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COMPUTER-BASED MODELING AND SIMULATION OF PRODUCTION PROCESSES OF AGRICULTURAL PLANTS

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1. Objectives

In my dissertation I examined the possibility, it is able to implement a simulator, which is a simple, easy to use, and is able to reliably track the virtual space real agricultural production processes. It is also able to provide the information necessary for management decisions.

This way I would like to find a suitable procedure for simulation of all the economic and agricultural processes, either indirectly or directly, qualitative or quantitative way involved in the production of commodities and the run of the plant.

To do this you need to examine these processes, and common characteristics should be highlighted that the impact of the production process of the product are clearly defined, mathematically described by a fair way, and they can be incorporated in the simulation.

My further aim is to consider that a good production process simulation can provide any more data that previous models were not given to help the Manager paint a more detailed picture of the production process, of the actual product states even if it is not prepared to sale. This would be very helpful for the management for change the marketing strategies even before completion of the products.

A process simulation description assumes that the production-process is known in details, and able to understand its logic. In many cases we can not handle the logic and elements of a complicated process in a resolution that the simulation rules require, because sometimes it leads to uncontrollable large data sets, sometimes simply unnecessary for the results. It is therefore necessary to examine whether there is any depth of the product manufacturing processes, which is in the process of achieving change in terms of product demand is characterized, and more detailed examination gives no more accurate result, and additional benefit. In the agricultural production are increasingly being used methods that enable the necessary mapping of the critical production processes.

In the possession these detailed data is raising the need for a simulation system, on which the decisions could be tested. Even it is possible that after demanding all these information, the system itself makes decisions, and tests them, offering alternatives close to the optimum for the management.

Of course, there are already system-simulations. Many process were excellent described used nearly every element of the wide spectrum of modeling. The simple, verifiable circumstances has a process, more detailed, more accurately can be described its elements.

However, the complex biological nature of agricultural production processes, the close relationship with the natural factors, the production conditions, and differentiation of resources is not favorable by the simulation options of the agricultural production processes.

Regarding to all these options and information I try to analyze in my thesis the applicability of the simulation as a decision support system trough the example of a real agricultural plant, highlighted the handling of the effectiveness influencing factors with the highest priority. I mention first of all the available resources, which are the basis for mapping technologies and processes to the allocation of resources, secondly the components of the daily operation which can not be described by technologies and are usually based on personal decisions and refer to regularities of natural factors

2. Materials and methods

2.1 Simulator Structure

The plant-simulation model has been created by the generic simulation model developed by Béla Csukás and his colleagues. This simulation technique demonstrated many times that it is suitable in wide range for very accurate imaging of very complex processes trough its pioneering principle.

This simulator generates from active and passive components result variants with the help of a genetic algorithm by defined regularities. The results are examined from the aspect of the objective function. The generic simulator generates the process describing active and passive elements, signs and active elemental changes and rules from an input datasheet. The simulation is mapped directly to a dynamic database of active processes for calculating and accounting passive components.

The substance of the model is feedback between the status and change elements describing all the conservation- and information process with the same data structure. Simulation, therefore, closes with an assessment by the provided criteria.

Since the graphical mapping of processes results quite complicated and uncontrollable large files, the bi-layer net model offered better graphic representation.

Passive components containing the conservation rates in certain elements and the corresponding intensive properties, limitations, the originate changes, and the data including various other input/output- and administrative parameters. There are further program components available examining options and calculating consequences to the passive elements which are able to dynamically generate, freely modify and/or delete.

The active elemental-changes and rules are representing the operation of the model in, and determining which passive element-content has to be read, what conditions must be verified, how to calculate the rate of change, and which passive element-content and where it should be increased, reduced or overwritten according to the determined stoichiometric variables.

Types of active elements:

- describing the transformation between certain areas or
- describing the transport between certain areas or
- describing the information-type-rules.

The smaller part of the relations determines the context of the examined process and the environment – so it declares the limitation of the model, but the greater part defines the internal structure of the process.

The graph-edges comply with readings represented by the active element, or with the increasing - decreasing or code modification caused by the mentioned change.

The internal structure is dominated by the passive→ active→passive feedback loops. The feedback is that the condition represented by passive elements determines the basic processes carried out by the active elements; however, these processes modify the elemental state. Accordingly, the "selfdetermined" indicator suggests that the examined conservation process is working on a way, because its state is declared, and so its state will change because it works on the same way. It is essential that the exclusiveness of the active→passive and passive→active links represents always the conservation process- models with a bi-layer net structure. In that structure the dynamic model means that the operation of the active elements determined by the state of the passive elements, and so the modified state of the passive components is determined by the changes modeled by the active elements.

The essential structure of conservation process-models is able to characterize with a structure built of two different graph-point and graph-edge. The two graph-points are matching to the conservation rates containing (passive) component, or to the transformations or displacements of the rates and signs representing changes or rules. The two graph-edges represents the passive component readings which are necessary to calculate the elementary processes, and the increases and decreases of the conservation rate caused by the elementary processes.

2.2 The model plant

The structure of a plant-simulation can only be authentic if the simulation results are able to test. So it is possible to adapt structure of the model to a real production system, a functioning plant.

This is quite important because the necessary information to render the production processes of the system could be extracted from the observation of the production workflow and the monitoring and management system. During the monitoring of the processes becomes apparent that how many operations contain a workflow, and those elements have any valuable relationships in terms of he model is (such as labor, energy, or substances).

The observation reveals that the various operational elements, in addition to the used materials/energy, have a significant influence on the product, or material and energy prices, as the model's important features.

This should determine how detailed must be a workflow examined to ensure to obtain an appropriate sensitive model with a controllable value of data and information.

The examined plant is a diversified agricultural incorporated company, which may be a typical example trough its sectors of production for similar types of plants and farms with a single production sector.

