem detection	Information scanning; paying attention	Forecasting consequences	Consequence evaluation; problem?	Checking the choice
Problem definition	Information search; finding options	Forecasting consequences	Consequence evaluation; choice of option to study	Checking the choice
Analysis & choice	Information search	Planning & forecasting consequences	Consequence evaluation; choice of option	Checking the choice
Implemen-tation or action	Information search; Clues to outcomes	Forecasting outcomes and consequences	Consequence evaluation; choice of corrective action(s)	Bearing responsibility for final outcome; feed forward information

Compared to the traditional conceptual model, information search is not a function of its own. Instead, it is included as a sub process in all the functions. The information is used for estimating consequences and evaluating them. In problem detection, consequences of differences between expected and observed information are forecasted. In the other functions, consequences refer to broad consequences of option ideas, more detailed consequences of an option, and consequences of differences in planned and forecasted outcomes, respectively.

Responsibility has to be taken for the outcome of each function. Each function gives the farmer a deeper understanding of the problem and the options. This deeper understanding normally caused the farmer to revise the outcome of earlier functions.

A farmer needs information in all the four decision making functions. What information could accounting data provide?

Problem detection

In detecting problems a farmer compares his observations to his expectations. He pays attention to differences, forms an opinion about consequences of the differences, evaluates the consequences and chooses whether he has a problem.

In an analytic process in general, the issue (or system studied) is decomposed into known and manageable parts (or subsystems). Each part is analyzed separately, and the conclusions of each part are summarized into a solution for the entire issue. Examples of analytical sub processes are that the farmer compares his accounting data to (1) budget, (2) previous years, or (3) similar farms, where accounting data are the observations, and 1, 2 and 3 are used to form his expectations. The accounting data could be transformed to key indicators, such as solidity, rentability, liquidity, etc., before the comparison to expectations. This is a part of the alarm aspect discussed in literature on key indicators (Mossberg, 1977; Ånebrink, 1985).

In an intuitive process in general, the manager judges the entirety. He recognizes similar situations from own or others' experiences. He integrates information about differences in the current situation, and simulates the consequences of these differences. Based on how the similar situation was solved, and the outcome of it, he judges how to solve the current issue. Examples are that the farmer observes that the feed prices go up and the milk price is constant. If he has been in this situation previously and managed it, he may use the same solution this time.

Kleindorfer et al. (1993) review research that distinguishes between reactive (or passive) versus proactive (or purposeful) problem finding (Smith, 1988a; Smith, 1988b; and Smith, 1990). In reactive problem finding, the recognition of the problem is triggered by an outside influence such as another person, a reminder letter or a personal experience that forces the decision maker to recognize a problem situation. The conceptual representations may be in the form of historical models, based on extrapolations of the past, or communicated models that are passed on through books, the media and word of mouth. Proactive problem finding involves thinking creatively about the goals the decision maker wishes to accomplish. Techniques such as planning and performance monitoring are used. The decision maker uses conceptions of what can be achieved, measurable control indicators and goals to enable him to understand whether things are going "according to plan". An example is budget projections. Reactive problem finding is the same as our concept intuitive problem detection, and proactive the same as our analytical.

Problem definition including finding causes and options

In finding causes and options, a farmer searches for and analyzes the cause(s) of the problem, searches for options to solve it, does an initial evaluation of the options, and chooses options to develop further.

Finding causes is the diagnose aspect discussed in the analytic literature about key indicators (Mossberg, 1977; Ånebrink 1985). The causes could give some indications for the search of options. Accounting data, or economic key indicators, could be analyzed in economic models to find the causes. Examples are financial analysis, bench marking, the du Pont model, and the lever formula (Asztely, 1981; Hallgren, 1982). A method of searching options is to analyze the firm's strengths, weaknesses, opportunities and threats (SWOT analysis). Examples of other methods are Product-Market matrix, Boston matrix, Product Life Cycle model, and Porter's Market Competition model (Robert, 1993; Ansoff, 1965; Porter, 1980, 1985).

Lipshitz (1993) has studied several models describing decision making in realistic settings. He found situation assessment, the sizing up and construction of a mental picture, included in all of the models he studied. Information is acquired from the person's memory and, if this is not sufficient, from written material and other sources external to the firm. As described in the behavioral literature (see reviews by, e.g., Hogarth, 1987; or Kleindorfer et al., 1993), many individuals generate options by local search (i.e., close to the current situation) and identify options in isolation of others. A local search is associated with such terms as incrementalism, anchoring, noncomprehensive analysis, business as usual, not changing a winning horse, narrow problem focus, and non-creative decision making. A more analytical approach is the isolation effect, which refers to our approach to simplify problems by dividing them into smaller ones of manageable size and for which we often have standardized solution procedures or earlier experience. However, it is not certain that we will come close to the global optimum in this approach. The evaluation of the options has also been discussed in the literature. Van Raaij (1988) suggests that the options are evaluated in general, affective terms such as like or dislike. Beach (1993) has found that the options are evaluated in terms of whether the options are compatible with the decision maker's morals, values, beliefs and implications for existing goals. This initial evaluation results in the identification of options for further study, elimination of options or immediate implementation of an option. Noble (1989), Noble et al. (1987a) and Noble et al. (1987b) have found that knowledge and expertise are used for situation assessment, problem recognition and choice of options that have worked in previous, similar situations.

Analysis and choice of options

In planning an option, textbooks recommend the manager to use investment analysis methods, budgeting methods, organization planning methods, etc. These methods are mostly based on forecasts of incomes and costs, and profit (or utility) maximization. Accounting data are used in forecasting the incomes and costs. This is the planning aspect discussed in literature on key indicators (Mossberg, 1977; Ånebrink, 1985).

According to theories of bounded rationality (Simon, 1957; March and Simon 1958; Simon, 1987) or the behavioral theory of the firm (Cyert and March, 1963), managers analyze only a few options in an approach of satisficing aspiration levels. Lipshitz (1993) found that none of the realistic models observed by him used calculative cognitive processes for choosing options. The different cognitive processes, which were used, related to creating images of the situation: categorization, use of knowledge structures, and construction of scenarios. Several options may be identified, ranked by preferences and evaluated one at a time until a satisfactory one is found (Calderwood et al., 1987; Klein, 1989; Klein et al., 1986). Forecasts on incomes and costs based on accounting data, or the accountant's comments, may be a part in creating the images.

Implementation or action

During implementation, textbooks recommend to frequently compare performance, based on accounting data, to budget, and analyze eventual differences to conclude on the need of corrective actions. The budget represents the goals and plans. This is a part of the alarm aspect discussed in literature on key indicators (Mossberg, 1977; Ånebrink, 1985).

Öhlmér et al. (1998) have found that during implementation, farmers continually checked the performance of the implemented actions. This control process began as soon as information was available—when the information was still only clues. The expectations about the outcome of the action were adjusted and became more accurate as the implementation proceeded, for example, the estimated cost of a new building. At the end of the implementation the managers usually perceived their outcome expectations to be so accurate that their interest in an ex post calculation and accounting was low. Accounting data may be used in the control process, such as in comparing actual performance to budget.

Information from implementation could result in changes in the expectations of the action. If the cause of this change in expectation is perceived to be random, only the plans of the continued action are updated. If the cause is perceived to be nonrandom, the rules of thumb or planning methods (including information search rules) used to form the expectations are updated also. This is the building experiences aspect discussed in literature on key indicators (Mossberg, 1977; Ånebrink, 1985).

