SZENT ISTVÁN UNIVERSITY
Doctoral School of Management and Business Administration

PLANNING OF AGRICULTURAL ENTERPRISES WITH INTERACTION OF ENVIRONMENTAL EFFECTS

DOCTORAL (PhD) THESIS

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Table of contents

1. Abstract

1.1. Importance and actuality of the topic

While in the process of preparing the various enterprises' decisions, apart from knowing how the economic system works, and the effect mechanisms of external factors, it's also highly important to know the magnitudes and influence levels of the actual impact factors. The basis required for this is made up by the *input-transformation-output* relations defined by the methodology. In this relation, the analysis of the *input-transformation* side is extremely important, because in most cases, to produce the output (product or service), a high amount of inputs is required, not to mention that they are needed in various combinations to allow the creation the designated output. Regarding economic efficiency, the effectiveness of economic processes have a defining role in what amounts and combinations of inputs are used in processing the actual products or services. Naturally, the goal to be envisioned is always the effective operation of the system in its entirety, however, the input-conversion side, meaning the analysis of costs is what takes the most significant portion of tasks regarding decision preparing. Due to this, I designated the goal of my thesis to be the detailed exploration of the *cost analysis*, and making its role in preparing decisions clear.

On the field of *agricultural enterprises*, we meet a lot of specialties which make the preparation of decisions much harder. The natural factors (f.e. climatic or weather effects), biological factors (f.e. the reproduction or growth processes of creatures), and their organizational consequences (immovability, seasonality, risks, etc.) raise the time required for preparation of decisions on the one hand, and decrease the effectiveness and precision of said decisions on the other hand, when compared to more controlled economic processes. Therefore, in order to prepare the decisions of agricultural enterprises, specific procedures and methods are often needed. In light of this, I will also try and evaluate, or in some cases further develop some of these specific analysis methods.

Corporate planning, as the most important task of corporate governance, collects the steps of preparation of decisions, which influence the overall operation of an enterprise, and how its future will play out. Corporate planning which keeps up with modern expectations is impossible without cost analysis, which makes planning decisions possible. The cost analysis related to planning presumes routine procedures, since most of the plan decisions are repeated annually. Also, in case of more drastic changes in the external environment, the need for specific planning and cost analysis methods or run-downs may also surface, which are part of strategic governance (strategic management). During these analyses, the role of forecasts, information and decisions which influence the future become more important, which requires the usage of complex planning methods.

1.2. Goals

Clearing up the theoretic questions regarding the planning of agricultural enterprises is imperative to realize the above mentioned goals. Also, we can't disregard pinning theory against actual use, meaning the inclusion of limitations on agricultural corporate practice. Many scientifically well-prepared processes may go to waste, due to not having their limitations evaluated, which are forced on them by absence of information on implementation, theoretic unpreparedness, lack of motivation and other various reasons. Therefore, in my analyses, I'd also like to spare some thought on the *feasibility* of planning, and the outlining of planning methods useful for actual practice via actual plant inspections.

During the planning, extreme difficulties may arise in the form of including the environmental effects, and making the impacts of the entrepreneur's decisions on the environment felt. Modeling these environmental interactions, and their inclusion into planning models is what's in the focus of this thesis.

The analyses were done in the Experimental Farm of Józsefmajor, which has served as the background of different plant economy analyses since 1992. My experiences regarding more than ten years of planning, preparation of decisions, and analysis in the experimental farm allow me to draw many useful conclusions.

1.3. Hypotheses

Regarding the topic, and the definition of goals, I defined the following hypotheses.

H1: in the case of agricultural enterprises, importance must be put on factors related to cost analysis, and which have an influence on system operation, due to the specifics of these enterprises.

H2: A modified research methodology, which can support preparation of decisions regarding crop rotation is applicable to the crop production sector of agricultural enterprises.

H3: It's important to strengthen inner material flow processes between the two main sectors for agricultural enterprises of mixed profiles.

H4: Technological processes which lessen climate damage can help enterprises in managing environmental effects via re-structuring the production framework.

H5: The GHG (Greenhouse gases) calculation methods defined for climate change may be used to create complex models, which assist the adaptation proficiency of enterprises, and to achieve a better understanding of enterprises' reactions to the environment.

2. Source and Method

During my thesis, I primarily concentrated on how corporations function. The characteristics of natural resources cannot be excluded from the processes of planning and preparation of decisions, since the proper management of these fundamentally defines the efficiency of the enterprise. Therefore, there is a need for an outlook and information base to manage problems, which is applicable to creating and evaluating information required for making the proper decision.

The information base of my research was the data-collection system created at the Experimental Farm of Józsefmajor. The data processed here was subjected to primary evaluation, mostly cost-wise, and a lesser degree results-wise. During the research, the input-conversion-output connection system was stressed, especially the connection between crop production and husbandry.

My thesis aims to shed light on the impact factors of a complex, mixed-profile agricultural enterprise's processes of planning and preparation of decisions, which is why I tried to create a framework, which can manage changes in material flow, activity and financial processes simultaneously. An important point was for the system to include decisions in the presence of uncertainty, which is very typical of the decisions of agricultural enterprises.

All these aspects lead to the creation of a complex model, which made the highlighting of more important factors via the Pareto principle and the system- and decision-centered grouping of costs possible, which factors were later put in the focus. After that, using the cost-benefit analysis was the way to calculate the effects of the decisions made by the enterprise, in a way that both positive and negative impacts are present. Finally, using the methodology of IPCC, and an operation research method, I summarized the planning model into a unified system, which enables the analysis of assumptions related to future changes, and what effects their answers have on income.

3. Results

3.1. Characteristics of cost analysis regarding agricultural enterprises

In my thesis, I introduce the opportunities of dividing costs into groups via various criteria. Of these, I highlighted the grouping which embodies the mixing of practice and concept, which shows that during the planning and decision making, we can't strictly adhere to accounting thought, especially in situations, which are the hard to structure kind of problem.

Table 1.: Costs grouped via decision and eligibility

		Dependence on decision maker	
		Variable	*Fix*
Dependence on accountability of costs	*Direct*	Direct variable	Direct constant
	Indirect or reduced	Reduced variable	Reduced constant

Source: self-made

In this grouping, the views of accounting and plant economy are mixed. The total costs are as follows:

$TC = VC + FC = (VC_{direct} + VC_{indirect}) + (FC_{direct} + FC_{indirect})$

This equation can be used as a fundamental element in process-based costs management as well. The costs related to various enterprise processes and activities can be ordered into this category, depending on how much they are represented in the total costs related to the activities.

After the categorization, we can decide what inputs are to be dealt with primarily, to raise the effectiveness of the results.

To plan costs, it's useful to mix the above mentioned grouping opportunities in various combinations. Meaning, we have to map what "A" category costs are noteworthy, which need highlighting or are to be managed separately during the detailed planning of costs, decided by the Pareto principle. In case of the "B" category, whether the actual cost can be automated via some method, or we should use a cost-change variable during our calculations is a matter of decision.

Enterprises have to have a return during product realization on a scale that covers:

- the full costs of resource requirement and usage, also
- the management costs of resources which are mandatorily on standby, but not used during the planning phase, and
- offers a profit beyond this, that makes the use of resources for the determined goal economically valid.

Expenditures are refunded analytically in the prices of the various products. During the planning process, the only costs which are in direct relation with the production plan are the variable costs. Between the price of the product, and these costs, there has to be a margin, a so-called cover, which can proficiently support the non-plannable fixed costs by product, while simultaneously able to generate profits for the enterprise.

