Complexity of Information Society Prevents Achievement of Satisfactory Decision Making

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Abstract: Current society is characterised by increasing number of complex situations which require the prompt and efficient decisions. It has repeatedly been proved that humans confronted with complex situations fail to perform decision making at the desired level of quality. This study searches for understanding how the current information society influences decision making, which is not always as successful as we expect. The main research question of this paper aims at the identification of the factors limiting the outcomes of decision-making processes based on three case studies. The methodology includes the repetitive semi-structured interviews with domain experts and the consequent creation of three scenarios. The main finding, the set of characteristics of decision-making processes, is provided to consider more issues related to those situations and to eliminate their threats and bottlenecks. In addition to this, mutual relationships among characteristics are outlined with the help of the causal-loop diagram. Altogether, twelve characteristics of complex decision making typical for information society are identified in this study. This study reveals that due to growing complexity the decision-makers in the current information society have to deal with issues that are associated with the Law of Requisite Variety. This confirms that growing complexity of information flows represents an inevitable trait of the information society.

Keywords: *Information society; case study analysis; decision making; meta-system;*

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1. Introduction

Recent developments of the environment we live in redefine the way in which we perform all activities. Not long ago, individuals, families, companies or even nations were closely related to different values, worked with different technologies, or preferred different leisure time activities. Modern age sets the development pathways, social change, quality of life or economic development that were hard to imagine only a few decades ago. The spread of information and communication technologies support the establishment of a new type of society called information society or postindustrial society (Martin, 2017). This concept has been analyzed and investigated for many years. It deals with the fact that today the development and application of new information and knowledge is essential for the survival in almost all domains in our society, ranging from business and politics to education or medicine. Many reasons might be identified to support this argument. For example, a shift from goods producing to the service industry is often mentioned. Furthermore, the current economy is closely associated with intangible products. Ideas, processes, or information are taking a growing share of global trade from the traditional manufacturing economy connected to tangible products (Bureš & Stropková, 2014). Moreover, information, knowledge and related continuous innovation are increasingly considered as the only sustainable competitive advantage for all, individuals, organizations or nations. For instance, in order to tackle complexity, Bureš et al. (2012) while working cluster initiatives, suggest exploring all these levels from the economic, social and ecologic perspectives. The current information society is typical by many features, while the most dominant is the extensive production of data that is continuously transformed in information. Availability of information improves various processes and decision making is quite often provided as an example (Wang, Gong, & Wang, 2017; Wang, Wang, & Martínez, 2017). However, there are also contra productive effects. Information overload is another characteristic of information society which shapes the quality of decision making in any domain. Moreover, as already known, human decision making is negatively influenced by the complexity of a situation in which decisions at the desired level of quality need to be made (Gonzalez, Vanvukov, & Marin, 2005; Quesada, Kintsch, & Gomez, 2005; Osman, 2010). The substance of the issue is associated with Miller's seminal work (Miller, 1956) in which he assumed finite ability of human brain to process parallel interacting phenomena at the required level of validity, accuracy, and reliability. Other studies scrutinized, investigated or tested this idea (Corbett

& Smith, 2017; Konstantinou, Constantinidou, & Kanai, 2017). In fact, the list of limitations of human performance is quite extensive and referenced as cognitive spans. It might seem that these spans are strengthened in the current society. The existence of complex situations are typical for uncertainty, included non-linear interactions, delays of consequences associated with taken actions. Consequences are also difficult to be identified or modified by natural dynamic changes (Karakul & Quadrat-Ullah, 2008; Diehl & Sterman, 1995). Therefore, experts and decision makers dealing with complex situations need to be supported not only by available decision-making methods and tools which help to overcome cognitive spans and perceive broader situational understanding (Tremblay, Gagnon, Lafond, Hodgetts, & Doiron, 2017), but also by other methods and techniques. A plethora of them have been developed in order to cope with complexity of situations in which decision making takes place, ranging from fuzzy cognitive maps (Hájek, Procházka, & Pachura, 2017), optimisation (Niu, Lu, & Zhang, 2009), simplification methods (Bureš, 2017), simulation and modelling (Blecha, Mikulecký, Tučník, & Matyska, 2016) to heuristics as simple but efficient strategies that do not have to be necessarily related to a profound situational knowledge (Gigerenzer & Gaissmaier, 2011). Velasquez and Hester (2013) provide quite interesting and comprehensive list of available methods based on extensive literature review. However, regardless the support provided by techniques or methods, human decision makers always meet their limitations described by Ashby's law of requisite variety (Ashby, 2011). It implies that the more complex situations we have to deal with, the more complex analytical decision-making strategies or hypothesis-testing we have to apply. The main issue is that the current state of the information society with embedded information overload lead to insufficient decision making at the general level, regardless the domain in which decision-making processes are conducted.

