Improving administrative decisions through expert systems: empirical analysis

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Abstract

Purpose – The purpose of this paper is to introduce and identify the basic components, tasks and application areas of expert systems (ESs) as a decision support system that has been increasingly used in the business world lately and explore its potential for improving the effectiveness of administrative decisions in the public sector. Empirically, the paper explains the role of ESs in fostering decision-making processes at the Ministry of Investment and International Cooperation (MIIC) in Egypt.

Design/methodology/approach – The design of this research is descriptive in the theoretical section and quantitative in the empirical one. Theoretically, the study adopted both the analytical approach and systems approach to demonstrate main concepts and relationships, while it conducted an empirical study to investigate the correlations in practice.

Findings – The research concluded that the usage of ESs is deemed to be on the top of the technical solutions that might help public organizations develop their management quality and maintain competitive strength. In addition, the results proved that ESs contribute to administrative decisions at MIIC.

Practical implications – The paper provides profitable findings and recommendations which can be applied by Egyptian public executives, in an attempt to ensure high quality and successful decisions using modern technology.

Originality/value – This study has valuable implications for theory and practice together, as it offers numerous contributions to literature in the area of concern.

Keywords Expert systems, Decision support systems, Managerial decision making, Public sector reform, Ministry of investment and international cooperation in Egypt

Paper type Research paper

1. Introduction

For further development of organizations in the present highly dynamic environment, their analysis is not just anticipated, but also required (Bolfikova *et al.*, 2010, p. 155). Certainly, decision-making is becoming the remaining basis of excellence and competitive advantage that can guarantee superior returns for organizations (Harvey and TIS, 2007, p. 3). Successful organizations outperform their competitors in at least three ways; they make better decisions, they take decisions faster, and they implement decisions more. While most would agree with this, much less is known about what makes good or bad decisions (Dillon

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et al., 2010, p. 229). On the other hand, computers have been remarkable means used in managerial decision-making for decades. However, the hottest computerized decision aid during the 1980s was expert system (ES); that is the rising need for expert knowledge in decision-making within management can be most efficiently satisfied with the use of ESs, which would enable skills, experience and intuition to be used in real time and for an indefinite number of problematic situations (Dasic *et al.*, 2011, p. 30) Hence, many organizations – private and public – have used ESs to assist their managers make better decisions.

Indeed, understanding the technology and its implications and limitations is a central and critical aspect of any technology-related reform (Ahmad and Munir, 2016, p. 2). In general, the major difficulty in designing and implementing ESs is still the lack of knowledge and techniques on how to develop and apply them properly (Jayaraman and Srivastava, 1996, p. 27). Additionally, another vital challenge is to capture and encode the needed expertise/wisdom from experts (Artificial intelligence and expert systems: knowledge-based systems, 2018). This problem seems to be more obvious in public sectors, putting into consideration the cognitive limits within the conservative organizational culture of these institutions. In sum, despite the progress and widespread usage of ESs, there is an alleged uncertainty about how people will react to this advanced technology, whether those using them as decision support systems (DSSs) or the others affected by the decisions reached, especially in public organizations, which makes ES applicability in governments a little bit questionable. For that reason, much of this discourse in literature is associated with business.

Otherwise, past research in ESs has been minimal owing to the relative scarcity of information that exists on ES application within an organizational setting (Jayaraman and Srivastava, 1996, p. 27). Liao (2005) considered ES applications development as a problem-oriented domain. Consequently, until very recently it has been noticed the lack of a strong theoretical basis for viewing ESs – mostly DSSs – from a managerial perspective, not a technical one (Arnott and Pervan, 2008; Shim *et al.*, 2002), in spite of the significance of this topic to management commonly and managerial decision-making particularly. The publications in this topic were scattered over many specializations, like artificial intelligence (AI), computer science, control engineering, logic, operations research and decision-making. Therefore, the ability to obtain new understanding using different social science methodologies should be the driving power of the future ES work (Liao, 2005). ES research needs to be based on more contemporary behavioral decision theory imported from management and other related fields to provide a stronger theoretical foundation for projects. In addition, this solid theoretical basis needs to be based on an increased number of interpretive case studies to illuminate areas of contemporary practice (Arnott and Pervan, 2008, pp. 667-669). So that, the researcher here believes this is a meaningful area that entails more attention and study, with specific reference to Egypt. Over and above, it is worth mentioning the distinct methodology adopted herein (open system approach) to address the concept of ES and the whole subject as well; is that the present research differentiates between ES outputs (recommended decisions) and actual administrative decisions, which is – this separation – not always found in literature (Jaradat *et al.*, 2009). Thence, outputs are regarded here as a sub-indicator of the independent variable (which forms a system itself), not the dependent one.

In conclusion, this work is designed to discover an obvious, concrete, and helpful means to know how to employ ESs in managerial decision-making. Thus, this study contributes to the existing body of knowledge by displaying an overview of ESs and the different decision areas in this regard. Besides, it is of interest to academics investigating the applications of these systems in public organizations. Moreover, the paper provides a way of exploring some of the changes and challenges that maybe encountered in practice. Hopefully, it could

be a modest step towards conducting future inclusive research to appraise the technical and organizational renovations adopted by the Egyptian public sector, in its quest to achieve the sustainable development strategy (Egypt's Vision 2030) with regard to maximizing the efficiency of governmental institutions.

2. Problem statement

This research examines the beneficial aspects and the applicability of using ESs in governments, with the sake of bolstering the effectiveness of public executives' decisions. The study provides a framework for introducing this modern decision instrument, and then it identifies the elements influencing the success of decision-making in the organizational practices, and analyzes the generic types of decisions that often require expertise to see when and if they are applied in public settings. Furthermore, this article looks at the bulk of technical reforms implemented in Egypt during the past years and evaluates the progress in this arena, through assessing the main characteristics of ESs and the organizational context that may affect the quality of the decision-making process in the case of the Ministry of Investment and International Cooperation (MIIC) to point out the limitation of the current procedures and to propose some practical solutions.

