PROBLEMATIC RESEARCH DESIGN IN QUALITY MANAGEMENT- IS AGENT-BASED SIMULATION A PANACEA?

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ABSTRACT
Quality Management (QM) problems are mostly researched by means of inductive reasoning based on statistics. Statistical models, albeit having several limitations, have been applied for a ling time in QM-related researches. Although some people present different definitions for QM and Total Quality Management (TQM), they are assumed to be the same in this research. Quality Management Systems (QMSs) are defined as a different notion later. This paper is an attempt to shed light on the alternative research methods to explore interactions between organizational performance and Quality Management (QM). To reach this objective, the problems of inductive reasoning, as the dominant research method, are categorized in three categories, namely research design, definitions and measurements, and analysis. The problems in each category are scrutinized and then the potentials of Agent-based Simulation (ABS), as new research method, are presented. It is argued that by applying ABS a virtual environment is provided to improve the quality research efforts in QM and deduce more reliable results.

Keywords: Quality, Performance, research method, Agent-based simulation

1. INTRODUCTION

Improving organizational performance has long been among significant activity for engineering managers. Performance is universally related to the efficient conversion of resources into products. It is important to managers because resources are scarce and local and international competition is severe and ever-increasing. Therefore, to overcome competitors and survive in the market, astute resource allocation and investment are of paramount importance to organizations in order to maximize their gains.

Improving quality has become a priority for some companies only in the last few decades of the twentieth century. One reason for the slow adoption of quality programs could be the widely-held belief in industry that improving quality would reduce productivity. However, global competition has forced companies to seek continuously competitive advantages and in this regard, quality initiatives may be helpful.

The relationships between quality management and performance have long been of interest of both management academics and practitioners. No matter what the exact definitions of quality and organizational performance are, it is common knowledge that quality and organizational performance are interrelated concepts; however there does not appear to be an explanatory model for clarifying the hidden causal relationships between these two important concepts. In modeling the relationship between performance and QM, in addition to productivity, other business performance measures like innovation, flexibility, financial performance, market share and competitiveness are discussed (Neely 1999, Neely et al 2000, 2004, Rathore et al 2005, Bititici and Turner 2000, White 1996). Within this framework, there are research works by which the effects of Total Quality Management (TQM) on financial performance (Wayhan and Balderson 2007, Sila 2005), or the impacts of competition on quality (Das et al 2000), or the effects of contextual factors (Sila 2007) or Just in Time (JIT) and ISO 9000 (Dreyfus, Ahire, and Ebrahimpour 2004) on TQM, are studied. A review of literature reveals that QM-related studies suffer from some fundamental defects in the research method itself and its implementation.

The aim of this paper is to outline major problems of research on QM-performance relationship. To alleviate the existing problems, a new methodology of research based on complexity theory is proposed. This methodology is an attempt to explore the potentials of complexity science in QM-related research. It begins with the description of TQM and Quality Management Systems (QMSs) followed by the problems associated with QM-performance. They are grouped in three categories: research design and approach, definitions and measurements, and analysis. Next, the outlooks of ABS as a new tool of conducting research are discussed.

2. PRINCIPLES OF TOTAL QUALITY MANAGEMENT

Quality draws the attention of economists, operation managers and marketing strategists, each with their own vantage point. Competitive pressures and technological developments have affected the core knowledge of operation and production management and introduced many new concepts in the literature. In fact, these developments are a response to managing the ever-increasing complexities associated with production and operation management. "The increased competition led to a proliferation of new inventions in how to manage for quality" (Juran 2004, page: 343). Feigenbaum (1991) categorizes the development of the quality field into *operator quality control, foreman quality control, inspection quality control, statistical quality control, Total Quality Control,* and *Total Quality Management (TQM)*. It is seen that the scope of quality has been extending from a single workstation to the upper levels of management. Within TQM framework, it is suggested that quality be considered as a major business strategy. Gradually "concepts, methods, and tools accelerated the evolution of a new science- the science of managing for quality" (Juran 2004, page: 343).