The main objective of this study is to present results acquired during the investigation of factors that influence decision making in the information society. The main research question is formulated as follows: What are the main factors influencing the quality of decisions made in the current information society? The remainder of this manuscript is structured as follows. After the introductory section, description of applied methods and selection of the domain are explained. Acquired results are presented in the following section. Consequently, analysis and explanation of main findings and related limitations are provided. The last section concludes the paper.

2. Research methodology

The current society provides a plethora of systems, situations or domains which are information intensive and in which identification and analysis of underlying factors influencing decision making can be performed. This study focuses on three case studies in the field of management of biological incidents. There are three main reasons justifying this selection from the information society perspective.

First, management of biological incidents is multidisciplinary in nature. It represents an actual topic in several fields of studies concerning their cause ranging from the use of the biological weapons to unintentional occurrences such as the leakage of toxic liquids or gasses from a laboratory, or natural outbreak of a disease. Domain knowledge is needed in order to identify significant information, determine single influence factors, and decide about their relevancy. Therefore, intertwining knowledge coming from disciplines such as toxicology, sociology, decision sciences, biology, psychology, public health, medicine, or computer science has to be applied if we need to properly cope with the complexity of the issue. The characteristic traits of biological incidents include uniqueness, unpredictability, relatively high amount of mutually interrelated factors, constraints, criteria, and alternatives.

Second, the decision making during emergency situations represents a specific set of decision cases. A lot of factors should be considered and evaluated to make the decision as efficient as possible. However, biological incidents belong to the group of semi-structured or unstructured problems (Turban, 2007), which are hard to be automated or algorithmically expressed. Therefore, decision makers who make decisions and coordinate the situation are mostly people with their bounded rationality and subjective perspectives on various issues. Thus, information overload plays a significant role here.

Third, biological incidents are information intensive and represent complex issues. A vast amount of data has to be considered if the resolution of incidents should be effective and useful. The decision about proper combination of acceptable reactions and appropriate countermeasures should be based on available data that provide information about the environment, in which the incident takes place as well as the biological agent that the incident is caused by. However, there are materials, documents or reports which can be investigated and analyzed.

Fourth, there are numerous techniques, tools or methods that are applied to support decision making in practice (Gret-Regamey, Sirén, Brunner, & Weibel, 2017; Rajagopal, Venkatesan, & Goh, 2017). However,

experience confirms that regardless the intensity of technological support for decision making during chemical and biological incidents, the application of tools is always associated with specific issues and consequent low efficiency of decision making. Bureš, Otčenášková, Čech and Antoš (2012) found out that one of the underlying problems was the involvement of various people with unclear responsibilities, undefined workflow, or poor understanding of the whole decision-making process. That is why the main research question introduced in the previous section was formulated. The answer to this question is grounded in an analysis of case studies associated with elaborated models of complex decision-making processes.

Data gathering process conducted in this study was based on semi-structured interviews representatives of the main domain stakeholders. Altogether six experts underwent in-depth interviews, which duration was 60-90 minutes. They were performed in respondent's workplaces. Only general questions related to decision making in their work (e.g. what barriers can you identify, who mostly you cooperate with, or what is/not your daily routine concerning decision making) were asked and interviewees were allowed to answer without any content or time restrictions. Answers were recorded and consequently coded. Interviewees' working positions and responsibilities were identified during the work on specific project tasks as crucial in the management of biological incidents in the Czech Republic. Hence, interviews were conducted with representatives of military hospital (lieutenant colonel responsible for medical aspects of incidents), healthcare institution (deputy director of the university hospital), public administration body (director of the regional hygiene station), educational institutions (an epidemiologist from a state university under the Ministry of Defense, and a biologist from the public university under the Ministry of Education). All interviewees were working at senior positions with at least ten years of experience in the field with both theoretical knowledge, and practical experience. Thus, sufficient expertise and experience were ensured. The first round of interviews was based on the framework depicted in Figure 1 which divides interview into several stages. Interviewees were free to say anything they considered important. The feedback in Figure 1 was used as a source for the formulation of additional questions that may have been valuable from the research perspective (aligned with the main objective of this paper). Thus, interviews were repeated in additional rounds with selected respondents. The acquired results were visualized using the flow charts presented in the following section.