Therefore, the study investigates a major research question which is:

RQ: How can public sectors benefit from using ESs in improving the quality of administrative decisions and to what extent do ESs contribute to the managerial decision-making at MIIC?

To answer *RQ*, the paper intends to detect the answers of the following sub-questions:

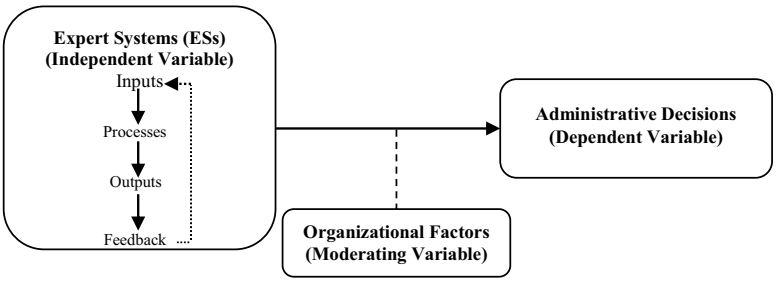
Q1. What is the meaning of ES and what are its various tasks and benefits to management?

Q2. What are the main classifications and stages of administrative decisions?

Q3. How do ESs influence the decision-making processes in public organizations?

Q4. How could ESs be applied for enhancing the quality of decisions at MIIC, considering the organizational factors?

Subsequently, the research tests its master variables as illustrated in Figure (1):



Source: Prepared by the researcher

Figure 1.
Research conceptual model

3. Literature review: concepts and relationships description

3.1 Expert systems

The field of AI is concerned about ways of developing systems that display elements of intelligent behavior. Those systems are designed to simulate human capabilities of sensing and thinking (Expert systems and applied artificial intelligence (2018)). ESs are a class of computer applications developed by researchers in AI. In essence, they are computer programs made up of a series of rules that analyze information about a nominated class of problems, as well as providing analysis of these problems, and depending upon their design they suggest a course of action to implement solutions or corrections (Alasgarova and Muradkhanli, 2008, p. 297). In that way, ES is a problem-solving package that imitates a human expert in a certain field, so it combines computer equipment, software, and specialized information to mimic expert human reasoning and advice. Typically, there are three key types of information transfer in ES which differentiate it from other DSSs (Arnott and Pervan, 2008). ES requires relevant information from the user about the problem domain. It also provides a recommendation based on the data given by the user, and if a non-expert requests information it offers a justification for the suggested decision (Jayaraman and Srivastava, 1996, pp. 27-28). As a result, ES differs from traditional DSS in that its knowledge base is way complex because of less reliance on the end-user to interpret and evaluate findings [Artificial intelligence and expert systems: knowledge-based systems, (2018)], although the current study believes that the two terms are used interchangeably in somehow.

Early ESs performed fundamentally medical diagnoses and geological prospecting. With the mounting number of successful applications of ESs in those areas, AI specialists started to think that this technology might also be used to assist management in taking and implementing decisions. Research in this sphere has typically focused on how information technology can uphold the efficiency with which a user makes a decision and the effectiveness of that decision (Shim *et al.*, 2002, p. 2). Nowadays, ESs are applied widely in commercial and industrial settings (Sahin *et al.*, 2012). They have been used in manufacturing sectors, production scheduling, mining operations, agricultural activities, medical services, financial transactions, sales, control, and security departments. Moreover, they have been utilized to perform plenty of functions; the most popular among them are; consulting and recommending certain behaviors, designing and putting specifications, diagnosing and verifying objects, interpreting and confirming reliability, planning and creating actions, predicting future events, monitoring and evaluating signals, teaching and propagation of knowledge (Jayaraman and Srivastava, 1996, p. 29-30), classifying and identifying objects, and eventually generating options and solutions.

In general, ESs have four main components; knowledge base, inference engine, knowledge acquisition module/justifier and user interface. The knowledge base contains the domain specific knowledge derived from the expert's experience. One of the most commonly used ways to represent knowledge is as rules. The inference engine is a computer program that offers a methodology for reasoning and formulating conclusions (Expert systems and applied artificial intelligence (2018)). The knowledge acquisition module enables experts to save their knowledge in the knowledge base to draw and deduce new knowledge from the existing one via a machine learning process. Therefore, the justifier presents the whole chain of the decision-making process and the rules used to reach a conclusion. Finally, the interface for input/output is designed to communicate and interact with the user, environment and other systems such as databases (Alasgarova and Muradkhanli, 2008, p. 298).

In this respect, the major players in developing ES are the knowledge engineer and the domain expert who act as builders. Once the system is completed, it is subject to consultation by end-users [Artificial intelligence and expert systems: knowledge-based systems, (2018)]. Actually, there are five essential stages for building ESs as follows (Chau, 1991):

(1) *Identification*: in which the domain expert and knowledge engineer agree on the system's purposes, specify the needed computer facilities, conduct a feasibility study and set a time frame for the project.

(2) *Conceptualization*: the expert and knowledge engineer here determine the system design, basic concepts, data relationships and information-flow traits that describe the problem solving process.

(3) *Formulation*: where the expert and engineer develop a knowledge base using the key concepts and relationships. The engineer must choose a programing language, and with the help of the expert, they represent these key relationships within the language framework.

(4) *Implementation*: here the engineer makes this formalized knowledge compatible with information-flow. The resulting set of rules and associated control structure identify a prototype program capable of being executed then revised.

(5) *Testing and Maintenance*: it involves judging the prototype program and refining/modifying it to conform to the standards of excellence set by the expert. Besides, the knowledge database must be frequently updated to maintain timeliness and relevance.

