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APPLYING SIMULATION IN MODELLING A COMPANY'S ECONOMIC PROCESSES

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Abstract

Due to growing competition, companies' future orientation and future-oriented strategy have recently been appreciated. However, this presumes the existence of an appropriate company vision and more accurate knowledge about resources and possibilities of actions.

The subject of our research is scientific uncertainty which is one of the most important issues of economic and social sciences nowadays. Managers and company owners still have neither an exact method nor an indicator to tell which production factor to which extent can contribute to the organization's output, result and efficiency. Besides several concepts, theoretical bases, the question is still open in case of specific business activities. The solution to the problem is not unambiguous even for practical experts and managers who are familiar with economic processes. It is not evident which to analyse and which methods are used.

In a case like this, how we can expect that enterprises should create successful objectives and achievable vision in an accelerated competition?

In our work we examine a novel methodology which combines artificial intelligence with simulation modelling and tries to find limits of an arbitrary process, and to determine results of the possible combinations by modelling real life processes and testing virtual entities (orders, units of material flow, process objects).

In this article we focus on the unutilised possibilities of the process modelling. We do not create another cost optimizing algorithm but to search for new possibilities to utilize experiences of simulation experiments in practice.

Keywords

simulation, artificial intelligence, controlling, optimisation

1. Introduction

System Uncertainty

It is commonly accepted that results of business organisations depend on the combination of resources and the chosen strategy. Plenty of scientific approaches also suggest that processes can be predicted and optimised by profound researches of systems and better understanding of relations.

However, several factors support the fact which the interpretation of processes in complex systems is not always coherent; moreover, even results are not consistent in all cases. Forecasting the internal operation of systems and the critical factors affecting mostly the results can be difficult due to several reasons. The main reasons, which are the follows:

- In case of simple systems the operation of a system is predictable and easy to model and optimise physically and mathematically. As increasing the complexity of systems they become more and more chaotic, and the results depend less and less on predictable factors. In other words it is the so-called "butterfly effect" when connections of the separate events are form a complex system in which the separate states are not predictable by formal logical methods either now or later. Someone says what future "quantum" computers will solve this problem but there is no guarantee for that.
- Business systems as well as other systems have their idiosyncrasy which result of the system operation is determined not only by the kind of the object connections of the system but also by external effects (external disturbing factors) which usually can only partly be modelled or not at all (e.g. natural forces, instationary phenomena, competitors' reactions, human factor). In extreme cases the outcome might be unfavourable despite appropriate decisions and strategy due to external disturbing factors unpredictable and uninfluenced by decision makers.
- In the course of modelling systems we find a frequent phenomenon which reliability of a system model is sometimes not enough due to data uncertainty which is intensified by multiple data links and the model becomes useless. Due to the uncertainty of data, static theoretical and practical (experimental) models are often useless for managers; that is why the confidence level significantly decreases in methods.
- Mathematical and modelling difficulties. Today several types of modelling techniques are available (hyperbolic programming, convex-concave programming, quadratic programming, stochastic programming models involving uncertainty values and utility functions) although these methods handle a problem only from a certain point of view not by their complex combinations like in real systems. Furthermore a traditional way of modelling several coherences and target criteria is difficult or even it is completely impossible without excessive simplifications. In many cases even the formulation of the target criterion is impossible since the decision maker cannot formulate it without excessive simplifications because they involve factors and conditions

which cannot be merged or are antagonist or even cannot be measured.

- Nonlinear character of relations. Biological and social systems, consequently economic systems are not of self-consistent character [1] in every case therefore the reaction of the system is not predictable even we have full knowledge about it. Sometimes the system gives different reactions to identical events under identical circumstances. Changes may not happen incrementally, certain changes may not lead to a state change because the system is buffering until a certain level, and which is more certain effects may happen with time delay [2].
- Modelling paradox means the phenomenon when the more realistic model is less possible has to optimise (or to solve it for a given target function). If the accuracy of a model is not legging behind that of the real system, it is as impossible to solve as the real one. The dilemma of modelling is which the model should be simplified enough to work with while it should be complex enough to be worth considering its results. We call this dilemma is the modelling paradox.
- The trap of decision making means that we can accept or refuse the result of the optimising model, namely the proposal; there is little possibility to utilize the results partially. Optimising models do not pay enough attention to suboptimal solutions which are closed to optimal but not reaching that; yet in other terms they can be valuable since several relations that cannot be modelled can give reasons for them. If we interpret the relationships of systems in such a static way, even the best model does not be satisfactory for us.