Accounting likes to use the differentiation analyses beyond cover calculations. The goal of these analyses is to show the reasons for differences between the plan and the actual facts. This kind of analysis is differentiated into four different groups by the literature: cost-, quantity-, selection- and quality-selection differentiations. Figure 1. shows the result of a cost analysis by structuring possibilities.

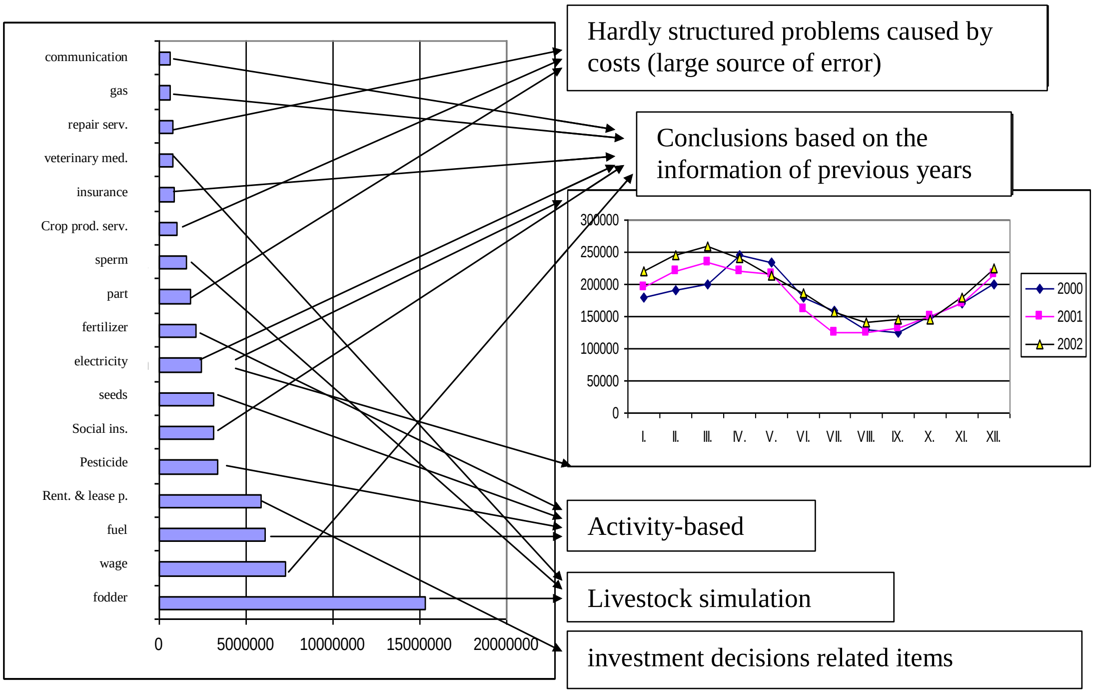

Figure 1.: Analysis of costs by how much they can be structured

Source: self-made based on SZÉKELY

Generally, we can say that cost analyses may have a high level of fluctuation and uncertainty. This is due to the characteristics of biological systems on the one hand, and the exposedness of the sector, and improper regulations on the other. Therefore, the analyses highlight the factors influencing the annual results of various sectors, but can't help in identifying the reasons behind them.

3.2. Results of cost-benefit analysis in agricultural sectors

From the possible set of economic analyses and evaluations, I did the evaluation of precision farming and the economic evaluation of a technology transition to a milking robot.

3.2.1. Cost-benefit analysis during evaluation of transition to precision farming

Precision farming, from an economic standpoint can be evaluated by the criteria also known from technological development. The difference may mostly be that while the previous attempts at technological development mainly focused on replacing human labor with more effective technological-biological processes, precision farming bases on replacing with a more developed, localized production technology - mainly built on the foundations of communication technology and information technology - which are a new alternative to mostly homogenous agronomy process-using traditional methods.

The following basic analysis tasks were to be solved regarding the precision farming:

- modeling the system of precision farming,
- acquiring the extra information on production locations, and evaluating its thrifty,
- re-definition of cost-benefit connections (production functions) from the viewpoint of precision farming,
- defining models and algorithms which calculate the optimal quantities of the used factors,
- including economic factors into economic calculations,
- developing models which calculate revenue generation of transition to precision farming,
- evaluating size-efficiency questions of precision farming.

To clear up all these questions, we have to shed light on all the various tables', partial areas' cost-benefit connections in a detailed manner, and have to draw conclusions based on the results.

During the outlining of previous analyses, SZÉKELY et al. (2000) had the goal of including only the few factors into their calculations, which change the economic value compared to traditional methods. The following generic equation was defined for the calculation of this extra income:

$$NEI_{cv} = -(IC - DC) + (SR - EC \pm IE)\,\frac{q^{n-1}}{q-1}$$

where:

NEI_{cv}	= the net present value of extra income
IC	= Surplus investment costs of equipments to be acquired
DC	= possible subsidies and discounts
SR	= surplus revenue resulting from the extra yield, and quality-improvement effects of using the precision farming system
EC	= the balance of extra costs and possible savings of the precision farming system
IE	= indirect economic effects of using the precision farming system
q	= interest factor
n	= number of years (lifespan)

Using this simple calculation, the investment cost's (IC - DC) return is calculated via comparing it to the annually unchanging economic advantages, and their re-calculation to present values. (The re-calculations must be done via multiplying the annuities with the factor which makes calculating present value possible.)

While defining the base model, the calculated surpluses and savings for each sector were defined as constant. The following step was to change the goals in a way that after processing both the literature and the information from specialists, I defined the intervals, between which the parameters of the economic calculation can differ, taking the sector's specifics into consideration.

Using this data, I defined an optimist and a pessimist scenario, behind which lie the cost-savings, surpluses, and extra revenues reachable via precision farming. This way, the various intervals were sorted into two groups, and according to the scenarios and the technological expectations, the various items were assorted by category. As an example, during the cost calculation of the insecticides, the pessimist side lists it as a saving factor, while the surplus cost due to using a better, more effective one appears only on the optimist side. As it can be seen from the results below, the optimist scenario may become less relevant. We have to clear up what indirect effects do the more effective insecticides have on the environment (externalities), since in this case, the points of evaluating social effects, and their expression on an enterprise scale come into play, which may suggest the use of the better insecticide is more desirable.

Figure 2. shows the model built for precision farming.

As we can see from the results, the winter wheat sector's extra income from precision farming is lower on the optimist side. The correct evaluation is influenced by how much the results of using a better insecticide, which generate positive externalities can be acknowledged by the market, and by what methods the scale of this can be defined (see also: consumer surplus, opportunity cost, accounting price, secondary optimal, and related to external effects: internalization, equal indemnification, costs of reaching improvement in Pareto sense, benefits of resting areas; based on MISHAN, 1982).

The model calculates as it did before, meaning we calculated the elements of the cost-benefit analysis using the crop rotations generated for the analysis interval on a field scale, including the approach (optimist or pessimist), and the results of chance effects in the various ranges. The data of the charts was summarized, and the elements of the cost-benefit analysis were defined annually, on an enterprise level.

The expansion of the model's analysis happened in two approaches. I defined how much the chart shows homogeny or heterogeneity from the perspective of the various fluctuation yields of crop cultures. This is shown by the yield spread diagram of one of the Experimental Farm of Józsefmajor's fields.

