University of West Hungary
István Széchenyi Management and Organisation Sciences
Doctoral School

MODELLING, PREPARATION AND IT SUPPORT OF DECISION MAKING

Thesis Booklet of Doctoral (PhD) Dissertation

Prepared by
Viktor Nagy

Sopron
2012

Doctoral School: István Széchenyi Management and Organisation
Sciences Doctoral School

Head of Doctoral School: Prof. Dr. Csaba Székely D.Sc.

Programme: Business Economics and Management

Programme Manager: Prof. Dr. Csaba Székely D.Sc.

Supervisor: Dr. István Szűts C.Sc.

…………………………………...
Supervisor's signature of approval

1. Objectives and hypotheses

From consumption-related personal decisions to strategic corporate and political decisions, decisions are always made by a person or a group of people. When making a decision, this person or group estimates the impact of their decision on unknown future states. Their choice, aiming to reach a specific goal or outcome, is obviously influenced by potential future states. In a static case, there is a clearly defined goal, while in a dynamic case, the goal may continuously change already in the decision preparation phase. With respect to this, potential future states should be identified and it should be decided whether it is possible to identify all of them in a given situation. On the other hand, the probability of these states should also be considered. Decisions are made after careful consideration. If future states or an appropriate range of potential states is known, the next step is to make a preliminary assumption on the probability of their occurrence. It can be done based on relative frequency, personal impressions, experience, beliefs or using various forecasting methods.

As a first step of my dissertation, I measure the attitude of people in situations when the distribution of the probabilities of states

determining the outcome is totally unknown. I also check the existence of a pessimistic attitude in these cases.

> H1: When no information is available on the probability of states of nature, but the combined result of various alternatives and states of nature is known, most people tend to adopt a pessimistic attitude.

Attitudes cannot be reliably estimated based on a single choice situation. Therefore, two equivalent situations are set up. If the respondent of the questionnaire has the same personal attitude in both cases, this attitude can be considered stable and can serve as a basis for determining the validity of hypothesis H1.

Decision makers cannot make perfect decisions due to their human nature. Mistakes can be caused not only by lack of preparation (objective cause), but also by many other (subjective) reasons. The decision making process may include cognitive errors, distortions, or limited thinking capabilities. These factors can prevent decision makers from making the right choice, or they generate inconsistencies that have been researched and identified by many. Nevertheless, research has always focused on proving the existence of a specific type of potential mistake. In my research, I attempt to

prove the existence of distortions related to personal decision making in new situations, and I also identify how a rise in the number of such pitfalls impacts the number of inconsistencies.

> H2: With the number of pitfalls rising, that is, adding more potential errors, the total number of inconsistencies increases at a decreasing rate. That is, the cumulative (relative) frequency of inconsistencies shows a logarithmic curve.

The scope of my research prevents the analysis of a large number of pitfalls. It is critical to keep respondents interested so that they will not be bored and stop answering questions half-way through the questionnaire. As a result, I studied only an acceptable number of alternatives. My research includes up to six cases when inconsistencies can be identified in decision-making. The validity of hypothesis H2 is determined based on these six cases.

Strategic decisions are milestones for a company's future. They can make or break its success in a competitive market. High barriers to entry (expertise, capital, special tangible assets, etc.) may lead to oligopoly (e.g. banks or mobile operators). Market players continue to compete in an oligopoly market. In this case, they sometimes need

to make strategic decisions to maintain the status quo of a distorted competitive environment – and keep pace with technology growth (e.g. the launch Internet banking). For this, market players need to use resources. The next hypothesis of my dissertation is related to these factors of production.

> H3: Information is a new addition to the list of common factors of production (labour, capital, land or natural resources, entrepreneur and entrepreneurial skills). Information plays a key role in strategic decisions.

Scarce resources are always valuable. The value of the various factors of production can be expressed in money as a general equivalent (value measurement function) more or less accurately. It is especially valid in manufacturing but also applies to services (e.g. call centers, teleworking) where the demand for cheap labour overcomes geographical barriers. Obviously, factors of production can substitute each other, which adds some uncertainty to the verification of hypothesis H3. If it can be proved that the new factor (information) is generally available in smaller quantities than one of the four "common" factors, hypothesis H3 can be considered verified.

