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Major Issues in Mixed Use of Grounded Theory and System Dynamics Approaches in Qualitative Secondary Data

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Abstract: This article explores the methodological issues in mixed use of Grounded Theory and System Dynamics approaches in a research project. We discuss how analysts dealing with qualitative secondary data in the conduct of System Dynamics Modeling work through the questions of the role of existing literature and generic structures in system dynamics, directions of research (inductive, deductive, or abductive), the mixed method's ability to extract system dynamics modeling information, and potential outputs of such research. These discussions are based on an analysis from an empirical research project. The article describes a research design and suggests next steps to develop a coherent analytical technique for researchers.

Keywords: Grounded Theory, System Dynamics, Abductive Approach, Mixed Methods, Generic Structures, Archetypes

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1. Introduction

A longtime dispute between qualitative and quantitative researchers has produced a large body of material debating the merits and disadvantages of these approaches (Weber, 2004). As these discussions contributed common understanding, some researchers integrated qualitative and quantitative methods under the name of mixed methods since 1980s (Brewer & Hunter, 1989; Johnson & Onwuegbuzie, 2004). But System Dynamics as a methodology that uses qualitative data to develop quantitative simulation models has not been a significant part of these method oriented discussions. Since its introduction in mid-1950s, the System Dynamics approach has used qualitative data to study complex social systems. Most of the time, the end product of this approach is a mathematical model that describes the structure and behavior of the complex system quantitatively. Despite the central role of qualitative data in system dynamics model development process, the System Dynamics field does not have detailed protocols to describe the use of qualitative data or qualitative research methods in the modeling process (Luna-Reyes & Andersen, 2003). In a response to this gap, this article explores qualitative data and research methodology issues in System Dynamics modeling based on an analysis from a research project that adopted the Grounded Theory approach.

The mixed use of Grounded Theory and System Dynamics approaches raises a number of methodological issues. One set of issues involves how to combine the use of existing literature and generic structures in a research project. This issue is closely related with the direction of research (inductive, deductive, or abductive). Direction of research is important to understand the role of existing literature (theories and preexisting concepts) in the Grounded Theory approach. While there are conflicting views about introducing fundamental concepts early in Grounded Theory development (Glaser, 1978; Kelle, 2005), System Dynamics researchers are very enthusiastic about the role of generic structures in exploring complex systems (Forrester, 1998; Wolstenholme, 2003). Another issue concerns how to go about extracting necessary information from qualitative datasets to build quantitative models. System Dynamics researchers look for causal relationships to understand system structure and reference modes (behavior of variables overtime) to understand system behavior. This information is extracted from research subjects or gathered from other resources. System Dynamics models are being grounded on these findings, which are most of the time qualitative data. The possibility of improved methods for collecting system related information from qualitative datasets is an important challenge for the researchers. The final issue is about the output of such a research project. The output expectations from mixing Grounded Theory and System Dynamics are focused on System Dynamics artifacts. Fully developed simulation models and causal loop diagrams are such artifacts that explain the phenomenon in question and articulate different hypotheses all grounded on qualitative data.

Based on the discussion of these issues, a research approach will be described to address the need of protocols to combine these approaches. Our intention is to provide a detailed protocol in the mixed use of Grounded Theory and System Dynamics that has long been missing (Luna-Reyes & Andersen, 2003).

This article is based in large part on an earlier study of responses to the attack on the World Trade Center on September 11, 2001. This earlier study will be referred as "the WTC research". The WTC research (Akcam, 2009) extends and elaborates a generic dynamic theory (Luna-Reyes et al., 2004) by using Grounded Theory approach. It explores the socio-technical processes in an interorganizational collaboration by exploring a generic dynamic theory in more depth. The generic dynamic theory offers dynamic hypotheses about causal relationships between socio-technical processes and social accumulations derived from a study of interagency information integration initiative among New York state agencies—focusing in the WTC research on the response and recovery process following the World Trade Center (WTC) attack, which involved an enormous amount of interagency collaboration in response to a very tragic event.

The data from this case are used to model the socio-technical processes of collaboration in IT development and use by using the theoretical lenses of the generic dynamic theory described by Luna-Reyes et al. (2004). Researchers at the Center for Technology in Government (CTG) at the University at Albany-SUNY interviewed 29 responders over a ten-month period in 2002-2003. These responders held positions at critical decision-making points in the response and recovery process. This interview dataset covers rich stories of interagency collaboration in the context of information, technology, and coordination.

All the issues identified in this article emerged from the interaction between parts of the WTC research. In summary, the WTC research aims to extend a generic dynamic theory. Having a rich qualitative dataset encouraged researchers to use it for this purpose. But clear-cut data analysis protocols were not available to apply to this dataset to gather necessary system dynamics information to extend and elaborate the generic dynamic theory. The System Dynamics community developed methods to elicit modeling information from mental database through several interactive techniques with subjects, but other methods were limited with the written database, specifically with the qualitative datasets such as interview transcripts as secondary data. Grounded Theory approach among qualitative methods was selected in the WTC research, because the interviews were based on semi-structured questions.

The issues identified in this article are from the perspective of secondary data analysis of a qualitative dataset (interview transcripts in this case). This point is very important, since other qualitative methods such as interviewing (Luna-Reyes, Diker, & Andersen, 2005) with subjects can give researchers ability to elicit necessary modeling information directly from them. But in a secondary dataset, researcher interacts with transcripts of interviews. Most of the time interviewers from other backgrounds do not do these interviews with the system dynamics modeling information in mind. So extracting necessary information to gain systems insight and producing System Dynamics artifacts such as reference modes, causal loop diagrams, and fully developed models are becoming more challenged. System Dynamics researchers faced similar challenges by using grounded theory approach to analyze qualitative data and theories to generate new theories (Black, Carlile, & Repenning, 2004; Rudolph & Repenning, 2002).

'Qualitative Data and Analysis in System Dynamics' section of this article explores data types, qualitative data, and qualitative data analysis methods in System Dynamics field. The following three sections discuss main issues in mixing System Dynamics and Grounded Theory in qualitative secondary data. After exploring the main issues, the article ends with a research design suggestion.