Nowadays, Total Quality Management (TQM) and QMS are two terms that are used repeatedly and are presumed to be perceived by those who apply them, but especially this is not the case for TQM. Unlike QMS which has a systematic definition developed by International Organization for Standardization (ISO), there is no formal definition of TQM. However, there are numerous definitions, presented by different quality consulting organizations, academic scholars and quality practitioners. A review of different definitions shows that there is no consensus on the basic definitions of these buzzwords.

According to Harrington (1995), the term TQM was popularized in mid-1980s to label the extension of the quality discipline into all areas of an organization. In a TQM model presented by Oakland (2003), constituent elements of TQM are the so-called 4Ps including Planning, Performance, People, and Process along with three Cs- Culture, Communication and Commitment. Harrington (1995) defines TQM as a methodology dedicated to quality improvement efforts, whilst Cole and Mogab (1995, page: XI) consider TQM and continuous improvement as "different perspectives of the same phenomenon: a lean firm". The former's focal point is the beliefs and practices required whilst the latter acts as a change tool.

Feigenbaum (1991, page: 14) argues that TQM is an extension of Total Quality Control to cover the "full scope of the product and service life cycle from product conception through production and customer service" while a quality system "is a company-wide and plant-wide operating work structure, documented in effective, integrated technical and managerial procedures,…, to assure customer quality satisfaction and economical costs of quality" which is the foundation of Total Quality Control.

In another school of thought, TQM is defined, in a broader perspective, as a system approach to management rather than quality management. For instance, Stahl (1999) adopts this approach and states that TQM is targeted at continuously increasing value to customers by designing improving organizational processes and systems. TQM is a combination of a philosophy (e.g. compete on superior quality (Stahl 1999) and tools or a set of guiding principles (as Besterfield et al (2003) cite). ISO 8402:1994 contains the same definition of TQM as a management method: "a management approach of an organization, centered on quality, based on the participation of all of its members and aiming at long-term success through customer satisfaction and benefits to the members of the organization and to society". However, this viewpoint of TQM has vanished from the recent versions of ISO 9000 series (refer, for instance, to ISO 9001: 2008).

The key elements of TQM are: commitment and leadership of the top management, planning and organization, customer focus, using tools and techniques, education and training, workforce involvement, teamwork, measurement and feedback, continuous improvement culture, treating suppliers as partners (Oakland 2003, Besterfield et al 2003, Harrington and Harrington 1995). A part of researches about TQM include identification of different constructs and their interrelationships in order for conceptualizing TQM principles. The logical outcome of this conceptualization process seems to be developing casual models to relate TQM constructs to performance measures because the ultimate objective of management theory in general may be summarized as acquiring profit and competitiveness through organizational performance.

The same argument holds for QMS. ISO provides a rigorous definition of QMS and its elements. A QMS is a "management system to direct and control an organization with regard to quality" (AS/NZS ISO 9000:2006). A QMS along with other management sub-systems like the financial management system form the organization management system (ibid). In this view, QMS acts as a framework for continuous improvement, encouraging customer requirement analysis, process definition and process control with the aim of enhancing stakeholders' satisfaction (EN ISO 9000:2005). Acting as a stabilizer of quality efforts, a quality management system is a prerequisite to ensure consistent achievement of customer satisfaction and determines how organizations operate to institutionalize a continuous improvement culture throughout the company. In other words, QMS is the means for sustaining the improvement gains, a solid foundation of continuous improvement initiatives (Harrington and Harrington, 1995). A quality management system, in this viewpoint, is contemplated as the elementary step towards TQM (Stahl 1999, Besterfield et al 2003). Based on the several field studies, Dale et al (2007) reports the following benefits from a successful quality program:

- Increased productivity
- Better marketplace performance
- Improved business performance

Here again, the question is whether QMS is effective to produce desirable outcomes for organizations.

To develop a sound, operational model between quality management and organizational performance, an efficient methodology is needed, but inductive reasoning by means of statistical models falls short of expectations. Instead, Agent-based Modeling raises promising prospects that are discussed later in this paper.