Human participation is critical in decision making. The possibility of modelling human thinking can be neither confirmed nor fully rejected. Neural networks and fuzzy systems are attempts in this direction. Decision support systems, in the strict sense of the word, are no longer confined to IT systems generally termed as decision support systems. The dissertation gives a precise definition of the above terms. The concept of decision making systems has broadened to include all kinds of information systems supporting corporate decision making mechanisms at any level. This is mostly due to the fact that some corporate processes cannot be fully separated from each other, which has caused overlaps in their support systems. Sometimes these systems are based on each other or they run on parallel tracks.

The resolution of less structured problems or ill-structured ones can be clearly supported by various IT systems, but the final decision always comes as a result of human approval. IT systems used to prepare and support decisions can be considered models trying to simulate real-life situations. As no model fully describes reality, simplification is required. Another reason for simplification is that calculations are extremely time-consuming even using a computer. Consequently, results should be treated with some reservation.

Nevertheless, the general consensus is that people need to make decisions rather than choices. This is what hypothesis H4 is about.

> H4: As for the IT systems used in decision support, points can be identified where human supervision and intervention are essential and the person's role is not limited to choosing between alternatives.

Although hypothesis H4 is general in nature, its verification would require the analysis of a huge number of decision support systems. Instead, I attempt to generalise the specific case of a fairly complex system and use it as a basis for setting up a model.

In line with the above, the dissertation first highlights the bounded rationality of human behaviour and thinking and potential distortions. Then it analyses a complex system to prove that human decision makers are essential when using decision support systems.

2. Scope, method and justification of research

Because of the nature of the preliminary hypotheses, secondary research should aim to synthesise normative and descriptive approaches and review literature from an interdisciplinary perspective.

The primary research approaches the hypotheses of the dissertation from two distinct angles. Qualitative research conducted at MOL Nyrt. is based on both interviews and personal involvement. To make comparisons for the questionnaire-based quantitative survey, the skills to use normality tests and the relevant statistical hypothesis tests are required. To measure the attitude to uncertainty, experience with the methods is required in order to measure the stochastic relationships between the factors, as well as with the analysis of matrix games against nature. The logic of transitive ranking applied to the three factors should also be evaluated.

3.   Research findings

In secondary research, I review Hungarian and international literature to demonstrate how the traditional rational approach shifted towards a model of bounded rationality. I present the findings of many experimental studies supporting this new approach and conduct primary research to show decision making anomalies in new situations. I also describe two-player symmetric games with two-variables as a useful methodology to predict attitude.

I also study decision making under risk and uncertainty, and how decision-making is influenced by information and time. Having reviewed the relevant literature, I present the general role of these factors based on the findings of my own primary research.

I also study the role of IT systems supporting corporate decision-making versus personal consumption decisions. Using my own research findings, I set up a model to reduce uncertainties in such decision making situations and identify the points of human intervention in the decision making process.

3.1. New scientific results

The new scientific results of the dissertation are based on a comparison of the primary research results and the initial hypotheses.

> H1: When no information is available on the probability of states of nature, but the combined result of various alternatives and states of nature is known, most people tend to adopt a pessimistic attitude.

This hypothesis can be verified based on the questions of the questionnaire survey. One of them is related to a financial investment, while the other is related to an agricultural production scenario. Both scenarios have states of nature on which there is no information available. In the first case, it is the unpredictable change of share portfolios, while in the second case it is weather events. The number of states of nature and available alternatives, as well as the payoff of their combinations, are known in both cases. The values are simple amounts that can be appropriately judged by anyone. The two cases are virtually equivalent. Respondents of the questionnaire had to choose from 5 alternatives (less than the magical number seven by Miller) considering 5 potential states of nature. In this way, the transparency and comprehensibility of the task were guaranteed. The

answers given to the two questions were comparable in 433 cases with 166 persons changing their behaviour. In 267 cases, respondents had the same propensity to risk, whose distribution was used to verify the hypothesis. 28 respondents made a choice according to the Wald criterion (10.49%), which indicates a pessimistic attitude. None of the participants demonstrated a purely optimistic attitude in the modelled situation. 199 people (74.53%) behaved according to the Hurwitz criterion (α=0.2-0.6), 36 people (13.48%) behaved according to the Laplace criterion, while 4 people (1.50%) behaved consequently but not according to these criterions.

