

SYSTEM DYNAMICS: An Effective Tool for Organizational Analysis and Prediction

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ABSTRACT

We are living in a complex world, and where education and interest have created wide differences among individuals; they have also taught us to appreciate diversity as a lively attribute of life. In order to recognize diversity and recognize individual perception, and interpretation of various phenomena of life and the knowledge of different people about it, qualitative research is conducted and is becoming popular each day. The researchers and scientists keep devising new instruments and methodologies for enquiry, which are rational, holistic and solve real life problems. The problems in organizations are not smooth and patterned like those in natural science and do not conduct themselves in a predictable way. Thus, logical positivism and reductionism often fails when we deal with complex problems in organizational perspective, especially involving human decision making. Massachusetts Institute of Technology, USA has developed a special research methodology to address complex problems of the systems called 'System Dynamics'. The methodology involves, (1) identifying a problem, (2) developing a dynamic hypothesis explaining the cause of the problem, (3) building a computer simulation model of the system at the root of the problem, (4) testing the model to be certain that it reproduces the behavior seen in the real world, and (5) devising and testing in the model alternative policies that alleviate the problem, and (6) implementing this solution. However, we have focused more upon first three keeping in view the constraints of space and time. The paper is conceptual, divided into 4 segments. 1st discusses systems approach in organizational studies; the 2nd explores connection between systems approach and qualitative research; the 3rd identifies the similarities between qualitative methodologies and those used by system dynamics and lastly the paper shortly describes the system dynamics inquiry process. Some sample models are also attached as annexure.

KEY WORDS: Organizational Development. System Dynamics. Organizational Research. Systems Thinking.

1. INTRODUCTION

We are living in a knowledge age, which commands rational approach to all problem solving conditions. Therefore, it is difficult to rely on the judgment of selected few, no matter, how much elaborated and vast their personal experiences might be. It has led the modern organizations to adapt to use systematic and scientific research for knowledge construction for its effective use. It is also believed that each situation is an individual phenomenon having its own needs, characterized by a particular value system that an organization has bred over time, an amalgam of the tacit values of its key characters. Individual differences in knowledge, skills and values, socio-economic status and background, learning styles and work attitudes create diversity in any organization.

Any worker of an organization is not just a working unit like a machine but has its own set of values, beliefs, and knowledge which he/she keep translating into various practices from time to time. Some of these values and practices are accepted, which help move the organization toward some direction in pursuit of goal. Such practices and behaviors are adopted and followed by many, but what about others? Do they create noise or resistance? They may abruptly hinder the smooth ongoing of the organization as well. Amongst this diversity of behavior and attitude, certain behavior patterns are adopted by the organization, which become its hallmark with passage of time. However, the organizations are open social systems; people come and go leaving their values and practices behind. Whether these values and practices will be acceptable for people joining the organization with new knowledge and technological skills or not? Whether the young will be interested to translate old values into new practices or not? It is the challenge that modern organizations face making the situation more and more complex.

How can we approach this complexity: through bounded rationality and logical positivism? Are these systems of inquiry best equipped to answer all the questions we have raised above or we have to either modify this system to suit our needs or develop a completely new system of inquiry, which is rational but flexible and can deal with hosts of variables at one time. This is the main theme of our paper and we will step by step lead

toward introduction of recently established system of inquiry used to uncover and deal with complex organizational issues, whether dealing with growth, productivity or change or with project or supply chain management - 'System Dynamics' a management theory and approach developed by Massachusetts Institute of Technology, USA. In order to understand this approach fully we will have a quick overview of Systems approach developed into systems thinking first. [*See end note (1)*]

1.1. Systems Science

Systems Theory, including Systems Science, Systems Technologies and Systems Philosophy (Bertalanfy, 1975), has provided a conceptual basis for such methodologies as Cybernetics and Research Operations, which are widely applied in management and administrative sciences. Akatova (2005) informs us, In business, system approach expressed in multiple perspectives allows for the integration of suppliers' and customers' interests and the provision of long-term development. This approach does not end with integration of technical, organizational, or personal dimensions but also explicitly brings ethics and aesthetics into play. (Courtney, 2001).

According to Argyris and Schon (1979), a social group becomes an organization when members devise procedures for "Making decisions in the name of the collectivity, delegate inquiry. All organizations are human systems. Thus, Banathy (2004) has argued, while working with such human systems, we must recognize that they are unbounded. Factors assumed to be part of a problem are inseparably linked to many other factors, e.g. a technical problem in transportation of goods into market may demand the building of a freeway. This apparently simple looking solution ultimately becomes a land-use problem, linked with economic, environmental, conservation, ethical, and political issues. Hence, in such situations not only it becomes hard to draw a boundary, but also the unattended problem becomes further complex, deteriorating into what Peccei (1977), the founder of the Club of Rome, calls, "problematique". He has noted:

Within the problematique, it is difficult to pinpoint individual problems and propose individual solutions. Each problem is related to every other problem; each apparent solution to a problem may aggravate or interfere

with others; and none of these problems or their combination can be tackled using the linear or sequential methods of the past" (p. 61).

We operate in a diverse "problematique" world with the help of complexity theory. Complexity science reframes our view of many systems that are only partially understood by traditional scientific methods. Systems as apparently diverse as stock markets, human bodies, forest ecosystems, manufacturing businesses, immune systems, termite colonies and hospitals seem to share some patterns of behavior. These patterns provide insights into sustainability, viability, health and innovation. (Weaver (1948); Seth (2006)).

2. System Dynamics (SD) and Systems Thinking

Kauffman (1980) has defined systems thinking as a "collection of parts which interact with each other to function as a whole". According to him, Kauffman a system is different from a "heap". A heap is something made up of a number of parts, and it does not matter how these parts are arranged, e.g. a pile of sand is a heap but a living organism is a system. One can divide a pile of sand into two parts and each will still be a pile of sand but a cow divided into two parts will not become two cows but no longer remain a cow. Hence, Kauffman declares: "An organization is more effective if it functions as a system instead of as a heap." (ibid.)

It becomes imperative that while dealing with organizational issues, one must learn to view various situations as a system of problems rather than a collection of problems. It means that there is no one right answer of the problem, hence no one solution of the problem. The problems are multidimensional and we cannot deal with them in a one-dimensional linear way. In order to reach the best solution, we have to approach the problem through multiple angles reaching to its core. Its not simply qualitative approach having a contextualized overview of the problem or quantitative, studying relative aspects of interest of a problem; it aims at the holistic analysis of all key variables that are interacting in a situation to make it complex.