2. Qualitative Data and Analysis in System Dynamics

In his discussion of information sources in modeling, Forrester (1980, 1991) defines three categories; mental data base, written data base and numerical data base. Forrester uses data bases in an extended sense. In his description of data, he references its dictionary meaning and indicates that data is *"something that is given from being experientially encountered"*, *"material serving as a basis for discussion, inference, or determination of policy"* and *"detailed information of any kind"* (Forrester, 1991, p. 23). This description of data is far broader than in its common usage as numerical data.

In Figure 1, Forrester compares the sizes of information content of different information sources. The mental data base is far more extensive than the other information sources. While he indicates the importance of mental data base, he also discusses that the significance of information residing in mental data base is not adequately appreciated in the social sciences (Forrester, 1980). For modeling purposes, mental data base's content consists of observations about structure and policies, expectations about system behavior, and actual observed system behavior (Figure 2).

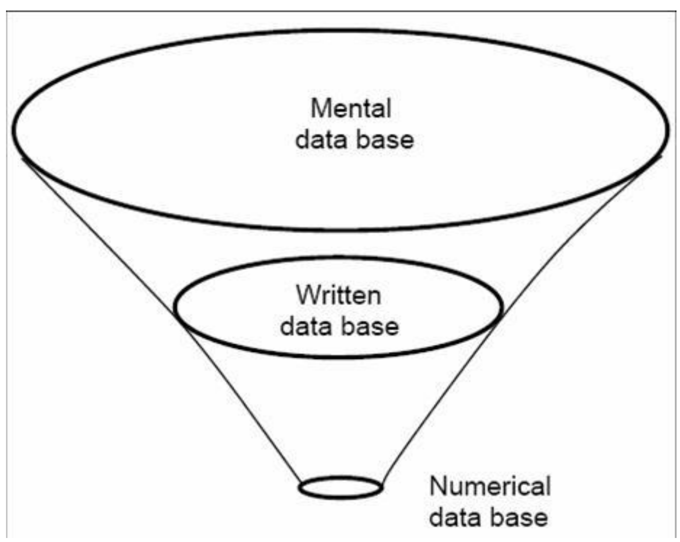

Figure 1- Decreasing information content in moving from mental to written to numerical data bases (FORRESTER, 1980, p. 556, 1991, p.23)

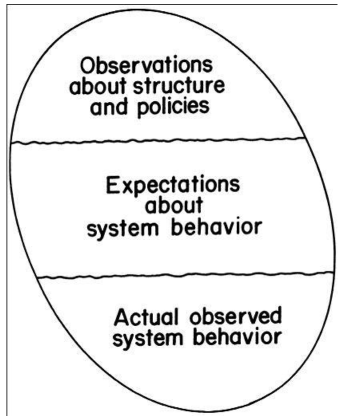

Figure 2 - Content of the mental data base as related to components and to behavior of a social system (Forrester, 1980, p. 556)

While the size of a written data base is less than mental data base, some part of the written data base is a recording of mental data base. Other part of the written data base contains concepts and abstractions that interpret other information sources. Forrester (Forrester, 1980) finds daily and weekly, public and business press more important than textbooks, journals and professional literature, because public and business press have more capability to reflect current pressures surrounding decisions. For a system dynamics modeler, it is important to understand those daily pressures in order reveal the behavior of systems more accurately. Forrester (1980) also indicates the importance of abstractions about system structure. He exemplifies Cobb-Dougles function to discuss the contribution of such abstractions into the structure of system dynamics models.

In his description of shortcomings of written records, Forrester indicates that an author filters information from his or her perspective and purposes, while he or she is transforming mental information into written information .Another shortcoming is, *"unlike the mental database, the written record is not responsive to probing by the analyst as he or she searches for a fit between structure, policy, and behavior"* (Forrester, 1980, p. 557).

A numerical data base has the narrowest scope in information sources. The structure and policies that created the data are missing in numerical data. The cause and effect directions among variables cannot be extracted from the numerical data. Numerical data base's contribution to system dynamics models can be categorized as parameter values necessary for variables, summarized characteristics of system behaviors in professional literature, and time series information for comparing model output rather than determining model parameters.

Although numeric information may be seen as very important to build such models, most of the time information available to modelers is in qualitative nature. Actually Forrester (1991) finds qualitative data residing in people's heads more important than the quantitative data. He (1991, p. 5) discusses that despite qualitative information's importance, management and social scientists have long been neglected this *"far richer and more informative body of information that exist in the knowledge and experience of those in the active, working world."*

It is not easy to elicit the wealth of information that people carry in their heads. System Dynamics researchers acknowledge this challenge. Forrester (1994) indicates that the strength of system dynamics comes from the fit between *"the level-rate-feedback structure"* and *"the fundamental and universal structure of real social and physical systems"* which is necessary for an information flow from real-world into a model.

System dynamics researchers developed a series of guidelines for the model building process to ensure (Richardson & Pugh, 1981; Wolstenholme & Coyle, 1983; Sterman, 2000, 3). Group Model Building approach became effective in terms of eliciting the mental data (Vennix, 1996; Andersen & Richardson, 1997). But it is not always possible to directly access mental data base. As in the Classic Maya Collapse model (Hosler, Sabloff, & Runge, 1977), researchers didn't have a chance to gather old Maya people for a group model building session. Even in some cases, people as problem subjects may be alive, but it may be hard and cost ineffective to reach them due to their location or availability. This was the case in the WTC research process. It was very hard for the researcher to access the WTC responders to gather necessary information to avoid the shortcomings of written records described by Forrester (1980, p. 587). That information was already collected by other researchers through interviews before and they indicated that these interviews had rich descriptions of the events. They also agreed that analyzing this interview dataset can help the researcher to extend and elaborate the generic dynamic theory.

Luna-Reyes and Andersen (2003) discuss collecting and analyzing qualitative data for system dynamics. Despite the widely accepted importance of qualitative data in the system dynamics model development process, there is not a clear description about how or when to use it. This creates further discussions in system dynamics field about incorporating qualitative data into quantified model variables, behaviors, and structures. There are well known research approaches in social sciences that may guide system dynamics researchers in these discussions. Luna-Reyes and Andersen (2003) indicate that data-gathering techniques such as interviews and focus groups, and qualitative data analysis techniques such as grounded theory methodology and ethnographic decision models could have a critical role in rigorous system dynamics efforts.