The plant has crop and livestock sectors as well. The horticulture sector is operating on 1951 hectares, of which 310 hectares wheat, 360 hectares barley, 350 hectares sunflower, 921 hectares corn, 4 hectares of alfalfa and 6 hectares is in the cultivation of grassland. The sector operates a total of 35 people.

The livestock sector operates on two sites with reproduction and fattening pigs. There are 2300 breeding sows and 63 boars and sow's progeny on the breeding site. The fattening farm has a capacity of 5300 fattening pig. 18 employees are working on the breeding site and 9 on the fattening farm.

In the Inc.'s head office further 8 employees arranging the daily activities. This includes the management of the Inc, and the sector executives and management-assistants.

3 Results

3.1 The adaptation of the model

Before building the model had to be taken into account any event, as well as to examine the available resources, and factors affecting the use of labor. They must be evaluated in different aspects, but it should to keep in mind to write down a rules system, which is able to operate with the actual labor-, material- and energyflow along the declared technology in order to fit to all the criteria, which helps the normal functioning of the company.

These rules are the first group of the model, which are - together with the mapping of technologies and processes - freely able to adapt to the different resource allocations, and (re) groupings.

The second group of the limits are elements which are unable to describe by technologies, or does not apply to any regularity, they are just elements of the system. In real life they will be those elements of the daily operation, which are usually personal decisions, or established habits are built into the operating system and have become elements, which are regularly used.

The third and largest group of limits is composed of those regularities, which are related to technologies and to necessary activities not linked to any technology or to environment, to time or to natural factor.

Once the technology used in some sectors erected, have examined the extent to which available resources are tied up during the production period. This study continued to be detailed, if the staff regularities (the model's limitations), and they are a well-defined groups violate the model. Of course we can not change those rules which make it possible to carry out the work, and the action time and duration is determined, but it is possible to review the rules for assignment of resources, to violate the second set of limits under certain conditions. As these rules had been adopted by the decision makers, in many cases a subjective assessment, questionable the ability to ensure efficiency of the overall operation of the system.

The study (and of course with it the suspension of the rules) is only meaningful if the model is also operational, that is, until the model is only intended to reproduce the actual operation, the limits can be real and inviolable. When the model is reliably followed by the actual production process, I add tasks to it, and test the necessity of limits, but even the resource allocation. In the first case I can analyze the professional merits of the personal decisions and the second case, the correctness of the technology is, but in both cases in order of the set goal.

3.2 The mapping of the company and the production processes

First of all I registered the productive and unproductive employees in all sectors of the company. Subsequently I have described the technology of the production in all sectors of the company with operational accuracy. This practice has allowed me to follow the exact items with the highest achievable resolution. Next step, I traced the use of the resources following the technology. So I could to allocate the machines and employees to the operations used by the working processes. In this case, I analyzed whether the individual sectors is dependent on other sectors, what resources / materials / labor - is the interoperability of certain sectors, and between the sites and plants.

It soon became clear that the machines allocated to the machine operators due to a static manner (only one driver is able to use a certain tractor), the interoperability is high, though this does not necessarily justify the simplicity of the workflow. Furthermore, it has become apparent is that the various sectors are in need of each other's machines. Therefore, I created a virtual server industry into which included all the machinery, equipment and living labor, is that many sectors are regularly utilized.

Subsequently, production technologies were analyzed. I described the workflow based on the operational practices of the company, taking into account their regularities. The goal was at the technology-mapping to develop the simplest possible model structure.

3.3 The Structure of the Model

In our case the model is structured in the following principles.

1st: The company current (2005th year) of production, financial data, and detailed production technologies based on a model for the target, which - if possible - completely covers the processes of production and business results.

2nd: In the second case, at the basis of the existing model the main aim is to develop a version, which provides greater freedom in regulating the use of resources, in strict accordance of the production technology.

It is an important criterion that the user interface must be able to handle the developed tools-system which helps the initial processing of data and the calculated results are displayed. This is the Microsoft Excel application in our case. On the sheets of the application is determined the input data and the exact location of the same application in other pages displayed by the calculated (output) data (results) is set in one compact and easy to use resulting data set.

The operating data file of the genetic algorithm is always a transformed input stock of a particular task, transcribed in a form which is processed directly through the general-purpose model generator.

At the prescribing of the model for the first time in a passive model of elemental resources had to be collected. Because the company is diversified and more resources is used in more sectors as well, so I developed a resource table to be included in the total resources, irrespective of the sector in which they are used. It is significant because the crop sector machinery, equipment and people are working in the livestock sector as well. Conversely, the same is not true. So to the animal breeding included power- and working machines - and of course with their staff – according to the technological systems that do not carry out work in the horticulture industry.

The second step is to prescribe those passive components; I can assign the resources and the rules. The stables have been here for the livestock sector, according to the description of the plant model rules. Given that fact, the principle is the same descriptions of the processes, why the flow of material (crop: seed, plant protection, etc; animal: food, water, medicines, etc), energy, resources, manpower and money (cost) creates products in both cases.

Thirdly, the regularities to be described, which implements the model of passive components used in production processes along the lines of the necessary changes. These rules are always determined by the production technology. The technology is determined by the specific work processes have completed with the machines, which conducted the session, and with the people who manage these machines.

In addition for each session I marked the passive components and resources and the possible rates of change, and the fact that in which area to work.

3.4 Model Validation

The model of prescribing-2005-2006 to financial year was used. My primary aim was to disclose the results produced by the model of the economy, the actual productions. Because the economy is known about the model set up was simple and the first runs gave approximate results. In some cases, however, the results had to be corrected. The reason is that there are costs and processes of economic activities which are not actually in production (unproductive staff: cleaners, administrators, etc.). These costs are not necessary to simulate a fixed annual salary for a day almost exactly degradable with all the additives, so it can easily be corrected by the current results.

The result of the first post-installation adjustments shows the first table.