In fact, the usage of ESs guarantees numerous advantages. Indeed, ES is not a substitute for a knowledge worker's overall performance of the problem-solving task, but it can dramatically minimize the amount of work the individual must do to fix a problem. Here are some possible organizational benefits of ESs [Sheikhtaheri *et al.*, 2014, p. 110; Expert systems and applied artificial intelligence (2018)]:

- ESs can complete their part of the task much faster than an expert, and so raising the speed of response.
- The error rate of successful ESs is often much lower than human error for the same task, which enhances the efficiency and quality of work.
- ESs can make consistent and reliable recommendations, and thus improving decisions by non-experts and shortening the whole process.
- ESs can capture rare knowledge and maximize the use of scarce expertise, and thereby elevating profits while reducing costs.
- When used as training vehicles, ESs result in a rapid learning curve for novices.

Nevertheless, no technology can offer perfect solution. Large ESs are costly and require significant development time and resources. Therefore, there are various kinds of obstacles which would hinder organizations from developing successful ESs. Technical difficulties are always a problem, whereas non-technical barriers as well might pose an equally serious challenge. For instance, [Sheikhtaheri *et al.*, 2014, p. 110; Chau, 1991; Artificial intelligence and expert systems: knowledge-based systems, (2018)]:

- Problems with knowledge acquisition: maybe the employment of required experts is highly expensive, and sometimes they are not available, capable, or cooperative. In addition, knowledge transfer is often subject to biases and mistakes.

- Problems with knowledge engineers: help from knowledge engineers is costly and hard to obtain. In addition, knowledge engineers sometimes do not have much expertise in building business-related ESs.
- Problems with management: sometimes management is not supportive enough or does not know how to deal with the organizational change arising from the operation of ESs.
- Cognitive limits of users: in some cases, end-users do not prefer and trust the system or trust it too much.

Hence, the term ES has been controversial. On the one hand, it creates high expectations and has been used as a buzzword for funding and a flag to wave for all types of projects. On the other hand, many people have criticized its feasibility (Liang, 1987, p. 14). In sum, successful ESs should have at least four indispensable features; selection of an appropriate problem sphere, realistic expectations, unhesitating commitment of top management, and comprehensive testing of the product (Jayaraman and Srivastava, 1996, p. 28). Eventually, it is worth mentioning that a primary idea in ESs technology is that problem solving could be generally accomplished through applying specific knowledge rather than specific techniques. This reflects the belief that human experts do not process their knowledge differently, but they do possess diverse knowledge. According to this philosophy, when ES does not produce the desired results, work must begin to expand the knowledge base, not to redesign procedures (Alasgarova and Muradkhanli, 2008, p. 299).

3.2 Administrative decisions

In organizations, decisions are the signals of action and the portents to accomplishment or failure. Failure, in turn, marks the need for new decisions. Therefore, decisions and decision-making processes are best viewed as one major determinant of performance (Bozeman and Pandey, 2003, p. 2). Many researchers and practitioners believe that any organization faced with bad or negative decisions will be unproductive and continue to fail. In contrast, creative and innovative decision-making is of pivotal importance to the growth and success of all institutions (Ejimabo, 2015, p. 1). Undoubtedly, in a modern world, producing surplus of information and making administrative decisions have become more complicated. It is mainly about the fact that even the best and most efficient intelligence of decision-makers can be totally insufficient. Otherwise, it is necessary to exploit the array of decision-making tools which draw on such disciplines as psychology, sociology, economics, law, political science, computer science and others (Raczkowski, 2016, p. 33).

For that reason, managerial decision-making is a notion that is seriously considered critical in the operations of the organization. It has gained the attention of scholars all over the world and it has almost several definitions. For example, some argued that decision-making is a decisive and deliberative social action concerned with selecting what to do in face of a problem, while others regarded it as a commitment to action or a concrete and discrete phenomenon driven by rationality. Thereby, administrative decision could be defined as a choice has been made from among two or more alternative objects or courses of action, given because of the advantages and disadvantages of supporting information about each (Ejimabo, 2015, p. 2). In that way, decision-making as a theory focuses exclusively on choice and the capability of decision-maker/leader to select the best option from the many available alternatives (Glaholt *et al.*, 2010, p. 1).

In other words, decision-making is deemed to be an integral part of every organization. Indeed, administrative decisions are made in organizations on a daily basis. Additionally, organizations are making decisions at all managerial levels. In this regard, there are three

levels of management decision-making: strategic long-term management, tactical middle-range management and operational short-term management (Harvey and TIS, 2007, p. 3). Furthermore, there are three types of decision structure: unstructured decisions (related to the long-term strategy of the firm), semi-structured (some decision procedures can be pre-determined, but not enough to lead up to a certain decision) and structured decisions (the procedures can be specified in advance) (Management information systems and decision-making: an overview, 2018).

On the other hand, much of the decision literature differentiates between technical and political aspects of decisions. (Bozeman and Pandey, 2003, pp. 5-6) stated that political decisions require more external players/actors and involve higher levels of conflict and a tendency to concentrate on ends rather than means. Similarly, they had expectations for technical decisions that they entail higher levels of economic rationality, technique and modeling are likely to be more paramount, and participants' roles are mitigated by their technical status and specialization. According to Daft (1989), a rational/technical approach is idealistic under conditions of high goal consensus and high technical knowledge. On the contrary, situations of low goal consensus and less technical knowledge are better suited for political/non-technical decision operations. Perhaps, it is worth to think of decision content as a combination of technical and political content, with the pure technical content as a mooring at one end and pure political content at the other.