Although the IT toolkit of decision support is widespread and diversified due to the factors mentioned above, their practical application does not reach the expectations even at a global level.

Business organisations try to interpret their own processes from necessity and they continuously try to improve their efficiency with obvious reasons. Despite these efforts they have to cope with several poorly structured (under informed) problems. To handle these problems, companies usually set up indicators and precedence's but they cannot be confident either about modelling or about answering questions. Solutions provided by indicators can give promising results; however, the adequate and expected results integrated into the factor of subjectivity do not seem satisfactory.

Validated real-time realistic data, solutions and alternatives to choose, which are supported by experimental results, are still missing; these could guarantee results and also provide further information in connection with the systems investigated.

Earlier several efforts have been made to find a solution for this problem, but only a few concepts were introduced which were able to raise the decision maker's activity level (association plane) and standard, which are the followings:

- The widespread balance sheet based approach can be used to improve decisions but the main problems are that data collection serves external interests and its aim is an accurate and reliable presentation and recording of the past instead of preparation for decisions.
- As opposed to the balance sheet based approach the cash flow based approach has the advantage of referring to a certain period instead of one moment in time. The measures of data are not so relevant rather the dynamics of their change and the extremes. Its disadvantage lies in being aware of that it is more difficult to decide which is to do in a given moment.
- Transaction following systems' great advantage is which they make possible for us to recognize important processes and help in ensuring possibilities to intervene. Their disadvantage is which they have distracted our attention from the objectives and strategy since the real target is not the process but the result.
- The great advantage of value stream mapping focuses on the importance of certain processes. Since value is in the focus the value has been creating ability of the whole system improve. However, the method does not tell us anything about solutions (resource combinations) which are better or worse at the level of a complex system.
- Proper allocation or optimisation of resources is good in local terms but at the level of the whole system contradictions and conflicts can take place while complex optimisation sees barriers of modelling (see above).
- Dilemmas of indicator systems (e.g. BSC [3]; ABC [4]; Controlling [5]; Performance Prism [6]) have been mentioned earlier (system reliability, modelling difficulties, etc.). In general, these methods can give answers to recognize problems rather than solving them.

There is still uncertainty about the question where exactly managers should intervene into processes and consequences, which should be expected. As for decision making traditional methods have the following deficiencies:

- traditional accounting and controlling mainly focus on the past, which mostly data-oriented;
- corporate problem and growth management focus only on individual subprocesses, are not holistic;
- specific and complex components of company output are either unmeasured or operated by rough theoretical models that do not have a dimension of practical or operative use.

Besides these traditional analytical or logic bases the interpretation and modelling have barriers not only due to general characteristics of a system but also human factors, which bring further uncertainty into systems expecting improvement.

Personal Uncertainty

When leaders of company have to operate and improve complex systems, they often make decisions to assume company organisation and especially its human factor, which do not affect on the consequences of the decisions. It is obviously not true in real situations. Participants' attitude towards decision making is personal relationships and motivation among the most important factors. It is easy to imagine that even a good action can result inadequate or unfavourable changes in case of participants' disinterest. Naturally it can happen that the other way round and so inadequate actions can bring partial success. In this latter case the principle of erudition cannot be applied and this can mislead the arrogant decision maker. Therefore the role of personal factors is important and cannot be neglected. The most important factors, which are as follows:

- The decision maker does not usually act rationally even if he intends to do something. Rational decision making is hampered by lack of information, needs of the moment, bottlenecks, limits, subjective attitudes and the contradiction, which state that making decisions are for future outcomes in the present based on current preferences.
- In many cases the decision makers' successful or bad experiences can detain the rational behaviour of systems. Objectives and decision making criteria should not depend on earlier positive or negative experiences.
- Decision makers cannot act absolutely rationally, because decision making, as the process itself and also the execution of decisions have economic sacrifice, which affects the choice among the decision alternatives.

As a summary, companies are not able to optimise their systems, or even in many cases to minimal discernment due to system characteristics, the participants' unpredictable attitude and the absence of normative conditions of decision making. Therefore we need to create a modelling technique that tries to solve the problem in a completely different way [7, 8].