The relationship between quality and performance could be analyzed in two layers: first quality as an outcome and second quality management system. Output quality is an outcome of quality management systems implemented all around the organization. Quality as an outcome cannot be achieved at random but by a well-established quality management system. If we consider output quality, it is directly related to performance because it could be construed as having lower defect rates and more usable products but the interaction of performance and quality management is not straightforward because discovering the effects of QM on organizations is a rigorous research due to the involvement of several interacting elements such as people, organization, technology and contextual factors. In the next section, the ubiquitous research method in QM, inductive reasoning, is critically analyzed.

3. RESEARCH METHODS IN QM AND THEIR DRAWBACKS

Based on the literature review, it seems that the majority of QM-related research is done by applying inductive reasoning. Different statistical methods like regression analysis, factor analysis, and structural equation modeling are used to analyze the data, mainly collected by questionnaires as the research instrument. Although inductive reasoning seems to be the only method for conducting research on QM-performance problems, it is not error-proof. In fact, some flaws are fundamental, yet hidden. The problems of current research on QM and performance relationship may be categorized into three groups: research design, definitions and measurements, and analysis. The details of each category are explained herein.

3.1. Research Design

Research design means planning the overall research. In QM literature, the dominant research method is induction based on statistics but it has several problems, discussed here.

The Drawbacks associated with induction reasoning in comparison to deduction is the first problem. Induction based on statistical methods is a dominant approach in QM-performance research, applied when deduction is very arduous (sometimes even impossible). In Bowell and Kemp (2002) words, "to say that an inference is an inductive inference is to say: (a) it is not deductively valid; (b) its premise is a generation about a sample of a given population, and (c) its conclusion is a generalization about the total population from which the sample is drawn". The main problem is that causal inductive arguments can provide us only probable conclusions (Vaughn 2005). Therefore, inductive conclusions must be viewed with caution (Powell 1995). Despite this weakness, it is still a useful tool in doing research in many fields because there is no other equally efficient alternative. In addition, there are major difficulties in modeling synergies and interactions of QM elements through statistical methods (Stahl 1999). In other words, interactions, for example between organizational culture changes due to TQM and performance, are nonlinear that is difficult to take into account with statistical models.

The second problem is lack of universally accepted theoretical foundation for QM. In the quality management literature, a considerable number of papers deal with basic quality concepts, which is argued to be because of a dearth of well-founded theory of quality management (Sousa 2003, Ghobadian and Speller 1994, Singh 2006, Foley 2000). In fact, QM look more like a collection of different methods and tools without any structure) and there is no theory to test it or expand it. Ghobadian and Speller (1994) report the lack of conceptual framework and sound instructional methodology as the main drawbacks of previous theories of quality. This idea is reiterated by Singh and Smith (2006) where other barriers like difficulties in successfully imitating quality management implementation and underestimation of the magnitude of change that is needed are noted.

The third problem is lack of originality in research on QM-performance relationship based on statistical models. There are many works in this area already done albeit with various methods and depth of research (see for example: Singh 2008, Dow et al 1999, Sila 2005, and Kaynak 2003). On the one hand, these similar researched may test the falsifiability of conclusions, which is a criterion for demarcation in Popperian philosophy (see Popper 2005 page: 17). Therefore, similar researches could be interpreted as a tool for strengthening evidence for relatively similar hypotheses. For instance, the effects of communication, information flow, and measurement are emphasized under different concepts in QM research, each addressing relatively a similar notion (see for example: Sila 2007 or Singh 2008). On the other hand, there has yet to be a theoretical system for QM, as it has been explained in this paper, without which falsifiability or verification makes no sense. It means that each author, as is a standard method in social science, defines his/her own conceptual model first and then tries to test some relevant hypotheses to prove the validity of the conceptual model. Therefore, similar research projects

with different conceptual models provide little evidence for a hoped-for general theory of QM.

Existence of external disturbance obscuring the links between QM and performance measures is the forth drawback. The hoped-for theory for QM-performance includes supposedly a set of cause-effect propositions but they cannot be deduced without deliberately controlling different variables that is very difficult in inductive reasoning. Existence of some important contextual parameters like organization culture or competition pressures exacerbates the situation (Das et al 2000, Sila 2007, Davies and Kochhar 2002, Stahl 1999).