1st table

The comparison between simulated and actual economic outcomes after reconfiguring

Categories		Model	Company
Financial result	1st Quarter [Ft]	2248257	2243532
	2nd Quarter [Ft]	3194453	3265439
	3rd Quarter [Ft]	2012023	1983454
	1st year [Ft]	-626319	-766575
	Machine operating hours per year	6883	6991
Crop Results	wheat [kg]	1301938	1301922
	corn [kg]	7081002	7080812
	barley [kg]	1166601	1166578
	Sunflower [kg]	640049	640034
	Alfalfa [kg]	77000	76989
Livestock Results	total piglets born [pc]	15150	15151
	total weight gain [kg/day]	2269	2261
	total feed consumption [t]	6852	6944,2
	total water consumption [l]	12568045	12568045
	total power consumption [kWh]	492750	492750
	Spend all working hours	16045	16060

Source: Own calculation

Of course, every run, the models objective - in sync with the aspirations of farm policy - was the same: to maximize profit.

It is therefore concluded that a model can be written by the exact following of current technology that is able to reproduce the functioning of the plant.

It was further analyzed that a higher-resolution technology results any changes to the model's output side. In this case, the models ground scale was an hour, and I wrote the technologies that the technological steps were determined in hourly resolution.

The simulator in this case was unable to process the data. This is probably due to too much data. This is proven by the fact that if you keep the resolution, but not the overall company, but sectors such as the cultivation of a single plant trial, the simulator is running fine.

If the resolution is slightly decreased and the technology shifts to share, so the size of the model still remains within a manageable size, and the simulator is able to process the data. In this case, the majority of the models data is represented by the animal breeding, because the shift-scaling here means more value of operations, the mechanization of crop production, apart from the effect of peaks (sowing and harvesting) has hardly changed in the operation (condition), number of lines.

It is visible, that the company results (Table 2) or liquidity (Figure 1) compared to no significant change in the past.

2nd table

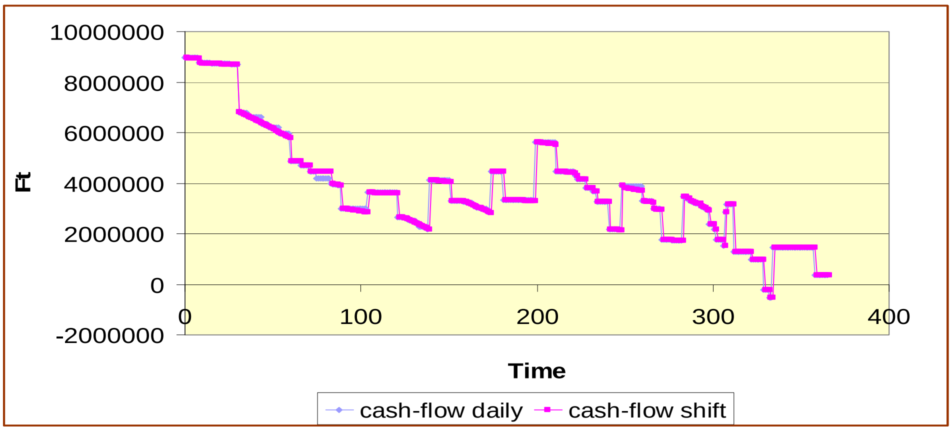
Comparing the data obtained by the day- and shift- scaled model runs

Kategóriák		modell napi lépték	modell műszakonkénti lépték	gazdaság
Financial result	1st Quarter [Ft]	2248257	2244879	2243532
	2nd Quarter [Ft]	3194453	3198397	3265439
	3rd Quarter [Ft]	2012023	2011454	1983454
	1st year [Ft]	-626319	-636243	-766575
	Machine operating hours per year	6883	6883	6991
Crop Results	wheat [kg]	1301938	1301929	1301922
	corn [kg]	7081002	7080989	7080812
	barley [kg]	1166601	1166577	1166578
	Sunflower [kg]	640049	640041	640034
	Alfalfa [kg]	77000	76991	76989
Livestock Results	total piglets born [pc]	15150	15151	15151
	total weight gain [kg/day]	2269	2266	2261
	total feed consumption [t]	6852	6852	6944,2
	total water consumption [l]	12568045	12568045	12568045
	total power consumption [kWh]	492750	492750	492750
	Spend all working hours	16045	16048	16060

Source: Own calculation

1st figure

The cash-flow diagram of the company with day- and shift scaling

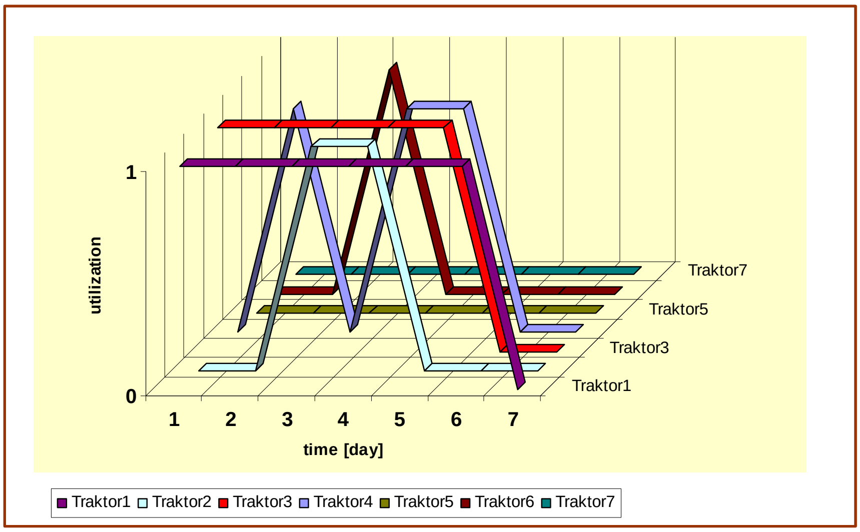


Source: Own calculation

However, if the resource utilization is considered, a much more detailed picture can be seen; for an example of the machines to commit (the second, third figure).