Based on the above, hypothesis H1 is not supported by the result of 10.49%; that is, H1 should be rejected. It can be concluded that the vast majority of people (74.52%) make their choice based on some kind of a combination or weighing of the best-case and worst-case outcomes. They may pursue different kinds of thinking but their choice is still based on the Hurwitz criterion.

H2: With the number of pitfalls rising, that is, adding more potential errors, the total number of inconsistencies increases at a decreasing rate. That is, the cumulative (relative) frequency of inconsistencies shows a logarithmic curve.

This hypothesis can be verified based on the combined analysis of several questions included in the questionnaire. The first possibility of inconsistent decision making is when people change their behaviour; that is, they choose a different alternative in matrix questions measuring risk propensity. The second possibility for an anomaly is when general opinion about a superior exceeds (or falls short of) the best (worst) result of judgement based on professional or human qualities. The third area is non-transitive answers given in a decision space applied to a choice between pairs of factors; that is, preference ranking between information, time and capital. The fourth kind of inconsistency stems from the fact that there is a contradiction between a) the relation established based on the availability of information and time in percentage terms and b) the preference ranking of the scarcity of time versus information. The fifth and sixth inconsistencies are related to decisions made under pressure or coercion. If there is an overlap between the ratios of regretted and successful decisions, that is, the sum of the two is more than 100%, there is distortion. Actually, these are two inconsistencies, as internal and external pressure can be studied separately.

The potential inconsistencies and distortions are analysed both in a breakdown by positions and in a cumulative way. This analysis

produces a function rendering the cumulative (relative) frequency of inconsistencies as per Figure 1.

Figure 1: Cumulative relative frequency of inconsistencies
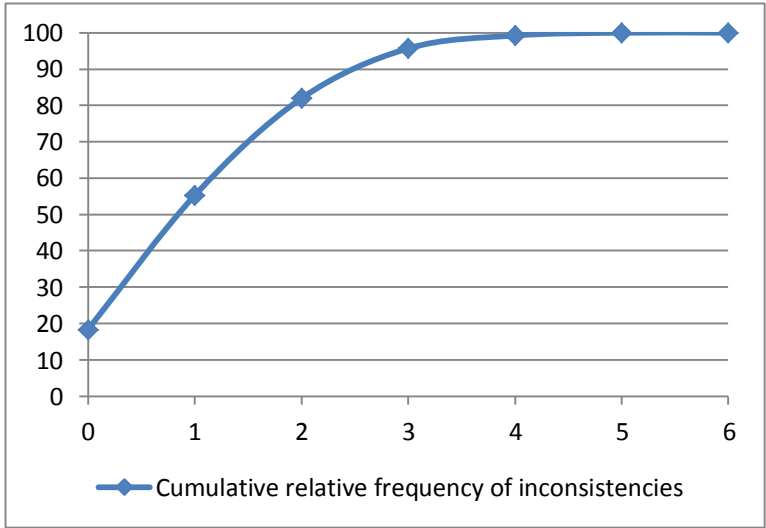
Although the number of inconsistencies is discrete rather than continuous, the individual cumulative relative frequency points can be connected to better visualise results. Based on this, hypothesis H2 can be accepted. The rising number of pitfalls increases the number of mistakes by a decreasing rate. The function clearly shows a logarithmic curve (with a base higher than 1).

H3: Information is a new addition to the list of common factors of production (labour, capital, land or natural resources, entrepreneur and entrepreneurial skills). Information plays a key role in strategic decisions.

Information as a newly assumed factor of production was paired with capital for comparison in the dissertation. I decided that if respondents confirm that information is a scarcer resource than capital, the hypothesis can be accepted. According to 60.18% of respondents, information is a scarcer resource than capital. Consequently, information can be considered as a factor of production. Note, however, that it is unclear what would have happened if information had been compared to land or labour. This can be the subject of future research. In light of the above, hypothesis H3 can be accepted.