In an intuitive decision process, accounting data are not used, at least not directly. The accountant may transform the accounting data to changes from current (or previous) conditions as directions and crude quantitative categories, which would be understood by intuitive thinking. However, managers prefer a feed forward and compensation approach, so they look for changes in the production processes as well as in the market and other aspects of the environment before the changes could be observed in accounting data. They are not willing to wait until the changes have had an effect on the payments and, thus, could be observed in accounting data.

Why are farmers using the intuitive process?

Many farmers are not using the recommended rational analytic decision making process. It is the same with many other managers, as is described in the literature. Why?

There are some advantages with the intuitive process. It is a low cost of using it for a specific decision, because you do not need detailed information and calculations that is both expensive and takes time. Instead you go directly on a probable solution. However, to make a good decision you need experiences, which take time to acquire. The experiences are like an investment, which is paying off when you can use it in intuitive decision making. You use quick, simultaneous processing just in your head without any paper work. You can include all information, even the vague or qualitative. You will not come to an exact answer, but often the correctness of the intuitive process is enough. If you get new information, it is easy to update your judgments, because it is just your mental models to update. If you can try the solution in small scale, or implement it in small steps, you do not need to be so correct, and you will quickly get new information about the consequences of the solution and can adjust it if needed.

So, we cannot say per se that it is wrong to use the intuitive process. As information providers, we had better to design our information to fit both the intuitive and the analytical process.

Method

The pilot study was done in the following steps:

1. Interview of advisors
2. Development of a farm example with analytical and intuitive accounting information
3. Choice of a farm population for a limited empirical investigation
4. Data collecting by a questionnaire about the understanding and judgment of the farm example
5. Grouping the farmers after using an analytical or intuitive decision making process, and analysis if the collected data support the hypotheses

Step 1: Interview of advisors

Advisors at accounting service offices have experiences of presenting accounting information to farmers that use various types of decision processes. Some senior consultants of LRF Konsult were interviewed to learn how they presented accounting information to farmers, especially to farmers with an intuitive decision making process.

Step 2: Development of a farm example with analytical and intuitive accounting information

The outcome of the interview of advisors, and the findings of the literature study, were used to develop a farm example containing:

- Farm description
- Profit and loss statement
- Financial statement
- Analytic accounting information commenting the previous two items
- Intuitive accounting information commenting the same items.

The farm example had the same production as the farms of the population, i.e. milk production. The analytic information was designed traditionally with a key indicator report covering five years including turnover, outcome before depreciation, solidity, gross margin (outcome before depreciation divided by turnover), cash liquidity, and debt limit (maximum debt possible to pay interest on). The intuitive information included graphs and verbal comments related to the same issues but no key indicators. The comments included consequences for the entire farm.

Step 3: Choice of a farm population for a limited empirical investigation

The chosen population was farms with milk and forest production in the Uppsala province. The reason for focusing on just one production mix was that the respondents' experiences had to be applicable on the example farm to be able to use the intuitive approach. The frame finally used was the milk quota register of Statens Jordbruksverk (Swedish Board of Agriculture). The addresses were provided by the province organization of LRF. All farms with at least 30 ha of acreage and 5 ha of forest in Uppsala province were chosen. The number of chosen farms was 194. The acreage limits were decided based on the needed number of acceptable responses.

Step 4: Data collecting by a questionnaire about the understanding and judgment of the farm example

A questionnaire was developed with questions about:

- What problems the respondent could see in the farm example
- What should be done to solve the problems
- The respondent's attitude about the accounting reports, where one question differed depending if the respondent had got the analytically or intuitively designed information
- How the respondent handled his own accounting and judged his own accounting information

Step 5: Grouping the farmers after using an analytical or intuitive decision making process, and analysis if the collected data support the hypotheses

Some questions were formulated as a basis to judge if the respondent used an analytical or intuitive decision making process:

- an intuitive let an accounting bureau or similar do his accounting, because an intuitive does not want to analyze all parts included in accounting by himself.
- an intuitive judges by experiences if the outcome is enough or he trusts others' experiences. If he compares with outcomes of previous years or of other farms on his own, he had to divide the comparison in different parts, i.e. be analytical.
- an intuitive does not do a budget.

Half of the respondents got the analytically designed information, and half of them the other example. Farmers with either analytic or intuitive decision process are represented in both these halves. This means that the respondents could be divided in four groups (Table 2).

Table 2 Response rate depending on the type of decision process and respondent

TYPE OF DECISION PROCESS	TYPE OF RESPONDENT	
	Analytic	**Intuitive**
Analytic	*Group 1*	*Group 3*
Intuitive	*Group 2*	*Group 4*

We could compare how these four groups understood and judged the accounting information, and by that we could investigate how the empirical data supported the hypotheses.

The response rate was very low, only 23%. The main explanation being that many farmers found the material too time consuming. However, the interest for the study was big. Some farmers said that they would gladly take the time needed if we paid for it. We made a non-response investigation by telephone, in which the respondents answered all questions either over the phone or by sending the questionnaire. The number of answers corresponded to 19% of the whole population. This allowed us to test if non-respondents would answer differently from the respondents. Even if the questionnaire respondents and the interview respondents could be grouped together in the analysis, the response rate of 42% is too small to allow generalization to the whole population. On this basis we can only develop hypotheses to be used in continued research.

Results and discussion

Non-response investigation

Farmers answering the questionnaire used to a significantly higher degree the analytic decision making process than the farmers interviewed. See Table 3. This indicates that there are more intuitive decision makers among the 58% not responding than among the 42% responding. However, when comparing the questionnaire respondents and the interview respondents grouped in the four respondent groups listed above, there was no significant difference in the answer of any question. Therefore, the questionnaire responses and the interview responses can be summarized to one in the continued analysis resulting in a response rate of 42% (81 observations).

Table 3 Response rate depending on the type of decision process and respondent

TYPE OF DECISION PROCESS	**TYPE OF RESPONDENT**	
	Questionnaire (n=55)	**Interview (n=26)**
Analytic	64%	50%
Intuitive	25%	38%
Both processes	11%	12%

Respondents

Grouping the respondents after type of decision process resulted in 48 analytical and 24 intuitive. The rest, 9 respondents, could not be grouped because they seemed to use both processes. So, around 1/3 of the farmers used the intuitive process. Other studies (Öhlmér et al., 1997; Öhlmér, 1998; Bergkvist et al., 2001) regarding strategic decision making indicate that 2/3 of the decision makers are intuitive. One explanation to the difference is that the other studies had a higher response rate (60–70%). Another explanation is that it is easier to be analytic when the information is quantitative and has a low degree of uncertainty compared to strategic decision making when the information is qualitative and has a high degree of uncertainty.

We used a Chi-Square test to examine if the response rate differed between persons using the analytic versus the intuitive decision making process depending on the type of accounting information. Table 4 shows the observed number of respondents and the number expected (if no difference in response rate) in each of the four respondent groups. There is a tendency that analytic farmers getting analytic information and intuitive farmers getting intuitive information have a higher response rate than expected, but the differences are not significant. The response rate of each question was tested in the same way, and there was no significant difference for any question.