2. Material and method

Conscious vision making has always played a role in the professional governance of business organisations, and this was mostly the task of managers. For a long time this has been sufficient which these visions existed only in the managers' mind. As the competition is intensifying, this informal way of planning for future is less and less sufficient. As the company develops and expands its scope of activity, the increasing competition and the changing environmental factors make demands for creating methods of structured planning.

Although strategic planning has the same objectives, reaching conscious and scientific results are difficult because of problems of chosen methods and system and personal uncertainties (see above). Large diversified companies often communicate that they perform better by using strategic planning consciously than without it. Nevertheless, even Mintzberg [9] and Meyer [10] criticised strategic planning:

- the process of strategic planning cannot be fully integrated into the operations of the company organisation;
- planning is sometimes inflexible because this detains quick changes in the plan;
- strategic planning separates the development and the execution of the strategy considerably.

In the next part we present the basic elements of the modelling technique developed by us; we recommend that as such kind of methodology to professionals facing with the same problems [11].

Novel Modelling Solutions

The interest of social sciences towards complex systems and non-linear models has been increased by the extension of computing capacities [12]. Corporate performance measurement and evaluation as well as planning and decision support (i.e. management) have key importance in every business organisation for it, which is a part of the control process in the company. In this article we put the emphasis on planning and decision support using a simulation methodology.

Simulation models are used worldwide. For example, Europe's Airbus Industries uses simulation for testing aerodynamics of their newly developed airplanes. The U.S. Army tests military actions with simulation "games". Business school students test their knowledge with business simulation games. Car manufacturers test their products with simulation instead of costly crash tests. Even ports are tested virtually under different loads in the phase of design. The world's most large enterprises use different kinds of simulation models.

A heuristic simulation model was used to optimise the processes with time limit in biomass production in agricultural areas as micro logistics systems [13, 14]. To realize Just in Time, work has to be organised taking into consideration the possibility of both cost minimisation (economical operation) and finishing tasks within optimal time limit. Briefly, plant cultivation process has to be optimised. The optimum can be found by the coexistence of minimum cost and time limit.

Simulation is a mathematical and/or logical model which can reflect the best original system in operation from certain point of view. Another essential element in the interpretation of simulation is the possibility to perform sequential experiments with the helping model in a virtual environment in order to assess the effects of different interventions. The basic idea of simulation can be split into three parts (steps):

1. mathematical-logical mapping of real situations,
2. then educational system specialities and functional characteristics using these models, and
3. finally making conclusions and decisions of actions based on results of the simulation experiments [15, 16].

The decision maker can apply simulation in a given situation "… to rationalize existing systems, or to design creating new (sub)systems" [17]. Common purposes of application are the follows:

- to avoid of planning errors in case of complex systems;
- to compare (expected functioning of) alternative plans in realistic environment;
- to determine maximum and marginal performances (bottlenecks) for a certain system;
- to forecast operational dysfunctions and to investigate possibilities of their elimination [18];
- to test and induce proposals for kaisen development;
- to prepare strategic decisions by getting (practical) experiences that could have been obtained in real life only through decades of active involvement, or it would risk human lives or extremely large amount of capital.

Due to the variety of problems, the build-up of simulation is evidently various, however, there is always a concept which can be set up (standardized) for different cases. Figure 1 below shows that the so-called simulation core or in other terms the system model fits a framework which seems to be standard. The system model can exist in several different varieties such as Monte Carlo Simulation (simulation of randomized state), genetic algorithm, or neural learning system or even an optimising linear programming model [19, 20, 21].

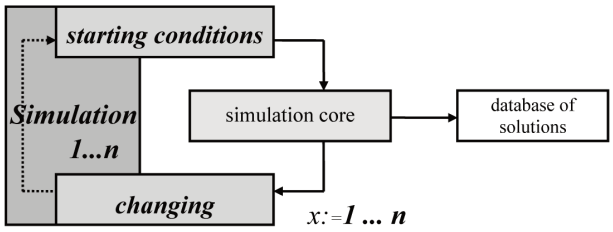

Figure 1. The theoretical build-up structure of a multifunctional simulation

1. In the general model the simulation framework program makes possible not only "stepping" a variable simply but also changing more "coefficients" (conditions) together at the same time in a programmed method regarding the research goals determined initially.
2. Data obtained in the model can be made visual or present in a number of methods, for example in the form of raw data, multi-dimensional collecting graphs, dynamic graphs, charts, structural diagrams, virtually generated pictures, animations, virtual reality (VR) simulation.
3. In the course of feedback we start a dependent or independent cycle. In the case of independence the individual cycles make use of the "brutal power" of IT (e.g. randomized states), otherwise we can get models developing in certain directions based on the advancement of "heuristics" or "artificial intelligences". In this latter case an adaptive model can be envisioned in which the results obtained in the cycle make an impact on the starting conditions of the next round.