2nd figure

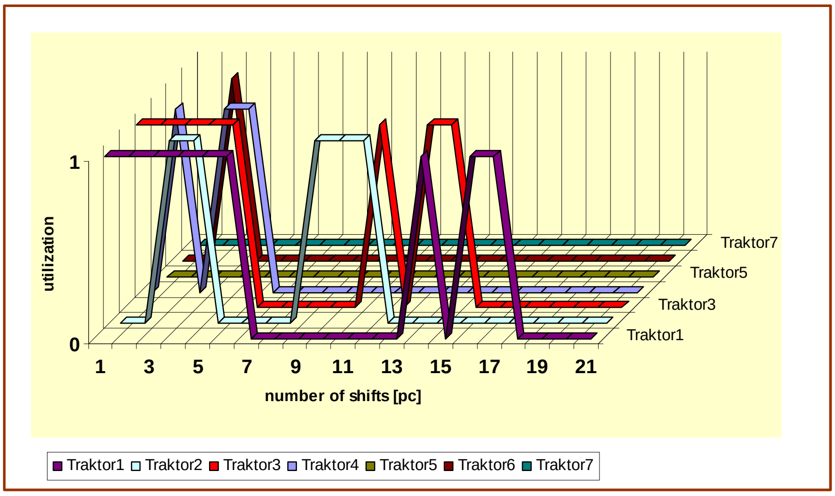
Utilization of tractors day represented scaling



Source: Own calculation

3rd figure

Utilization of tractors shift represented scaling



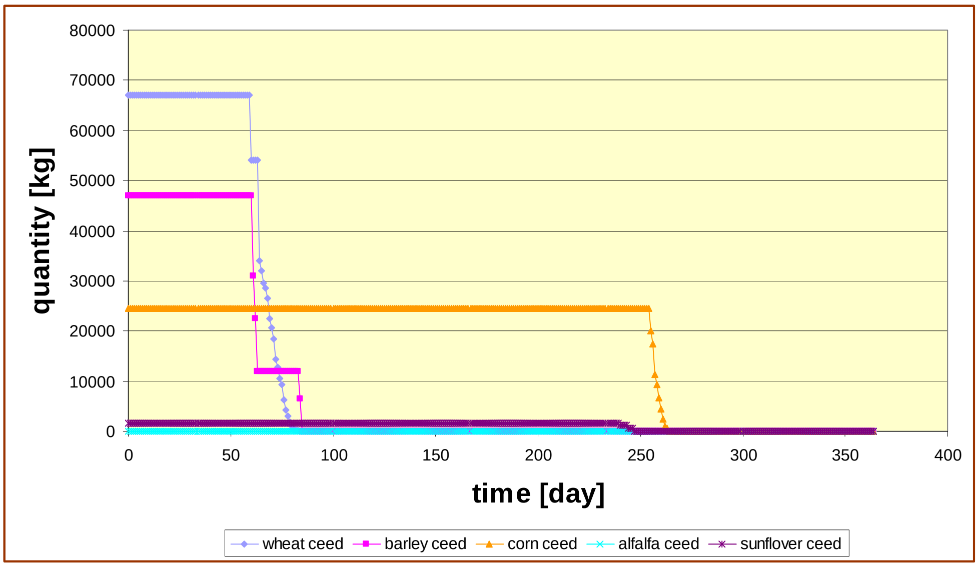
Source: Own calculation

It is therefore concluded that the detailed technology prescription paints more nuanced picture for the management about the functioning of the company, the peer-building processes and the consumption of materials and energy, finance, and labor used by the processes, and even their costs.

It is very easy to get information about the state of the company or a sector obtained from the simulation data. I can get reliable information for example, about the production material status in the horticulture sector. The 4th and 5th Figure shows an example of seed and grain store