Scholars see potential in mixing System Dynamics with Grounded Theory and case study research (Kapmeier, 2006; Kopainsky & Luna-Reyes, 2008; Laws & McLeod, 2004). Several examples demonstrate successful results in research projects by mixing System Dynamics and Grounded Theory (Black et al., 2004; Morrison, Rudolph, & Carroll, 2008; Rudolph & Repenning, 2002).

3. Issue I: Existing Theories, Literature, Generic Structures (Archetypes) and Heuristic Concepts

The very first issue of mixing Grounded Theory and System Dynamics is the use of existing theories, literature, and generic structures in a research project. In the early phases of a research project, researcher decides when to use existing theories, literature and generic structures. As an inductive approach, Grounded Theory specifically emphasizes theories emerging from data and sensitive use of existing literature before data analysis. On the other hand in System Dynamics, generic structures can be used upfront *"as a means of using their isomorphic properties as a way of starting the model conceptualisation activity by transferring insights from other models"* (Wolstenholme, 2003, p. 8).

The critical question is *'Do System Dynamic archetypes or generic dynamic models pose a risk of developing preconceived ideas in researcher's mind that colors qualitative data and force data into a Procrustean bed?'* Both System Dynamics and Grounded Theory researchers are interested in the answer of this question and current discussions in the Grounded Theory enlighten this important issue for System Dynamics researchers too. Following subsections summarize these discussions.

3.1 Existing Theories and Literature in Early Phases of Grounded Theory Research

Grounded Theory is one of the most widely used approaches among the qualitative research methods. With their Grounded Theory approach, Glaser and Strauss (1967) challenged the hypothetico-deductive approach that *"enforces the development of precise and clear cut theories or hypotheses before the data collection takes place"* (Kelle, 2005, para. 2). They indicated that this approach led overemphasis on the verification of theory and *"de-emphasis on the prior step of discovering what concepts and hypotheses are relevant for the area that one wishes to research"* (Glaser & Strauss, 1967, p. 1f). As an alternative to the hypothetico-deductive approach in social research, the Grounded Theory approach responded to these pitfalls by allowing categories emerge from the data.

One of the main advantages of the grounded theory approach is that researchers have the opportunity to work open minded with the possibilities of the data and the perspectives of the subjects instead starting with a theory and let that theory to 'color the data' (Hyde, 2000). Being open minded here means that *"literally to ignore the literature of theory and fact on the area under study, in order to assure that the emergence of categories will not be contaminated ..."* (Glaser & Strauss, 1967, p. 37). All these efforts are intended to prevent forcing of data into a procrustean bed. As a result Grounded Theory became one of the most popular research methods used by qualitative researchers in the social sciences.

This popularity led some adoption and changes of the Grounded Theory and different versions of Grounded Theory were evolved over time (Morse, Stern, & Corbin, 2008). As one of the original theorists, Glaser (2004, para. 5) criticizes mixing of Grounded Theory and qualitative data analysis methodologies by indicating *"the effect of downgrading and eroding the GT goal of conceptual theory."* Having different versions of Grounded Theory Methodology are important from mixing it with System Dynamics perspective, because these versions have different approaches to existing theories and literature. While Classic (Glasarian) Grounded Theory selected more sensitive approach to existing theory and literature, Strauss and Corbin version (Corbin & Strauss, 2008; Strauss & Corbin, 1998) took more liberal approach by allowing use of all kinds of literature before a research project.

3.2 Being Free of Any Theoretical Preconceptions

Strauss and Corbin version of Grounded Theory supports the use of literature before a research project, but they (1998, p. 12) also indicate that *'a researcher does not begin a project with a preconceived theory in mind unless his or her purpose is to elaborate and extend existing theory'*. If we revisit the WTC research's goal of extending and elaborating an existing generic dynamic theory, the Strauss and Corbin statement solves a theoretical part of using existing generic structures in such a research project and directs us to methodological protocol issues. But his article not only explores issues of extending and elaborating a generic dynamic theory as in the WTC case, but also discusses issues of developing a new dynamic theory with the generic dynamic structures and archetypes in System Dynamics researchers' minds. That's why, understanding the criticism of Grounded Theory's approach to existing theories helps us to better develop the protocols needed to mixed use Grounded Theory and System Dynamics.

Udo Kelle explores theoretical preconceptions issue in depth (Kelle, 1997, 2005). He (2005, para. 4) indicates that the classic Grounded Theory methodologists' standpoint represents one of the roots of positivist epistemology. The earliest empiricist philosophers like Francis Bacon and John Locke also supported the idea of inductive process of theory building by being open minded (free of any theoretical preconceptions) before approaching empirical data. But this approach, often called "naïve empiricism" or "naïve inductivism", lost most of its supporters after *"Immanuel Kant's sophisticated critique of the pitfalls of early empiricism"* (Kelle, 2005, para. 4). The idea of *"being free of preconceived ideas"* has been heavily criticized.

> *"Both historical examples and recent philosophical analysis have made it clear that the world is always perceived through the 'lenses' of some conceptual network or other and that such networks and the languages in which they are embedded may, for all we know, provide an ineliminable 'tint' to what we perceive"* (LAUDAN, 1977, p. 15 from KELLE, 2005, para. 4)

Kelle (Kelle, 2005, para. 5) emphasizes the impossibility of freeing empirical observation from all theoretical influence. He refers Lakatos's thoughts (LAKATOS, 1978, p. 15 from KELLE, 2005, 5) as *"one of the most crucial and widely accepted insights of epistemology and cognitive psychology"* that *"there can be no sensations unimpregnated by expectations"*. Kelle (Kelle, 2005, para. 6) criticizes inductive research strategy that neglects existing theories for demanding an empty head instead of open mind since it is not possible to build a theory without already accumulated knowledge. Qualitative researchers bring their own lenses and theoretical concepts with them in their scientific investigations. Dropping them prevents their ability to perceive, observe and describe meaningful events any longer (Kelle, 2005, para. 5).