Most of the problems in organizations are product of human decision making and are embedded in uncertainty requiring subjective interpretation. Churchman (1971) has suggested that in working with human systems, subjectivity cannot be avoided. What really matters, he says, is that systems are unique, and the task is to account for their uniqueness; and this uniqueness has to be considered in their description and design. Our main tool in working with human systems is subjectivity: reflection on the sources of knowledge, social practice, community, and interest in and commitment to ideas, especially the moral idea, affectivity, and faith. Checkland (1981) and Checkland and Scholes (1990) developed a methodology based on soft-systems thinking for working with human activity systems. They consider the methodology as:

...a learning system which uses systems ideas to formulate basic mental acts of four kinds: perceiving, predicating, comparing, and deciding for action. The output of the methodology is very different from the output of systems engineering: It is learning which leads to decision to take certain actions, knowing that this will lead not to "the problem" being now "solved," but to a changed situation and new learning" (1981, p. 17).

2.1. Using Kolb's Model of Experiential learning

Saeed (2003) has advised us to use Kolb's model of experiential learning to understand and draw models for SD. Kolb (1984) had identified that a phenomenon is experienced through four categories of perception, namely, observation, (what has been happening around) thinking (how and why something is happening), intuiting (what might be its future stance or impact, if it continues to happen the same way) and feeling (does it feel good or bad, the way things are happening).

It requires both assimilation of observed facts plus generalization of themes of previously learned facts about the same or a similar phenomenon, and finally some symbolization and abstraction of the reality as it may take shape. Such an abstraction has usually much higher chances of being conceived as total reality by the thinker himself/herself, which creates misconceptions and misunderstanding, since individual abstractions are quite different from present reality, and what is stored in mind has yet to become. But by sharing these abstractions in a linked manner better help others to view links and gaps in

an individual perception and objectively analyzing it together in the shape of concrete model, it will be easier to reach at a mutual consensus rather than jumping (hopping) at quick fixes here and there, but reaching no where. Hence it involves delving into complex cognitive processes of one's own mind, rather than leaving it to reach an automated chance solution by itself. SD is the best tool for a person who can think like a cognitivist and act like an operations engineer. SD provides us the real tools and methodologies to develop praxis for any system.

Senge (1990) has advocated: the organization must shift from seeing itself as separate from the world to connected to the world, from seeing problems as caused by someone or something 'out there' to seeing how the actions of people create problems (Bolman and Deal, 1997: 27). A learning organization is a place where people are continually discovering how they create their reality and how they can change it. A learning organization is a Gestalt. Organizations are living and dynamic and in the name of management, we cannot apply simplistic frameworks to solve their problems; thus, Senge (1990) continues to argue that a better appreciation of systems will lead to action that is more appropriate suiting complex systems. [*See mental map in Appendix A*]

2.2. Developing competency for System Dynamics (SD)

Richmond has defined systems thinking in terms of competencies, "The systems thinkers' forte is interdependence. Systems dynamicists look at the same type of problems from the same perspective as system thinkers do. Systems thinkers use diagramming languages to visually depict the feedback structures of these systems. They then use simulation to play out the associated dynamics." (1993:113) He has also identified seven core systems thinking skills including: (1) dynamic thinking, (2) closed loop thinking, (3) dynamic thinking, (4) structural thinking, (5) operational thinking, (6) continuum thinking, and (7) scientific thinking. According to Kim, however, "There are at least ten distinct types of systems thinking tools... They fall under four broad categories: brainstorming tools, dynamic thinking tools, structural thinking tools, and computer-based tools." (1994: 10)

SD scientists choose a good mix of these tools to draw SD models for various problems across disciplines. System dynamics takes the additional step of constructing computer simulation models to confirm that the structure hypothesized can lead to the observed behavior and to test the effects of alternative policies on key variables over time. Their specialty is understanding the dynamics generated by systems composed of closed loop relations, which will be explained in the last section of this paper.

Helal et al. (2007) have explained that SD has been successful as a system thinking approach that targets top management levels with a comprehensive integrative perspective, with relatively minimal data requirements. SD is appropriate for modeling large scale systems and the higher levels of decision making where aggregation is preferred. It focuses on the policy decisions that are embodied in the feedback loops, and not on individual localized decisions. However, while SD permits the study of the stability of the system over the long range, the trends of behavior that it generates do not indicate what specific actions to be made and at what values of the action parameters.

Bergbauer (2007) has related to us that an open systems view of organization is related to the interaction of the organization and its environment. As such, organizations have two sets of complexity to deal with, those that represent internal dynamics and those that deal with external environmental changes. The ability to deal with complexity requires the ability to learn from observed patterns of change overtime. In turn, groups that learn and engage in collective sense-making together should, by all standard accounts, and be more effective. That is, more able to improve effectiveness of their decisions in such complex environments by leveraging the value of contemporary tools, techniques, and technologies to their advantage. What about the social system where one has to deal with environment not on one-to-one basis but an integrated system having a set of beliefs, values and complementary practices as well. Saeed (2003) warns, in cases with increased complexity, just obtaining statistics, is though helpful, but just mathematical calculations will not guide toward a proper solution until and unless the problem is understood in a systemic perspective, and “system’s internal tendency to behave is correctly identified.” He points out:

The behavioral tendency is not merely a snapshot of existing conditions of a system, but they must represent a set of patterns, or a set of existing conditions that appear resistant to policy interventions. In most cases there are peoples' perceptions and attitudes and their established mind set and behaviors about the issues, about which no mathematical formulas informing us or providing any logical solutions. (ibid.)

[See model in Appendix]

3. System Dynamics (SD) and the Qualitative Research

Creswell (1998:15) has defined qualitative research as “an inquiry process of understanding based on distinct methodological traditions of inquiry that explore a social or human problem. The researcher builds a complex holistic picture, analyzes words, reports detailed views of informants, and conducts the study in a natural setting. Qualitative research is well suited for the purposes of description, interpretation, and explanation. (Lee, et al.:164), and the reason for choosing a qualitative methodology revolves primarily around the type of question or problem to be explored. Questions that begin with how or what lend themselves to qualitative study (Creswell 1998; Lee, et al. 1999), whereas questions about why are more appropriately approached from a quantitative perspective (Creswell 1998). The how or what questions generally arise because little is known about the problem or phenomenon being studied (Hoepfl 1997; Nassar 2001). Either no theory exists or the existing theory is underdeveloped and cannot explain a phenomenon adequately (Merriam 2002b; Nassar 2001).