4th figure

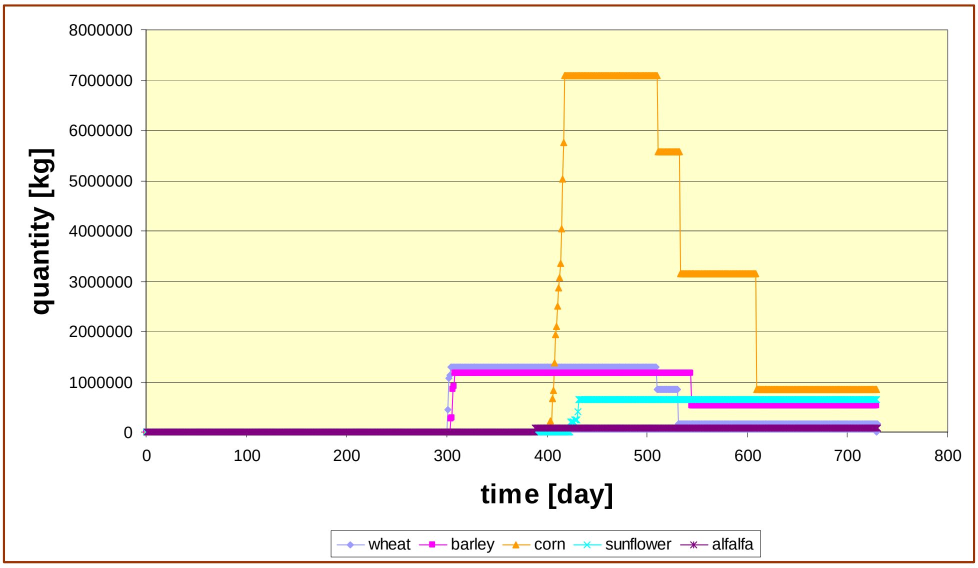
Seed-Stock Changes



Source: Own calculation

5th figure

Grain-Stock Changes

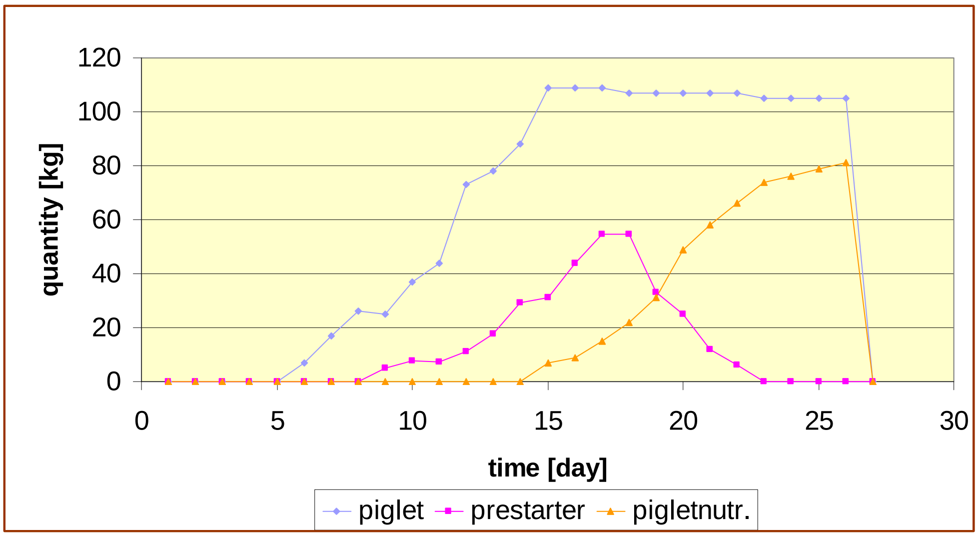


Source: Own calculation

The images are created by the information that you want to define the structure of the diagrams. Where appropriate, variable resolution data and a chart for several associated with the desired data sequence is also depicted. The significance of this is that to the decision-making processes necessary information is in a presentable state, of which the decision is the most appropriate support is provided. Visually more complex calculations (whether mathematical, statistical) analysis can form opinions without a process, or even a whole industry works, and its effectiveness. As an example I mention specific details of piglets in one of the halls of the dropping stall in one conditioning cycle (26 days). (Figure 6)

6th figure

Dropping room data

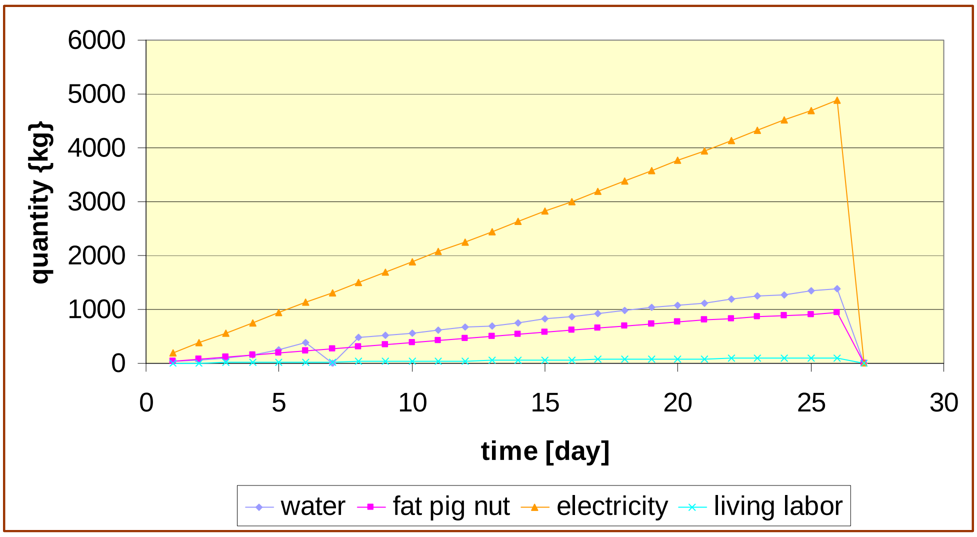


Source: Own calculation

On the 7th Figure can be seen the data of the sows and the observed conservation volumes in the same dropping room. The shown up characteristics allows at any time the determination of the production costs and the added value of the product.

7th figure

Conservation volumes in the dropping room



Source: Own calculation

3.5 Hypothetical studies

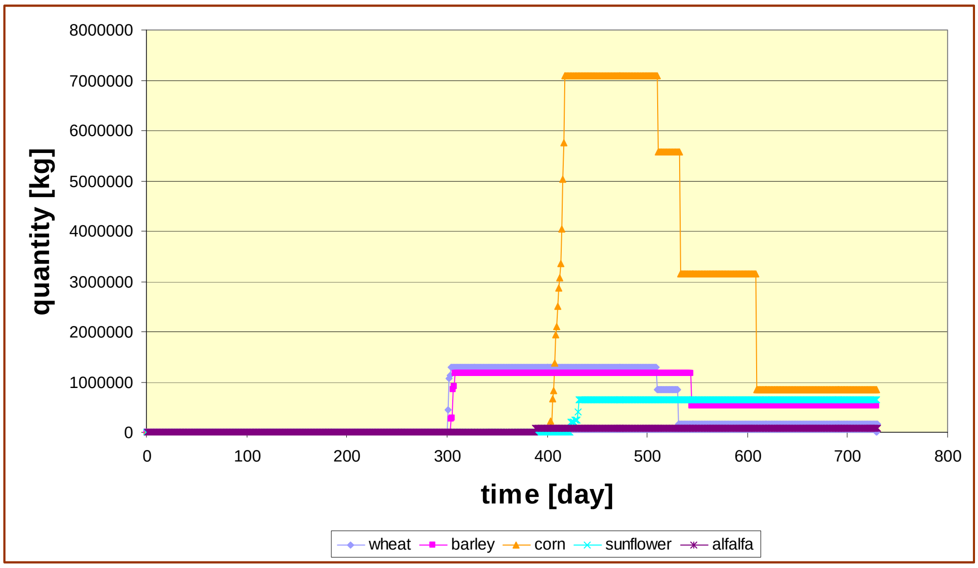
The great advantage of simulators is that, that we can do different studies, which in reality we can not or do not dare to try, in part, to the very high economic risk, in part because the production period is very long. In most cases, a farm manager spends a lot of time to find out, what steps are possible in an unforeseen (Vis Major) case the damage caused by the event or situation to compensate.