Supporting an early review of literature in their article on improving qualitative methods in public administration research, Brower, Abolafia and Carr (Brower, Abolafia, & Carr, 2000, p. 389) emphasize the importance of having a clear research question and understanding how present theory bears on the question. They describe it as an iterative process between theory and data. They recommend that *"the researcher should plug theory into the data early and often…"* and *"must remain informed, considering and reading new theoretical possibilities even as he or she codes and analyzes data"*. This is important for allowing *"the research question to develop in productive directions and the range of possible interpretations to grow"*. As an important point, they note that *"researchers who do theoretically sensitive coding of social, political, and economic conditions in field notes and interview transcripts will reveal more theoretically powerful pictures of causality"*. But an essential concern is commonly shared by qualitative researchers that theoretical sensitivity should be exercised with caution to prevent forcing data forehand and to allow the regularities and anomalies in the data to suggest possible theories.

3.3 Theoretical Codes and Generic Dynamic Structures

Kelle (2005, para. 7 and 8) acknowledges that the classic grounded theorists are aware of the problem of excluding theoretical concepts early from research project. Glaser and Strauss' (1967) *"theoretical sensitivity"* concept originally recognizes the use of theoretical concepts in advance in grounded theory by addressing researcher's ability *"to reflect upon empirical data with the help of theoretical terms"*. They (1967, p. 46) note that *"Sources of theoretical sensitivity build up in the sociologist an armamentarium of categories and hypotheses on substantive and formal levels. This theory that exists within a sociologist can be used in generating his specific theory (...)"*. A parallel idea was later developed by one of the original grounded theorists, Glaser (1978), as *'theoretical codes'* that theoretical concepts can be at researcher's disposal independently from data collection and data analysis. Kelle (Kelle, 1997, para. 4.3) also indicates Strauss and Corbin's more liberal position by quoting them that *'all kinds of literature can be used before a research study is begun…'* (Strauss & Corbin, 1990, p. 56).

While the grounded theory field discusses how to introduce theoretical concepts into data analysis early in a research project, System Dynamics field has been more enthusiastic about introducing them into research projects through concepts like 'generic structures' and 'archetypes'. System Dynamics field used generic structures as a way to store insights gained in specific cases by generalizing them since the beginning of the field (Lane & Smart, 1996). Archetypes have been seen as a way to "generate understanding in new application domains and systems" (Wolstenholme & Corben, 1993, p. 583). *"Forrester had always advocated building a general model or theory first, and then modifying it to fit the particular situation under study as the preferred method for building any system dynamics model"* (Lane & Smart, 1996, p. 92).

Key questions at this point are *'Is it possible to use generic dynamic theories in similar way to theoretical codes? Is it possible to divide generic dynamic theories into theoretical code parts, so that researcher can use them in the mixed method?'* Our experience indicates that once divided into parts generic dynamic theories can become theoretical codes. In order to understand how these divided parts can be used in the mixed method, 'empirical content' and 'falsifiability of statements' are explored in the next section.

3.3.1 Empirical Content of Theoretical Codes

A source of confusion of using theoretical codes in Grounded Theory comes from the differences between qualitative and quantitative understanding of hypothesis. Even within the qualitative research, the nature and use of theoretical codes is significantly different from the grounded theory approach.

In order to understand these differences, Kelle (1997, para. 3.9) explores understanding of *'hypothesis'* from a broad qualitative and quantitative perspectives. In quantitative approach, *"whatever specific claim the successful H(ypothesis) will make, it will nonetheless be an hypothesis of one kind rather than another"* (Hanson, 1971, p. 291). Focus is on attempting to falsify an empirically contentfull statement. In qualitative research, especially in Grounded

Theory, hypotheses emerge as researcher interacts with data and initially hypotheses are vague ideas about relations. Kelle (1997, para. 3.9) proposes that *"instead of calling them hypotheses one should rather call them hypotheses about what kind of propositions, descriptions or explanations will be useful in further analysis"* in Grounded Theory.

Based on the above discussion, Kelle (1997, para. 4.5) explains that qualitative researchers (whether they apply a 'grounded theory' approach or not) use the theoretical preconceptions to structure data material. These theoretical preconceptions play an important role in their abductive inferences. In qualitative analysis, these theoretical preconceptions do not often represent explicit propositions about empirical facts and Kelle (1997, para. 4.5) proposes that *"they should be referred to as 'heuristic concepts' which can be used to formulate 'orientation hypotheses'"* (Merton, 1957, p. 88).

Hypothetical inferences enable a creative process to combine new and interesting empirical facts with existing theoretical knowledge. But this doesn't mean that *"the theoretical knowledge of the qualitative researcher should form in the beginning a fully coherent network of explicit propositions from which precisely formulated and empirically testable statements can be deduced"* as in the hypothetico-deductive approach (Kelle, 2005, para. 32). In qualitative inquiry, *"it should constitute (a sometimes only loosely connected) "heuristic framework" of concepts (or "coding families") which helps the researcher to focus the attention on certain phenomena in the empirical field"* (Kelle, 2005, para. 32). But this notion brings an ambiguity of theoretically sensible category development process.

3.3.2 Falsifiability of Statements

"Falsifiability" or "empirical content" concepts are commonly used to identify sound scientific hypotheses in a hypothetico-deductive framework. In that framework, it is important to originate *"clear-cut and precisely formulated propositions with empirical content as adequate hypotheses"*. Any concepts and hypotheses without these qualifications are regarded as highly problematic, since they lack of empirical content and cannot be falsified. Kelle (2005, para. 33) indicates the opposite picture in grounded theory generation framework. In that framework, *"Theoretical concepts with low empirical content, however, can play an extremely useful role if the goal of empirical research is not the testing of predefined hypotheses but the empirically* *grounded generation of theories, since they do not force data into a Procrustean bed—their lack of empirical content gives them flexibility so that a variety of empirical phenomena can be described with their help"*(Kelle, 2005, p. 33). Kelle (2005, p. 33) acknowledges that such concepts cannot be tested empirically. But they can be used as heuristic devices as theoretical lenses to approach the phenomena and the data.