Actually, managerial decision-making is inherently complicated. It is well known that effective administrative decisions are a result of a systematic process with obviously defined elements handled in a distinct sequence of steps. (Kryssanov *et al.* (2018), p. 4) presented a framework for the decision-making process. It is usually initiated by an external inquirer, and begins from gathering information to identifying a problem/task. Then, associated information is recognized and relevant/local reality models are chosen. Next, the models are evolved and possible alternatives/solutions are assessed. At the end, the best solution is selected for the final decision. After the decision is made, the new reality is considered and the process could be repeated under other circumstances. In this respect, managing implementation requires that the decision should be well communicated and the expected consequences are reflected in performance metrics. This guarantees that goals will be accomplished. Trial and error maybe allowed as tactical experiments within acceptable risk parameters, but duplicating past mistakes should be inexcusable. The outcome of previous decisions should be captured as a part of the corporate memory of the organization to ensure that lessons are learned (Harvey and TIS, 2007, p. 8).

Generally speaking, the level of managerial decision-making can be promoted through providing proper decision support. The nature of this support depends on a number of variables, including the organizational context of the decision (public vs private sector), the quality of available information, the willingness of the decision maker to take advantage of such support (Dillon *et al.*, 2010, p. 229), and of course the availability of resources, particularly technical ones. According to Nagy *et al.* (2011, p. 14), there are three indicators of good decisions; consistency, integration, and transparency. Whereas Bozeman and Pandey (2003, pp. 8-13) examined some familiar decision criteria for evaluation such as cost-effectiveness (doing more with less), fairness (sharing the pain), technical feasibility and usefulness (meeting the goal). This is in addition to the amount of time/timeframe required for the decision (the cost of taking so long to make decisions), its stability (permanence), participants (internal and external), the information quality (including accuracy and objectivity (intrinsic dimension), relevance and timeliness (contextual dimension),

interpretability and ease of understanding (representational dimension) and access (accessibility dimension)) (Dillon *et al.*, 2010, p. 230).

Finally, a crucial challenge here is to develop an appraisal system to guide the process of making and selecting administrative decisions, by consolidating the up-to-date technology available at an early phase of the decision-making process (Alasgarova and Muradkhanli, 2008, p. 297). The decision traits like speed, capacity, quality, desired output. . ., should be harmonized with the distinctive equipment attributes to arrive at best solutions. The next part of this research will discuss this point in some detail.

3.3 Expert systems and managerial decision-making in public organizations

The debate on public performance has had major impact on public reforms in the late decades. Since the 1970s, a number of reforms have been adopted by governments; most of them aiming to reduce the size and expenses of bureaucracies, to improve accountability and transparency, to enhance efficiency and democracy, and to provide citizens greater access to services and better quality of life (Rauta, 2014, p. 58). Consequently, public management authors have regarded decision-making as a central focus for public performance reform. Managerial decision-making can be illustrated as a proposition considered by decision makers in the setting of the organization and its strategic status. Alternatives, risks, opportunities and potential outcomes are investigated, and thereby a decision is taken. Hertz (2013) highlighted what the decision-making challenges are in terms of faith, trust, and information excess; is that the decision maker sometimes has to take thousands of decisions a day, and doing this in an intelligent manner needs concentration and time (Raczkowski, 2016, p. 28). In addition, the decision-making process is mostly subject to human errors, as leaders have diverse personalities, prejudices, self-interest biases and varied attitudes towards risk (Harvey and TIS, 2007, p. 5).

Hence, there is an urgency to think about how to make administrative decisions more properly and consistently. Some argued that many factors contribute in the complicated decision-making process, such as the development of new technologies, reducing access to financial resources, and limited capacity of decision makers (Ahmad and Munir, 2016, p. 3). In this respect, the complicacy of decisions justifies the utilization of ESs. ES as an advanced technology designed to provide information and uphold decision-making for various business functions, can ensure that decisions are evidence-based and that different probabilities are taken into account. Moreover, the use of ESs is a considerably cheaper, more accessible and rational way of solving problems in this arena (Dasic *et al.*, 2011, p. 27).

Actually, ESs are designed commonly for problems in which there is no single correct solution that can be encoded in a conventional algorithm. One would not use ES to find out shortest paths through graphs or sort data, as there are easier ways to perform these tasks. Simple systems use simple true/false logic and probability theory to assess data, but more sophisticated systems are capable of doing at least some evaluation considering real-world uncertainties, using methods as fuzzy logic (Sahin *et al.*, 2012). Such sophistication is difficult to develop and yet comparatively imperfect in practice (Alasgarova and Muradkhanli, 2008, p. 297). In the health-care domain, for instance, ESs have shown many advantages, such as gaining and using rare expertise, more consistent medical decisions and shorter decision-making processes. Besides, ESs have assisted in making efficient and environmentally-sound agricultural decisions. They also have served as a training tool and in natural resources conservation, controlling, planning, marketing, and financial analysis (Baig *et al.*, 2005, p. 208). Nevertheless, they have faced some challenges including problems with knowledge acquisition and data entry, wrong recommendations and responsibility, appraisal and maintenance of the system's performance, aside from the

limited scope of such systems and the need for integrating them into the routine work flow (Sheikhtaheri *et al.*, 2014, p. 110).

In spite of this, there are still a lot of direct benefits of applying ESs in organizations. ESs are capable of handling enormously-intricate tasks and functions, as well as an extremely-rich knowledge database content and structure. As such, they lessen production downtime and lift outputs and productivity. In addition, disseminating expert knowledge and advice, especially to remote and far locations using digital communications, enhances quality and reliability. As a result, the ongoing usage of ESs may be less expensive and more prosperous than assigning a human expert in specific situations (Expert systems, 2018). Furthermore, the use of ESs, particularly in strategic management, boosts the pace, efficiency, and consistency of decisions based on them. With the employment of ESs, there would be changes reflect in management hierarchy, where the authority at middle and top senior management levels is transferred to lower levels, as even convoluted problems are successfully-resolved within the scope of lower operations management with the help of ESs. Thus, extra time is left to middle and top managers which they use to solve other problems. Therefore, the functioning of the entire management system could be promoted to a higher level (Dasic *et al.*, 2011, pp. 28-29).