3.5.1 Hail

The tested simulator reflects well the functioning of the company. The question is, what it does, a situation which strongly interferes with the status quo: is it able to manage Vis Major events? One example: a strong hail worth of sunflower and corn stocks, the loss of the crop sunflower, 30% for corn, 40%. I wonder what possibilities is there that as soon as possible to stabilize the state company. In this case, the model is identical to previous examinations, thus maximizing the profitability of the company. The 8th and 9th Figures shows the change in the quantity of crop and cash-flow diagram (Figure 10) the crop selling income is significantly smaller. In this case, it is not calculated with hail-insurance.

8th figure

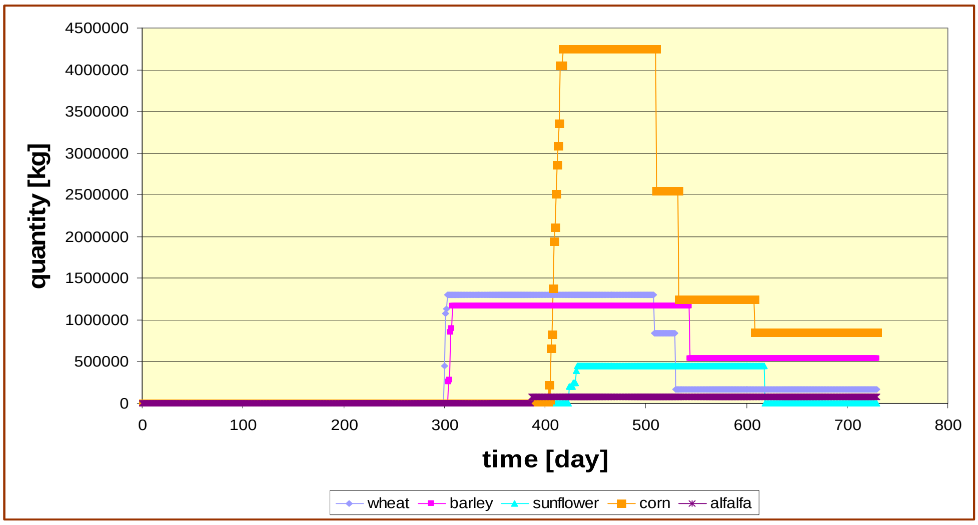
Grain stocks under normal operating conditions



Source: Own calculation

9th figure

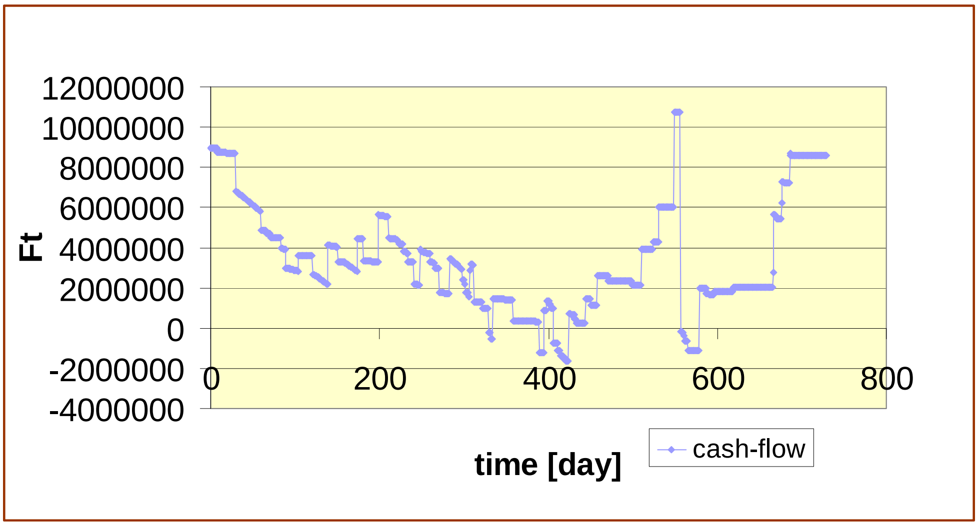
Grain stocks: Vis Major event is triggered



Source: Own calculation

10th figure

Cash-flow diagram in the Crop section: hail event



Source: Own calculation

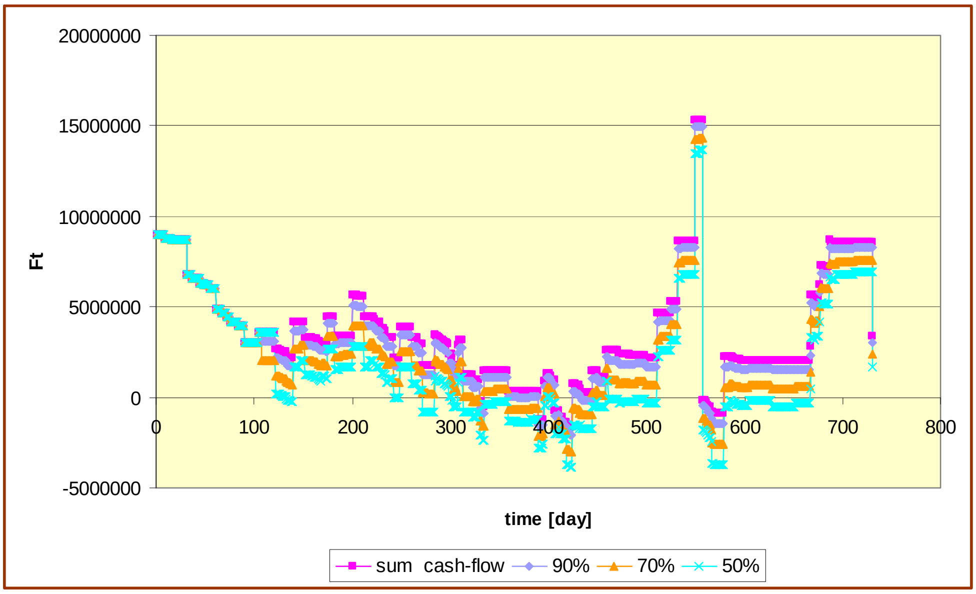
3.5.2 Changes in the purchase price of slaughter pigs