Eisner (1991) has pointed out that qualitative inquiry has an interpretive character. The process is inductive, flexible and adaptive to individual research needs. Most importantly, The research problem typically (1) is related to lack of theory or previous research; (2) may be derived from the notion that existing theory may be inaccurate, inappropriate, or biased; (3) may be based on the need to describe phenomena or develop theory; or (4) may involve phenomena that are not suited to the use of quantitative measures.

Though historically, qualitative methods of inquiry have often been viewed with ambivalence and a degree of trepidation by researchers as it has been pointed out by

Wainwright (1997), over the last ten years the situation has begun to change, and qualitative research has gradually acquired a new respectability, where even the British Medical Journal is prepared to recognise its worth (Mays & Pope, 1995). Imel et al. (2002) have discovered: A paradigm shift has been observed about choice of research methodologies in recent research; the interest of the researchers has been shifted from quantitative methodologies to qualitative and combined methodologies; quantitative methods decreased from 40-50% in 1983-88 to 10% in 1996-99, whereas qualitative methods increased from 15-18% to 30-40%. (Barrett and Ahmed, 2000)

3.1. The Role of the Researcher

Qualitative inquiry occurs in natural settings, typically examining a small number of sites, situations, or people over an extended period of time. Researchers are themselves the instrument for data collection. Therefore, merit of qualitative research is largely dependent on the skills and knowledge of the researcher. (Imel, et al., 2002). The method and the analytical and data collection techniques are rendered useless if the researcher is not able to provide appropriate meanings (believable, trustworthy conclusions) for the findings. As argued by Cheek et al., “simply interviewing someone is not qualitative research” (2004: 148).

According to the researchers, qualitative research process is powerful and deeply meaningful experience for the researcher, the participants, and for its consumers as well. (Donalek, 2005; Ullman, 2005 in Waker et al., 2008), The researcher may undergo a profound experience of learning, while conducting the research and if the research findings are communicated skillfully, some of the power of this experience can be shared with the readers. (ibid.) “The expert qualitative researcher is also an excellent writer who creatively but faithfully conveys an aspect of human life that was not previously expressed or appreciated” (Kearney, 2005: 147). Moreover, qualitative researchers are interested in understanding multiple constructions and interpretations of reality that are in flux and that change over time. (Merriam 2002b: 4), individuals engaging in qualitative research must be open to multiple ways of viewing what they are studying and comfortable with the assumptions of the qualitative approach (Nassar 2001).

3.2. Making most of the bias

Within qualitative research the researcher's perspective, or "bias," is a necessary and unavoidable component of the research process, but this is not considered problematic. Rather, the researcher is viewed as a kind of interpretive lens through which the qualitative data are given meaning and significance. In other words prejudices are not necessarily erroneous or necessarily distortions of truth. Our situatedness as interpreters, our own historicity, do not constitute an obstacle. Prejudices are the conditions by which we encounter the world as we experience something. We take value positions with us into the research process. These values rather than getting in the way of research, make research meaningful. (Koch, 1994: 977)

Qualitative research expands the range of knowledge and understanding of the world beyond the researchers themselves. It often helps us see why something is the way it is, rather than just presenting a phenomenon. According to Hull (1997: 14), "the purpose of qualitative research is to understand human experience to reveal both the processes by which people construct meaning about their worlds and to report what those meanings are. Ziman has noted: "the objective of science...is a consensus of rational opinion over the widest possible field" (1968:9). Sterman has thus argued while discussing the SD modelling process, which he regards essentially "a process of communication and persuasion among modelers, clients and other affected parties."(2000: 850). He recommends that all SD modelers should focus on tests that can reveal the limitations of our current models, mental and formal keeping in view the advice from Orsekes et al.:

"We must admit that a model may confirm our biases and support incorrect intuitions. Therefore, models are most useful when they are used to challenge existing formulations, rather than to validate or verify them. Any scientist who is asked to use a model to verify or validate a predetermined result should be suspicious." (Orsekes et al., 1994)

[See model in Appendix]

3.3. Types of Data

SD scientists argue: most of what we know about world is descriptive, impressionistic, and has never been recorded. Such information is crucial for understanding and modeling complex systems. Imagine trying to manage a school, factory or city using only the available numerical data without the expertise of the participants, the results would be chaos. (Sternan, 2000: 850) On the other hand, what makes qualitative research very special and unique is the fact that there are no rules or formulas to determine how much data to collect, who to collect it from, and what kind of data should be collected, nor are there any computer packages or mathematical formulas to tell researchers what their data mean. Researchers must make these decisions based on their experience, knowledge, and strategy of inquiry from within the philosophical and theoretical framework they have chosen. In presenting the results of their study, they must also demonstrate the veracity and relevance of their interpretations and of the meaning of their work.

Good qualitative research . . . is that which produces coherent accounts of experience from the viewpoints of people being investigated, along with trustworthy and relevant interpretations that demonstrate a commitment to multiple realities. These intentions require skills, knowledge and a stance from which researchers can see possibilities, see familiar things in a strange way, or render the strange familiar.

(Rowe & McAllister, 2002: 10)

SD founder, Forrester (1980) has identified three types of data needed to develop the structure and decision rules in models: numerical, written and mental data. Numerical data are familiar time series and cross sectional records in various databases. Written data include records such as operating procedures, organizational charts, media reports, emails, and any other archival materials. Mental data span all information in people's mental models, including their impressions, stories they tell, their understanding of the system and how decisions are actually made as opposed to what is written in the procedure manuals, how expectations are handled, e.g. Mental data cannot be accessed directly but must be elicited through interviews, observation, and other methods.

Sterman (2000) posits, the constructs for which quantitative metrics and numerical data are available are sometimes termed as “hard data” or “hard variables”; “soft variables” in contrast are those for which numerical metrics and data are not available, including such factors as goals, perceptions, and expectations. The term “hard” intends to explain that numerical data are more accurate and real than the qualitative data, judged by many as unreliable and insubstantial. Hereby he has agreed with Disraeli: “ There are lies, damn lies and the statistics – both hard and soft data can be biased, distorted, and unreliable.”