Otherwise, the organizational impact of ESs is deemed substantial. It may range from the establishment of additional departments (re-structuring), the modification in the communication system, in the degree of centralization/decentralization, in requirements and duties because of replacement-based ESs, and in the power of certain individuals and groups, to the improvement of the decision-making process and organizational effectiveness and efficiency of the whole entity (O'leary and Turban, 1987, p. 12). One relevant question remains here which is; "how will people react to the implementation of such advanced systems?" In fact, losing managerial control and offending employees are on the top of concerns that might be likely to surface. So that, despite the progress and wide-spread application of ESs, there is an alleged suspicion about how people will respond to this modern technology, both individuals using it as a decision aid and those affected by its decisions, especially in public sector organizations, taking into account the cognitive limits within the contrastive organizational culture of these institutions. This emphasizes the possibility that knowledge transfer maybe subject to some kind of interception or biases on the part of experts, or the potential for lack of trust or over-trust on the part of end-users.

In this regard, O'leary and Turban (1987, pp. 12-13) stated that the influence of ESs on managerial decision-making depends on some variables such as the industry/sector in which the organization belongs to, the organizational climate, percentage of people affected by ESs, frequency of using ESs, number of operating ESs, suitability of the tasks, software and computing environment. Concerning the sectoral impact, it is emphatic that private and public sectors generally have diverse environments. The private sector is more noticeably associated with market forces, while the public sector is typically shaped by political considerations. One is about business and the other is about government. One tends to be decentralized and the other centralized. These different contexts imply unlike decision content (Dillon *et al.*, 2010, p. 231). It needs to be realized that decisions made by public decision makers are indeed social decisions of social choice theory. In addition, it needs to be well recognized that decisions in the public sector are very often made on the basis of conflict between accepted and important values, thus reaching a decision-making compromise here is not easy (Raczkowski, 2016, p. 31).

Whereas in public management like in commercial one, the decision-maker must learn how to accept chaos existing in modern global economy. This means decisions taken today maybe totally different tomorrow, both much better or worse (Hertz, 2013). A famous author

compared public and private sector decision-making using the metrics of analysis and bargaining, and concluded that private sector managers are more supportive of analysis-based decisions, while public executives are more supportive of bargaining-based decisions. Analyzing the two sectors separately suggests that public sector decision-making is typically more open, transparent and structured, while private sector decision-making is generally more ad-hoc and occurs more proactively. Contextual influences and constraints play significant roles in structuring public sector decisions. Because of the restricted nature of decisions made in this environment, human behavioral aspects have much less impact (Dillon *et al.*, 2010, p. 233-234). Thereby, in a structured domain exactly as in public sectors, where qualitative reasoning is crucial to problem solving and expertise is quite available, developing an ES to bolster repetitive decisions, in particular, maybe convenient (Liang, 1987, p. 7). Here, ESs can reduce the workload of a public officer and allow him to take care of certain severe cases. Moreover, with the decreased impact of human factor, administrative decisions based on ESs are standardized and objective to a great extent.

For that reason, the current research intends to continually examine the applicability of ESs in public organizations, with specific reference to Egypt. As the reviewed literature has shown that ESs are not completely unified and as such scholars tended to focus on several determinants to analyze (e.g. components, tasks, stages) depending on the theoretical perspective. Then, as long as this paper adopted the systems approach in management (open system) and claimed that ES is a system in the first place, so it could be best identified through its four basic dimensions: inputs, processes, outputs and feedback. Besides, the quality of administrative decisions is measured here through their major indicators such as consistency, integration, transparency, timeliness. . ., which were extracted from previous research (Nagy *et al.*, 2011; Bozeman and Pandey, 2003). On the other hand, the present study believes that the impact of ESs on the performance of administrative decisions often relies on the various organizational factors such as leadership support, organizational culture and resources availability, as it was confirmed before by some researchers.

Eventually, for successful implementation ES decision must be regarded as a good advice which can, but does not have to be fully approved by the decision maker (Dasic *et al.*, 2011, p. 29). This explains the methodology adopted in this research and the necessity of distinguishing between ES outputs (recommended decisions) and the actual administrative decisions taken by leaders. In the next part, the study will test the effect of ESs on the efficiency of managerial decision-making at a critical Egyptian public agency, which is the MIIC; is that the role of technology here is fundamental because of the significance, accuracy, and promptness of the output desired to offer quality services to the investors in the Egyptian market.

4. Application: empirical study discussion

4.1 Methodology: research design and techniques

The design of the study is descriptive in the theoretical part and quantitative in the empirical one. Theoretically, the research jointly adopted the analytical approach and the systems approach to demonstrate main concepts and to determine the relationship between variables as well, while it used an applied study to investigate correlations in practice. Hence, in addition to providing a concise overview of relevant literature, a field survey was conducted during the first two weeks of May 2018 to capture the executives' attitudes towards developing and applying ESs, and their impact on the quality and effectiveness of administrative decisions at the MIIC.

This entity was opted as the case study here because it is considered one of the crucial Egyptian economic ministries that have launched many substantial reforms, particularly

technical ones, during the past years to enhance work processes and provide access to improved public services to all citizens (MIIC official website, 2018). Furthermore, after conducting a number of interviews with some prominent governmental executives inside and outside MIIC, it was noticed that this type of systems (ES), which is not widespread in the Egyptian public sector, is found in some way in this case although it is not yet complete/perfect, as they are still working on some planned developments to allow for the full utilization of its capabilities in the near future. Therefore, it is necessary to explore the current situation and to evaluate the efficiency of existing ESs and how their effectiveness could be boosted to promote the quality of administrative decisions at the ministry. This might be regarded as a kind of process evaluation which takes place while implementing a project to discover the aspects that need to be changed during delivery. Its goal is to find ways of improving the program while it is realizing.