In this case, the animal husbandry reached crisis simulating, when the price paid for pigs sinks to 90%, 70% 50% from the 100th day in the simulation. This study is interesting in two respects. First, the sectoral point of view, so far in terms of liquidity, which is now a well-performing animal position, on the other, the whole company, that this revenue loss will affect the functioning of the company, what is the revenue decline, which he tolerated without any intervention by the Inc. Because in that simulation nothing has been changed but the price, I just analyze the interesting moments of the examination.

The 11th Figure shows the company's liquidity condition in the original notes. The figure presents clearly that the overall effectiveness of the sales price of pigs a 10% reduction, although reduced somewhat, but this has not caused serious liquidity problems. The 30% decrease is significant output resulting produced, and it appears that the economy still had a positive balance most of the year, but the 50% decline, especially in the second year it was almost cash flow disruption caused, apart from the periods in which the crop was realized results credited.

11th figure

The cash-flow diagram of the company with the influences of the livestock production



Source: Own calculation

Only analyzing the cash-flow in the company can be said that the simulator operation can provide reliable information for the management The figure also shows how bargaining position without having to go into that, it would significantly burden the economy and would put a dangerous situation.

3.5.3 Fusarium infection

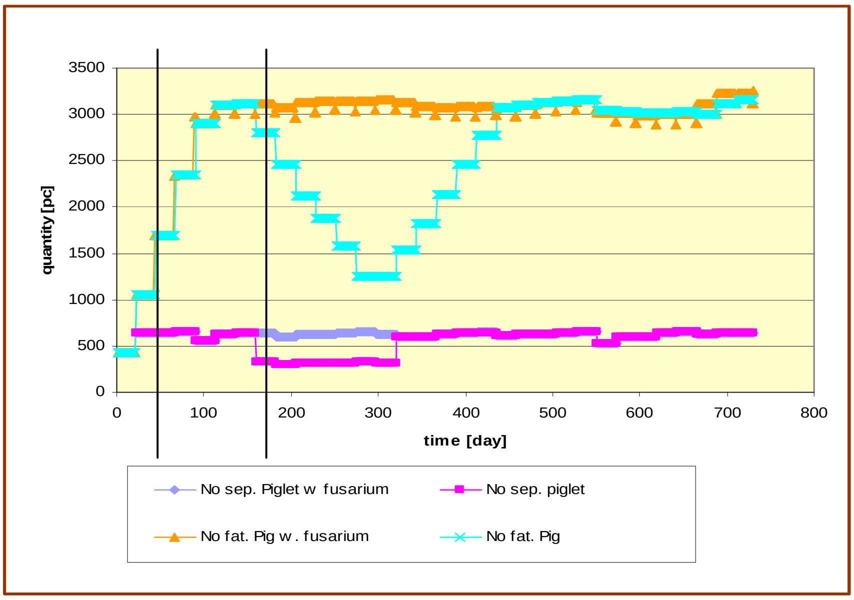
The following example I made a simulation for a greater complexity problem of the company. I tried to simulate the adverse situation that the harvested corn has been infected with Fusarium during storage. Since the 40th day of the simulation the corn was fed, the breeding prolificacy dramatically declined by 50%, and the stored corn could not be sold, so the revenue is not able to realize, drying, storage costs, however, are present in the system. The leadership of course, noticed the mistake and buys fodder, and from 180th day this feeds with that, which makes the company, starts to recover balances. The question is how much time is needed to restore the original production level.

The 12th Figure shows changes in the number of individual groups of animals. Vertical lines separate 40th and 180th days was also indicated. Clearly visible that in the diagram 'the number of piglets at the separation' compared to the 'the number of piglets with fusarium at the separation' decreased with the gestation time delay. Subsequently, the nutrition during recovery returned to normal operating levels. Livestock production is important in terms of turnover fattening stock also declined significantly over the previous period. The grading of the decrease is caused by the periodic regrouping of the animals this muster can not be seen at normal circumstances. With the recover of the prolificacy the curve is returns near to the normal operation level.

The financial result of the livestock production has a great change because of the significant loss of the livestock. Equally influenced by the outcome of both the crops of corn caused by fusarium revenue loss and, secondly, the company had to make up for the necessary amount of corn, therefore, additional funds were paid to buy corn. The 13th Figure shows the cash-flow graphs of the main sectors without and with fusarium infection