Furthermore, no numerical data is available for some important variables in organizational research known to be critical to decision making such as customers perception of product’s quality, the level off trust between a manager and subordinates, a purchasing manager’s belief about the reliability of a supplier, employee morale and investors’ optimism. Hence, the choice of qualitative data and SD methodology becomes a valid choice for any organizational researcher.

3.4. Model Fitness

The audience for the research might also determine if a qualitative approach is appropriate (Creswell 1998; Nassar 2001). Similarly, Churchman (1971) posits, “a point of view or model is realistic to the extent that it can be adequately interpreted, understood and accepted by other points of view.” Will the audience understand and support the approach (Nassar 2001)? Some audiences, for example, are more receptive to qualitative research because the findings offer a richness and depth of understanding that is uncommon in quantitative studies (Skinner, et al., 2000). One practitioner characterizes qualitative research as an umbrella concept covering several forms of inquiry that help us understand and explain the meaning of social phenomena with as little disruption of the natural setting as possible. (Merriam, 1998: 5) and notes that qualitative researchers use a variety of terms (e.g., naturalistic inquiry, field study, participant observation, inductive research, case study, ethnography) [*See model in Appendix*]

System Dynamics research is deeply grounded in reality; The source of modeling is not just one research, or data collected by individual or a single group of researchers, but it aims at meta-analysis of the patterns of behavior identified by scores of researchers in recent or remote past, regardless of the fact, whether it is quantitative or qualitative in nature. Hence, subjectivity is countered, which has always been the major point of criticism against qualitative research.

It is always the analysis of the data and making meaning out of it in some special context, which poses major challenge to a qualitative researcher, especially where theory building is required from commonplace experiences, by organizing scattered abstract ideas. Morse (1994) has encouraged qualitative researchers to take risks in the creation of theory: to play around with different ideas and to, essentially, make the “best guess.” He has described this process as one “of speculation and conjecture, of falsification and verification, of selecting, revising, and discarding” (Morse, 1994: 33). Such an art is best displayed in SD models.

SD can capture the causal relationships that are not captured by other approaches that are based on the flow diagramming approaches; DES and other object oriented techniques (An and Jehn, 2005). Further SD offers the ability to model qualitative and *soft factors* (e.g. level of commitment, level of management support, etc.) as explained by Sterman et al. (1997) who modeled the management’s attitude towards various departments in the company after implementing a Total Quality Management program. SD also facilitates conducting designed experiments at the business level (Ashayeri et al., 1998).

Mostly the highly detailed data is available for operation level but for top-level decision making one has to do with the rough estimates and expert guesses (Zulch et al., 2002; Mandal and Sohal, 1998; Anthony et al., 1989). Keenan and Paich (2004) used SD to build a model of General Motors and the North American auto industry, to assist GM senior management assess the existing policies and improvement initiatives that had been implemented. The initiatives were considered successful but concerns were that the combined impact of them had not met the performance objectives in terms of market share and profitability. The model was comprehensive; including macro-economic

variables, market, dealerships, customer behavior, and processes at the various manufacturing facilities located at geographically distant locations.

4. Systems Dynamics (SD) the process

System Dynamics is a methodology that starts with important problems comes to understand that structures that produce undesirable symptoms, and moves on to finding changes in structure and policy that will make a system better behaved (Forrester, 1968). The formulation of a System Dynamics model has been described by many authors as an iterative process (e.g. Sterman, 2000) that requires knowledge of the problem domain on one hand as well as technical modeling skills and experience of the modeler on the other hand. SD practically using systems thinking is a continuum of activities which range from the conceptual to the technical (Richmond, 1987). This comprehensive definition of Barry Richmond describes the steps of modeling process. The model building process involves the following phases (Sajjad & Yusuf, 2007)

	Problem Definition
Conceptual	System Conceptualization
	Model Representation
	Model Behavior
Technical	Model Evaluation
	Policy Analysis

Regarding the first step, Saeed (2003) has pointed out, Some developmental problems like food shortage, poverty, poor social services and human resources development infrastructure, technological backwardness, low productivity, resource depletion, environmental degradation, and poor governance can become eligible cases for study in SD, which are often perceived as preexisting conditions in a system that must be changed.

The 2nd step is usually establishing a reference mode, which aims at building and experimenting with computer models of problematic patterns. Such construction starts

with and has firm grounding in historical information, in most cases, the quantitative data in a graphical form, the organizational charts showing growth or collapse in market share, the investment ratio, the expansion plan, or any other stock information, serving as useful statistics to begin with. However, it establishes the organized and established patterns rather than point by-point description. Above all, it includes both: the past behavior, and the future expectations, (kind of a systemized regression analysis). [*See model in Appendix*]

The other way of conceptualizing a model would be forecasting or identifying a trend. Sterman has stressed,

“Expectations are fundamental to decision making. All decisions depend upon our mental models of the situation. Expectations about the future behavior of the system from a critical component of these mental models, what is likely to happen and these expectations guide our actions. Modelers must portray the way the agents represented in their models from forecasts and update expectations.” (2000: 631)

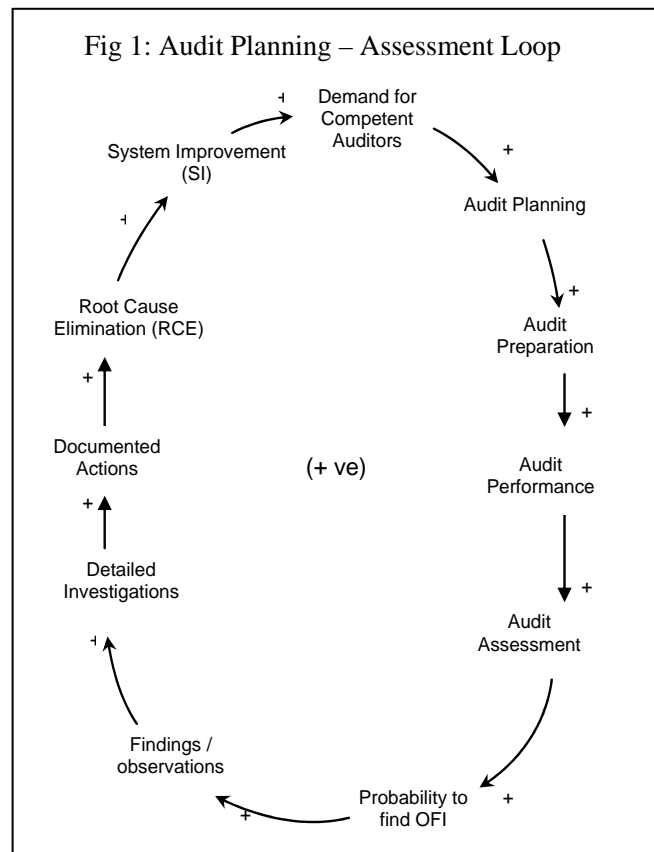
The modeling process uses two important schemes to highlight the dynamics of system i.e. thinking about how the quantities vary through time and thinking about whether a substantial feedback relationship exists (Richardson, 1981). Feedback refers to the situation of X affecting Y and Y in turn affecting X perhaps through a chain of causes and effects. [*See model in Appendix B*]