Finally, the last problem is existence of tangible and intangible (sometimes behaviorally-oriented) factors of performance and TQM. Like QM, organizational performance is a multi-faceted concept that may be interpreted as a combination of output quantity and quality, flexibility and service-related indicators. Output could be intangible which makes it difficult to be quantified such as short order lead times, on-time deliveries, and high quality (Tangen 2005, Ray and Sahu 1990, Bernolak 1997, Yousif et al 1990, Jackson and Petersson 1999, Kaydos 1991). The performance indicators in era of mass production (e.g. early 20th century) sometimes criticized as being just an efficiency indicator, when the emphasis was put on more production, not contemplating intangible outputs and ignoring important issues like profitability, quality, on-time delivery and after-sale services. With the introduction of lean manufacturing concepts, customers have become more important than production itself. In other words, owing to market pressures and the shift from mass production to mass customization, traditional definitions of performance could not evaluate the organization success, which is related directly to the enterprise objectives and the quality of output as well. It means that traditional indicators like output to input ratio does not measure "*effectiveness*", another index used by scholars like Son (1994) in an attempt to alleviate the inherent exposed weakness of the traditional definitions. Nevertheless, contemplating intangible outputs in performance measurement models is not an straightforward job. This is also the case for QM with its behavioral factors.

To be successful, QM requires changing individual mindsets and the organization (Stahl 1999). In other words, some major changes in behaviors are inevitable but they cannot be captured and modeled within mathematics/statistics framework. This provides fresh impetus for more research on the feasibility of alternative research methods, discussed later in this paper.

3.2. Definitions and Measurements

The first requirement of an efficient research is basic definitions. Without definitions, nobody could define appropriate, measures. Both performance and QM suffer from fussiness of definitions and measures. This is explained in the following.

Lack of exact definitions of basic concepts like quality, QM, performance, etc is the first problem. There is no universally agreed definition for quality and it remains subjective, and easily misunderstood (Crosby 1996, Juran 1992, Deming 1986). This is also the case for performance (Tangen 2002, Bernolak 1997). The definitions of quality as "degree of goodness" and "the minimum number of conceptions required" were first suggested by Shewhart (1931). Despite the wide acceptance of simple definitions suggested by some quality gurus like "fitness for use" by Juran (1989) or "conformance to requirements" by Feigenbaum (1991), Garvin (1988) presented a thorough, multi-faceted definition of quality, based on what he called quality dimensions: performance, features, reliability, conformance, durability, serviceability, aesthetics and perceived quality. Although this definition is multi-faceted but it is difficult to define appropriate measures based on it.

Second, the differences between QM, TQM, quality awards, and business excellence models are unclear. There was a change in scope of quality initiatives from mere inspection in a workstation to company-wide quality management systems (QMSs) and further to Total Quality Management (TQM). Unlike a QMS, which is a management system to direct and control an organization with regard to quality (AS/NZS ISO 9000:2006), TQM has no formal definition. However, there are numerous suggestions, presented by different quality consulting organizations, academic scholars and quality practitioners (Harrington 1995, Oakland 2003, Cole and Mogab 1995, Stahl 1999, Besterfield 2003). This vagueness of differentiation hinders developing a consistent mental model among managers, consultants as well as academics and is reflected in biased, erroneous surveys

Third, there are several difficulties in data collection. The main problem of data collection in TQM researches is the difficulty in determining whether a company has implemented TQM (and to what extent?) (Davies and Kochhar 2002). There is no straightforward guidance to differentiate between a quality-oriented organization and an ordinary one. Data collection methods vary from mail survey and direct observation to in-depth interview. The danger of biased data always exists; as Sila (2005), Davies and Kochhar (2002), and Stahl (1999) report, respondents are mainly quality managers and like case studies, report positive results; furthermore, direct observation and in-depth interview are time-consuming and produce qualitative data. The tendency to try `to give the "right answers" not the "actual answers" and to exaggerate TQM programs by managers (regarding the time and the scope of implementation) are other sources of bias (ibid). Data accuracy, sample size, and measurements are other sources of challenge in data gathering. Firstly, data inaccuracy does exist, because many studies rely on self-reported data from CEOs (based on their own perceptions) that cannot consider all variables and assess any causal linkage between TQM and

performance. Secondly, in statistical models, the sample size is of paramount importance in obtaining reliable results but a review of previous researches shows that respondent rates are low (often less than 25%). Consequently, sample sizes are small (Dow et al 1999, Singh and Smith 2006). Thirdly, serious measurement problems exist in even standardized indexes of firm performance like market share, profitability and productivity (Stahl 1999). They are insubstantial notions that exist only as concepts with fuzzy definitions. The fuzziness makes it hard to develop an appropriate, measurement yardstick. Most surveys lack operational definition of the terms they use and thus are ambiguous (Stahl 1999).