On the left side of the Figure, I modeled the benefits of transition to precision farming, using the yield density diagram, and the soil composition of the field, and its terrain specifics. Using this, a different applicability can be defined for each field, for the transition to precision farming in nutrient supplementation. This is where the density histogram can be applied, or the analysis that evaluates how "peaky" the density function applied to it is (Figure 4).

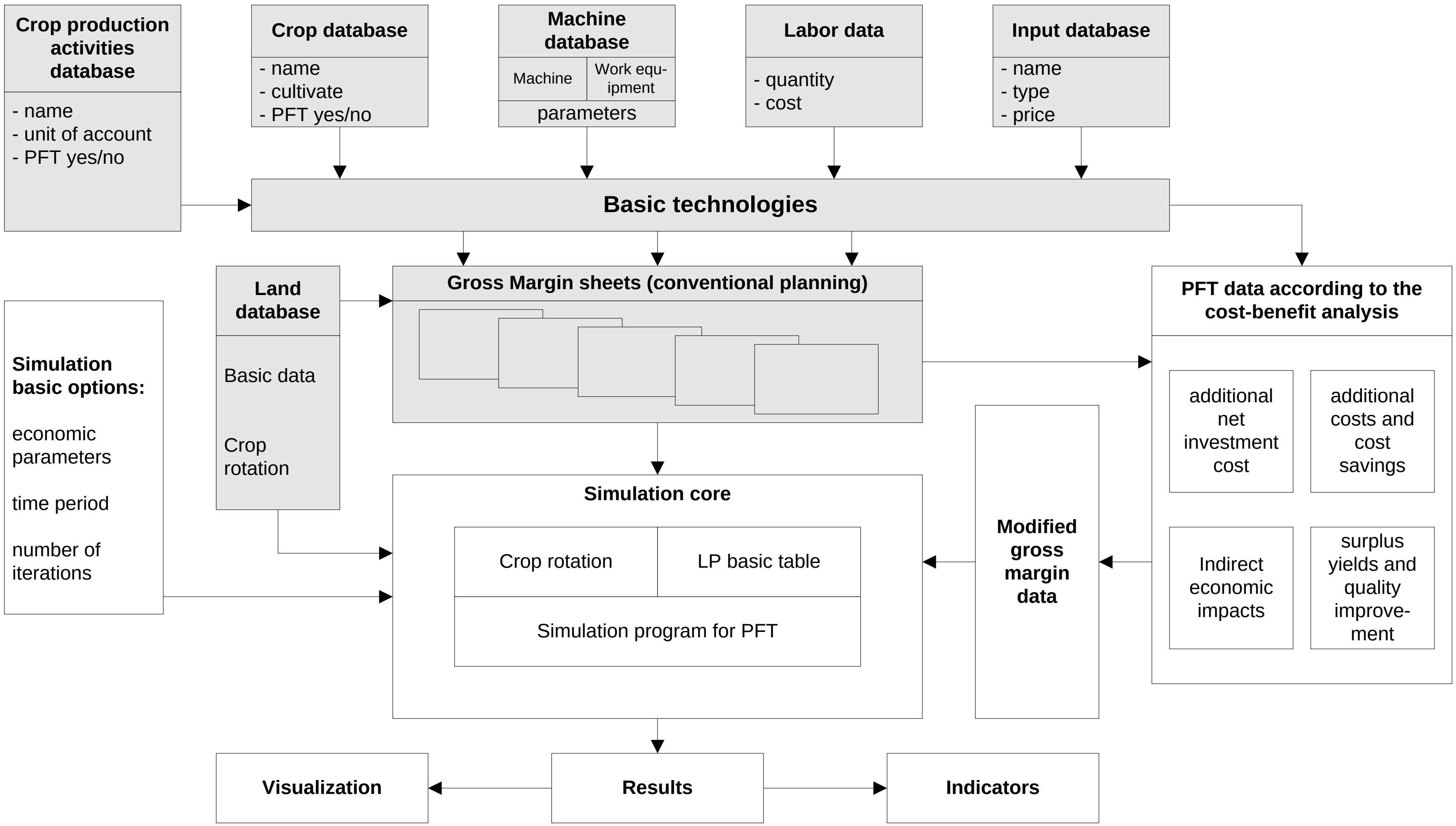

Figure 2.: The process diagram of the model evaluating the precision farming at Józsefmajor

Source: self-made

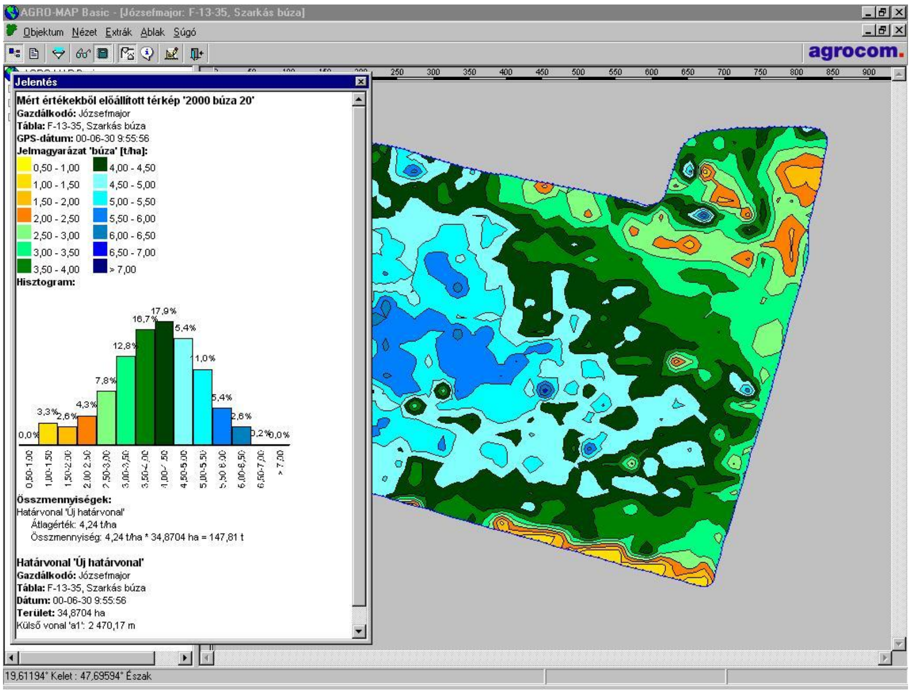

Figure 3.: The yield value of field F10 of the Experimental Farm of Józsefmajor in 2001

Source: Income map of Józsefmajor application, 2001

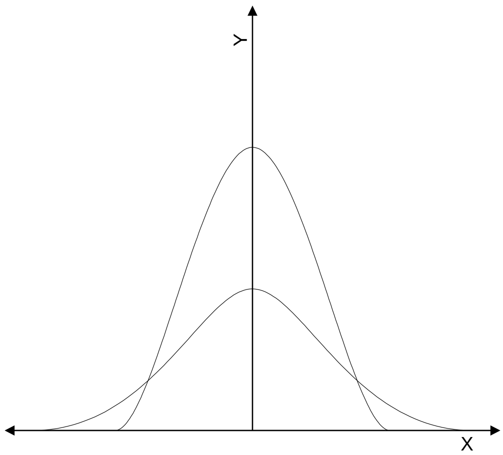

Figure 4.: Density functions for the various data sets

When compared to the normal spread, the function shows how pointy or flat the spread is. Positive values mean relatively pointy, negative mean relatively flat spreads. The definition of how pointy it is, is as follows:

$$\left\{\frac{n(n+1)}{(n-1)(n-2)(n-3)}\sum\left(\frac{x_j-\bar{x}}{s}\right)^4\right\} - \frac{3(n-1)^2}{(n-2)(n-3)}$$

where,

s is the spread of the sample.