Main phases of creating and building up simulation of economic processes, which are as follows:

1. Research work: Analysing and mapping the processes of the system involved (data collection, interview, value stream, semantic and numerical analysis). In this phase of being aware of the mapped system we attempt to determine goals of the simulation. It can easily and often happen that it is later modified during modelling or model use.

2. Modelling: Creating and background programming a specific process simulation model, its parameterisation, forming definitions at model level. By testing the model systematically and programming agents at several levels a balanced model takes place which virtually represents results obtained in reality. Modelling continues until it becomes capable of being validated, as comparable with the operation of a real system and its results as data.

3. Model use: Executing "process" research with analysing simulation cycles, discrete event simulation with different conditions. In relation to the effects of agents on each other analysing the utilisation of given resources, limits and bottlenecks, economic forecast. In using a model new questions and building up new model variants can occur depending on demands. In this phase using a model decision support work and learning process are going on. Continuous result evaluation and analysis also take place.

4. Working out new applications, methods, procedures consisting of forming proposals, creating new models, observing regularities, making inductive conclusions and decisions, creating inductive theories.

Different interpretations of goals in the simulation of economic processes

There is a significant new difference in the approach towards the simulation of economic processes [22, 23], which is in many cases due to problems of modelling mentioned earlier and especially decision making, which we are not looking for somewhat ideal state (see system uncertainty and personal uncertainty). In the area of technical sciences (planning, operation, logistics, electronics etc.) we create a simulation with a purpose of finding a seemingly ideal combination or a much better combination than a satisfactory solution. In case of economic process modelling or simulation we experient that there is a much more substantial goal of putting the decision maker into a real decision making situation by recognizing (and visualizing) the real character of problems, and obtaining experimental experiences.

With the help of the method the sensitivity areas of solutions and the limitations of their more intensive changes can be followed. This new approach can be seen as a great advantage of our method. With proving this approach the main goal is to examine the location of solutions (in many cases "suboptimal" solutions) being realized among different conditions, their mutual relations, critical domain, and to widen the professional knowledge of the participants in decision making in favour and more satisfactory attitude (Figure 2).

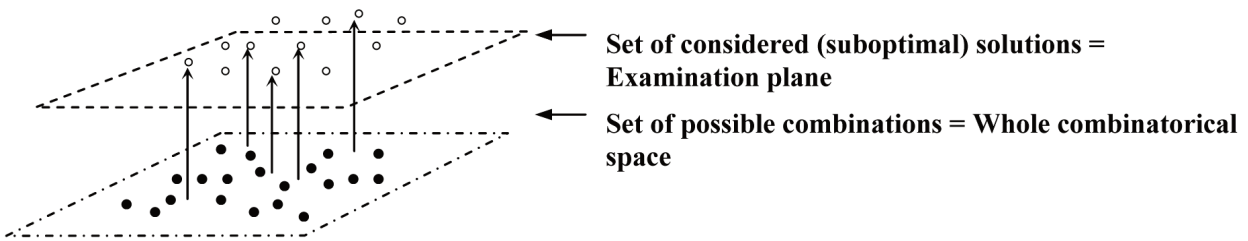

Figure 2. Lifting up possible "solutions" from the combination space

Simulation technology itself has not been a new approach since simulation technology as an analytical method remarkably conquered some areas of industry in the last decade, moreover in social sciences various system dynamic models appeared in measurement. In our opinion the simulation modelling, namely a complex modelling of economic processes (covering not only technical processes) is ready for widespread use in the future. Simulation is available for modelling real processes, flow analysis, observation as well as manipulation.