For the purpose of gathering the required primary data, an Arabic-language structured questionnaire was adopted, as Arabic is the official language in Egypt (it was initially written in English and then translated). The questionnaire was formulated on the basis of literature review (Nagy *et al.*, 2011; Bolfikova *et al.*, 2010; Faisal and Hanzal, 2009). It encompasses 52 items other than demographic data and consists of three sections: determinants of ESs (inputs-processes-outputs-feedback) (independent variable), organizational factors (moderating variable), and administrative decisions criteria (dependent variable) (Appendix). Here, it is worth mentioning that the study utilized the questionnaire to collect data using a five-point Likert scale as the measurement tool, ranging from 1 = strongly disagree to 5 = strongly agree.

Finally, statistical package for social survey (SPSS-V.18) and Analysis of MOment Structures were both the tools for compiling and processing data in this research. Multiple statistical tools were also used for data analysis, which are descriptive analysis, Pearson correlation coefficient, simple linear regression and structural equation modeling. Moreover, Cronbach's alpha test was applied to assess the reliability of the research measures, and it was noticed that all coefficients are above 0.50, so there is evidence that the variables seem to be stable, consistent, reliable, and valid.

4.2 Demographic and professional data of respondents

The whole population was around (120) people who perform as managers at MIIC (headquarter/main premises in Cairo). A manageable and convenient sample size of (52) people was examined. This sample was randomly selected. Knowing that 60 people (50 per cent of the population) were sampled and 52 only responded, thus the response rate was 87 per cent.

Empirical results indicate that the majority of 73.1 per cent of the sample are males while 26.9 per cent are females, 86.6 per cent their ages are less than 50 years and 84.6 per cent of the sample are post graduates, whereas 15.4 per cent have only a BSc degree. In addition, the majority of 78.8 per cent of respondents are department managers while 21.2 per cent are considered upper level management, and eventually 53.9 per cent have spent at least 10 years working for MIIC.

4.3 Building indicators of the research variables

Statistical technique was used to combine each group of related questions in one indicator. It is important to mention that seven indicators were already created: inputs, processes, outputs, feedback, organizational factors, administrative decisions and ESs, as shown in Table I which presents the descriptive statistics of them. The first six indicators were composed by using equal weights method, via adding the scores of the questions which are

related to each indicator and then dividing the sum by the number of those questions. However, the last indicator (ESs) was calculated through the following formula (0.4 × inputs + 0.3 × processes + 0.2 × outputs + 0.1 × feedback) to take into consideration the hierarchy of these sub-items. From Table I, it is obvious that the values of the mean for all indicators are around 3 and 4 (in Likert scale), which clarifies that the respondents tended to be neutral or agreed to the questions that measured those indicators in common. It is clear also that the highest mean value is for the one of processes (4.00), which means that the presence of this indicator was good at MIIC. On the other hand, the least mean value is the one of administrative decisions (3.46), which means the level of this indicator was average.

Table II indicates the relation between the whole indicator of ESs and its sub-variables using Pearson correlation coefficient. As shown in this table, there is a significant (p-value is less than 0.05) positive relationship at significance level $\alpha = 0.05$ (with confidence level 95 per cent) between ESs whole indicator and each sub-variable. Knowing that the highly correlated indicator is inputs (0.838) and the least is feedback (0.488), which is logical in light of their hierarchy and reflects their influence on ESs at MIIC. In addition, this confirms the fact that feedback is oftentimes neglected in reality.

4.4 Testing the research hypotheses

To accomplish the empirical goals, the research set out the following hypotheses:

4.4.1 First hypothesis

H01. "There is no significant relationship at significance level $\alpha = 0.05$ between ESs and the quality of administrative decisions at MIIC."

H01.1. "There is no significant relationship at significance level $\alpha = 0.05$ between inputs and the quality of administrative decisions."

H01.2. "There is no significant relationship at significance level $\alpha = 0.05$ between processes and the quality of administrative decisions."

Table I.
Descriptive statistics of the research indicators

Indicator	Minimum	Maximum	Mean	SD
Inputs	3	5	3.94	0.59
Processes	3.2	5	4	0.42
Outputs	2.79	4.36	3.63	0.34
Feedback	2.33	4.67	3.92	0.44
Organizational factors	3	5	3.94	0.55
Administrative decisions	2.69	4.56	3.46	0.59
ESs	3.35	4.67	3.89	0.34

Table II.
Pearson coefficient of ESs sub-variables

Sub-variable	Inputs	Processes	Outputs	Feedback
ESs				
Pearson coefficient	0.838	0.569	0.588	0.488
p-value	0	0	0	0

H01.3. "There is no significant relationship at significance level $\alpha = 0.05$ between outputs and the quality of administrative decisions."

H01.4. "There is no significant relationship at significance level $\alpha = 0.05$ between feedback and the quality of administrative decisions."

To prove whether the previous hypotheses are acceptable or not, simple linear regression was used to test the total effect of ESs, along with the influence of each component separately on the quality of administrative decisions, as presented in Table III. Note that the hypothesis will be denied if the significance of the model is less than 0.05, and vice versa.