4.1. Positive and Negative Causal Loops

A causal loop that characteristically tends to reinforce or amplify a change in any one of its elements is called a positive loop (Richardson, 1995). A positive loop is often defined by the fact that an initial change in any variable eventually brings self-change in the original direction. A causal loop that characteristically tends to diminish or counteract a change in any one of its elements is called a negative loop (Richardson, 1995). Causal loop diagrams are the powerful tool to capture the problem statement and conceive the problem properly. Causal loop is a closed sequence of causes and effects, a closed path of action and information. A decision is based on the observed state of the system. The

decision produces action which alters the state of system and new state gives rise to new information as the input to further decisions. Behavior of the system is the result of interaction of positive and negative feedback control loops. The polarity of a circular causal loop reflects the loop's tendency either to reinforce or to counteract a change in any one of its elements. (Richardson, 1995) By strengthening polarity through inducing table functions during simulation process may help to design the plausible and sustainable policies. Most often system dynamics is applied to dynamic complex problems of strategic importance (Strohhecker, 2005) The methodology, however, proved to be valuable and capable of supporting decisions on even short term scenarios and measures (Strohhecker, 2005). Followings are the examples of Positive and Negative Loops with its interpretations.

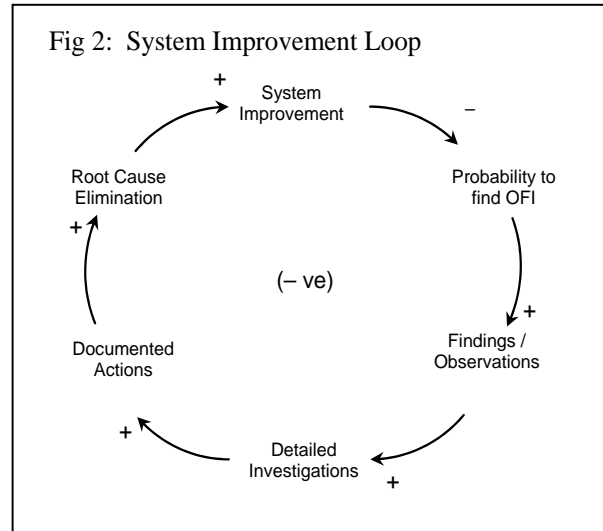
Fig. 1 explains the need of Audit Planning and Assessment Loop, this loop explains the audit planning and assessment is only possible if the auditor is competent. Competent auditor is organized and well planned auditor he has better audit approach and on the basis of better approach he prepares the audit plan thoroughly. As a result audit is well prepared and then audit performance is enhanced. This enhanced audit performance helps to assess the system properly and comprehensively.



Comprehensive and detailed assessment provides the opportunity to find the areas of improvement which ask for effective documented actions that ensure the system improvement. Against the identification of Opportunities of improvement (OFI) findings

have been identified which demand the detailed investigation and documented actions, The root cause elimination will consequently affect the System improvement and improved system will be a source of motivation to ask for more competent auditor who adds the value in the system for audit purpose. As procedures are set up, regular Programme of system audits needs to be established, to ensure the systems are maintained, adjusted and improved.(Hunt & Gilmour 1996)

Fig 2 Explains the System Improvement Loops basically moves around the Opportunities for Improvement which may be result of corrective actions requests (CARs) against the non-conformance or the preventive action requests (PARs) as a preventive measure on the basis of best observation against the bench mark industries.



It may be the suggestions (OFIs) for the system improvement which may comprises new valuable inputs for system improvement which ask for detailed investigations and documented actions. If the documented actions are appropriate and dig out the root causes that bring the improvement in system then improvement is permanent in nature.

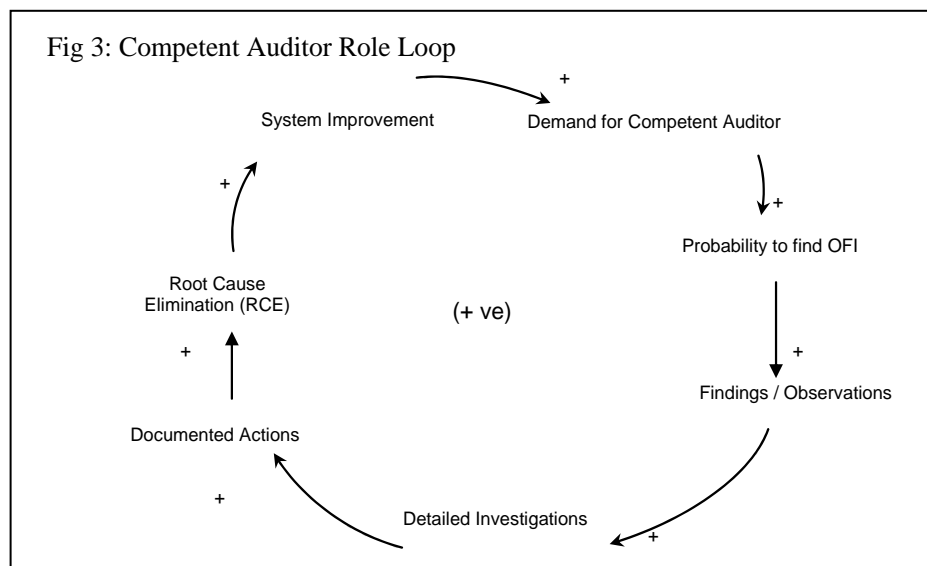


Fig 3 Loop of Competent Auditor Role portrays the picture for the demand of competent auditors along with the sector specialists. The processes are complex in nature and really demand the expertise in that area to add the value in the system. It has been observed in Pakistani industries, the certifying bodies those have competent auditors and sector specialists and may interpret the standards very well has good name in the market. The standard relies too much on people's interpretations of quality, particularly those of auditors. (Rouzbeh,1999).