H4: As for the IT systems used in decision support, points can be identified where human supervision and intervention are essential and the person's role is not limited to choosing between alternatives.

This hypothesis can be verified based on the complex analysis of MOL NyRt.'s XPIMS system. The dissertation identifies the points of human intervention and supervision.

Figure 2: The scope of human intervention and supervision
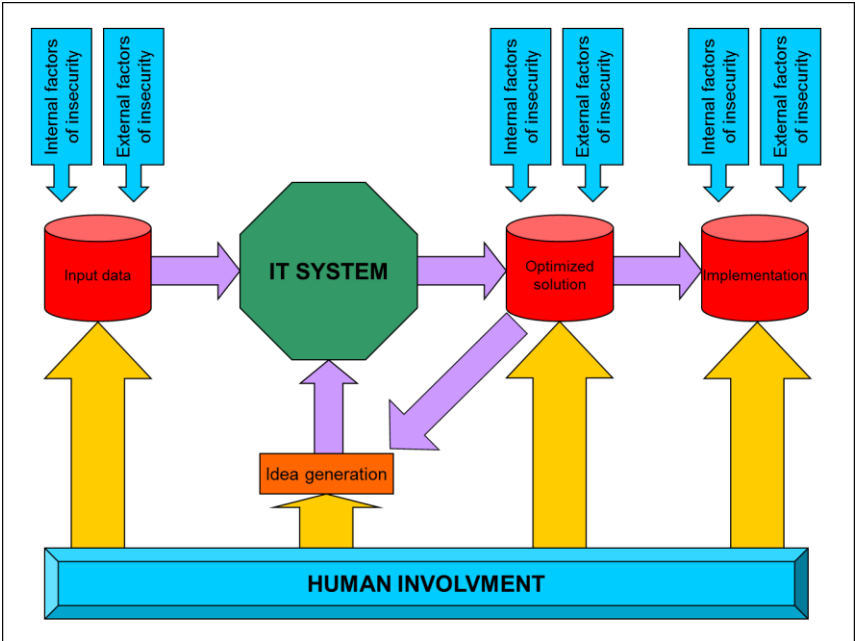
Human interventions to operate the system were centred around three points of uncertainty that can be further classified into internal and external factors. The three critical points include input data, optimized solution and scope of implementation. Hypothesis H4 can be verified because a model for the scope of human intervention and

supervision was successfully set up. The general validity of this model can be proved and the system of identified relationships can be further fine-tuned by continued research.

4. Conclusions and recommendations

The findings of secondary and primary research demonstrate that factors with no real impact on decision-making can motivate people to select different alternatives. These are not necessarily related to making the "right" decision but show inconsistency relative to one's previous decisions. The findings of primary research confirm the impact of heuristics and distortions of human decision making processes in new situations. It can be the subject of future research to identify whether there is an "average" propensity to make mistakes in specific (e.g. financial or agricultural) types of situations and the difference between them.

The importance of IT systems used for decision support should not be overvalued. The uncertainties of input and output data call for in-depth non-machine evaluation requiring human intervention. In the course of actual implementation, more factors are added to the process. The modelling of human thinking is the subject of many research projects. Nevertheless, the findings of my research show that active human involvement in decision making has no alternative.

5. Publications related to the subject of the dissertation

Book chapter:

[1.] Bátori Zoltán – Nagy Viktor – Szűts István – Tóth Zsolt (2008): A customer loyalty új paradigmái a bankszektorban. In: Herczeg János (szerk.): Marketingkutatás módszertan. Első kötet: elméleti alapok. Sopron, Papírmanufaktúra Kft. (ISBN 978-963-88242-0-2 Ö, ISBN 978-963-88242-1-9), p. 280-352.

[2.] Herbat Péter – Mészáros Szabolcs – Nagy Viktor (2011): Ipari klaszterek definiálása környezet tulajdonságok alapján. In.: Logisztikai Rendszerek és Elméletek, Universitas-Győr Nonprofit Kft. (ISBN 978-963-9819-67-2), p. 53-68.