In the model, using a random number generator, and the definition of a fixed border value, the model decided the inclusion, or the exclusion of the field during further analyses.

During the modeling of crop protection, it became clear that from a validity perspective, the plow-able area may be greater, or equal to the area which can be included, decided by nutrient management. Meaning that whether the area can be included or not, is decided by the crop which is grown on it, which wasn't fixed even in our previous analysis. However, the quantity of the insecticides we can spare, and the possible savings on machine processes is defined by the question of how the hazards causing given plant diseases on the given field are located area-wise.

For further analyses, the level of infection on the field must be modeled. This requires a two-way fine-tuning on the basic data. On the one hand, we have to elevate processes from the plant protection costs, which are definitely required for the given plant species on the whole canopy. This cannot be influenced using precision farming. For the remaining plant protection treatments, we can analyze the modeling of infection. This is where the analysis is divided into two parts. On the one hand, we have to define the level of infection, and on the other hand, its spread on the field. Using the first, we can evaluate the material savings, and using the second, savings on machine cost savings. This is how we can start a detailed analysis on cost savings, which is primarily based on natural information. In other words, the cost factors can be linked to the savings of the material- and area-access of the given field. This is how the characteristics that define the field area and plant species can be included into the economic analysis once more. This means that we need specific analyses to define what level of infection still validates thinking in material- and machinery cost-savings for the various plant species.

The results of the analysis are shown on the two Figures below, following the usage of prior optimist and pessimist outlooks.

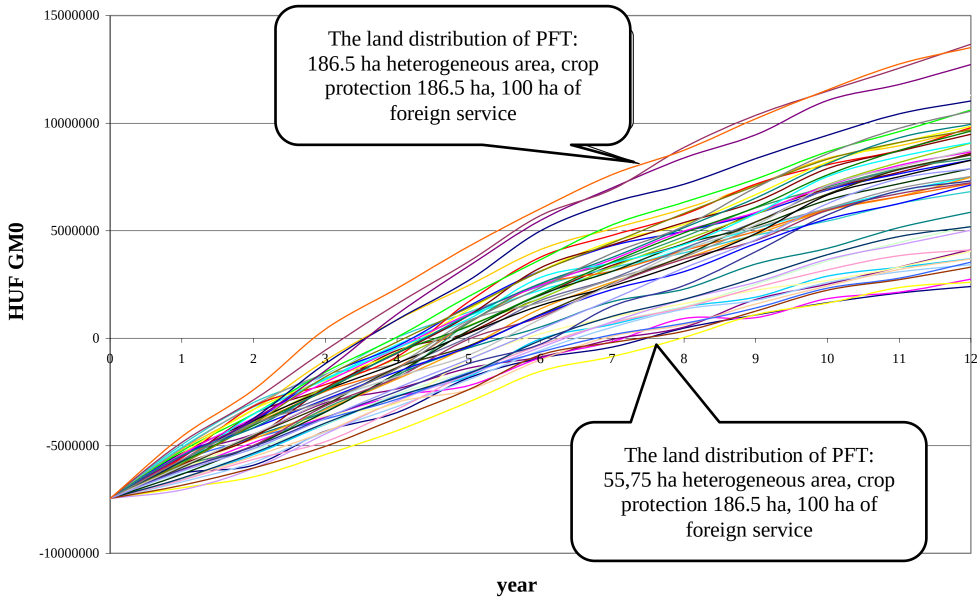

Figure 5.: The time required for return for the optimist version, for various levels of area utilization

Source: self-made.

The optimist outlook can still be seen on the Figures, meaning the economic cons of using the more effective insecticide. This detrimental effect is further supplied by the differing area requirement of precision farming's identical time required for return, for the two outlooks. Therefore, the (shortest) time for return of the third year can be reached with 176,5 hectares for the pessimist version, and 186,5 hectares for the optimist version.

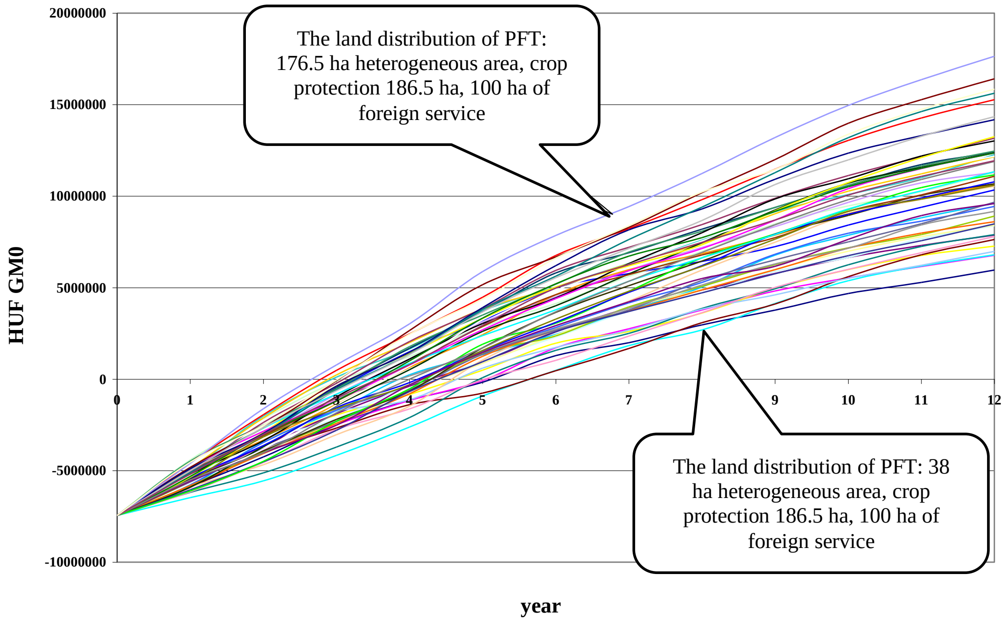

Figure 6.: The time required for return for the pessimist version, for various levels of area utilization

Source: self-made.

As a *summary*, we can state that the economic interpretation of precision farming is a difficult problem. We can only define the surplus pros and cons only with exhaustive work, which surpluses have an effect of the efficiency of the farming, and we also have to define the factors which are to be excluded from the analyses. For example, regarding soil management, the stable manure's delivery, or the desiccation costs which have an impact on the complete crop canopy have to be highlighted from the plant protection costs. These factors can't be influenced using precision farming, meaning they shouldn't be included in the information base of the cost-return analyses. This means that we have to do detailed analyses for the various crop species, to decide which production-technology processes we can employ precision farming for. We can also see from the results of the analysis, that although this holds true, sometimes, we need detailed, yet selective information for material management and the machine plants, meaning cost-information broken down to sector element levels. Before we begin the data collection, we have to define what kinds of sector-activities validate the collection of information from the agronomy side, and for what hazards we can speak of cost-savings in plant protection processes.