The input of the auditor and sector specialists is warmly taken for value addition tool and implementation of their recommendation have been considered as a positive step for system improvement. Opportunity to improve may relate with product, process, personnel and the system. It may happen the competent auditor is the sector specialist as well and has a good market image. No one can challenge his valuable input and system improvement as the result of his audit is more than 100 percent sure phenomena. Tetra Pak, Packages, Pakistan Tobacco Company, Nestle Pakistan and Unilever Pakistan are the organizations which always demand the competent auditors and there is no compromise on it. The audit date may be delayed and audit may be rescheduled but demand for competent auditor is never compromised.

Fig 4 indicates the phenomena of the issuances of corrective action requests (CARs) and preventive action requests (PARs). It is reasonability of the management representative to issue the CARs and PARs for system improvement.

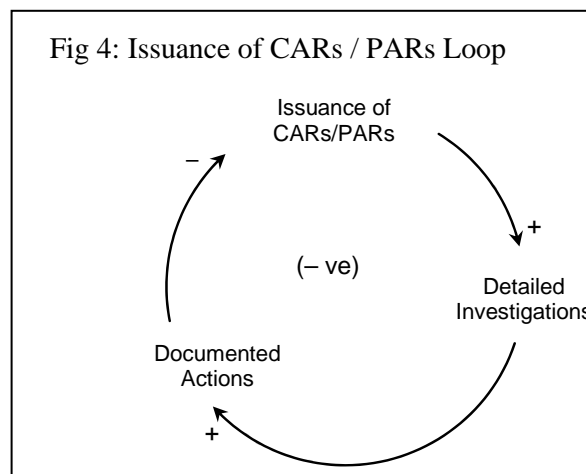
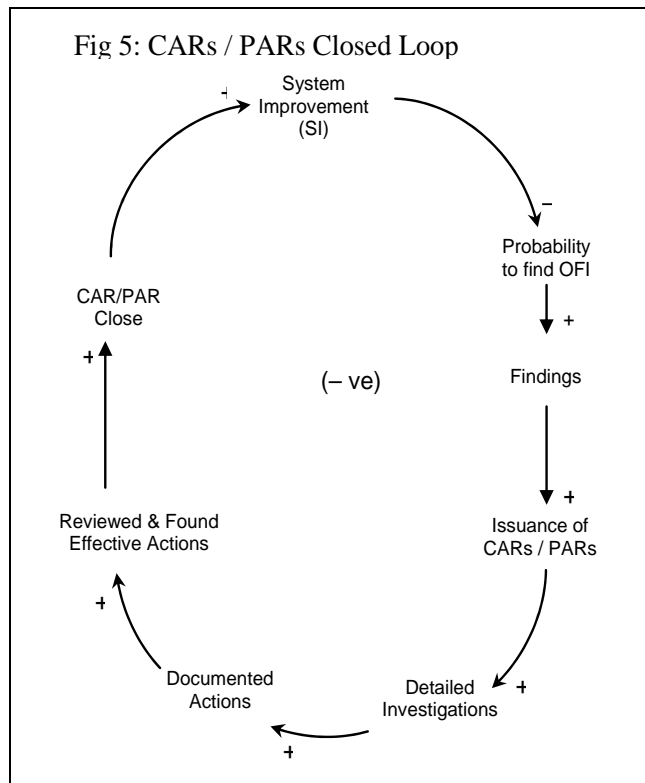


Fig 5 represents the the CARs and PARs must not be closed by the auditor if the documented action is not effective and it does not create any improvement in the system. It is ultimate responsibility of the auditor to verify the documented action and do not allow the any departmental head to close the CARs/ PARs with ineffective documented action. The role of fair and firm auditor is very much required in this scenario.



4.2. Modeling Supply Chain

Sterman has explained that a supply chain consists of (1) the stock and flow structures for the acquisition of the inputs to the processes and (2) the management policies governing the various flows (2000: 663). Stock management flows are useful in modeling supply chains in all types of systems, not only business systems, but also physical, biological, and other systems. [See model in Appendix]

To maintain a supply-chain, certain balancing acts are required; such balancing processes always involve negative feedbacks. A negative feedback processes involve comparing the state of the system to the desired state, then initiating a corrective action to eliminate any discrepancy. Thus, manager tries to maintain a stock (the state of the system) at a particular target level, or at least within an acceptable range. Stocks are altered only by

changes in their inflow and outflow rates. (ibid.: 666) Typically, the manager must set the inflow rate to compensate for losses and usage and to counteract disturbances that push the stock away from a desired value. Often there are lags between the initiation of the corrective action and its effect and lags between a change in the stock and the perception of that change by the decision maker. The duration of these lags may vary and be influenced by managers own actions.

4.3. System Dynamics as a vehicle for Learning Reflective Practice

System dynamics overcome some of the limitation of the traditional methods by providing well-defined organizing principles to develop explicitly models of complex social and processes and to affect system improvements through experimentation with these models. The study of the organizing principles of systems, together with possibility of computer simulations of the outcomes of the hypothesized system relationships provides an easy-to-use means of such experimentation (Saeed, 2005).

Using system dynamics generate a self-reiterating process of knowledge construction, which ultimately helps organizations to grow in a chosen direction or to develop better vision, strategies, even crafting developmental policies for a nation. Because of its holistic vision, it is getting popularity all over the world and is used to identify chronic ill behaviors of organizations especially in business and industrial sectors. The process of discovering identifying risks and uncertainties in organization could be greatly enhanced by qualitative system dynamics, which is also used for 'qualitative uncertainty discovering': qualitatively tracing out the possible structures and dynamics related to different structural representations, structural options, and leverage points. However, when occupied in our desired venture, it is imperative that our solutions are objective and fact based, so we cannot undermine the importance of the facts and figures, calculated by any quantitative measure. Hence, we can proclaim, that where quantitative research finishes, the system dynamics takes a start to view the whole phenomenon in both quantitative and qualitative perspective.