Table 4 Observed and expected number of respondents

DECISION PROCESS	TYPE OF ACCOUNTING INFORMATION	
	Analytic	**Intuitive**
Analytic	Observed number: 29 Expected number: 27	Observed number: 19 Expected number: 21
Intuitive	Observed number: 11 Expected number: 13	Observed number: 13 Expected number: 10
Both processes	Observed number: 5 Expected number: 5	Observed number: 4 Expected number: 4

Comparison of the four farmer groups

Table 5 shows the results regarding the respondents' perceived difficulties in interpreting the accounting information.

The results indicate that the respondents only to some extent perceived that the information was difficult to interpret. According to our hypotheses, respondents with an analytic decision process would prefer analytic information. The results show that the analytic farmers perceived fewer difficulties to interpret the intuitive information than the analytic information (t=1.94). The results show also that the analytic farmers perceived fewer difficulties to interpret the intuitive information than the intuitive farmers did (t=-2.29).

Table 5 Respondents' perception of difficulties in interpreting the accounting information in a four grade scale, where 1 means that it is not difficult and 4 that it is difficult. "m" is average, "s" is standard deviation, "N" is number of respondents

DECISION PROCESS	**TYPE OF ACCOUNTING INFORMATION**		**Difference**
	Analytic	**Intuitive**	
Analytic	m = 1.68 s = 0.82 N = 28	m = 1.26 s = 0.56 N = 19	0.42 t=1.94
Intuitive	m = 1.90 s = 0.88 N = 10	m = 1.85 s = 0.90 N = 13	0.05 t=0.13
Difference	-0.22 t=-0.71	-0.58 t=-2.29	-0.17 t=-0.60

The same type of tables was developed for other questions giving the following results.

Is the accounting information important for **detecting problems***?*

- The intuitive information is more important than the analytic information for both intuitive and analytic farmers.
- The intuitive information is more important for the analytic farmers than for the intuitive farmers.
- The intuitive information increases the importance of both the profit and loss statement and the financial statement for the intuitive farmers.
- The profit and loss statement is more important than the financial statement for analytic farmers.

Is the accounting information important as a **decision basis***?*

- The intuitive information is more important than the analytic information for the analytic farmers.
- The intuitive information is more important for the analytic farmers than for the intuitive farmers.
- The intuitive information increases the importance of both the profit and loss statement and the financial statement for both the intuitive and the analytic farmers.
- The profit and loss statement is more important than the financial statement for analytic farmers.

Is the accounting information important as a **basis for investment decisions***?*

- The intuitive information is more important than the analytic information for both intuitive and analytic farmers.

- The intuitive information is more important for the analytic farmers than for the intuitive farmers.
- The profit and loss statement is more important than the financial statement for analytic farmers.
- The profit and loss statement is more important for analytic farmers than for intuitive.

Is the accounting information important for ***decisions about the daily business****?*

- The accounting information is not as important here as for the investment decisions.
- The intuitive information increases the importance of the financial statement for the intuitive farmers.
- The profit and loss statement is more important than the financial statement for both analytic and intuitive farmers.
- The financial statement is more important for the intuitive farmers than for the analytic.

Is the ***design of the accounting information*** *good?*

- The design of both the profit and loss statement and the financial statement is perceived to be less good by the intuitive farmers than by the analytic.

Is the ***accounting information*** *valuable?*

- The value of the accounting information is perceived to be higher by the analytic than by the intuitive farmers.

As a summary we can see that the accounting information is used to detect problems and as a decision basis, especially for investment decisions. The profit and loss statement is more important than the financial statement. The intuitive information, which included comments to the accounting information and conclusions about problems and options for resolving them, increased the value of the profit and loss statement and the financial statement. An unexpected result was that the intuitive information was more important for the analytic farmers than for the intuitive. Explanations may be that also analytic farmers need more and simpler accounting information, and that our intuitive information was too complex for some of the intuitive farmers but not for the analytic. We may have used concepts not understood by all intuitive farmers.

Multivariate analysis

In Figure 1, a path diagram for the hypothetical model is formulated. Answers to the survey questions measures the following latent variables:

1. P&F value: perceived importance of profit and loss statement
2. P&F design: appreciation of the design of profit and loss statement
3. Fin.st value: perceived importance of financial statement

4. Fin.st design: appreciation of the design of financial statement
5. Comm value: perceived importance of commentary information
6. Comm design: appreciation of the design of commentary information
7. Detecting scale problem: the magnitude (from zero) of detected scale problem
8. Detecting efficiency problem: the magnitude (from zero) of detected efficiency problem
9. Finding growth option: if the farmer found a growth option that may resolve the scale problem
10. Finding other option: if the farmer found another option that may resolve the efficiency problem

Several survey questions were formulated to measure each latent variable. The first six latent variables are assumed to affect the next two latent variables (No 7 and 8). These two (No 7 and 8) are assumed to affect the last two latent variables (No 9 and 10). The arrows in Figure 1 indicate the relationships.

In addition, we assume that the type of decision making process used by the farmers, intuitive versus analytic, and the type of commentary information, intuitive information versus analytic, affected all ten latent variables and the relationships between them.

The parameters were estimated with path analysis and the Maximum Likelihood estimator according to the LISREL method (Jöreskog and Sörbom, 1989). However, due to the small number of observations in the pilot study, it was not possible to divide the farm observations in the four groups, so we could not study the effect of the type of decision making process or of the type of information. The number of parameters to estimate is higher than the number of observations even in the largest group! Thus, in order to demonstrate the method we estimate the model for all observations as an entirety, irrespective of the different decision processes and treatments. In addition, we have to skip the estimation of the two variables representing finding options to solve the detected problems. One consequence of treating the material as just one group is that the variation is big. This means that many of the variables included in Figure 1 are not significant.