From the results of the expanded model's results, we can also see that the size of the precision farming also has a great level of influence on the return of the investment. The cost-benefit indicators of the model show a positive value everywhere. However, the over-expectations of the technology show a great level of insecurity. This can primarily be seen in the fact that technology allows for the use of materials, which don't have detrimental effects on the environment, or only slight effects altogether, and have a naturally higher cost. The offset of this is not present in the model. Using the "internalization" mentioned before, we can fix this problem, but the question of how this can work from an economic viewpoint arises. This can be covered by two sides, either higher prices - supposing that on the product side, a lesser level of insecticide use means higher quality - or the possible subsidies for protecting the environment. For the latter, we could define the support system of precision farming using the previously mentioned techniques.

The two-way questions mentioned at the model calculations are already subjects of research, using which we can define the calculation methods of basic numbers, with which we can decide if a given area can be included into precision farming.

3.2.2. Applicability of cost-benefit analysis for husbandry sectors

On the milk-farm of SZIU's Experimental Farm of Józsefmajor, with a rearing of 100 cows, the automatic milking system DeLaval VMS was put in operation in April, 2013.

The automatic milking system replaced the 2*5 milking position herringbone milking parlor, operating since 1996. The re-designing of the parlor area took place before the automatic milking system was put in operation, during which the machinery required for controlled herd management was made. Selection and control gates were placed, and the water supply system was also revamped. The investment totaled 55.680.000.- (HUF) net.

The goal of the analysis is to show what kinds of economic processes and methods may help the farmer in choosing between the different milking technologies.

In this thesis, the decision to invest in an automatic milking technology was made using the previously introduced calculation scheme of converting surplus income to present values, based on SZÉKELY (2004).

In our present calculation, the only items directly included are the ones that we gained actual practical experience during the 5-month operation period. Also, the possible income from selling the previous milking parlor machinery was excluded as well.

Regarding the full rearing of the milk-farm, there was a need to lower the rearing by 10%, since the milking machine in question has the ideal amount of cows milked daily set to 70, which is less than the previous 90-100 rearing. The drop in production due to less rearing (while including the amount of produced milk, and quantity of calf) is 5.459.490.- (HUF). The raise in income due to technology change calculated for 81 cows is 9.606.762.- (HUF), which is due to the annual rise in produced milk. The rise in income is partly due to more daily milking, and partly because the losses can be reduced using the new technology, and the time required for breeding. Due to this, the time period between birthing two calves is shortened, and the lactations of the cows is improved, thereby resulting in extra income.

The change in milking technology results in increased income, which consists of the following:

- electricity costs increase by 23%, which is 1.028.052.- (HUF) annually;
- supplement milking feed is 1.992.514.- (HUF) annually due to surplus milk production;
- DeLaval service pack (dug disinfection mechanism, chemical for somatic cell-counter, maintenance service with parts) is 2.760.000.- (HUF).

The change in milking technology results in increased cost-savings, which consists of the following:

- wage is 5.859.229.- (HUF) less annually, if two persons caring for, and milking the cows are dismissed;
- mass feed is less by 538.740.- (HUF) annually due to reduced rearing;
- maintenance costs of previous milking technology results in 1.366.215.- (HUF) cost reduction annually.

Due to lowered rearing, producing the mass feed can be managed on a smaller field, which means re-arranging 6,78 hectares to sale-crops becomes possible. Due to the indirect economic effects of changing technology, a surplus income of 30.000.- (HUF) was used.

During the economic efficiency analysis of investments, the analyzed time interval is 15 years, and the calculative rate of interest is 4%. The return analyses were done for two different investment strategies, which are the following:

1. case: 100% self-financed
2. case: 40% subsidy intensity

Regarding the results of the cost-benefit analysis calculations, we have to keep in mind that the operation results of 5 months were re-arranged proportionally for a year. During the calculations, the basic indexes were defined as annualities, due to the 1-year conversion.

The results can be summarized as follows. We can say based on *the results of investment analyses done,* that the introduced milking technology change was valid from an economic point of view. When compared to the investment strategy which requires self-funding, the other one yields nearly half the time for return on investment, and doubled annual profits.

Table 2.: C-B analysis of the milking robot investment of Experimental Farm of Józsefmajor

Return on investment calculation		
	Time period	15 year
	Calculative rate	4,00%
	Subsidy intensity	40,00%
1. Return on total cost of the development		
	NPV (or NEI)	26 208 757 HUF
	Payback time	10 year
	$(r\text{-}c)_{min}$	2 357 244 HUF
	IRR	9,10%
2. Return on capital costs and subsidies		
	Opportunity cost of capital	4%
	NPV (or NEI)	41 051 896 HUF
	Payback time	6 year
	$(r\text{-}c)_{min}$	3 692 253 HUF
	IRR	16,90%
Break-even point calculation		
1. Return on total cost of the development		
	Milking average (for 70 cows)	23 kg/day/pc.
	The total daily amount of milk	1620 kg/day
C-B break-even differential value		5 kg/day/pc.

Source: personal calculations.

The milk production required to reach the return of investment (break-even point) is 23,14 kg/day/individual, which means an approximate 1620kg of milk for the farm daily.

To summarize, we can say that the decision maker has to focus on the differences between systems as well, when using this methodology.

3.3. Questions on practical use of results from the linear programming model during establishment of production framework

I set the production system of agricultural enterprises using linear programming model as the focus of these analyses. My prior experience shows that the actualization of results of optimal solution is usually impossible. The reason for this is that the LP model offers information on product frame proportions for the solution, which is a simple, determined cost - holds true in case of marketing price proportions, and the decision maker doesn't get sufficient information on the field-level use of the solution. In my work, I evaluated the applicability of the calculated results, and tried to determine the hardships of this. Also, I created a solution advice on using the LP on a field scale.

To create the LP model, we need prior analyses and acceptance of technical impossibilities, in order to make a clear to understand and solve chart initially. The profession-related and methodology questions which surface, and their answers are as follows:

1. Using the planning and operative information, the prior analysis and evaluation of resources is required. We have to search for the resources which are in the narrow cross-section. These resources can be evaluated with f.e. capacity-scale analysis, which can use f.e. the field registers, or the tractor log as a starting data set.

   The capacity-scale analysis is used to determine the prior, actually used resource quantities. We can concentrate on pitting activities against each other during the basic chart creation, which have a high importance of resource allocation, and using the LP model, we can do further economic analyses, and get new evaluation-assisting data for the completely used (exhausted) resources in the given interval (f.e. shade price).