Effective use of system dynamics in cultivating reflective practices entails integrating laboratory or studio practice with teaching as well. This calls for the redesign of teaching formats and the preparation of textbooks and materials to facilitate teaching and learning of system dynamics in various disciplines at undergraduate and graduate level.

End note

Jay W. Forrester of the MIT Sloan School of Management System Dynamics founded MIT System Dynamics Group in the late 1950s. At that time, he began applying what he had learned about systems during his work in electrical engineering to everyday kinds of systems. Later on, the idea was used to explain dynamics of manufacturing supply-chain of an industry. The first published article by Jay W. Forrester in the Harvard Business Review on "Industrial Dynamics" was published in 1958. However, System Dynamics Society has chosen 1957 to mark the occasion, as it is the year in which the work leading to that article, which described the dynamics of a supply chain, was done. Last year, the System Dynamics society celebrated its golden Jubilee at Boston with more than 200 members from more than 16 countries.

Source: Sterman, J. (ed.) System Dynamics Review. Special Issue, Exploring the next great Frontier: System Dynamics at 50. Vol. 23 No. 2-3. 2007

More information can be obtained from the society's website: www.systemdynamics.org

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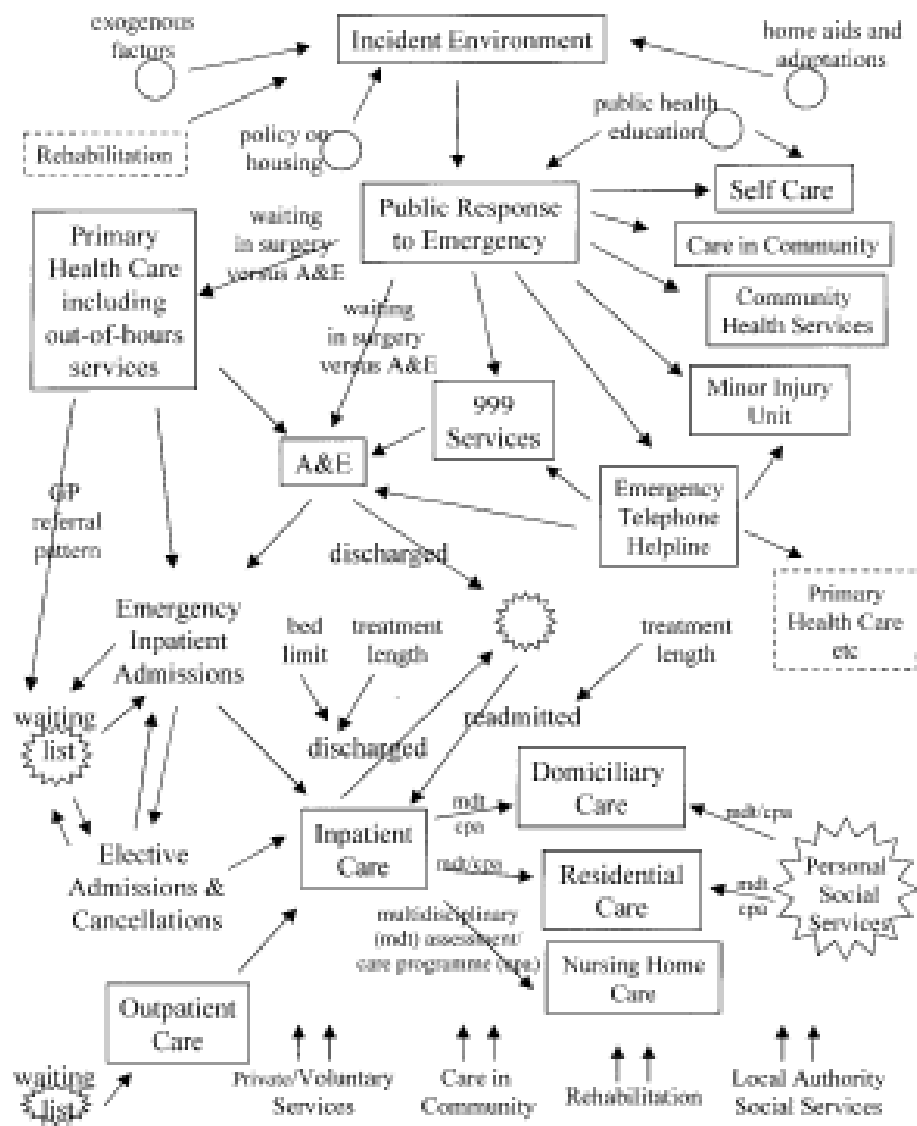
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Appendix A



A mental map of the interrelationship within system of emergency health and social care UK.

Source:

Roystona, G., Dosta, A., Townshendb, J.& Turner, H. (1999). Using system dynamics to help develop and implement policies and programmes in health care in England. *System Dynamics Review*. 15. pp. 293-313. Wiley