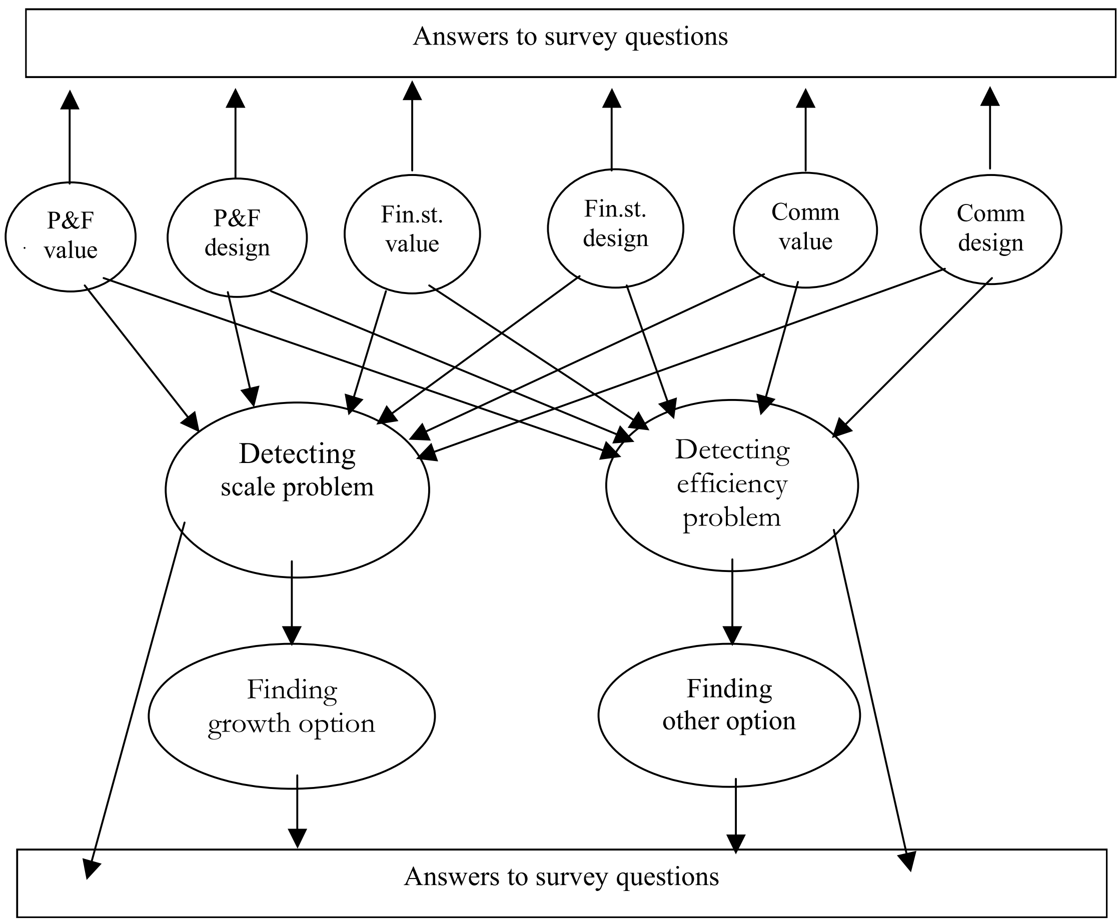

Figure 1. Path diagram for hypothetical model (P&F=profit and loss statement, Fin.st.=Financial statement, Comm=commentary information).

After reduction of these variables, the structural equations of the final adopted model are:

Detecting scale problem = 0.29*P&F design + 0.58*Fin.st value

*Detecting efficiency problem = 0.43*P&F value + 0.25*Fin.st design + 0.32*Comm value*

With Chi-Square=25.33; df=15 P-value=0.046 RMSEA=0.099

RMSEA means "Root Mean Square of Approximation", which is a measure of discrepancy per degree of freedom. It should not exceed approximately 0.09, and the p-value should be at least 0.05, so the model is not quite significant.

The first equation shows that the values of the financial statement are most important for detecting scale problems, and the design of the profit and loss statement is second most important. The second equation shows that the values of the profit and loss statement are most important for detecting efficiency problems, the content of the commentary information is the second most important, and the design of the financial statement is the third most important. However, the commentary information is a mixture of analytic and intuitive information because we couldn't analyze each group separately. Apart from that, the magnitudes of the coefficients are logical. Such an analysis of each group would be very interesting and add a lot of information, and with more observations the model of each group could be estimated. Alternatively, the degree of intuition could be defined as a continuous variable.

Conclusions

The results support hypothesis 2, that farmers using an intuitive decision making process have a higher probability to detect a farm problem if the information is designed to fit the intuitive process. However, they didn't reach the same level as the farmers using the analytic process, so the design of intuitive information has to be improved. Probably, we need to interact directly with intuitive farmers to develop such information, and we should test the resulting intuitive information in case studies before using it in a questionnaire study.

The results did not support hypothesis 1, that farmers using an analytic decision making process have a higher probability to detect a farm problem if the accounting information is designed to fit the analytic process, at least not with the design of intuitive and analytic information used in this pilot study. The analytic farmers benefited more from the intuitive information than from the analytic information. We used experienced advisors to design the information, so also the accounting information currently provided to analytic farmers has to be improved, which is an unexpected result. The comments and conclusions about problems and options to resolve them, which we included in the intuitive information, should be included in the information given to analytic farmers.

The result is important and much can be gained if the information is designed in a way that is understood by the decision maker and helps him/her in the decision process. Thus, we wish to make a full-scale study utilizing our experiences from this study. Several key issues need to be solved. One is the design of the information presented for the decision maker. More work must be spent on this. The difference between the two alternatives must be made clearer.

Another issue is how to convince farmers to take the necessary time for participating in the study. One key may be that they recognize the case. That will make them more motivated. For example, one could base the investigation on customers of auditing consultants. In this way it will be possible to group the farmers before approaching him/her. The information given could be based on the actual economic situation of that farm. One weakness with this approach is that it requires that the consultant and the customers accept the study. Some will accept to participate, others not. Thus, the sample will not be representative. We have also been talking about participating in a study circle for farmers about financial data and annual results. Also in this way we may group the farmers and adopt the information given to the actual case. Once again, one drawback is that the sample will not be representative.

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References

Ansoff, I., 1965. *Corporate strategy*. McGraw-Hill, New York.

Asztély, S., 1981. *Finansiell planering*. Lund, Studentlitteratur.

Batte, M.T., E. Jones, & G.D. Schnitkey, 1990. Computer use by Ohio commercial farmers. *American Journal of Agricultural Economics* 72, 935–945.

Beach, L.R., 1993. Broadening the definition of decision making: the role of prechoice screening of options. *Psychological Science* 4, 215–220.

Bergkvist, L., D.Lunneryd, & B.Öhlmér, 2001. Value based design of information for strategic decision making – the case of milk farms' converting to organic production. Working Paper Series 2001:8, Department of Economics, SLU, Uppsala.

Boehlje, M.D.& V.R. Eidman, V.R 1984. *Farm Management*. Wiley, New York.

Bradford, L.A. & G.L.Johnson, 1953. *Farm Management Analysis*. Wiley, New York.

Calderwood, R., B.W. Crandall, & G.A. Klein, 1987. *Expert and Novice fire ground command decisions* (KATR-858--(D)-87-02F). Klein Associates Inc., Yellow Springs, Ohio.

Castle, E.N., M.H. Becker, & A.G. Nelson, 1987. *Farm Business Management: The Decision Making Process*, 3rd ed. Macmillan, New York.

Castle, E.N., M.H. Becker, & F.J. Smith, 1972. *Farm Business Management*, 2nd ed. Macmillan, New York.

Chaston, I., 1992. Supporting new small business start-ups. *Journal of European Industrial Training*, 10:16, pp. 3–8.

Cyert, R.M. & J.G. March, 1963. *A behavioral theory of the firm*. Englewood Cliffs, NJ. Prentice Hall.

Davis, F.D., R.P. Bagozzi & P.R. Warshaw, 1989. User acceptance of computer technology: a comparison of two theoretical models. *Management Science*, 35(1989):982–1003.

Hallgren, Ö., 1982. *Finansiell metodik*. Lund, Studentlitteratur.

Hogarth, R.M., 1987. *Judgement and choice*. John Wiley and Sons, New York.

Johannisson, B. 1992. *Entrepreneurs as Learners*. Växjö, Sweden: Högskolan.

Johnson, G.L., 1976. Philosophic foundations: problems, knowledge and solutions. *European Review of Agricultural Economics* 3, 207–234.

Johnson, G.L., 1986. *Research Methodology for Economists: Philosophy and Practice*. Macmillan, New York.

Johnson, G.L., 1987. A second perspective on Earl O. Heady's economics of agricultural production and resource use. *American J. of Ag. Econ*. 69, 707–711.