3.3. Analysis

By analysis, we mean the final stage of research in which the hypotheses are tested or research questions are answered. Some of the most important pitfalls in this category are explained in this section.

The first problem is the existing controversies concerning whether or not TQM has any tangible impact on performance. Because of its importance in companies surviving international competition, the notion of quality and implementation initiatives like QMSs or TQM have attracted the attention of both practitioners and academics and thus, a large number of publications in production and operation management have been devoted to these subjects. Studies of Holoviak (1995), Sebastianelli and Tamimi (2002), Garvin (1988), Seawright and Young (1996), Oh (1995), Reeves and Bendar (1994) and Zairi (2002) are examples of works focusing on the conceptual aspects of quality management. Although there are a very large number of publications supporting the effectiveness of quality initiatives, some scholars like Longbottom et al (2006) and Dayton (2003) raise doubts about the future of TQM. However, the reasons for TQM failure are unknown (Terzioski 2006, Sila 2007, and Singh and Smith 2006). This could, in part, be attributed to difficulties in building causal models between QM and performance (Dow et al 1999). Findings about QM and organization performance are sometimes contradictory and confusing because, on the one hand, most academics and consultants encourage applying QM principles and tools based on the tested hypothesis of a positive link between QM and performance (e.g. Dow 1999 or Wayhan and Balderson 2007). On the other hand, popular press report negative findings and the failure rate of 60-67% (Dow et al 1999, Sila 2007).

Temporal issues between short-term and long-term results are another source of problem. As it was explained before, QM includes some changes in the altitudes, behaviors, and working culture. They do not happen easily in a short time but evolve within a relatively lengthy time span. Therefore, their effects on the organizational performance variables take time to appear. In other words, researching in this area needs longitudinal analysis not snap-shot one. The major problem turns out to be the start date of TQM deployment which is ambiguous (Sila 2005, Davies and Kochhar 2002). Furthermore, sometimes TQM is implemented just in a section of a company and the performance data are not available or cannot be compared with other companies (Davies and Kochhar 2002, Stahl 1999).

The outcome of aforementioned drawbacks is contentious results, seen in the literature and, to ameliorate these problems, it seems that research in QM needs alternative methods. The problems associated with statistical models in QM-Performance relationship, uncovered by means of literature review have posed the first question of this research: is there any research method better than inductive reasoning? If yes, how can QM be researched by means of this new method? It is argued that ABS could play the role of an innovative approach to tackle the problems associated with inductive reasoning that are discussed in the next section.

4. THE PROMISING OUTLOOK OF AGENT-BASED SIMULATION

The ultimate goal of the research on QM-performance studies is to illuminate the causal relationship between QM and performance in a coherent model that preferably prescribes appropriate actions for establishing a quality system in organizations. There are two candidates: deduction and simulation. Deductive reasoning based on mathematics is a static model that either prescribes an optimized solution (e.g. linear programming) or describes a system (e.g. queuing models) based on a set of assumptions but, as Davies and Kochhar (2002) quoted, “in an environment as complex as manufacturing, variables do not remain constant” and thus the complexity and dynamism of QM related problems hinder application of such static models. In other words, there is no appropriate mathematical model to capture the associated complexities of QM. To avoid the pitfalls of induction and deduction, we require a pseudo-experimental environment to control noise and bias-inducing factors and develop abstract models and, as Axelrod (2005) names it the third way of doing science, simulation seems to be an effective tool in this regard. This might be drawn from the widespread application of simulation in natural and physical sciences. “Simulation comes into its own when the phenomena to be studied are either not directly accessible or difficult to observe directly” (Goldspink 2002). It is contemplated as a safe laboratory for testing hypothesis and making predictions (Dooley 2002).