- Medical staff – doctors or nurses are working at the operative level conducting operative decisions characterized by a low number of alternatives, strict criteria and time pressure.

- General practitioners – a source of information on which decision making is conducted (mostly related to individual patients).

- World Health Organization – a supranational institution which provides decision-making support, framework and guidelines at the most general level.

Furthermore, tools and equipment used for generation of alternatives in decision-making processes were identified. Their role is explained in the next section:

- BioDSS – a decision support system applied in the occurrence of biological incidents

- Surveillance systems
- Map visualizations
- EPIDAT – epidemiological database
- Laboratory equipment
- Database of agents
- Decontamination equipment
- International health regulations
- Specialized workplaces
- Measures
- Biological material samples
- Epidemiologic questionnaire
- Official catalogue of activities for the Integrated Rescue System

The last elaborated list comprises so-called critical decision-making points (Singer Fisher, & Burns, 2017; Haigh et al., 2015). These points represent specific positions in the process in which particular decision has to be made. It is necessary to note that decision-making points are not visualized in flow charts below by decision-making diamonds only. In fact, diamonds serve as guideposts which can be used only if any decision was made in the previous step.

- Selection of a specific scenario of further development from the set of scenarios

- Choice of the appropriate measures
- Selection of procedures that will be implemented
- Identification of protection equipment that has to be distributed

- The decision about prophylactic treatment
- Selection of additional actors who should be included in the process (e.g. psychologists)
- Determination of methods used for the sample analysis
- The decision about patients and their treatment (patients can go home, hospitalization in appropriate facilities, quarantine etc.)
- Measure cancellation
- Establishment of the disinfection plans

The whole process of biological incident treatment dealing with anthrax, diarrhea and influenza is visualized in Figures 2, 3 and 4 respectively.

Figure 2. Context of decision making related to the anthrax incident

Figure 3. Context of decision making related to the diarrhoea occurrence

Figure 4. Context of decision making related to the influenza occurrence

4. Discussion

This section opens a debate on decision-making issues in the information society based on factors that were identified during the case studies analysis. The acquired results are generalized to enable their application to other domains and prove that they do not necessarily have to be related merely to the management of biological incidents.

Three lists presented in the result section help us to go closer to the answer to the main research question. Now, the broader perspective has to be applied in order to capture the complexity and create a general context of decision making in the information society. Single items on the list of actors, tools, decision-making points, and visualization of three processes enable identification of the main characteristics of complex decision making.

1. Start and the end of the process – as it visible in Figures 2, 3 and 4, every decision-making process has its starting point as well as a termination point. This can be considered as the main assumption of successful decision making in practice (Meroni & Plebani, 2017). Without fixed start and a known form of the end, the context would have no boundaries. As the main consequence, the process could be repeated several times without any useful result. Moreover, the number of actors, tools or decision-making points could increase enormously.

2. Equifinality – this characteristic is closely associated with the previous item. It is the consequence of the existence of termination point. Regardless the pathways possibly included in the whole process, there is a state which has to be reached in order to close the decision-making process and thus solve the problem. Not only is this ensured by the boundaries shaping the decision-making context and communication among single actors, but also by a certain level of self-organization that emerges at the certain level of complexity at which there are no guidelines how to continue.

3. Multiple actors – complex situations are not usually linked with one decision maker. Various institutions, people or systems with distinct responsibilities, workflows or capabilities are involved. Mostly, these actors cannot meet, or it is even impossible to meet, to discuss and share experience and insights. Therefore, any available help is welcome to support multi-actor nature of complex decision-making process. For instance, Yu and Lai (2011) propose a methodology for distance-based group decision-making. They intend to support the solution of unconventional multi-criteria decision-making issues which are characterized by multi-personality. Their study demonstrates that the proposed methodology has a potential to improve decision-making objectivity. In addition to this, various

information, communication or knowledge technologies are used (Bureš & Tučník, 2014; Mikulecký, Olševičová, Bureš, & Mls, 2011).

4. Feedbacks – the complexity is the consequence of feedbacks that take place in the majority of both real, and conceptual systems (Kolerová, Bureš, & Otčenášková). It is clear from flow charts that some steps are performed repeatedly based on results acquired in the previous or next step. Therefore, the main issue is that the same decisions can be made under the same criteria and with the same alternatives, but final decisions can differ. This can be caused by various reasons, e.g. change of the input data or feedback distortion (Sterman, 2006).