A novel interpretation of time factor in simulation of economic processes

Usual quantitative methods focus on state-like examination of individual process characters and key indicators assessing the initial situation and then by interventions they describe the changed state characters. This kind of static examination satisfies most of the needs for analysing which is a revolutionary event as opposed to situations without measurement. For creators of decision supporting systems or systems calculating (optimising) or forecasting a certain future state, it is a frequent critical view that the later real state did not reflect the earlier planned and forecast state. In these cases it is difficult to defend the professional point of view which holds that factors changed in the meantime due to forecasts or regardless of them.

However, the problem is actually more difficult than that since at those points of analysis where results of the initial state and the endpoint were determined the analysis can be correct; the conclusions can be acceptable while reality is of different nature though. The main reason for that is the basic nature of time dimension. When time moments of a continuous phenomenon undergo an analysis then we truly force a discrete approach to a continuous phenomenon together with its errors. In a case like this either at analysis level or at decision making level there was no information about which really happened in the given process among individual points of time.

This problem can be solved theoretically if we have a great number (greater than usual) of measuring points in time for each and every result indicator. This task is almost unaccomplished in most of cases such as analysing a process of 6 months fragmented into seconds. One of the greatest advantages of our simulation methodology lies in the fact that it can examine time factor dynamically and not as a series of snapshots. Agents forming a process, elements of a process, resources and latent factors together affect the entities of the process; they can cause changes happening in quasi real time and can be observed in real time or slowed down, or speeded up. With our modelling method we try to visualise dynamics, which can present the nature of processes with great accuracy. Speeding or slowing time factor results new discoveries just like in biology. Think about growing trees and plants or the micro world of quantum physics (see more detailed in case of small and medium scale enterprises [24].

Time factor has another advantage in the course of analysis in a simulation environment, namely modelling the changes of agents. During going ahead in the process the agents participating in the process can iterate with each other, develop or decline, their characters can be modified. Great numbers of agents, probability distribution of outcomes, and their variability in time can be modelled by a dynamic framework, which is capable of analysing

and representing the time factor of the process. In our opinion this should be made visualised for the decision maker.

Novel interpretation of interactivity in simulation of economic processes

The other novelty in our approach is interactivity. Usual analysing methods are capable of creating different variants by changing initial parameters, and certain sensitivity analysing tasks can be done by changing parameters among steps and recalculating models. However if there are more changing parameters and they are able to take a value changing with time then it is rather hard to find appropriate tool support for the analyses.

A novelty of the method applied by us is that the user can intervene in running a given model in real time so as the result of intervention certain components of the operating process are altered while the process does not start again but run considering the new settings. As opposed to static systems its importance occurs in a way that the venue and complexity of different interventions, and their impact on the results cannot be interpreted in another way.

Combining discrete event simulation and multi-agent modelling

Agents and agent architectures are artificial creatures which have individual characters, and consequently they are capable of behaving and making decisions at a certain level. An important feature of agents is that they can show not only different behaviours but they also react on the simulation environment or their characters can develop with time. It can be solved by help of the latest modelling techniques that classic discrete event simulation should be combined with agent type of modelling with which we are able to create a simulation closer to reality. A combined simulation has a greater importance in those cases where human factor is considerable as opposed to relative estimate of technical processes.

Case study: Call Center

Representing the principles above we describe the structure of a simulation model with the following example.

Logical bases of the model

Customers call in with various problems, the arrival process of calls shows Poisson distribution. The intensity and type of incoming calls can be changed. The average service time per a call is also changeable. Waiting in line takes place according to a priority based on the types of cases but this priority is increasing by time (Figure 3).

Agent and DES (discrete event simulation) based combined simulation

Customers are agents whose rate of upset is ooted in their individual characters.

Customer – agent: has different upset numbers in different groups. Upset is increasing during waiting and also depends on the type of the case. A customer agent may have several characters which determines his behaviour as well as the process (Figure 4).

Main customer features determining their characters:

1. Sex (male, female)
2. Time of call in (time of the day, a day of the week, time before or after a public holiday, situation after vis maior …)
3. Time of customer's waiting (how much upset he will be – being graded)
4. Type of the case (case of type A, B, C)

These factors determine which they have behaviour features. For example a female is waiting long on Monday, her upset number is around 5; if a male comes with a case of type 'F' on Friday afternoon, then he is calm, his upset number shows lognormal distribution between 1 and 3. Colleagues are also agents, they are calm at the beginning but can become upset if the customer is upset or they have a lot of cases to manage in a short period of time; they have performance dispersion for every case type.