Computer simulation has been emerged as the main part of system modeling especially after conspicuous development of computers. “A simulation model may be considered as a set of rules (e.g. equations, flow charts, state machines, cellular automata) that define how the system being modeled will change in the future, given its present state” (Borshchev and Filippov 2004). Dooley (2002) categorizes simulation in three groups: System

Dynamics (SD), Discrete Event Simulation (DES), and Agent Based Simulation (ABS). The details of each method are not covered in this paper, because they are not within its objectives. However, it is worth noting that SD is equation-based simulation which applies differential equations to express the changes of aggregate variables over time but DES and ABS are entity-based in which the behavior of systems are produced by interaction among system elements. ABS and equation based modeling (EBM) differ in fundamental relationship among entities and the level at which they focus their attention (Parunak et al 1998). In EBM, the relationships between system components are modeled as a set of variables, representing the overall outcome of one-by-one interactions among entities (with restrictive assumptions like equilibrium, constancy of structure, and independence of entity behaviors (Dooley 2002)), and the focus is shifted toward the system performance as a whole. In contrast, the main focus of an ABS is agent-to-agent interactions constituting system variables. In addition, there is no adaptation in EBM (because of the independence assumption), whereas agents could alter their behaviors. There are also other differences that Parunak et al. (1998) summarize as follows:

1. Certain system behaviors (e.g. adaptation) are very difficult (sometimes impossible) to be modeled by mathematical formalism, whereas, within ABS framework, they are easier.
2. ABSs make it easier to distinguish physical space from interaction space, because they "permit the definition of arbitrary topologies for the interaction of agents".
3. ABSs offer an additional level of validation, because you can validate an ABS model both in macro (system) and micro (agent) levels.
4. ABSs support more direct experimentation, because it is easier to examine various what-if scenarios in an ABS than translating them into equations in an EBM.
5. ABSs are easier to translate back into practice, because they are expressed in terms of behaviors that could be simply transferred into the real world.

In addition, individuals are homogenous in EBM but heterogeneous in ABS and equations representing relationships among variables and observables are output of ABM but input for EBM (ibid). It means that opposed to statistical modeling or differential equations, there is no need to make assumptions like linearity, homogeneity, normality and stability in ABS (Bankes 2002). This is not a unique characteristic of ABS but a property of Complex Adaptive Systems (CASs) in general and offers ABS a considerable flexibility to examine problems, freed from within mathematical/statistical modeling framework.

The theory of CAS underlies the principles of ABS. "CASs are systems that have a large number of components, often called agents that interact, adapt or learn" (Holland 2006). If we contemplate QM as a method for enabling organizational change, improvement could be interpreted as an outcome of multiple interacting people. In CAS or complexity theory parlance, organizational performance is an "emergent" behavior (Lissack 2000). "ABS excels at relating the heterogeneous behavior of agents with different information, different decision rules and different situations to the macro behavior of the overall systems" (Lempert 2002). "Agent-based models usually emphasize change in agents schema via learning and adaptation, and also highlight the phenomena of emergent, self-organizing patterns in complex organizational systems" (Dooley 2002).

The key difference between DES and ABS is in entity properties; while entities are passive in DES, they are active and more autonomous in ABS. "The fundamental feature of an agent is the capability of the component to make independent decisions" (Macal and North 2006). Gilbert (2008) describes the features of agents as autonomy, social ability to interact, reactivity to stimuli from environment, and goal-directed proactivity. He adds that agents apply bounded rationality to find local optimums which is very important to find solution for complex problems as is the case for QM-related problems. In Figure 1, the important features of an agent are depicted (Macal and North 2006).