Johnson, G.L., 1994. Farm management – its potential contribution to rural America in the decade ahead. In: Burton, R.O., Jr., Watt, D.L. (Eds.), *Future Priorities and Agenda for Farm Management Research*, Dep. of Ag. Econ., Kansas State University, pp. 19–40.

Johnson, G.L., A.M. Halter, H.R. Jensen, & D. Thomas, (Eds.), 1961. *A Study of Managerial Processes of Midwestern Farmers*. Iowa State Press, Ames Iowa.

Jöreskog, K. G. & D. Sörbom, 1989. LISREL 7. *A guide to the program and applications*. Chicago. SPSS Inc.

Kay, R.D. & W.M. Edwards, 1994. *Farm Management*, 3rd ed. McGraw-Hill, New York.

Kleindorfer P.R., H.C. Kunreuther & P.J.H. Schoemaker, 1993. *Decision Sciences. An integration perspective*. Cambridge University Press, Cambridge.

Klein, G.A., 1989. Recognition-primed decisions. In: Rouse, W.B. (ed.), *Advances in Man-machine System Research*. JAI Press, Greenwich, Conn. 5, 47–92.

Klein, G.A., R. Calderwood, & A. Clinton-Cirocco, 1986. Rapid decision making on the fire ground. *Proceedings of the Human Factors Society 30th Annual Meeting, vol. 1*, pp. 576–580.

Larsson, M., 1989. *Att driva företag, sammanfattning av möte i SINDs grupp för småföretagsutbildare i Lund*. Dept. of Economics, SLU, Uppsala.

Lipshitz, R., 1993. Converging themes in the study of decision making in realistic settings. In: Klein, G.A., Orasanu, J., Calderwood, R., Zsambok, C.E. (Eds.), *Decision Making in Action: Models and Methods*, Chap,. 5., Ablex Publishing Corp, Norwood, New Jersey.

March, J.G. & H.A. Simon, 1958. *Organizations*. Wiley, New York.

Mintzberg, H., 1989. *Mintzberg on management. Inside our strange world of organizations*. The Free Press, Macmillan Inc., New York.

Mintzberg, H., D. Raisingham, & A. Théorêt, 1976. The structure of 'unstructured' decision processes. *Administrative Science Quarterly* 21, 246–275.

Mossberg, T., 1977. *Utveckling av nyckeltal.* Stockholm School of Business. Stockholm.

Noble, D., 1989. *Application of a theory of cognition to situation assessment.* Engineering Research Associates, Vienna, VA.

Noble, D., C.Grosz, & D. Boehm-Davis, 1987a. *Rules, schema and decision making.* Engineering Research Associates, Vienna, VA.

Noble, D. & R. Mullen, 1987b. *The adaptation of schema-based information processing theory to plan recognition.* Engineering Research Association, Vienna, VA.

Öhlmér, B., 1998. Models of farmers' decision making - problem definition. *Swedish Journal of Agricultural Research*, 28:17–27.

Öhlmér. B., B. Brehmer, & K. Olson, K., 1997. Decision making processes of Swedish farmers – detection of problems. In: *Advances in Economic Psychology* (ed. G. Antonides, W.F. van Raaij & S. Maital) p. 255–266. John Wiley and Sons, Chichester.

Öhlmér, B., K. Olson, & B. Brehmer, 1998. Understanding farmers' decision making processes and improving managerial assistance. *Agricultural Economics* 18, 273–290.

Porter, M., 1980. *Competitive strategy*. The Free Press, New York.

Porter, M., 1985. *Competitive advantage*. The Free Press, New York.

Putler, D. S., & D. Zilberman, 1988. Computer use in agriculture: evidence from Tulare County, California. *American Journal of Agricultural Economics* 70, 790–802.

van Raaij, W.F., 1988. Information processing and decision making-cognitive aspects of economic behavior. In: van Raaij, W.F., Veldhoven, G.M., Wärneryd, K.E. (Eds.), *Handbook of Economic Psychology*. Kluwer Academic Publishers, Dordrecth, pp. 75–106.

Robert M., 1993. *Strategy pure* & *simple.* McGraw-Hill, Inc.

Simon, H.A., 1957. *Administrative Behavior*, 2nd ed. Macmillan, New York.

Simon, H.A., 1965. *The Shape of Automation*. Harper and Row, New York.

Simon, H., 1987. *Making management decisions: the role of intuition and emotion*. Academy of Management Executive, February 1987

Smith, G.F., 1988a. Towards a heuristic theory of problem structuring. *Management Science*, 34 (12).

Smith, G.F., 1988b. Managerial problem identification. *Omega*, 17(1), pp 27–36.

Smith, G.F., 1990. Heuristic methods for the analysis of managerial problems. *Omega International Journal of Management Science,* 18(6), pp 625–635.

Wennberg, H., 1998. *Så blev 1998 – ekonomin i lantbruket 1994-1998*. LRF-Konsult, Stockholm

Westberg, S., 1983. *Informationsvägar för småföretag.* Delegationen för vetenskaplig och teknisk informationsförsörjning. Industridepartementet, Stockholm.

Witte, E., 1972. Field research on complex decision-making processes - the phase theorem. *International Studies of Management and Organization*, pp. 156–182.

Adding Value Through Direct Marketing—Management Dimensions of Different Marketing Channels

Anne Moxnes Jervell[a]

Abstract

Through direct marketing farmers can obtain higher unit prices and increase and/or retain a larger share of the consumer value of their production. On small farms, where economies of scale are unachievable, growth may still be possible through diversification, adding value and economies of scope. Sale of more or less processed farm products through farm shops, internet sales, direct sales to restaurants, consumer prescriptions, pick your own, farm tourism and farmers' markets is a growing trend. Farmers enter these activities both to increase their income, to reduce risk and to take opportunity of the growing demand for specialized food products.

The different short marketing channels have common characteristics but they also differ on a number of dimensions related to management. Added value, economic margin, marketing costs, key skills, necessary investments, flexibility and risk are among the dimensions involved when choice of marketing channel(s) are taken. The management dimensions that are relevant for the choice of marketing channels is discussed on the basis of emerging literature as well as on two case studies; one of a direct marketing producer with a farm shop as the main channel, the other of the Farmers' Market as a well established concept in the US and emerging channel in Europe.

Keywords: Marketing channels, Direct sales, Farmers markets

[a] NILF (Norwegian Agricultural Economics Research Institute)
Box 8024 Dep, 0030 Oslo, Norway. *anne.jervell@nilf.no*

Introduction

"Marketing channel decisions are among the most critical decisions facing management". (Kiang et al., 2000, p. 384)

Sale of more or less processed farm products through farm shops, internet sales, direct sales to restaurants, consumer prescriptions, pick your own, farm tourism and farmers' markets is a growing trend in Europe and the US (Verhaegen & Van Huylenbrook, 2001; Jervell, 2001). Through direct marketing farmers can diversify their products, obtain higher unit prices and increase and/or retain a larger share of the consumer value of their production and sell where organised value chains are missing (for example for organic products).

In an early study of 48 small-scale food processors in Sweden, Bergsten (1986) points to marketing and especially finding a marketing channel as the most important and difficult competitive instrument for small-scale rural producers. Almost all the rural producers (96%) depended on some form of direct marketing, while the prevalence of organized channels was relatively small. The same tendency, where direct sales dominate over sale through organized channels is indicated in a recent study of small-scale food producers (Brastad and Borch 2001).