12th figure

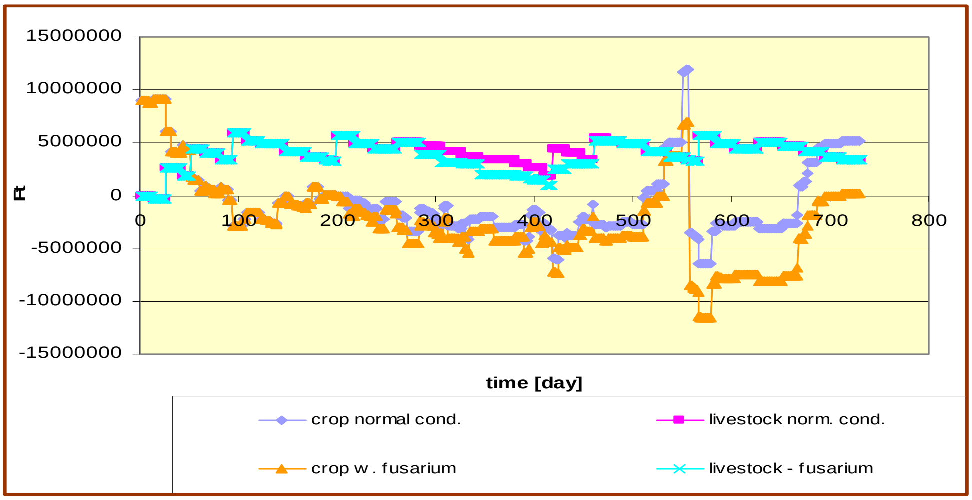
Livestock changes of the company



Source: Own calculation

13th figure

Comparing of cash flow diagrams of crop and livestock production



Source: Own calculation

The diagram clearly shows that the crop sector had a change earlier, because the contaminated feed for the animals need to be filled immediately after being stopped because of the perception of the leaders of the feeding of contaminated feed. Further reduction in revenue, is that the sell of the contaminated corn is impossible. The revenue sinking in the livestock production is caused by the selling of much lower volume of pigs. By the comparison of the sectors data, it is visible that the company's relative financial security has been upset by the Vis Major event, and only recovered slightly by the end of the second year. Against this background, it is considered that the simulator, with a well-structured model is able to supply data, which the management has information advantage. That means several circumstances can be tested, before serious decision to be made or a business plans drawn up.

4. Conclusions

The development of various simulation techniques ensures a growing potential for most of the production imaging process, in which the most important conditions are perfect under control. Most of the agricultural processes are non-compliant simulation subject, since the process of production is subjected to many factors of uncertainty.

The dynamic simulator supported by a generic algorithms is able to analyze the production process of products on that way, which is the same in all production processes, whether in agriculture (crops or livestock) or in industry. Previously I tried to show that the conservation values – based simulator is able to trace even very complex agricultural processes. As it presently stands, however, is not suited to the simulation of the processes observed in the full depth of examination. The reason for this is not precisely known, further studies are needed to determine. First, that there is a possibility to refine the sensitivity of the simulation, on the other there is any sense or mean- you have any kind of change in the simulation results, where they currently examining the production processes in high resolution.

Since the simulator is based on a completely non-specific algorithm virtually any process could be mapped using only a condition for the successful mapping of what exactly we are able to describe it. The simple user interface (Excel table) is to ensure ease of adaptation, on the other, an opportunity to further evaluate the data derived from mathematical and statistical evaluation programs to re-import.

Because of the process specifications based on the material- and energy flow, it is able to provide a very accurate snapshot of the production and products in any state. This allows even setting up an independent decision-making system. The simulator can be adapted in the regulation of certain automated processes. These can be built with PCs and non-PC (industrial) regulatory circles. Because the highly accurate simulation these management technologies would able to develop. In animal husbandry control of animal feeding systems or support of logistics systems could be solved. To do this, extensive studies are needed in several areas involving agriculture. The simulator is tested by the developers of sites supports this conclusion. User level ease of use allows anyone to use the simulator. The commonly used algorithm has a further advantage that the developed simulators of many experimental directions could be connected once like a modular system. After all, there are already livestock simulations, there are simulations of the animal's environment, there are simulations for a small farm, there is a farm simulation of the economic environment, and there are numerous other industrial, chemical product manufacturing ,process mapping. These parts organized to an independent system, a complex system simulator can be established, which examines in great detail and accuracy, and modeling processes, in which the aspect of simulation has not been connected before.

5. New scientific results

1. Based on a production processes of a working agricultural plant a simulation procedure was developed, which is easy to administer, and is able to reliably follow the virtual space to real production processes.

2. I built the application of an Agricultural plant simulation on a model establishing a decision support system, which can provide even in the practice useful information from examination of the factors influencing the effectiveness of the management (such as resources, technologies, natural factors, time)

3. I proved with my examinations that the generic simulator is suitable for handling Vis Major type events occurred in agricultural production.

6. Publications on the subject of the dissertation

- Takátsy T. – Csukás B. - Balogh S. – Lukács A. I.: Az állati metabolizmus makroszintű dinamikus szimulációja mérnöki alkalmazásokra. MTA Agrárműszaki Bizottságának Tanácskozása. Gödöllő, 2001. január 23-25
- Lukács A.- Takátsy T.- Csukás B.- Balogh S.: Baromfiistálló energetikai és makroszintű metabolikus szimulációjának tapasztalatai. Műszaki Kémiai Napok ’01, Veszprém, 2001. április 24-26. 248-253.p.
- Lukács A.I.: Állattartó üzem PC szimulációs modellje. K+F eredmények és feladatok a szlovák és magyar állattartásban Nemzetközi tudományos szimpózium Kaposvár, 2004.08.26 proceeding 73-77. p.
- Lukács A.: Állattartó üzem PC szimulációja. Gödöllő, MGI. Workshop. 2005.01.27.
- Lukács Aurél István: Mezőgazdasági üzem számítógépes modellje – poszter Multifunkcionális mezőgazdaság - nemzetközi tudományos konferencia - Hódmezővásárhely, 2008. április 24
- Lukács Aurél István: Mezőgazdasági üzem számítógépes modellje. Agrár és vidékfejlesztési szemle, 2008, III. évf. 1. szám ISSN 1788-5345
- Aurél István Lukács: New ways and possibilities in simulation of agricultural farm-processes. Acta Scientiarum Socialium, pp. 55-63 Kaposvár, 2008
- Károly, Szommer; Aurél I, Lukács: Set-up and comparison of dynamic simulation with different applications. Acta Oeconomica Kaposváriensis, p 75-82. Kaposvár, 2009