3.3.3 Heuristic Concepts

Kelle (Kelle, 1997, para. 4.5-5.10) describes three levels of 'heuristic concepts' from high empirical content to low. The first level heuristic concepts are derived from *'grand theories'* and they are *'highly abstract concepts about the relations between actors or between actors and society in general'* (KELLE, 1997, 4.6-4.8; 2005, 35). *"Sensitizing concepts"* are this type of concepts that they *"lack precise reference and have no bench marks which allow a clean cut identification of a specific instance"* (Blumer, 1954, p. 7). This type of heuristic concepts has low empirical content that can be applied to different phenomena. Kelle (2005, para. 35) indicates that these concepts may be useful in empirically grounded theory building. Abstract preconceptions can be gathered from different theories to structure the data. Although application of codes derived from specific theories makes the data structuration easier, it carries an important risk of neglecting other theoretical concepts that may be more useful to explore the phenomena in question. Kelle (2005, para. 37) proposes to use different and event competing theoretical perspectives on the same data to address this risk.

Second level heuristic concepts are *'theories of the members of the investigated culture'* (Kelle, 1997, para. 4.7). Strauss and Corbin's "coding paradigm" and Glaser's "theoretical codes" concepts are the second type of heuristic concepts (Kelle, 1997, para. 5.4). They can be derived from *"general common sense knowledge"* or *"specific local knowledge of the investigated field"* (Kelle, 2005, para. 38). At this type of heuristic concepts, a certain code may increase the risk of neglecting or excluding other relevant phenomena from examination.

Third level heuristic concepts are the ones that are closer to the Hypothetico-Deductive approach's 'theory'. These concepts have high empirical content and they are falsifiable (at least in principle). They are not as useful as the other kinds of heuristic concepts in an interpretative research, since they may force the data into a Procrustean bed (Kelle, 2005, para. 39).

“Empirical content” and “falsifiability” concepts can help to identify heuristic concepts that can help researchers to use their previous theoretical knowledge (whether they apply grounded theory or not). Kelle (2005, para. 34) indicates that the first and second levels of *“heuristic concepts may be used to define a category scheme useable for the structuration and analysis of qualitative data which can be supplemented, refined and modified in the ongoing process of empirical analysis”*.

3.3.4 Logic of Discovery: Inductive, Deductive or Abductive

Having discussed the importance of heuristic concepts in the mixed use of Grounded Theory and System Dynamics, the logic of discovery or the direction of theorizing becomes questionable. Researcher carries generic dynamic models, archetypes, and other related theoretical terms into a research project and analyzes data by consulting these concepts. This approach seems more deductive than inductive at this stage. Despite having more than twenty approaches to qualitative research, many features of inductive paradigm are widely shared by most of them (Brower et al., 2000). As a well established inductive approach, applying the grounded theory method in a deductive way doesn’t seem like a good methodological approach considering the Grounded Theorists’ rightful worries about not being sensitive about existing theories, and forcing data into a Procrustean bed. Although “theoretical sensitivity”, “theoretical coding”, “axial coding”, and “coding paradigms” are important concepts in grounded theory to overcome “naïve empiricism” of the emergence idea, clear cut methodological rules to address the concept of theoretical sensitivity are still not available (Kelle, 2005, para. 9). At this stage, exploring the phases of Grounded Theory and System Dynamics is necessary to understand the direction of theorizing in Grounded Theory to realize the role of theoretical codes in research methodology protocols.

Discussions in System Dynamics field on the direction of theorizing indicate some confusion in the field. While discussing theory-building processes in System Dynamics, Schwaninger and Grösser acknowledge that their chosen theory-building processes *“do not involve deduction or induction along, but they utilize both in combination”* (Schwaninger & Grösser, 2008). In his commentary paper on the Schwaninger and Grobler’s article, Größler (2008) focuses this issue and separates applications in the field by acknowledging that some of the applications are inductive and some of them are deductive system dynamics modeling. The logic of discovery depends on *"the process of model building, the nature of simulation results to be expected, and the validity of conclusions to be drawn from the modeling endeavor"* (Größler & Milling, 2007, p. 1). Barton and Haslett (2006) interpret of the SD's events-patterns-structure framework as an application of abductive inference.

Kelle (1997, para. 4.4) indicates that *'the application of a coding paradigm or of 'theoretical codes' to empirical data is based on a* ***logic of discovery*** *which is neither inductive nor deductive'*. He calls it **'*Hypothetical Reasoning*'** that '*represents a special kind of logical reasoning whose premises are a set of empirical phenomena and whose conclusion is a hypothesis which can account for these phenomena*'. Hypothetical reasoning is based on two forms of logical inference; qualitative induction and abduction. The main difference between qualitative induction and abduction is '*with qualitative induction a specific empirical phenomenon is described by subsuming it under an already existing category or rule*', with qualitative abduction, '*unknown concepts or rules on the basis of surprising and anomalous events'* are sought by researcher.

In Abductive Inference (or reasoning), identifying a particular phenomenon is the starting point. Then that phenomenon is accounted by relating it to broader concepts. Abductive inferences are not only seek in data, but also are seek in "explanatory and interpretive frameworks" such as researcher's own experience, stock of knowledge of similar or comparable phenomena, equivalent stock of ideas (theories, frameworks…) within one's own discipline and other disciplines. Although existing theories are useful, the researcher does not force the data to fit the phenomena into existing theories, but his search includes *"new, surprising, anomalous observations"*. At its core, there is *"a repeated interaction among existing ideas, former findings and observations, new observations, and new ideas"* (Coffey & Atkinson, 1996, p. 156).

Kelle (2005, para. 31) indicates the importance of careful usage of previous knowledge:

> *"In making abductive inferences, researchers depend on previous knowledge that provide them with the necessary categorical framework for the interpretation, description and explanation of the empirical world under study. If an innovative research process should be successful this framework must not work as a Procrustean bed into which empirical facts are forced. Instead, the framework*

which guides empirical investigations should be modified, rebuilt and reshaped on the basis of empirical material."

If codes from generic structures and the principles of system dynamics theory can be considered among low empirical level theoretical codes, inductive inference emerges as the mode of inference in the WTC case as a mixed use Grounded Theory and System Dynamics. If the system dynamics modeling process becomes the basis for decision of inference mode, abductive inference emerges as the mode of inference from the perspective of Barton and Haslett (2006).

The question remains on theoretical concepts with high empirical content that whether they can be used in a qualitative research or not. Literature search on this topic resulted in several other examples of deductive processes in qualitative research method (Hyde, 2000) such as 'pattern matching', 'referential adequacy' (Lincoln & Guba, 1985), 'analytical abduction' (Kramer, 2007), hypothesis testing (King, Keohane, & Verba, 1994; Yin, 1994) and 'content analysis' approaches and techniques. Kelle's (Kelle, 1997, para. 3.7) discussion of (quantitative) content analysis is an example of coding within a hypothetico-deductive research strategy. Hyde's (2000) application of "pattern matching" approach to a marketing research phenomena also exemplifies how to use theoretical concepts with high empirical content (clear-cut hypotheses).