Table III indicates that:

- For the first model, when inputs indicator is the independent variable: It is obvious that there is a significant positive relationship between inputs and administrative decisions at confidence level 95 per cent, and this appears from the value of beta. From adjusted *R*-squared, it is noticed that inputs have the ability to explain about 35.7 per cent from the variation in administrative decisions at MIIC.
- For the second model, when processes indicator is the independent variable: It is clear that there is a significant positive relationship between processes and administrative decisions, and that processes have the ability to explain about 8.3 per cent only from the variation in decisions.
- For the third model, when outputs indicator is the independent variable: It is obvious that there is a significant positive relationship between outputs and administrative decisions, and that outputs have the ability to explain about 35.2 per cent from the variation in decisions.
- For the fourth model, when feedback is the independent variable: It is clear that there is no significant relationship between feedback and administrative decisions cause the significance of this model is greater than 0.05, which means that feedback does not affect the quality of decisions at all. This is compatible with the result that feedback is the least-correlated sub-indicator with ESs and it is usually ignored.
- For the fifth model, when the independent variable is the overall ESs indicator: It is evident that there is a significant positive relationship between ESs and the quality of administrative decisions at confidence level 95 per cent, and that ESs have the ability to explain about 43.2 per cent from the variation in decisions.

From the previous results, the study can conclude that there is a significant relationship at significance level $\alpha = 0.05$ between ESs and the quality of administrative decisions at MIIC; is that it was proven that inputs, processes, and outputs of ESs have significant positive

Table III. Simple linear regression models of the dependent variable on the different independent variables

Simple regression model	Dependent variable	Independent variable	Beta	Significance of the model	Adjusted *R*-squared
First	Administrative decisions	Inputs	0.605	0	0.357
Second		Processes	0.449	0.023	0.083
Third		Outputs	1.053	0	0.352
Fourth		Feedback	0.203	0.324	0.02
Fifth		ESs	1.382	0	0.432

effects on administrative decisions at MIIC, whereas feedback has insignificant effect on the quality of these decisions, which means that the first hypothesis as a whole and its first three sub-hypotheses as well are all rejected, while merely the fourth sub-hypothesis is accepted.

4.4.2 Second hypothesis

H02. "There is no significant relationship at significance level $\alpha = 0.05$ between ESs and the quality of administrative decisions at MIIC, putting into consideration the organizational factors."

To show if the previous hypothesis is acceptable or not, a structural equations model, illustrated in Table IV, was used to test whether the moderating variable has significant impact on the relationship between the independent and dependent variables or not. Knowing that the moderating variable will have significant influence on this relation if there is a significant effect of ESs on organizational factors, as well as a significant effect of organizational factors on administrative decisions. In that way, Table IV clarifies that:

- The organizational factors have significant effect on the relationship between ESs and the quality of administrative decisions at MIIC at confidence level 95 per cent, as their p-values are less than 0.05 in both ways.
- The direct effect of ESs on administrative decisions = 0.663, while the indirect effect through organizational factors = $1.164 \times 0.611 = 0.711$, which means that when taking into account the organizational factors, the effect of ESs on decisions increases from 0.663 to 0.711 or the relation becomes stronger.

From the previous results, the research can conclude that there is a significant relationship at significance level $\alpha = 0.05$ between ESs and the quality of administrative decisions at MIIC, taking into consideration the organizational factors, so that *H02* is also rejected.

5. Conclusion: concluding remarks

ESs are gaining widespread admission in the business world today. Thousands of cases have proven that ESs are invaluable decision-making tools. However, managers still need to learn how to overcome obstacles of successful implementation. Therefore, it seems that there is much to be learned about the potential use of ESs in the realm of public sectors. This research has productive implications for both theory and practice; first it offers multiple contributions to literature, as it expands on the existing knowledge by formulating a conceptual framework identifies the desired role of ESs in improving managerial decision-making, specifically in public organizations, and second the paper provides a practical directory to executives and policy makers, particularly in the Egyptian government, to help them enhance their choices using modern technology, aside from providing an educational material for MIIC staff and a catalyst to support the application of ESs there. Nevertheless, the empirical study here has few limitations. All results are based on information taken from

Table IV.
Results of structural equations model

Dependent variable		Independent variable	Estimate	S.E.	C.R.	*p*-value
Organizational factors	←	ESs	1.164	0.218	5.345	0
Administrative decisions	←	Organizational factors	0.611	0.111	5.513	0
Administrative decisions	←	ESs	0.663	0.215	3.08	0.002

respondents. This is in addition to time limitations, i.e. findings represent the Egyptian economy within a period of great challenges and transformations in Egypt.

Through the theoretical and applied parts of this research together, it has reached the next results and recommendations:

5.1 Results and findings analysis

In general, this research claims that ESs do not aim to fully replace human experts in problem solving activities; however, they can serve as an extremely-useful expert advisor for numerous management tasks and issues. In that way, ESs are earnest assistants to public decision-makers and not substitutes for them. In this respect, the main results here are:

- The study confirms that ES is one of the most commercially fruitful branches of AI. ESs are more recommended when the problem field is structured, the decision is repetitive, and the knowledge involves qualitative reasoning. Besides, there are several functional categories suitable for this technology which may include interpretation, prediction, diagnosis, design, planning, monitoring and control.
- The paper highlights that managerial decision-making is one of the most challenging, dynamic, and ongoing tracks in every organization. Nowadays, there is a great need to modify the problem solving approaches among organizational leaders while accommodating technology and globalization. Hence, ESs can provide great potentials for automatization and modernization of this act.
- Findings indicate that because of the structured, complicated, and restricted nature which is an obvious trait of problems within public management, it is possible to resolve them with the help of ESs. For that reason, properly designed and implemented ESs could be a powerful addition to the ever-expanding tool box of public executives.
- Practical implications clarify that the presence of most of the indicators of ESs, administrative decisions, and organizational factors at MIIC is above average, which could be normal and expected in light of the fact that the ministry is still working on developing its systems to allow for the full utilization of their capabilities in future decision-making actions. This means there is yet an urgent need to support and strengthen these concepts in the work context of MIIC. Otherwise, it was noticed that individuals who had the opportunity to use ESs did not feel highly threatened by this decision instrument; instead, they thought it was a time-saver.
- The results of this analysis provide evidence that existing ESs have contributed to the decision-making process at MIIC (by 43.2 per cent), as demonstrated by the positive relationship between the independent and dependent variables; is that it was proven that inputs, processes and outputs are positively related to the quality of administrative decisions, while only feedback does not affect decisions at all. This refers to the quite-weak interdependence relation between ESs dimensions that might impact decisions, in addition to the relatively poor compatibility between ESs applications, as an advanced decision aid technology, and the practices and activities of decision-making at the ministry. Knowing that this could also reflect in somehow the moderating variable influence in this relation. In this regard, it was emphatic that the relationship between ESs and administrative decisions is moderated by organizational factors, which means when considering the organizational factors at MIIC; the effect of ESs on managerial decision-making becomes greater.