Appendix bb

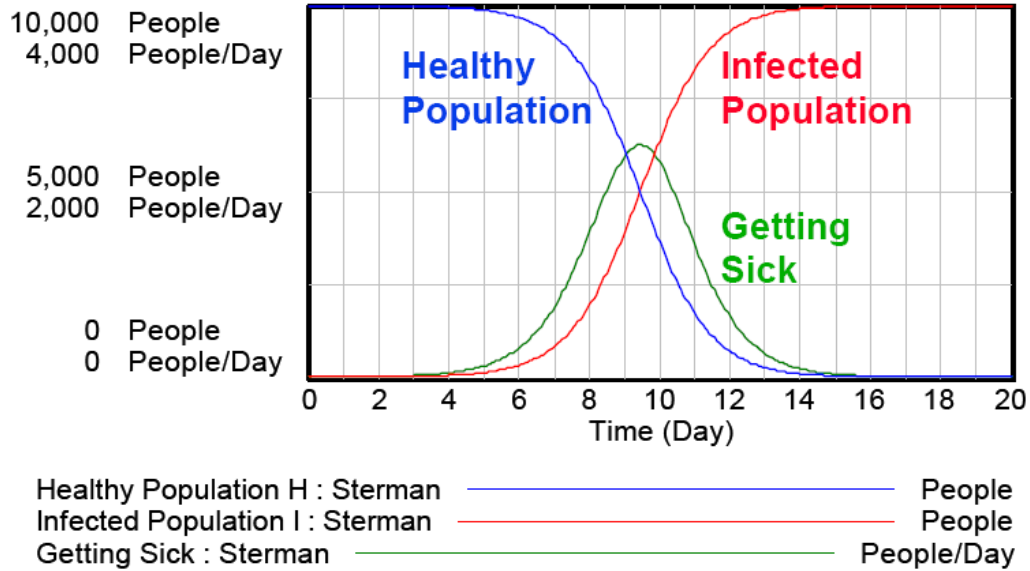


Figure 1: Epidemic Behavior Mode

Appendix cc

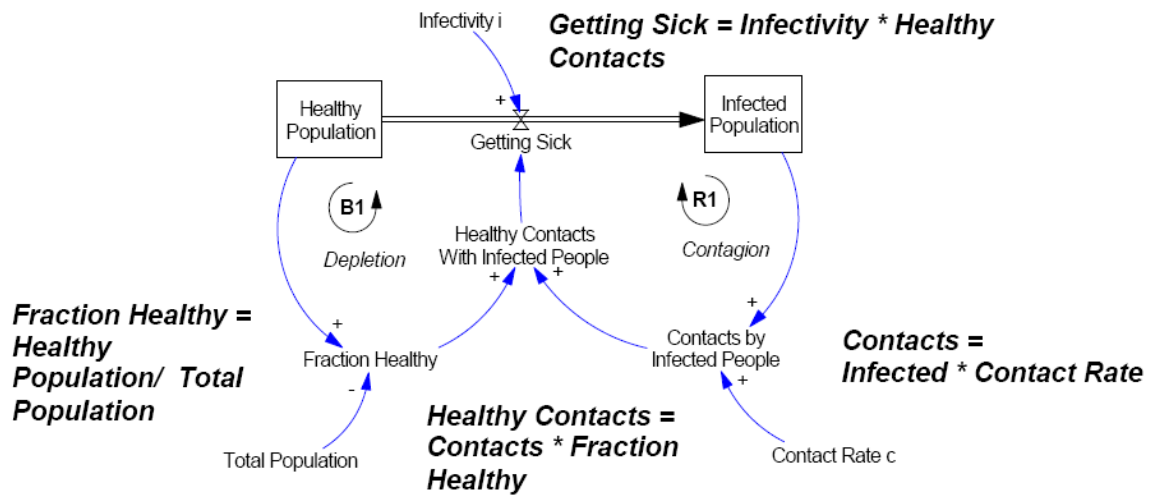


Figure 2: Two-Loop Model (adapted from Sterman)

Appendix B

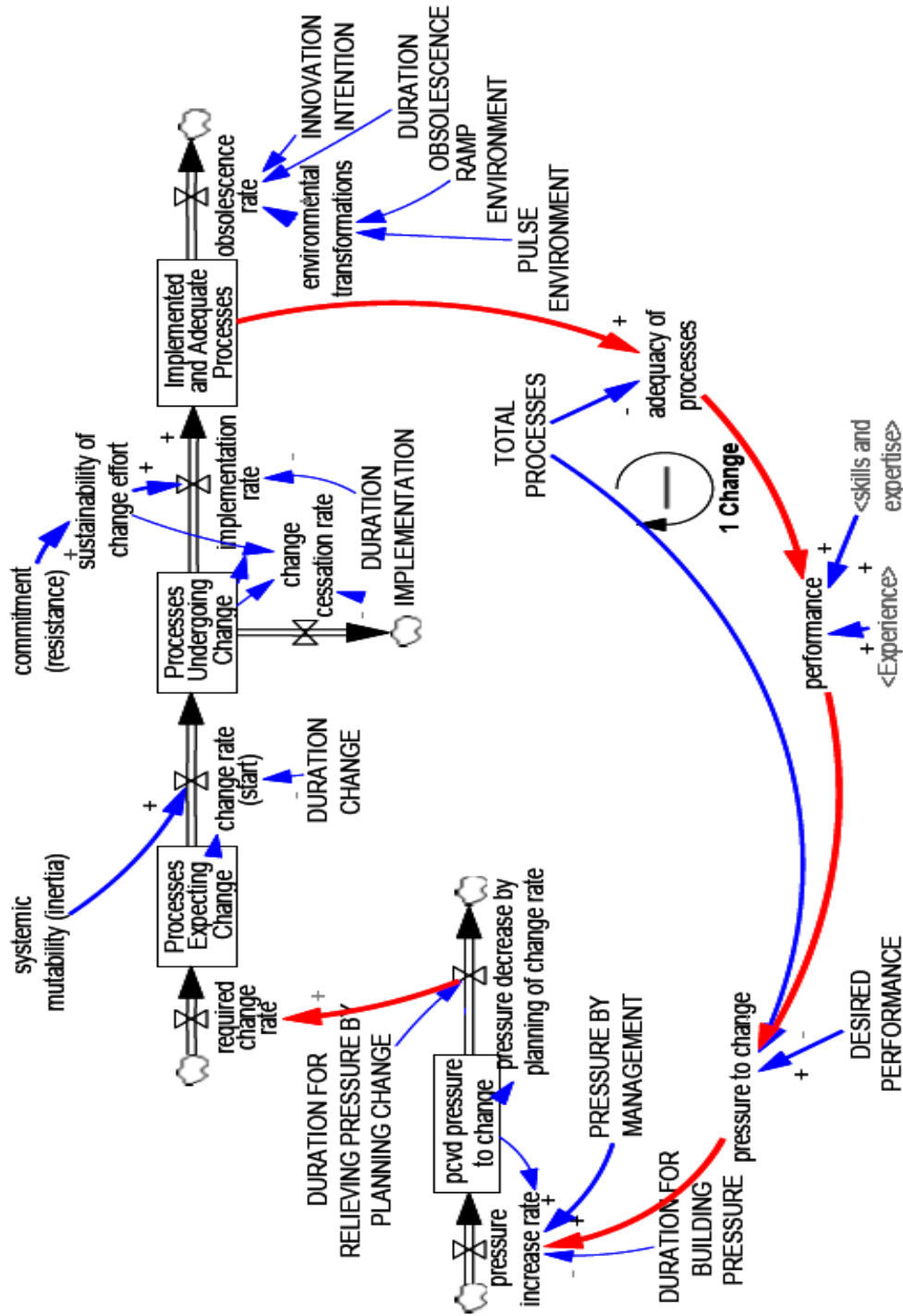


Figure 2: Base model of organizational change (SFD)