Although increasing empirical content increases the risk of forcing data, Kelle (2005, para. 41) also acknowledges that the use of categories and assertions with high empirical content can be fruitful in a qualitative study. He (2005, para. 42) refers *"Abductive Induction"* research strategy developed by the *"Chicago School"* of American sociology in the 1930s and it has been used in qualitative studies since then. Empirical cases (called *"crucial cases"*) were used to examine and modify initial hypotheses with high empirical content.

4. Issue II: Application of Grounded Theory Data Analysis to Extract System Dynamics Modeling Information

Second important issue is the capability of the Grounded Theory approach to extract necessary system dynamics modeling information from a qualitative dataset as a result of a secondary data analysis. At the very core of the data analysis, researcher's goal is to understand the phenomenon in question. System Dynamics researchers specifically study causal relationships and dynamic behaviors and they describe their understanding in causal maps, stock and flow diagrams, and simulation models. Major information resources and parts of a system dynamics model are depicted in Figure 3.

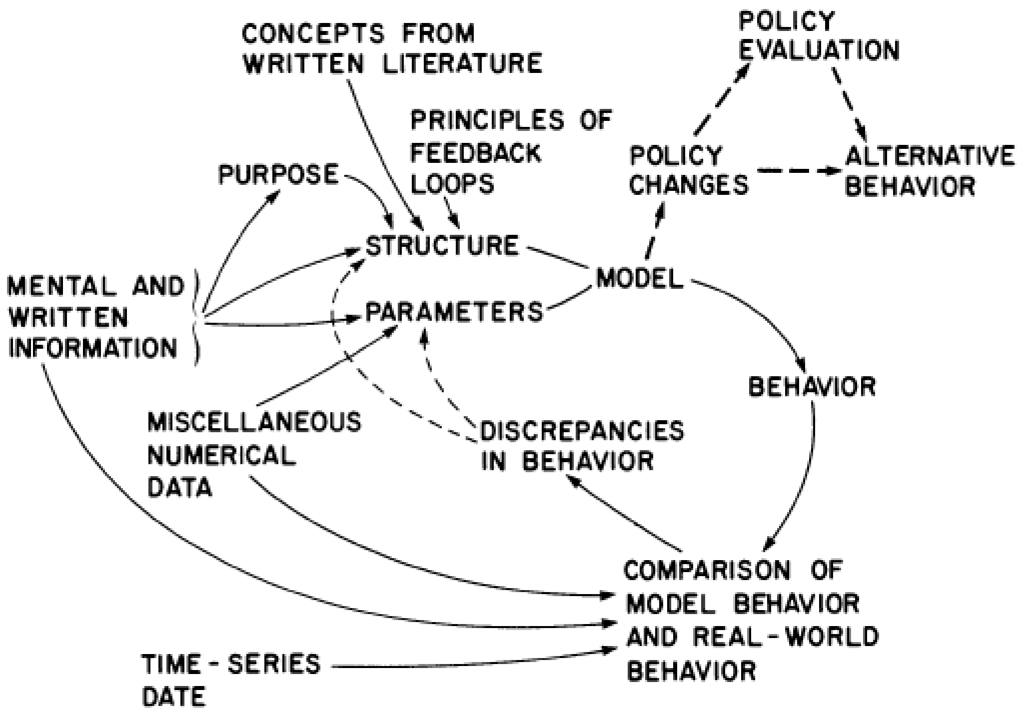

Figure 3 - Creating a System Dynamics Model (Forrester, 1980, p. 559)

Data resources for system dynamics model development (Figure 3) are (1) Mental and Written Information, (2) Concepts from Written Literature, and (3) Miscellaneous Numerical Data. In secondary analysis of a qualitative dataset, researcher is restricted to written information (interview transcripts in the WTC case) to understand mental data base of subjects. But the analysis process with literature and related numerical data can help researcher to extract structure, parameters and reference modes from qualitative dataset. This process is also highly depended on the richness of a dataset from system dynamics modeling perspective.

Important questions are *'What happen if qualitative dataset is not rich enough to extract enough modeling information? What should researcher do under uncertainty?'* There are two answers in System Dynamics field for these questions: One school of thought supports developing qualitative maps (causal loop diagrams) to explain the phenomenon (Coyle, 2000; Wolstenholme

& Coyle, 1983), another school of thought supports developing fully developed simulation models even under uncertainty (Homer & Oliva, 2001; Richardson, 1996, 1999; Sterman, 2002). Later group indicates that simulation adds significant value on top of qualitative models, because they are testable, they enable to draw behavioral and policy inferences reliably, and even under uncertainties, simulations can indicate the missing value required for reaching firm conclusions (Homer & Oliva, 2001).

System Dynamics researchers successfully adopted the Grounded Theory approach in an inductive way to analyze qualitative data and theories to generate new theories (Black et al., 2004; Rudolph & Repenning, 2002). These implementations demonstrate the capability of mixed use of Grounded Theory and System Dynamics to retrieve enough modeling information from written information and literature.

5. Issue III: Output of the Research Process

Outputs of a research project based on mixed use of Grounded Theory and System Dynamics can be listed as:

- Substantive Theories to Explain Specific Cases
- Causal Loop Diagrams
- Reference Modes
- Fully developed System Dynamics Models with Dynamic Hypotheses
- Extended and Elaborated Generic Structures

5.1 Substantive Theories to Explain Specific Cases

Since the main goal of researcher is to understand the phenomenon in question, researcher is subject to similar limitations that other Grounded Theory researchers face in analyzing their qualitative data. Although a researcher initially relies on some theoretical codes based on generic dynamic structures and principles of System Dynamics, these codes are empty abstractions without substantive codes (Glaser, 1998, p. 164). A researcher who adopt the mixed method can at least reach the same results of a Grounded Theory researcher, which is a substantive theory explaining a specific case.