Marketing directly represents opportunities for business development, but also requires specialized management skills, imposes costs and exposes the business to new types of risk. The management dimensions related to direct marketing are discussed and illustrated by two case studies[23]. The first concerns a diversified business that has chosen direct marketing and diversification as an alternative to horticultural contracts. This case illustrates some of the decision criteria and management tasks involved. The second concerns the phenomena of Farmers Markets, and illustrates how cooperative efforts can reduce the management burden and risk of the individual producer.

The paper is organized as follows: First I motivate the research through a brief guide to literature on the subject, with a special focus on the channel as seen from the viewpoint of the producer. The choice of marketing channel can be analysed in a cost-benefit framework and with focus on the transaction costs of alternative channels (Verhaegen & Van Huylenbrook, 2001). This theoretical framework is extended to allow a more explicit discussion of how choice of marketing channel affects different dimensions of management. The dimensions covered include managerial motivations, the needs for investment in human and physical capital and the importance of different management tasks. This framework is then applied to the study of two cases. One case represents the single entrepreneurial business facing

[23] The Farmers Market case was studied during a research visit to University of California, Davis in 2001, see Jervell (2001). The Rosetten case study is conducted in cooperation with Adriana Pontieri from IIASA and Oskar Puschman from NIJOS as part of a larger European study on European Rural Development, for more information, see Pontieri et al. (2002). (http://www.iiasa.ac.at/Research/ERD/)

alternative combinations of products and marketing channels, the other representing the choice between selling from the farm or marketing through Farmers Markets. In the last case some of the management functions are taken over by the cooperative organization and can be handled by a professional management.

Motivation for using direct marketing channels

Battershill & Gilg (1998) have suggested that farmers selling directly have widely different motivations and values, while some support traditional low-intensity farming this way, others have a highly dynamic attitude. Direct marketing may be chosen from lack of alternatives. Traditional commercial channels may have disappeared or become unprofitable, and products from small-scale food processors often lack access to traditional channels. Direct marketing is shown to be relatively more important for small than for large operations in California (Jolly & Hansen, 2000). Industrialized marketing channels may be unattainable for small operations because of the relatively large transaction costs or investments in relation specific capital or contracts that exclude participation (Bates et al., 1996). While agricultural cooperatives have often practised levelling of transaction costs (including transportation) among members, there is now a tendency to distribute costs and gains according to costs. Small scale operations are marginalized in the industrialized food-system where standardized products are traded over sometimes long distances and where competition is focussed on price (and observable quality), not on intrinsic and experienced quality.

The impression is still that positive decisions and motivations dominate the direct-markeing farm sector. While small farms may have limited possibilities when competing with farmers that can utilize economies of scale, growth may still be possible through extending the range of products and services created form the same resource base (economies of scope). Direct customer contact increases the opportunity to differentiate products and services in relational sales. Added-value and the combination of products with services may increase the economic basis of small farms and contribute to larger turn-over and profit. Farmers enter direct marketing activities both to increase their income (revenue) and to take opportunity of the growing demand for recreational services and specialized food products.

A recent study of alternative marketing channels in Belgium finds that the motivation for entering new marketing channels is mainly the higher prices obtained, also for products that under standard arrangements would be classified as "second class" (Verhaegen & Van Huylenbrook, 2001). While irregular products collect low values through channels such as auctions the possibility for marketing products on basis of production method and intrinsic value increases when producers are more directly connected to customers.

New marketing channels and production methods often require an element of innovation and farmers with entrepreneurial qualities will more often initiate such activities. Products, services and marketing methods may develop over time as the entrepreneur perceives new possibilities through contact with customers. A recent US study has looked at the role of Farmers Markets, where producer–consumer contact is essential, as an incubator for innovation (Feenstra et al., 2001).

Selling directly gives the producer a control over how the products are presented and over product quality that is seldom attainable when selling through wholesaler/retailer channels. Finally producers may derive social satisfaction from meeting customers and from the knowledge that people appreciate their products.

Costs and benefits of direct marketing channels

The choice of marketing channels involves many decision variables. Even if other motivations may be present, the prospect of increased economic returns are almost always a driving factor. While direct marketing creates increased turnover per kg produced, there are also costs involved in managing and operating the sales process.

Direct marketing channels have also been termed "short marketing channels", typically the producer/manufacturer and the customer are directly linked. This implies that many of the marketing channel functions[24] are taken care of by the producer. It also implies that the transaction costs are small.

The decision situation will vary according to goal structure, prior experience and available resources, but also according to the attainable choices among existing channels. Establishing innovative channels involves transaction costs that may be prohibitive seen from the perspective of a single farmer. As a result producers may choose to rely on their own efforts. Ilbery & Kneafsey (2000) found that producers in Britain, where there are a number of regional marketing initiatives, did not associate quality with geographic origin and that they did not regard certification or labels as particularly important.

In other settings the market pull, combined with political support has succeeded in organizing the marketing and or quality control of farm products through new channels. Verhaegen & Van Huylenbrook (2001) compare conventional channels with alternative (new) marketing channels based on quality differentiation and new cooperative marketing channels with individual direct sales based on interviews with producers in Belgium. The collaborative new channels all require a direct contribution from producers, but they also reduce their level of risk related to prices and volumes compared to direct sales. The farmers' choice of channels is analysed in a cost-benefit framework. Transaction costs are important, both the costs involved in setting up or entering a new channel, the costs of obtaining market in-

[24] Marketing research, distribution (transporting, sorting grading), price setting and bearing market risk, merchandise planning, customer services, display, promotion and advertising and buying.

formation, the costs of negotiation and of monitoring and controlling performance and the costs of changing trading arrangements[25].

Management dimensions of direct marketing

The direct selling farmer has implicitly compared direct selling with alternatives and concluded that direct selling is superior. This does not however imply that other marketing arrangements could not have performed even better. Direct marketing increases the marketing costs of farmers compared to deliveries to industrialised channels. Packing, marketing activities and sales management or in transport to market, stall fees etc. have to be paid through the increased margin. These marketing tasks also require other types of management and skills than production in the field or in the barn.

Farmers may specialize on one of several marketing channels or combine several as a strategy to distribute risk and increase revenue. Especially in initial phases innovative marketing channels may be combined with more traditional ones to reduce risk. Marketing directly often requires a more diversified range of products and services and may decrease the volume produced. New marketing channels may also involve investments on the farm, for example in farm shop, processing and storage facilities. Direct marketing will also require labour input to the marketing and sales process. Processing, marketing and sales require knowledge and competencies that are different from those required for production of agricultural products. On the other hand there may be buildings on the farm that can be used for shop and storage with moderate investments and the family may be able to provide the necessary labour and skills.

The decisions to use direct marketing will be influenced by management and will influence management needs. The motivation to market directly can be based on both short-term considerations (turn-over: value-adding, economies of scope, profits: reduced transaction costs) and longer term goal structure (entrepreneurial business development, self-reliance, social satisfaction.

The success of direct marketing will be dependent on whether the manager has or can invest in the necessary human and physical capital. Marketing knowledge and sales skills are crucial, while physical investments may involve, shop, storage and processing equipment.