   In case of agricultural enterprises, the time dimension of resources is stressed. In the 70's and 80's, so-called "campaign plans" were made for set intervals, when the resource requirements of the one-year plan may not be sufficient for daily activities. In these cases, doing a pre-emptive, descriptive calculation for the interval may become handy, and including it in f.e. the goal coefficient is possible, or the creation of a time dimension which doesn't result in the drastic scale growth of the pre-chart, and it becoming too hard to interpret.
2. The steps of plant production have to be analyzed. Analyses which focus on activities have to be done in a way that the influences of activities in the sector on the enterprise's income appear directly, or indirectly together with the changes in production framework. The cost-analysis of the various activities may help with this decision. During the ABC analysis of costs, we can make assumptions on the grouping and plan-ability the various costs. Cost-causes, which can't be automatically planned, or not impact factors in defining the results can't be included in the LP model's chart. The changes in economic value which are caused by these can be inserted into the actual plan after solving the LP. Regarding the remaining factors, the analysis in the model is fundamentally defined by which of the cost-causes related to the activities can be defined directly, and which indirectly. The cases of directly calculated cost-causes are quite easy, since prior to the activity, their assumed values can be defined easily. However, in cases of the indirect costs, it's not as easy as that. The best example for this is to show the tractor-plant's economic values, and the method of accountability of used labor as an activity. In this case, the problem is that the actual resource isn't maintained for the sake of one activity, since it's used by several activities, where the fact that the machine exerts different work amounts for the different activities comes into play as an additional problem. This is when the naming

the actual activity comes into play, and the technique to account its related costs. In the case of identical resources used for multiple activities, the different quantities also cause the differences in economic values defined in the goal criteria. The question of the time dimension also comes up related to activities, since any given activity, if not done in the optimal time interval may have an influence on production. In these cases, a possible solution would be the creation of technology varieties, which need the assumption that some sector-states or activities are partly incorrectly done, which obviously causes a fall in income.

3. Going from the problems in the previous points, the following solutions are present to fix them, according to the scale-criteria:
   a. In case of many different resource types, arranging them into groups helps. In this case, efficiency and effectiveness suffers a drawback, but manageability becomes easier. As an example, in case of the tractor plant, grouping tractors into light, medium-heavy and heavy classes. This means that the time-dimension of resources also becomes more manageable. This, however modifies the prior step of planning a bit, meaning that during the calculation of sector-plans, the requirement changes from including resources, to including groups. This also has the benefit of tool management decisions being differentiable from technological process decisions.
   b. The grouping via activity has to be managed in the scale-criteria. This requires a prior analysis of activities, which extends to natural quantities, and costs as well. In this case, we have the option of evaluating problems which are related to multi-goal programming, since the economic values of all activities may be represented in the goal-criteria.
4. Following our EU membership, we can mention several new factors, which are barring criteria to the production options of management. These don't always mean economically direct, displayable values. However, their evaluation is important, since they often mean the narrow cross-section of activities, which if freed, may lead to an increase in the efficiency of other resources (f.e. milk quota).

As I already mentioned, directly using the results of the LP model is next to impossible. The reason for this is that the LP model is only applicable to a given cost-sale price range, and that the decision makers don't get sufficient information regarding the results of the solution. The optimal production framework of solving the LP only tries to return the proportions of the different sectors which are represented in the plan. My experiences show that even if the field-level optimization model can be made, in this case - if we would like to consider all solutions - a matrix that's tailored to the product of number of plants and number of fields in the initial chart has to be made. The bigger the farm, and the more field parameters and activity types, the bigger the initial chart will be. It's simple to see that to do a work on this scale, making mistakes both in the contents and physical ones during creating the LP becomes significantly easier, which consume a lot of time and effort to correct. Therefore, it's understandable that we question how the problem set could be easily solved. This is what I created a simulation method in the Experimental Farm of Józsefmajor for, which offer a solution to this problem.

As a first step, I accepted the results of the LP model, but only as size proportion markers. This basically allows for the selection of solutions which resulted from the analysis, meaning that we try to close the gap between solutions. This can be defined easily using the RN-function, if we link its value to the given sector, thereby arranging crops to the various charts. The results I acquired were submitted to prior selection by the criteria of the solution has, or doesn't have a sector which was excluded from the LP. If there are, the solution can be rejected. Naturally, there's a chance that the result we get from this is included, but in my evaluations, I disregarded these solutions.

In the next step, we have to see if the resulting solution is applicable to the other criteria. Among these, we have to highlight the following:

- information which expels crop rotation according to crops grown on the given field in prior years,
- factors limiting production technology (f.e. water-ability, isolation distance),
- denials resulting from prior use of materials (f.e. herbicides, integrated plant production, etc.),
- and last, but not least, the productivity values of crops grown on the given field.

To manage these criteria in the model, I created so-called denying fields, by which the above mentioned criteria can be automated, and we can generate sub-optimal solutions as the results of a simulation.

3.4. The complex model based on GHG calculations

Related to an older study of mine [1] I had the opportunity to do GHG balance analyses for eight large economies using the IPCC system in 2008-2009.

At that time, I basically only used methods for the analyses, which build greatly upon the so-called emission factors in the national GHG asset stock, meaning the model doesn't use data on an enterprise scale. This meant the creation of the new model, which was applicable to the given systems, and included their specifics.

I linked the GHG-calculation-based model with the LP model, which is also useful for building complex analyses. There was a need to do this, since the economy takes part in the Hungarian National Rural Network (HNRN), and in the criteria of crop rotation, we also have to consider its regulations. These criteria were defined with the so-called intern definition.

Figure 7. shows how the complex enterprise model looks like.

I also included the weather into my analyses, and its effect on production results, through the different development phases of the given *crop culture*. Using this relation, and the research data of BIRKÁS (2002-), I generated the income effects of technological variations.

[1] The title of the study: Creating a model that calculates the emission rates of mixed-profile agricultural enterprises using the IPCC process, 2009.