5.2 Causal Loop Diagrams

A researcher can describe her causal understanding of case in causal loop diagrams. These diagrams are referred to as qualitative system dynamics models in the System Dynamics field. It is important to remember that the System Dynamics field has been discussing merits and disadvantages of qualitative and quantitative modeling since 1980s. Merits of causal loop diagrams were acknowledged in these discussions. Researcher adopting the mixed method may develop causal loop diagrams to explain case in question.

5.3 Reference Modes

Reference Modes are important part of problem definition and model testing stages of system dynamics modeling. A reference mode is a graphical description of historical behavior and inferred future trend (Saeed, 1998). Saeed (Saeed, 1998, pp. 2-6) explains the more complex nature of reference modes. A reference mode is an abstract concept that represents a pattern of behavior in a qualitative, intuitive, organized, integrated, and noise-free way to describe problem behavior (Saeed, 1998, p. 4). From this perspective, researcher's attempts to construct reference modes based on qualitative data result in rich descriptions of problem understanding. Reference modes by themselves can become an important medium to communicate the understanding from research.

Although researchers frequently emphasized dynamic changes in their studies, scholars (other than systems school) rarely presents these dynamic changes in graphs over time for key variables. In one of those rare presentations, Levina (2005, fig. 1) presented a degree of project involvement using different actors to describe the practical change in IT development (Figure 4).

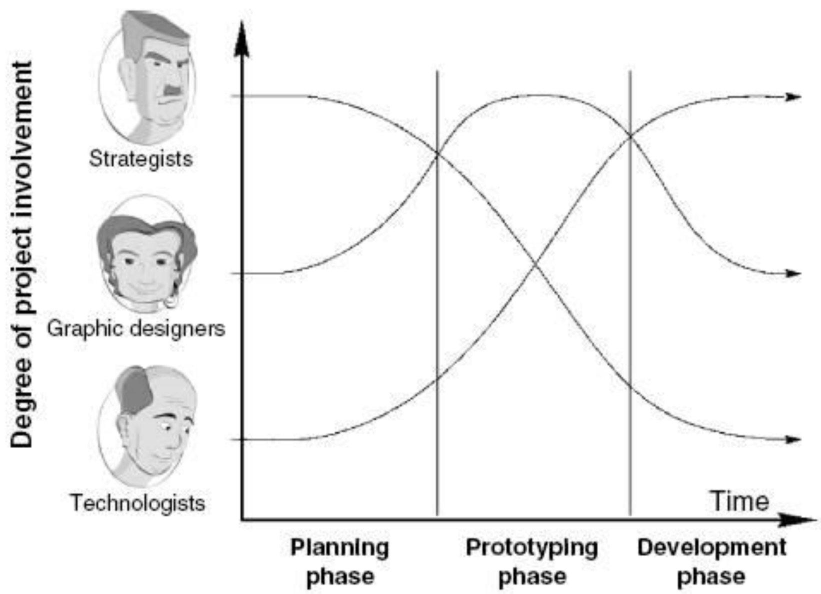

Figure 4 – The "Waves" Service Delivery Model (Levina, 2005, fig. 1)

In addition, Fichman and Kemerer (1999, fig. 2) introduced the assimilation gap concept by describing the behavioral change over time and modeling assimilation gaps for software process innovations (Figure 5).

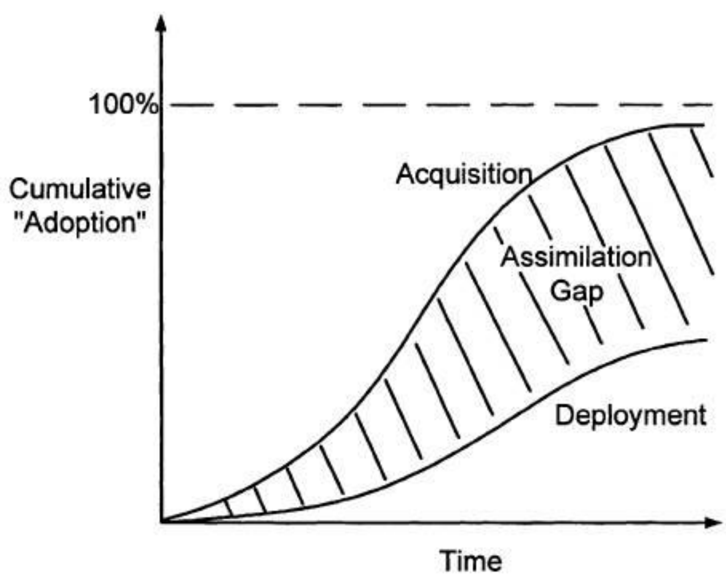

Figure 5 – Assimilation Gap (Fichman & Kemerer, 1999, fig. 2)

Researchers constructed these reference modes by adopting different research methodologies. A researcher using the mixed method can put the characteristics of reference modes into his theoretical codes and search for evidence during Grounded Theory analysis of qualitative data. This process can deliver reference modes with important behavioral insights about key variables.

5.4 Fully developed System Dynamics Models with Dynamic Hypotheses

Many System Dynamics researchers agreed that a research project reaches its maximum value with fully developed system dynamics models with dynamic hypotheses in System Dynamics field . The critical question in the mixed method is the ability to collect enough system dynamics modeling information from secondary qualitative data. This question is discussed in the 'Issue II: Application of Grounded Theory Data Analysis to Extract System Dynamics Modeling Information' section. As a result, the mixed method can deliver enough modeling information from a qualitative dataset. Depending on the richness of the dataset, some of the modeling information may not be available from it. In this case, the researcher either chooses to stop at this stage and delivers his understanding of the case through descriptions, causal loop diagrams, and reference modes, or researcher continues to build a fully developer system dynamics model by indicating missing information and discussing potential findings under such uncertainties.

5.5 Extended and Elaborated Generic Structures

The main goal of the WTC research was to extend and elaborate a generic dynamic theory. The theoretical codes in this project contained the concepts from the generic dynamic theory from the beginning. The analysis process in the mixed method delivered enough information about the structure, behavior and variables in the generic dynamic theory. At the end, the main goal of the research project was reached by extending and elaborating generic structures based on substantive theory in the WTC response and recovery case.

Archetypes and generic dynamic structures store insights gained in specific cases by generalizing them. This is an important research project goal in the System Dynamics field and the mixed method can deliver enough material to researcher to make changes on these generic structures.