Choosing to market directly will change the importance of management task and most often require that the manager has capacity to handle a larger range of tasks. Marketing management, sales management and customer management will require top priority. Risk management (through diversification and marketing research) will also become more important, while production management will focus less on cost minimizing and more on diversification, adjusting to customer demand and the coordination of production with sales and marketing.

[25] For a more complete description of a TCE analytical framework in the small-scale food sector see Verhaegen & Van Huylenbrook (2002).

Table 1 Comparing management tasks of traditional and direct marketing channels

(Frequency, importance of management tasks)	Traditional channels	Direct marketing
Production management	Cost reduction	Coordinate production with marketing and sales Often involves innovative practices
Marketing management	Not important	Very important
Sales management	Long-term contracts	Daily task
Customer relation management	Moderately important	Very important
Risk management	Low uncertainty, potentially large risk	High uncertainty, risk reduction through diversification and coordinated management

Comparing direct marketing channels: Two case studies

The different short or direct marketing channels have common characteristics but they also differ on a number of dimensions. This point will be illustrated and discussed on the basis of two cases where the focal point in the first case, Rosetten is the individual entrepreneur and the focal point in the second case, the Farmers market, is the creation of a direct marketing channel that reduces the need for skills, investments and the risk taken by the individual farmer.

Case Rosetten: from greenhouse contract production to farm shop and small-scale dairying

Rosetten is an example of entrepreneurial and market-driven development of diversified products and services on a very small farm relatively close to urban areas.

History and initiation

Inger and Aki bought and settled on Solheim in 1976. The holding is situated close to the Agricultural University of Norway where they are both educated, she as a landscape architect, he as horticulturalist. When their second daughter was born, Inger left her job and planned to stay home for a couple of years. The 0.5 haa holding became the basis for entrepreneurial activity and has been her occupation and life ever since. Contacts with chefs at a hotel in Oslo revealed an unmet demand for fresh speciality vegetables: for some years Inger grew and delivered up to 25 different types of vegetables twice a week. This was management intensive and when she saw a possibility for entering into contracts for salad production she specialised and invested in packing and eventually a large 0.35 ha greenhouse. After some years of successful salad production, reduced demand, unfavourable contracts and problems acquiring a stable and qualified workforce brought ideas about developing a farm-shop and a small scale dairy from the stage of dream to decision.

Rosetten farm shop

The farm shop Rosetten was opened in early 1998, while the small-scale cheese processing unit was operative in 2000. The farm shop includes a green house with excotic plants with a café/restaurant. In addition to her own products Inger will sell processed product from other small-scale producers in the area or in the Norsk Gardsmat, some vegetables and fruit and plants. The facilities are also used for party arrangements, an activity that started on the initiative of customers. In 2001 Rosetten arranged 25 evening parties and a pub is open every Thursday. Annual turn-over from these activities increased from NOK 500 000 in 1998 to approximately NOK 1.2 million in 2000. As planned, salad production was phased out in 2000. While vegetables from the greenhouses (pick your own tomatoes and herbs) represented a large part of the sales the first year, cheese now generates most of the income. Plans are to invest in a larger production of cheese with sales not only from the shop but also to restaurants and speciality stores. Earlier investments have been financed through the business, but without the salad income loans are needed this time.

Rosetten: Choice of marketing channels

Inger has changed both product mix and marketing channel several times over the years. The initial direct marketing of vegetables to the hotel market was initiated through interest, network and demand. When she specialized and entered into contracts in larger scale production of salad this was partly to reduce her own marketing costs, especially transportation costs. The contract partner for this production was established during initial years of vegetable production. Specialized production of salad gave stable and relatively good returns the first years, the problem was hiring and managing the necessary workforce. When salad markeds changed because new types of salad were introduced Inger found herself tied to a contract that required her to grow almost the twice as much salad as was actually sold while costs of heating were rising. These problems combined were important when she decided to start a farm shop and to phase out salad production.

Network and cooperation in marketing

The farm shop project was facilitated by government support to establish an organization for farmers selling directly of the farm. Rosetten has been a member of Norsk Gardsmat since its initiation. Creating a common logo, internet marketing and a management to establish the organization was financed through the KOSTRAT program. Membership fee is kept relatively low, while members use of logo through road signs etc. are paid for by members on a marginal basis. While the marketing effect of this initiative might have been smaller than Inger expected it has undoubtedly reduced the individual marketing costs.

Inger also cooperates informally with the nearby farm-based business Krukkegården, that sells large pots, plants, gifts and has a gallery, on marketing and purchasing (especially of plants) and formally with several small-scale rural businesses that might be of interest for tourist in the region through the Follonettverk.

Diversification and investments

During the initial farm shop period Inger sold mainly horticultural products from her own farm, supplemented by processed products from producers in the NG network. The greenhouse connected to the farm shop proved an attracting setting and on customer requests she started arranging parties. The scope of her activities was further developed when she started her cheese making facility. Processed cheese catches higher prices and proved more profitable on a volume and customer basis. It is also a year round activity and it made it possible to decide to phase out salad production.

Adding new activities has required attaining new skills and diverting management attention to a number of new tasks. In the initial phases of developing new cheese varieties it is important for Inger to take part in and control the cheese production process, while presence in the shop and direct contact with customers is also needed. Using hired staff for production and selling activities requires supervision and instruction. Administrative paperwork tends to be given less attention.

Table 2 Rosetten case: Identifying critical management dimensions of different marketing channels

	Lettuce contract	**Farm shop**	**Speciality shops/restaurants**
Production management	Meeting contract, cost reduction, managing hired labour	Produce with sufficient added-value	High quality standards
Marketing management	Long-term standard contract	Cooperation in national organization and local network	Personal relations and network
Sales management	Long-term standard contract	Investment in sales facility, numerous customers	Few short term contracts
Customer relation management	Long-term standard contracts	Direct contact in shop (opening hours, time constraint)	Personal relation
Risk management	Long-term standard contract (producer carries risk)	Diversification in products and services requires a range of skills	Quality management, contracts

Case Farmers' Markets (FM)

The "New Farmers Market" model for direct marketing has experienced a rapid growth and diffusion since its initiation in the US in the mid 1970s. Direct contact between producer and consumer is at the core of this marketing channel concept, while the cooperative organization serves both to increase the value to consumers and to decrease the transaction costs of individual farmers (Jervell, 2001).

"*A Farmers' Market is one in which farmers, growers or producers from a defined local area are present in person to sell their own produce, direct to the public. All products sold should have been grown, reared, caught, brewed, pickled, baked, smoked or processed by the stall-holder.*" (National Association of Farmers Markets, 2002)

The model has proved competitive enough to allow the successful transfer to states with different farm structures and climatic conditions, to the British Isles (Holloway and Kneafsey, 2000; National Association of Farmers Markets, 2002)) and even to the Nordic countries (Higson, 2002; Norsk Landbrukssamvirke, 2002).

Producers that sell at US farmers markets sell most of their products directly. As FM participants they have to observe the rules and regulations of the local FM, which might include paying a share of their sales to market management, meeting at specified hours, selling only a limited variety of products and adhering to standards of freshness, distance to market etc. In return the PR part of the marketing tasks are taken care of by the market management, who can also provide guidelines and assistance to individual sellers to increase their sales. The FM concept represents a type of branding and attracts and satisfies customers through the variety of producers and products guaranteed. Each producer can specialize on products, since the productmix of the market as a whole is taken care of by the market manager.