5. Nonlinearity – decision making is hardly straightforward. This is partially related to feedbacks, as mentioned above. However, other factors can be added. For instance, mutual interconnections of criteria or decisions, or unclear responsibilities can make decision making more difficult. Single decisions can be mutually affected which aggravates the ability to reach the termination point.

6. Decentralization – current information society support avoidance of one complex authority, which would control the whole process (Buntaine, Daniels, & Devlin, 2018). In the analyzed case studies, the Ministry of Health or World Health Organization could play this role. However, not always is such authority available and able to take the responsibility. In business practice, every process, whether supportive or primary, is assigned to the owner. This person is responsible for all related problems such as its execution, connection with other processes or acquired outputs. When this process perspective is generalized we can figure out that the quite low level of centralization of ownership can cause serious troubles. As a consequence, various problems in areas like budgeting or competence (e.g. willingness to overcome existing barriers or provide financial support) can occur.

7. Collective and distributed, instead of group and local – in group decision making, various decision makers (members of the group) make independent decisions on the same problem. They consider several alternatives and apply various evaluation criteria. Outcomes from this step are consequently aggregated in order to reach group consensus and identify the final decision. However, this cooperation is not always possible. Decision making can be spontaneous, and decisions or opinions of others might be either ignored or omitted. This characteristic is related to decentralization as described in the previous paragraph.

8. Vague or poorly defined criteria – complex issues might be linked with novel criteria or unknown variables which parametrization is

difficult, time demanding, or expensive. Then, decision-makers are forced to apply criteria that are not as exact and rigorous as they should be.

9. Multichannel – simple decision making can be done in one decision-support system or conducted by one individual. Then, no communication channels are needed. Other decisions can be performed by a relatively small number of individuals and one or two communication channels are used. However, many processes in information society imply various communication channels in which the messages can have various forms (emails, post, documents, proprietary information systems, or delivery services used for distribution of information, data, samples, physical objects etc.). Moreover, single actors do not have to have the chance to be connected to all channels, which makes the decision making complicated (Picot-Coupey, Huré, & Piveteau, 2016).

10. Dynamics – as already indicated by feedbacks and nonlinearity, our society is continuously developing and is not static. It slowly or rapidly changes in time. Dynamics is mostly difficult to be captured, which disables proper planning or advancement to next steps in the decision-making process.

11. Interface – there are also issues related to the mutual connection of particular actors or systems. Although the communication channel can be established, there can be various reasons why the communication does not take place or why it is useless.

12. Context-awareness – as decision-making situations are mostly complex, it is quite difficult for all actors to capture and figure out the main context. This study could serve as an example as it would not be possible to elaborate flow chart if only one or few interviewees had been asked. Although they are all competent experts, their experience and perspectives had to be merged to acquire the entire picture.

While almost all items increase complexity and make decision making more difficult, items 1) and 2) have the capability to support the potential to make at least some decision regardless level of its appropriateness. As indicated during their description, characteristics are mutually interrelated. In order to better understand them, the causal-loop diagram is developed, and relationships among them are outlined. The causal-loop diagram expresses the causal relationship between two variables with positive or negative polarities. The main idea of causal-loop diagrams is to apply polarities to all identified relations and consequently figure out what type of feedbacks emerges in the system. Positive polarity means that as the first variable increases (decreases), the second variable changes in the same way, i.e. increases (decreases). Negative polarity expresses the opposite

behavior. Once the cycles are closed, the polarity of feedbacks (loops) can be identified and reveals the behavior of the system. In fact, there are two types of feedbacks, namely balancing and reinforcing feedback. Details related to diagram notation can be found for instance in (Sterman, 2009). Created causal-loop diagram is presented in Figure 5. This diagram is considered as a metasystem, which means that it represents a system made out of single properties of an original system.