5.2 Recommendations and future research

In light of what was aforesaid, the research has made these recommendations:

- Problem solving is better achieved through applying specific knowledge rather than certain techniques. Accordingly, when ES does not produce the desired results, then work should begin to enrich the knowledge base, not to reprogram the procedures.
- When recruiting, employers must consider the decision-making experience of nominees. At the same time, nominees ought to be fully aware of the decision-making context within which the organization operates.
- Public managers need to clearly understand their essential part and substantial role in the ES development project. They should provide financial, informational, and psychological support to the project team. Moreover, hiring consultants to help implement the plan is recommended if management is inexpert in handling organizational changes, along with providing adequate technical training to assist in overcoming barriers.
- The empirical results suggest that there must be more genuine efforts to strengthen, integrate, and achieve consistency between ESs dimensions and applications on one hand, and between them and the managerial decision-making at MIIC on the other hand, which for sure will impact positively the quality and effectiveness of administrative decisions. In this respect, giving greater attention to the feedback that was evidenced it did not affect decisions completely, and at the same time, it was the least correlated indicator with ESs at the ministry, and linking this feedback together with inputs in a continuous cycle, or in other words taking advantage of feedback reviews in addressing current problems and promoting the level of inputs and thereby the other dimensions, all of this would undoubtedly boost the efficiency of ESs and thus the quality of the overall decision-making process at MIIC. Also, to foster the effect of the organizational factors that positively moderated the relationship between ESs and administrative decisions at MIIC, the researcher here recommends to place greater emphasis on these elements consecutively; the importance of leadership willingness and commitment to feeding and updating the ministry's knowledge bases with the latest data, which was proven that it had no impact among different organizational factors there. As well as, the need for allocating sufficient funds and recourses that had the least influence among organizational factors, and then the need for high-level technical assistance from inside and outside the ministry, in addition to encouraging creativity, transparency and empowerment in the existing work climate.
- Concerning future research, an obvious sequel to this study is to conduct longitudinal research to reveal over time if the ES feedback reviews reported at one point are associated with better inputs and outputs at a later point. This opens the way to replicate the framework of this research again at MIIC, but after a reasonable period which may give them the opportunity and time to complete the development of ESs and eliminate current limitations, to allow for fair evaluation of the efficiency of operations and satisfaction of service recipients. In addition, it is necessary to find and assess more applications of ESs in different service and manufacturing areas within both private and public sectors, and to test the various organizational antecedents and implications of using such advanced technology in these institutions, especially with its high requirements. Besides, further studies should also consider other moderating variables, such as organizational structure, system software, and computing environment. Finally, future work examining international rapprochement is urgently requested, particularly in close cultural contexts.

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Appendix. Questionnaire statements

A. ESs at MIIC

Inputs:

1. ES utilizes smart/modern technology.
2. ES requires qualified staff.
3. Adequate financial resources are needed.

4. Vital/various data is stored.
5. Scientific principles/practical experience are stored.
6. ES is fed with updated information.

Processes:

7. ES is used frequently.
8. ES performs numerous tasks.
9. Target is set up in line with ES purposes.
10. ES receives sufficient information to determine each case.
11. ES analyzes data and applies rules to address problems.

Outputs:

12. ES provides clear/accurate professional recommendations.
13. ES provides practical recommendations.
14. ES provides timely recommendations.
15. Recommendations look for proven solutions.
16. Recommendations look for novel solutions.
17. Recommendations suggest best solutions.
18. Recommendations justify chosen alternatives.
19. Recommendations set implementation plans.
20. Recommendations are usually applied.
21. ES outcomes support executives' decisions.
22. Outcomes support different stages of decision process.
23. Outcomes support a wide variety of decisions.
24. Outcomes affect decision structure.
25. Outcomes impact a broad range of citizens.

Feedback:

26. ES is simple/easily-used.
27. ES is flexible/responsive.
28. ES is comprehensive/integrated.
29. ES is reliable/trusted.
30. ES is efficient/effective.
31. Outcomes could be improved by developing the technological structure/knowledge base.

B. Organizational characteristics

32. MIIC assigns technical experts to design/implement/modify ES.
33. MIIC has a separate IT support unit.
34. MIIC has sufficient funds for developing ES and training employees.
35. Administrative leaders facilitate the implementation of ES and the enrichment of databases.
36. MIIC has an open/decentralized organizational culture.

C. Administrative decisions at MIIC

37. Decisions are in line with public policies objectives of the state.
38. Decisions are in line with environmental changes.
39. Decisions are timely.
40. Decisions are announced.
41. Employees are consulted in relevant decisions.
42. Decisions provide appropriate solutions for problems.

43. Decisions deal with different aspects of problems.
44. Reasons behind decisions are often obvious.
45. Available alternatives are usually clear.
46. General/collective interest is given priority.
47. Decisions are consistent.
48. Decisions are complementary.
49. Decisions are instantly executed.
50. Decisions are easily followed up.
51. Decisions are periodically assessed.
52. ES is utilized to promote decision-making within MIIC.

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