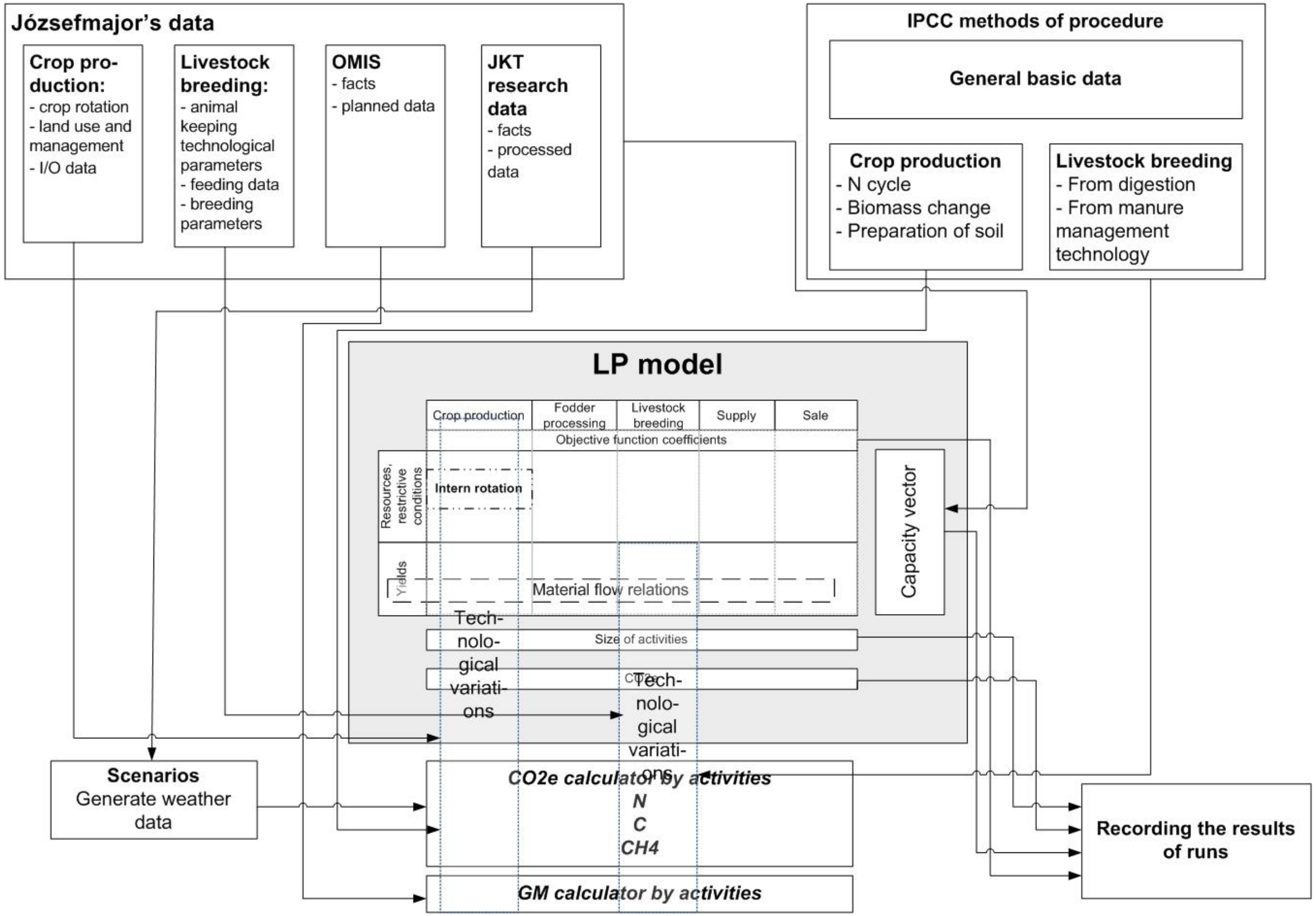

Figure 7.: Detailed structure of complex enterprise model

Source: self-made.

These incomes have an effect on the accomplishments of the given sector, and through these, their carbon-emission rates by how the weather criteria is applied to which season's evaluation combinations of which scenarios.

In the case of the *husbandry sector*, the technology change mainly concerns the cows through milk production, feeding and related body mass change. For this, I processed the unique body mass data of Józsefmajor, catalogued from 2002 to 2009, with which calculating the need for feeding can be automated. Currently, this was set as a constant value in the model, but there's an option to change it.

During the first executions of the model, as was foreseeable, changes in weather made up a separate combination space. These combinations were defined, and the reduced number of model executions was done after this. To sum it up, if we assume the scenarios by average and dry weather, the model was executed 2 * 81 times (four seasons, three rainfall distributions). Figure 8 shows the results.

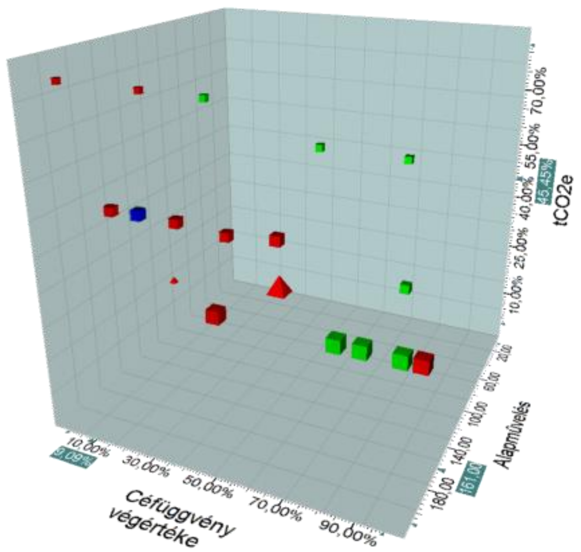

Figure 8.: Results of model execution

Source: self-made.

The red colors on the Figure mean the weather circumstances, while the green one means the dryness. Cubes show the results of executions where the manure from the husbandry was used in its entirety for plant production. The size of the dot shows the final value of the goal function, while the results of the executions were placed on the axis according to percentages. On the basic tillage axis, I demonstrate the rates of traditional and climate hazard reducing plowing methods.

4. New scientific results

Among the new and novel scientific results, I mainly highlight those that were alredy implemented in the Experimental Farm of Józsefmajor, and their results show their practical feasibility. The new and novel results are as follows.

1. The *complex enterprise model* made according to GHG calculations revealed that in case of unsteady weather circumstances, *combining different farming methods of plant production sectors is advised. This can furthermore be interpreted as a risk management method.* The non-realized part that's caused by using this mixed structure is basically non-existent compared to what the farm can lose if they specialize on a single technology. Obviously, in case of the weather circumstances becoming favorable, the farm can realize a greater income, but this doesn't mean a solution to unsteadiness between years.

2. The second result is that during the *cost-benefit analyses, defining the indicator I named 'surplus break-even point' is advised*. This indicator offers information for the decision maker, which shows him if the surplus value (income, cost reduction, improvement in production rate, etc.) of using a new technological process instead of the current production intensity is reachable to him, or not. Meaning, he immediately gains information on the question if there's a need for a drastic change, and what part of the system should be changed to keep the farm functional.

3. I consider the following further results:
    a. *The creation of the field-wise optimization method* for LP , which helps with including the influences of pre-crops, and the grow-ability of the crop post itself (extern and intern definition is furthered with the denying fields).
    b. *The enterprise level adaptability of the IPCC GHG calculation methods*, and its applicability through a Hungarian example.
    c. *The introduction of C-B analyses and decision-centered cost-grouping into agricultural enterprise planning*.

4.1. Hypotheses

The following answers can be given to the hypotheses introduced in the abstract.

H1: The Pareto analyses show that due to the characteristics of the biological system, we cannot disregard costs which seem negligible either, since these are frequently in connection with basic regulation processes. (Holds true)

H2: We can define models, which may be applicable to decisions regarding direct production structure, but the decision maker actually has to interpret these as a sort of marker. Since the technological processes and interventions in today's agricultural practice are more and more possible, the models must be more and more complex, which means new sources for errors. (Holds true)

H3-H4: The complex model shows that selling agricultural by-products which strengthen the internal material flow yields more income short-term (simultaneously, we can see a higher carbon-emission rate!), but as a result to this, we'll see a drop in organic material in case of the various carbon holders, meaning the value of the natural resources will drop long-term. (Holds true)

H5: I've been dealing with GHG calculations since 2008. In recent years, these kinds of analyses are spreading not only to the sector of agriculture, but the other, trade- and industry-related sectors as well. This shows up in an enterprise's so-called social responsibility missions. These models help to understand f.e. the demerits of transportation from too far away, or the negative effects of inputs put into agricultural systems. The model can show a compromise-based structure change through its executions, by which the drop in income compared to the best scenario becomes tolerable, even more so, if we regard the possibility of the best scenario. (Holds true)

5. Assumptions and suggestions

Since apart from working as an instructor, I'm also the leader of the Experimental Farm of Józsefmajor, I frequently hear professionals ask why they have to plan, why they have to waste time even on this activity? In my thesis, the main reason behind the importance of this question - I believe - is shown, since due to the complexity of agricultural systems, the decisions and factors which are not influenced by them are so numerous, that the feeling of insecurity rises in the planner, therefore, he disregards the documentation of this activity. And with this, he already makes the biggest mistake, since this isn't the way to generate a basis for comparison which may show the decision maker how the system works. The experiences of my past two decades show that without the document that results from documenting the planning, even the daily management questions lose their "compass", or in other words, the goals of the organizational criteria.