Figure 5. Metasystem of complex decision-making situation properties (authors' own work)

As apparent from the figure above, there are three dominant significant characteristic – Multi-actor, Collective and distributed, and Nonlinearity. Decision-making situations are typical of a high number of actors who are involved at various stages of the decision-making process. They significantly influence the whole system, but are rarely influenced. In fact, only decentralization has the ability to increase or decrease extent of this variable. Moreover, they have a relatively high level of independence. Simply stated, a number of actors may change, but very often there is no endogenous explanation for this. External influence can be mostly identified as the main trigger of multi-actor characteristic modification. Nonlinearity is usually solved by application of linearization methods. However, from the decision making point of view, information society reached the level of complexity, which makes linearization useless and unsuitable method for dealing with related issues. In addition to this, both characteristic are

mutually connected by collectiveness and distributive nature of decision making. This triad can be considered as the main source of issues associated with decision making in the current society. The reason is that characteristics influence each other at various levels of intensity with many local feedbacks. However, prevalence of positive polarities, which have a potential to create reinforcing feedbacks, cause serious problems. There are only two reasons why decision making problems do not cause collapse and do not go out of control - two balancing feedback B1 and B2, and the reinforcing feedback R1. While B1 and B2 have a tendency to stabilize the system, R1 supports equifinality and existence of start and the end of the decision-making process, which is a fundamental requirement for any decision making process. To sum up, the strength and number of reinforcing feedbacks cause a low level of stability of the system. This can be considered as the most general characteristic of complex decision making in the information society – its natural tendency is to develop more complicated context in which decision making is conducted and there is only weak spontaneous inclination to the reduction of complexity.

5. Limitations

This study is far from perfect. Like any other study, it is connected with weak points that need to be stressed. First, data reliability represents one of them as the applied methodology suffers from low inter-observer reliability. Based on semi-structured interviews and developed schemes, different observers can come to different conclusions when the research is repeated. However, we consider this weak point as a typical feature of interpretation of results acquired in qualitative research that is hard to overcome. On the other hand, the research is associated with relatively high test-retest reliability as repeated interviews would offer correlated results. This, together with similarities in all three schemes, also supports the test homogeneity and internal consistency.

Second, the applied case studies are based on management of biological incidents. Apparently, in order to maximize internal validity, the research methodology decreases external validity of the conducted research. The rationale for this selection is tied to the complexity of decision making and related issues. Simple case studies cannot reveal all characteristics. Only a few of them can be included, and thus more case studies must be applied in order to obtain a comprehensive list of factors. However, this represents an appropriate way in which this research can be extended. The verification of obtained results can be grounded in the summative approach to the

analysis of simpler incidents to create a sum of single results. This additively created list of characteristics can be compared to the list developed in this study which could identify inconsistencies. Needless to say, other complex decision-making processes from distinct domains should be analyzed.

Third, the national context of case studies should not be neglected. Described processes are based on the state-of-the-art in the Czech Republic. Although this country has been fully integrated into the supranational formations such as European Union or NATO for many years, processes associated with biological incidents are specific when compared to other countries. This statement can be successfully applied to other domains as well – culture, economy, education etc. However, they provide a good insight into the main issue linked with complex decision making in the information society. Thus, case studies obtained and described in any other country should support or supplement results presented in this paper. The main advantage is that once the complexity is captured, models can be used as a good resource for qualitative analysis and elaboration.

6. Conclusions

Information society itself represents quite a complex concept that is studied by experts from many fields of study. This manuscript focused on the decision science perspective and investigated how its complexity affects proper decision making. Identification of main factors can be performed in any arbitrary domain ranging from business-related decision making to medical decision-making processes or finding solutions associated with education. Actually, various stakeholders, technical systems, individuals, rules, procedures, legislative limitations or priorities are included in decision making in any system. This study is based on analysis of the management of biological incidents as its specific attributes enable to gather enough material for examination. Saaty and Peniwati (2012) question an old saying “there is strength in numbers”. This study supports their doubts as growing complexity of any system when intended to be managed properly, meet the Law of Requisite Variety. Hence, complexity is an issue that has been addressed by experts and practitioners for decades. This study contributes to understanding which factors significantly influence decision making in so-called information society which is characterized by the extensive production of data, information overload and instant pressure on improved effectivity and performance. Decision sciences developed original tools or methods that can help to make proper decisions. However, their complete understanding is mostly beyond capabilities of humans (Velasquez & Hester,

2013) and are not always utilizable in a given time and place. Decision making relates apparently to specific features that need to be identified in order to efficiently cope with related problems. Altogether, twelve characteristics of complex decision making are identified in this study. Apparently, they are studied individually as they represent standalone issues. However, they have not been put together as specific properties of decision making yet. Moreover, mutual interrelationships among identified characteristics are outlined. Constructed causal-loop diagram provides explanation and confirmation of something we feel about the information society – complexity has a natural inclination to increase and decision making becomes more troublesome.

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