Co-wokers are also agents whose characters are affected by demands of customers. Customer service representative – agent: if the customer is upset, then the representative will also be upset; his performance dispersion is getting worse and the customer service process becomes longer which is more expensive, the own cost increases, customer satisfaction (as a KPI) goes down. If a customer is too upset or is waiting too long (this is the maximum of his waiting), then he hangs up and the case will be unserved. However, the case served may be effective or ineffective depending on the case type and the rate of upset. The effective cases can be satisfied or dissatisfied.

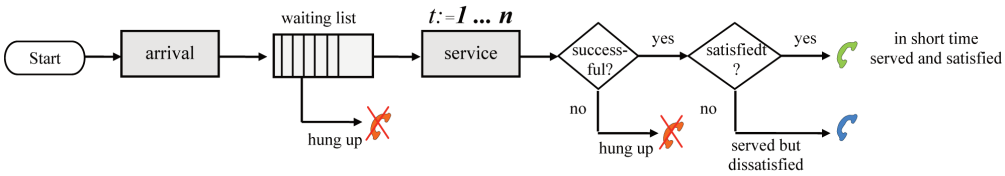

Figure 3. Call Center process

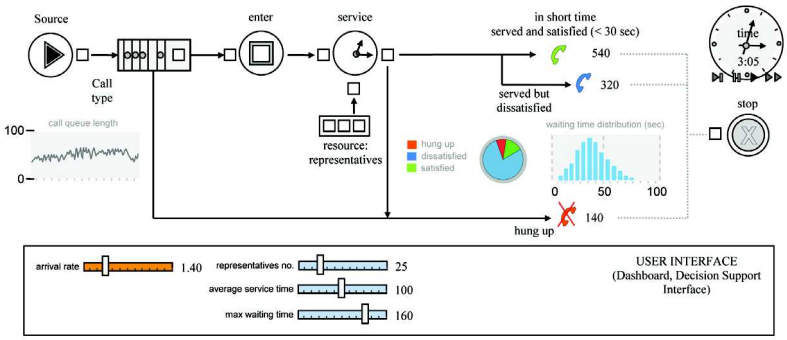

Figure 4. Interactive user interface of the simulation

3. Conclusion

Analysing the methodology above we see different interpretations of goals, a novel modelling accomplishment of time factor and interactivity as a methodological result. Our practical experience proves that simulation models built up along the principles above lift the work of managers of complex systems, chief executives and decision makers up to a new level. Although we have created a simulation methodology, the end result is an interactive surface running online on the Internet; it became a decision support tool in the hand of an experienced leader with which he could solve the problem dynamically even he also could interpret it at a new level by expanding his knowledge, he could ask new questions which have not been apparent so far concerning the given problem.

With the help of the solution the decision maker was able to analyse the operation of his complex system in a new dimension, he obtained new observations and experiences while he did not risk the owners' capital and performance. We are sure that this is a direction for the future by all means and every company leader directing a system complex enough needs a system like this, and he can discover totally new limits of competitiveness on his own meanwhile modelling and an older approach of (quantitative) optimisation can mean an intermediate step here.

References

[1.] Fogarassy Cs., Horvath B., Kovacs A.: 2015. Cross-sector analysis of the Hungarian sectors covered by the Effort Sharing Decision – Climate policy perspectives for the Hungarian agriculture within the 2021-2030 EU programming period. Applied Studies in Agribusiness and Commerce – APSTRACT Vol. 9. No. 4. pp. 17-24. http://dx.doi.org/10.19041/APSTRACT/2015/4/2

[2.] Zéman Z., Bárczi J., Hajós L., Zsarnóczai J. S.: 2014. Special conditions' Hungarian method of 2008 credit crisis. SYLWAN Journal, Vol. 158, Issue 5 of the Journal, the 3. Section, pp. 1-27. ISSN 0039-7660. Indexes: Science Citation Index Expanded, CAB International, and Polish Scientific Journal Contents. Ul. Bitwy Warszawskiej 1920 R NR 3, Warszava, Poland

[3.] Kaplan R., Norton D.: 1992. The balanced scorecard – measures that drive performance, Harvard Business Review, January-February, pp. 71-79

[4.] Wimmer Á.: 2002. Üzleti teljesítménymérés (Measure the output of firm) – 17. sz. Műhelytanulmány HU ISSN 1786-3031 pp. 1-48 Budapesti Közgazdaságtudományi és Államigazgatási Egyetem, Budapest.