"*Farmers' Markets are for all kinds of food producers and offer a low-cost entry point for many farmers who have not 'sold direct' before.*" (National Association of Farmers Markets, 2002).

Table 3 **Farmers market case: Comparing management dimensions of an organized market and direct selling on the farm**

	Farmers market	**Farm shop**
Production management	Adjust to FM product mix and market management	Range of products and services with sufficient attraction and added-value (cooperation?)
Marketing management	Cooperative efforts, learning through market participation	Attract customers to farm (through cooperation)
Sales management	Adjusting supply and sales effort to demand	Investment in sales facilities
Customer relation management	Personal contact important	Direct contact in shop Manage long hours, time intensive activity
Risk management	Small investments give low risk	Diversification in products and services Flexibility in investments

The marketing task for FM sellers is mainly direct customer contact. Planning and harvesting, transporting products to the market, pricing and exhibiting are tasks that have to be dealt with before the market opens. This is usually followed by 4–5 hours of selling at the market, dealing with customers. Sellers with a sufficient amount of products at a good market typically sell for NOK 5 000–15 000 on a market day. With time allowed for packing and transport back to the farm this should pay for 1–2 full days in marketing (depending on distance to market and on whether there are 1 or 2 sellers) as well as for the products sold. Some producers specialize in FM as their marketing channel and visit several markets every week (this is possible because most local markets are open only once or twice a week).

Compared to sales from farm shops selling at farmers markets demand less investments (in shop, parking space, signs etc), less time selling than sales from roadside or farm stands and less effort in advertising and PR. FM are especially attractive for producers whose farm or point of production is not well situated for on farm sales, either because it is out of the way or because of poor facilities. FM can be combined with on-farm sales, but this requires more man-power or restricted opening hours in the on-farm shop. FM are well suited for combination with the kind of direct markeing where customers place orders in advance for products that are either delivered by mail order, picked up at the market, on the farm or at some other location. The FM can then function as a meeting point and advertisement for products and delivery services. Farmers who use the FM (or other markets) mainly as meeting points and places to advertise products and services might restrict their participation to only a few markets a year.

Concluding discussion

The managerial motivations for selling directly can be categorized in two broad types; the relatively short term economic motivations of turn-over, retaining larger parts of the margin and earning a larger profit, and the longer term strategic motivations of developing the business and being in control of how products are marketed.

Setting up a direct marketing activity on the farm requires substantial investments in human and physical capital and in marketing and sales activities. The pattern of increasing turn-over observed at Rosetten is typical also of businesses in the Norsk Gardsmat organization. It takes time to establish a new sales channel and to attract and develop a sufficient customer base to a new marketing channel. These investments, the transaction costs involved in setting up the channel, as well as the increased sales and marketing costs will have to be covered from increased margins or turn-over if the investments are to be profitable. The firm must also have a level of risk bearing and management capacity to embark on this type of activity.

Organized marketing efforts, such as those offered by the Norsk Gardsmat organization, reduces the individual businesses transaction and marketing costs to a certain extent. For Rosetten the government supported NG initiative also made it easier to gather the support needed to take the step from entrepreneurial ideas to realized development.

The organized Farmers Markets offers a more standardized type of "spot" market outlet, while retaining the direct producer-customer contact. For the individual direct marketing producer the need for investments, both in human and physical capital is relatively low. The transaction costs involved in establishing the channel are shared. A professional management takes care of the marketing and the creation of a varied and diversified market that can attract and satisfy customers. The individual farmers most important management task is to manage sales and develop relations with customers. Offering varieties of fresh products or diversified processed products, selling stories and recipes as well as food becomes strategies for competing with other sellers for the consumers in the market. The successful FM seller can retain considerable profits, while the less successful participant carries little risk. The FM can therefore serve both as a strategic marketing tool for experienced small-scale food producers who have invested in farm shop facilities on the farm, as well as a low-threshold channel for traditional farmers motivated by potential profit and with less experience in selling directly.

References

Bates, S., A. Fearne and N. Wilson, 1996. Factors affecting the marketing of UK potatoes: results of a survey of UK potato growers. *Farm Management*, 9: 240–250.

Battershill, M.R.J. and A.W. Gilg, 1998. Traditional low intensity farming: Evidence of the role of Vente Directe in supporting such farms in Northwest France, and some implications for conservation policy. *Journal of Rural Studies*, 14: 475–486.

Bergsten, H., 1986. *Marknadföring av landsbygdsprodukter. En studie av livsmedelsproducerande familjeföretag på landsbygden*. Rapport 268, Institutionen för ekonomi och statistikk, SLU, Uppsala.

Brastad, B. and O.J. Borch, 2001. Upubliserte resultater fra spørreundersøkelsen *Utvikling av nisjematproduksjon i landbruket*, Nordlandsforskning.

Feenstra, G., C. Hinrichs and G. Gillespie, 2001. Personal communication of unpublished results from the study "Retail Farmers' Markets and Rural Development: Entrepreneurship, Incubation, and Job Creation" being conducted in NY, Iowa and CA.

Higson, J., 2002. Bondens Egen Marknad. *http://www.bondensegen.com/*, 2002.10.02

Holloway, L and M. Kneafsey, 2000. Reading the space of the farmers' market: A preliminary investigation from the UK. *Sociologia Ruralis*,40: 285–299,386.

Ilbery, B. and M. Kneafsey, 2000. Producer constructions of quality in regional speciality food production: a case study from south west England. *Journal of Rural Studies*, 16: 217–230.

Jervell, A. M., 2001. Farmers' Market – direkte kontakt mellom produsent og forbruker. *Landbruksøkonomisk forum* 2/2001, s. 5–18.

Jolly, D. and E. Hansen, 2000. Marketing patterns and Practices of Small-Scale Fresh Produce Operations in California. Implications for Technical Assistance and Marketing Education. USDA, Agricultural Marketing Service.

Kiang, M.Y., T.S. Raghu, and K. H-M. Shang, 2000. Marketing on the Internet – who can benefit from an online marketing approach? *Decision Support Systems* 27: 383–393.

National Association of Farmers Markets, 2002. www.farmersmarkets.net

Norsk Landbrukssamvirke, 2002. Bondens Marked. "Anbefalinger for etablering og viderføring av konseptet og forretningsideen Bondens Marked i Norge". Prosjektgruppens sluttrapport, Oslo, juni 2002.

Pontieri, A. , A.M. Jervell, O. Puschmann, and G. Heilig, 2002. Innovative Rural Development Initiatives. Case study 10: Rosetten. Innovative farm businesses in Norway. International Institute for Applied Systems Analysis (IIASA), Austria, 30th September 2002. Også publisert på http://www.iiasa.ac.at/Research/ERD/net/pdf/CaseStudies/Rosetten_3.pdf (12. 12.02).

Verhaegen, I. and G. Van Huylenbrook, 2001. Costs and benefits for farmers participating in innovative marketing channels for quality products. *Journal of Rural Studies*, 17: 443–446

Verhaegen, I. and G. Van Huylenbrook, 2002. *Hybrid governance structures for quality farm products. A transaction cost perspective.* Institutional change in agriculture and natural resources. Volume 6. Shaker Verlag: Aachen.