The workings of agriculture are inseparable from that of nature. Changes in nature demand a reaction from the farmer, or he has to deal with a loss of income, and long-term, a hazard to subsistence. Since numerous researches began about technological solutions to negative environmental effects, which were also published, their economic confirmation becomes more important. Generally, we can still say that those who think short-term, still finds traditional plowing methods better, but has to deal with detrimental effects long-term, which can only be compensated later with decisive cost sacrifices, mostly melioration decisions.

Therefore, the thesis further stresses the importance of structure-based thinking, most notably in this sector. This also results in that the requirement of deeper knowledge and trying a different approach surfaces. For example, to let the decision maker disregard the traditional grouping of costs, the pros which use a slightly more complicated method to make later management processes easier and more effective, have to be introduced to him.

Structure-based approach is supported by the development decisions based on cost-benefit analyses. These help learn the cost grouping via decision on the one hand, and due to the process-based thinking, the decision maker will be capable of including the pros and cons of the prior and present states into his thinking on the other.

Evaluation shows that Hungary has to improve the measurement and collection of effects of changes in environment. Sadly, due to the economic hardships of previous years, this area yielded negative decisions as well, meaning that the operation of numerous data collection systems were halted due to absence of source (f.e. Hungarian Feed Database). However, there are more and more publications and research topics worldwide, which deal with this topic. As for the data of the Experimental Farm of Józsefmajor, the next step could be repeating the analyses regarding different soil types, maybe even for different climates. The latter would clear up if we have to separate Hungary into regions regarding this (currently, IPCC handles the country as a single region).

The introduced complex model currently operates with the data of one given year, meaning it can't work as a dynamic model, in the sense that the one created for precision farming does. Therefore, one of the main development routes has to go this way. This development may make the interpretation of effects brought upon by changes in the soil, as one of the main carbon holders. A further development can be the advancement of husbandry onto a higher stage. Currently, there is no way to include the differences in different produced vintage feeds by digestibility, which have an impact on the emissions from digestion and excretion via the energy calculations.

Using the Pareto principle in agricultural systems shows the basic values of the method. These are: one, it helps navigate through the main factors fundamentally defining the system's operations, and two, shows the importance of the regulatory factors of biological processes. The latter shows in f.e. even though vitamins and trace elements wouldn't be included in factors to be planned, they have to be viewed as elements that have a decisive impact on the results. This resonates with the essence of the Pareto principle, since the planning system has to be tailored to the factors which have an impact on the system's results, and not their levels.

According to the analyses done, it's advisable to mix the so-called climate hazard-reducing plowing methods. Even though, the yield of a year might be less this way, but long-term, a higher income is realizable.

Finally, another suggestion is that, as it is in other countries, Hungary should also develop the carbon-emission calculator for agricultural enterprises. This can become important later, when a project aiming at reducing the emissions of the national asset-stock. This may help standardize the methods, and the required data. Sadly, we can frequently see that there are differences in the data collection methods of KSH and AKI when defining sub-categories, therefore, it's complicated, or in some cases, impossible to standardize the technological data. This would, however, not be the sole advantage of standardization, since during later data supplying, data which contain errors could be located.

6. Curriculum vitae

Name: Attila Zsolt Kovács

Studies:

1984 - 1988	Katona József Gimnázium, Kecskemét
1989 - 1994	Gödöllői Agrártudományi Egyetem Gazdaság- és Társadalomtudományi Kar
1992 - 1993	Külkereskedelmi Fősikola, OKJ
1995 - 1996	Sportoktató képzés, OKJ
1995 - 2002	Gödöllői Agrártudományi Egyetem, Tudományos Továbbképzési Intézet, doktori képzés, levelező tagozat

Graduate:

1988	Gimnáziumi érettségi - Katona József Gimnázium, Kecskemét
1993	Külkereskedelmi Áruforgalmi Felsőfokú szakképesítés
1994	Egyetemi diploma - Gödöllői Agrártudományi Egyetem Gazdaság- és Társadalomtudományi Kar
1994	Mérlegképes könyvelő
1996	Sportoktató, röplabda szakág

Scientific, professional and public activities:

1995	GATE GTK, Vállalatgazdasági Intézet, tanszéki mérnök
1995 - 2002	GATE (2000-től SZIE) GTK, Vállalatgazdasági Intézet, egyetemi tanársegéd
2002 -	SZIE GTK, Vállalatgazdasági és Szervezési Intézet, egyetemi adjunktus
1995-2005	Józsefmajori Kísérleti és Tangazdaság ügyintézői feladatai, tanüzemvezető helyettesi feladatok ellátása
2006-	Józsefmajori Kísérleti és Tangazdaság vezetője

Educational activities: oktatásban eltöltött idő hossza 20 év. Oktatott tantárgyak: Vállalatgazdaságtan I-II-III., Tervezési esettanulmányok, Döntési esettanulmányok, Vállalatirányítás, Állattenyésztési ágazatok ökonómiája, Stratégiai menedzsment, Stratégiai tervezés és menedzsment, Tervezési modellek II., Vállalati és intézményi stratégiák, Corporate and institutional strategies, Döntéselmélet és módszertan, Decision theory and methodology

Language skills:

Angol középfok
Orosz alapfok

Key professional honors and recognitions:

Miniszteri Elismerő Oklevél (FVM, 2005)
Miniszteri Elismerő Oklevél (VM, 2012)

The scientific and technical publications: 56 (by MTMT)

Number of independent citations: 30 (by MTMT)

7. List of publications connected to the dissertation

Part of scientific book:

Foreign language:

1. Ózsvári László, **Kovács Attila**, Vida Adrienn (2013): Economic Impacts of Lameness in the Hungarian Dairy Herds. In: Illés Bálint Csaba, Felicjan Bylok (szerk.), People, Knowledge and Modern Technologies in the Management of Contemporary Organizations: Theoretical and Practical Approaches. Gödöllő: Szent István Egyetemi Kiadó, pp. 254-269., (ISBN:978-963-269-399-6)

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2. **Kovács Attila** (2003): Alternatív mezőgazdasági vállalkozások szervezése. 6. fejezet, Alternatív mezőgazdasági vállalkozások menedzsmentje Szerkesztette: Székelyhidi Tamás) Mezőgazdasági Szaktudás Kiadó, Budapest, pp. 226-295., p. 495. (ISBN 963 9553 04 2)

Journal article:

Foreign language:

1. Székely, Csaba – **Kovács, Attila** – Györök Balázs (2000): The practice of precision farming from economic point of view. Gazdálkodás English special edition No. 1, pp. 56-65.,
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3. Takács-György, Katalin – **Kovács, Attila** (2003): Modeling the return on investment in plantation. Bulletin of the Szent István University; pp. 205-216., ISSN 1586-4502

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3. Székely Csaba, Györök Balázs, **Kovács Attila** (2003): Családi gazdaságok menedzsment információs rendszerének továbbfejlesztése. Gazdálkodás 5. különkiadása, XLVII. évfolyam, 13-22. pp. HU ISSN 0046-5518

Conference proceedings:

Foreign language:

1. Székelyhidi, Tamás – **Kovács, Attila** (1998): Information database and extention system of the hungarian sheep and goat sector - on CD where to use it? - Sheep and Goat Production in Central and Eastern European Countries - Proceeding of the Workshop held in Budapest, (In: REU Technikal Series 50, pp.140-141) Kiadó: FAO, Rome 1998
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5. Talajelőkészítési technológiai eljárások összehasonlító elemzési módszereinek vizsgálata – különös tekintettel az aszálykárok enyhítésére – a Vogel & Noot munkagépein

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