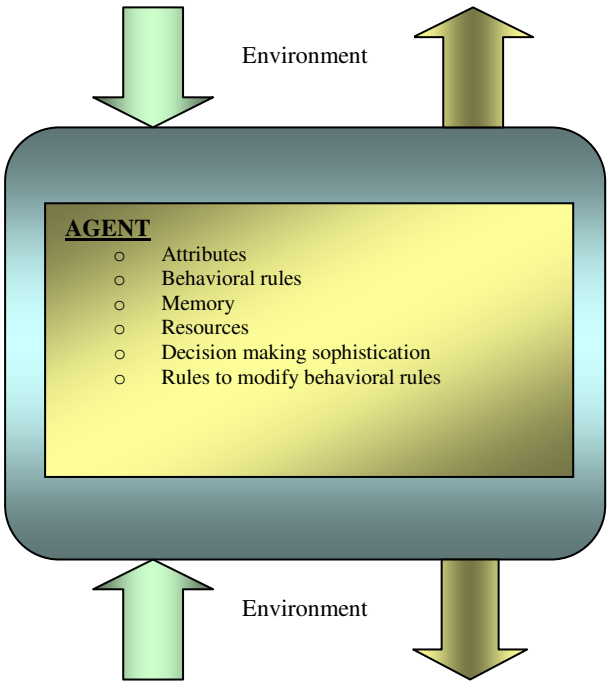


Figure 1: Feature of an agent

Aside from fundamental differences between an entity and an agent, they differ in modeling and

execution. In the words of Nilsson and Darley (2006), "firstly the execution of the agents is based on internal rules not on external and global policies… the focus is on the agent and its adaptiveness within the system being studied… and finally compared to DES models, agent-based models are mostly time driven". These differences make ABS suitable for modeling systems with changing elements. What Macal and North (2006) express as the reasons for using ABS are present in QM-performance researches as well:

1. There are employees, teams, and departments in an organization, naturally representing agents at different levels. The bottom-up approach embedded in ABS is consistent with execution of most organizational processes.
2. In an organization, there are events, decisions, and behaviors related to QM that can be defined discretely (e.g. customer complaints or quality defects). In other words, management of quality is done in response to discrete events by means of processes such that each are composed of discrete events as well.
3. Organizations at different levels adapt and change their behavior, suggesting they are made up of adaptive agents.
4. In organizations, behaviors at micro levels are summed as the organizational performance at the macro level. In ABS terms, these are "emergent" phenomena.
5. There is learning in the organizations (e.g. regarding quality problems)
6. In the organizations, the behaviors and interactions are heterogeneous.
7. Randomness could be embedded in ABS models of organizations
8. In CAS, every element is connected to each other (partially or completely) in a feedback loop, therefore, there is no equilibrium point because changes in any agent might influence negatively or positively other agents and the process of self-organization and emergence due to interactions, to be successful, requires some energy in an open system (Nilsson and Darley 2006). Similarly, organizations are open systems, interacting with their environment; business processes are increasingly nonlinear, self-organizing, changing and rationally bounded (ibid). There is no equilibrium state for quality management initiatives, because, within total quality philosophy, striving for perfection is a permanent task. In addition, QMS like other organizational systems is affected by the environment. Therefore, as McKelvey (1999) and Lissack (2000) conceptualize the basics, application of complexity theory (in our case ABS) to organization science seems plausible.

Borshchev and Filippov (2004) note that agent based modeling is more general and powerful and easier to maintain than other simulation techniques even "in the absence of the knowledge about the global interdependencies". As was mentioned before, ABS are more suitable especially for systems containing active objects like people, business units, vehicles or projects with a type of individual behavior (ibid). Therefore ABS could be an appropriate substitute for the currently pervasive inductive reasoning.

Simulation models of a single phenomenon/system could be various and is largely dependent on modeling objectives. The objective of simulation in general, and ABS in particular, could be prediction, performance, training, entertainment, education, proof, and discovery (Axelrod 2005). Prediction and discovery of hidden causal relationships between QM practices and organization performance and proof of some of general, related hypothesis could be among the research objectives by means of ABS.

5. CONCLUSION

The conflicting results of QM-performance researches suggest that something is wrong with the research method. It is argued that current research method based on inductive reasoning could not capture the complexities of QM principles that are mostly related to the behavior of people, units, processes and departments of an organization. In addition, it is difficult to model synergies, learning and working culture changes with mathematical/statistical models, contemplating that they are always present in QM initiatives. The characteristics of ABS, founded on the principles of CAS theory, make it an appropriate tool for modeling adaptive behaviors. It is argued that there is room for improving research efforts by applying ABS.

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