[5.] Perényi Á.: 2004. Vállalati stratégia és teljesítménymérés. Strategy of firm and output measure. "Fiatal regionalisták IV. országos konferenciája" 2004. november 13-14. Győr.

[6.] Neely A., Adams C., Crowe P.: 2001. "The performance prism in practice", Measuring Business Excellence, Vol. 5 Issue 2, pp. 6-13 http://dx.doi.org/10.1108/13683040110385142

[7.] Joutz F. L.: 2001. 20/20 Foresight. Crafting Strategy in an Uncertain World. Boston: Harvard Business School Press http://dx.doi.org/10.1016/S0169-2070(03)00033-5

[8.] Csaba L.: 2009. This is a Great Crisis (In Hungarian) In: Enkler, A., and Rosonczy, I. Esseayes of the year. Budapest: Antológia. Magyar Napló

[9.] Mintzberg H.: 1994. The rise and fall of strategic planning. Free Press, New York

[10.] Meyer K. E.: 2009. Thinking Strategically during the Global Downturn. AIB Insights, 2: 3-7.

[11.] Fodor P., Kiss T., Poór J.: 2011. Focus on the Impact of the Economic and Financial Crisis on the Human Resource Function – Four Eastern European Countries in the Light of Empirical Research in 2009. Acta Polytechnica Hungarica Vol. 8, No. 1, 2011., pp 1-27

[12.] Kovács B., Takács K.: 2003. Simulation in social sciences. Socilogical Review 2003/3

[13.] Tégla Zs., Hágen I., Holló E., Takácsné-György K.: 2012. Adoption of Logistic principles in Woody-biomass energy clusters, Review of Applied Socio-Economic Research, REASER 4 2012 (Volume 4, Issue 2/ 2012), p. 236 ISSN: 2247-6172; ISSN-L: 2247-6172

[14.] Loum A., Fogarassy Cs.: 2015. The effects of climate change on cereals yield of production and food security in Gambia. Applied Studies in Agribusiness and Commerce – APSTRACT Vol. 9. No. 4. pp. 83-92. http://dx.doi.org/10.19041/APSTRACT/2015/4/11

[15.] LaRocco L. A.: 2010. Thriving in the new economy. John Wiley&Sons Inc., New York

[16.] Lucas R.: 1976. Econometric policy evaluation: a critique. Carnegie-Rochester Conference Series on Public Policy, 1: 19-46.

[17.] Illés B., Tamás P.: 2014. Simulation of Logistics Systems in case of vehicle companies. Logisztikai Híradó XXIV évf. 1. szám 2014 febuár pp. 35-37

[18.] Muraközy L.: 2009. Today is past of the future. Budapest: Akadémiai Kiadó.

[19.] Gyenge B.: 2001A. Cardinal factors of developing Decision-Supporting Systems. Gazdálkodás 2001/1 XLV. évfolyam pp. 57-68

[20.] Gyenge B.: 2001B. Application of decision making systems in agricultural sector especially for the simulation and expert systems. PhD Dissertation, Szent Istvan University, doktori értekezés, SZIE Gödöllő p. 142.

[21.] Gyenge B.: 2001C. Possibilities of the integrated application of the linear programming models and the simulation studies in nitrogen loss, Gazdálkodás 2001/3. Supplement. XVL. évf. 9 p. pp. 89-98 ISSN 0046-5518 Index 25341

[22.] Fogarassy Cs., Nabradi A.: 2015. Proposals for low-carbon agriculture production strategies between 2020 and 2030 in Hungary. Applied Studies in Agribusiness and Commerce – APSTRACT Vol. 9. No. 4. pp. 5-16. http://dx.doi.org/10.19041/APSTRACT/2015/4/1

[23.] Fogarassy Cs., Horvath B., Szoke L., Kovacs A.: 2015. Low-carbon innovation policy with the use of biorenewables in the transport sector until 2030. Applied Studies in Agribusiness and Commerce – APSTRACT Vol. 9. No. 4. pp. 45-52. http://dx.doi.org/10.19041/APSTRACT/2015/4/6

[24.] Poór J., Kiss K., Gross A., Francsovics A.: 2007. Development of SMEs in Light of an Empirical Study. Vezetéstudomány, 12.: 35-43.