Conference publication:

[3.] Nagy Viktor (2005): Korlátozott racionalitás a döntéshozatalban. In: XXVII. Országos Tudományos Diákköri Konferencia, Közgazdaságtudományi Doktorandusz Szekció, Tanulmánykötet. Akadémiai Kiadó, Budapest (ISBN 963 9364 63 0), p. 67-75.

[4.] Nagy Viktor – Tóth Zsolt (2006): Közösségi tulajdon és zöld energia – Skandináv modellek. In: Az alternatív energiaforrások hasznosításának gazdasági kérdései nemzetközi tudományos konferencia. Nyugat-Magyarországi Egyetem, Közgazdaságtudományi Kar, 2006. november 8-9., Sopron, CD kiadvány (ISBN 978-963-9364-82-0), p. 1-12.

[5.] Nagy Viktor – Szűts István (2008): Bank- és hitelkártyához kapcsolódó hűségprogramok. In: 6th International Conference on Management, Enterprise and Benchmarking. Keleti Károly Faculty of Economics, Budapest Tech, May 30-31, 2008, Budapest (ISBN 978-963-7154-73-7), p. 385-399.

[6.] László Bujdosó – Tamás Hartványi – Viktor Nagy (2008): Benchmark on the Taxation Administrations in the EU: Competition for the Capital Invested. In: 6th International Conference on Management, Enterprise and Benchmarking. Keleti Károly Faculty of Economics, Budapest Tech, May 30-31, 2008, Budapest (ISBN 978-963-7154-73-7), p. 227-238.

[7.] László Bujdosó – Tamás Hartványi – Viktor Nagy (2009): Critical Decision Making Issues for Logistic Services from Users' Perspective in Hungary. In: 7th International Conference on Management, Enterprise and Benchmarking. Keleti Károly Faculty of Economics, Budapest Tech, June 5-6, 2009, Budapest (ISBN 978-963-7154-88-1), p. 161-167.

Publications in journals:

[8.] Tóth Zsolt – Nagy Viktor (2007): Konnektivizmus – egy új tanulás- és döntéselmélet felé? In: Gazdaság és Társadalom. 2007/2 (ISSN 0865 7823), p. 176-188.

[9.] András Farkas – Viktor Nagy (2008): Student Assessment of Desirable Technical Skills: A Correspondence Analysis Approach. In: Acta Polytechnica Hungarica. Vol. 5, Issue 2 (ISSN 1785-8860), p. 43-57.

[10.] Tamás Hartványi – Viktor Nagy (2009): Comparison of the Demand and Supply Sides in the Hungarian Logistic Market. In: Journal of Engineering – Annals of the Faculty of Engineering Hunedoara. Tome VII (year 2009), Fascicule 2 (ISSN 1584-2665), p. 135-140.

[11.] Tamás Hartványi – Viktor Nagy (2009): In-sourcing Model for Food Storage and Forwarding. In: Acta Technica Jaurinensis – Series Logistica. Vol. 2, No. 3 (ISSN 1789-6932), p. 469-476.

[12.] Tamás Hartványi – Viktor Nagy (2012): Violating transitivity in human decision making and the examination of superior-subordinate relation. In: Acta Polytechnica Hungarica (under review)

Conference presentation:

[13.] Nagy Viktor (2008): Kockázat és kockázatvállalás. Racionális választás és emberi magatartás a gazdasági és üzleti döntésekben – Rational Choice and Human Behavior in the Economic and Business Decisions. A gazdaságpszichológus Ph.D. hallgatók VI. Kutatási Fóruma. Szegedi Tudományegyetem, Közgazdaságtani Doktori Iskola, Gazdaságpszichológia Műhely, 2008. május 16., Szeged

Published research paper:

[14.] Zoltán Bátori – Viktor Nagy (2005): The Innovative Activity of Graphisoft Team in the Light of Complexity-Theory. In: Selected Case Studies. In: CETRA Research Results, Bologna: CETRA, http://www.learning-complexity.org