6. Suggested Research Design for the Mixed Use of Grounded Theory and System Dynamics Modeling

The purpose of this section is to describe the WTC research design and discuss some protocol related issues in depth. The methodological challenges arose from the interaction between components of the WTC research: existing dynamic theory, interview dataset, secondary data analysis, and the Grounded Theory approach. Although all of these components have their own consistent and widely accepted ways of uses, it is challenging to bring all of them together in a single research project. A research design was developed to address these methodological challenges in the WTC research (Figure 6). Given the iterative nature of qualitative research and system dynamics approach, we acknowledge the limitations of explaining and presenting the research design on a diagram. Understanding the fundamentals of qualitative research and system dynamics approach and then exploring the research design here is important to fill the potential gaps in this graphical presentation.

The research design has several iterative stages. The first stage is problem definition and research question formulation. This stage leads to the development of research questions and heuristic concepts. The second stage is data analysis where the WTC dataset was analyzed using a grounded theory approach (Strauss & Corbin, 1998). The data coding process is part of this stage. The second stage ends when theoretical saturation is reached. The products of the data analysis stage are (1) categories and properties, (2) relations among categories, (3) memos and diagrams, (4) system dynamics modeling information, and (5) causal understanding of the phenomenon. While a substantive theory was built along with the theoretical saturation, the theoretical concepts were densified to complete the theory at the third stage. The results of the analysis were compared to the generic dynamic theory‘s propositions to increase understanding of the phenomenon and to extend and elaborate the generic dynamic theory at the fourth stage.

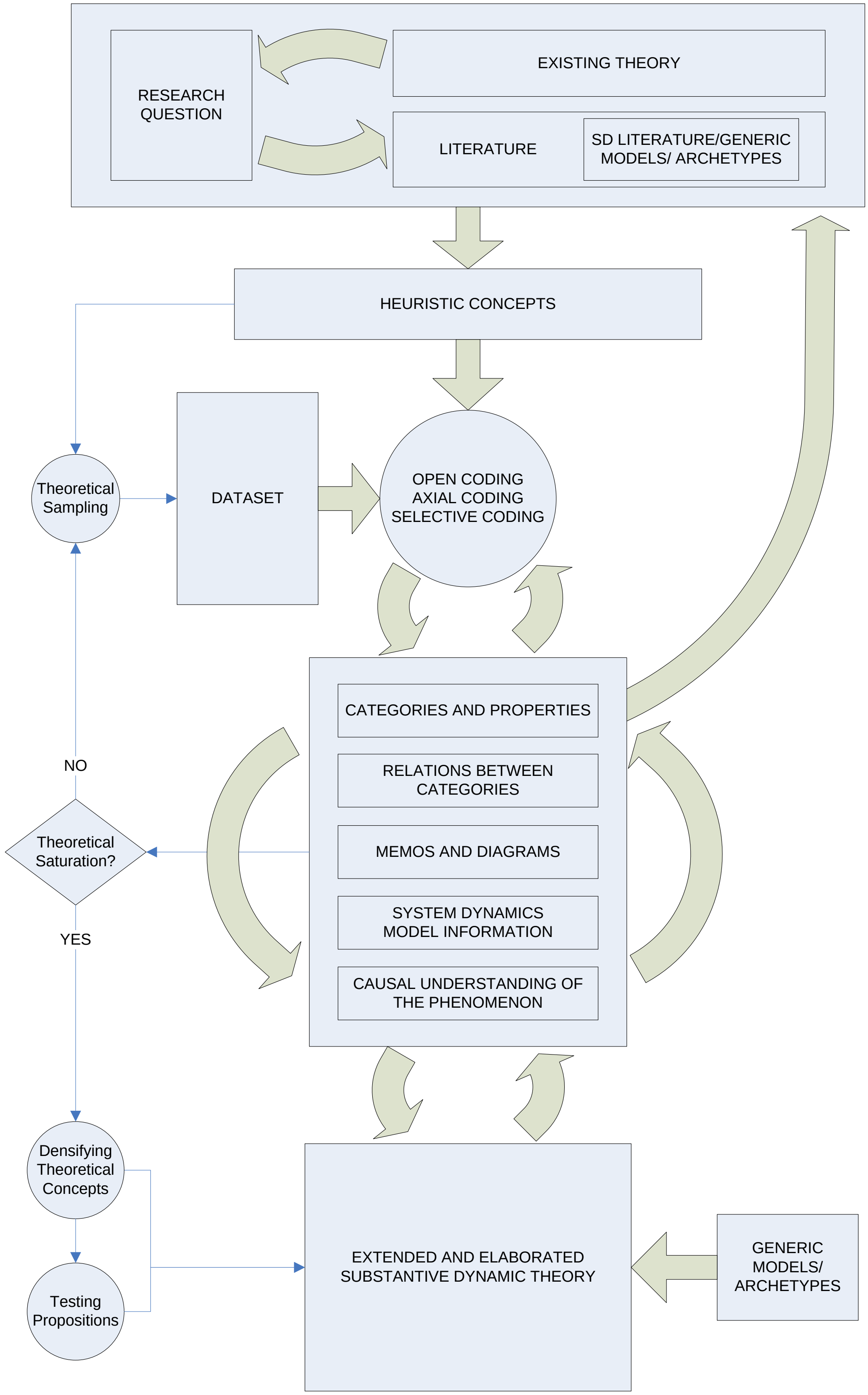

Figure 6 - Research Design

6.1 Problem Definition and Research Question Formulation

The first stage of the research design is problem definition and research question formulation. In this stage, research questions are shaped by the existing theory and literature. Following the fundamentals of research question evaluation in grounded theory (Strauss & Corbin, 1998), research questions start broadly to give necessary flexibility and freedom to explore a phenomenon in depth. In the WTC research case, the research problem and questions are based on extending and elaborating a generic dynamic theory. The research questions are defined based on the existing theory's concepts, hypotheses and claims, and themes emerging from the dataset.

The intensity of a literature review generally depends on the approach the researcher is adopting. Agreeing with the principles of classic grounded theory, a researcher may skip an extensive literature review initially and may come back after indentifying categories from the data. Given the notion that "*it is important for qualitative studies to articulate and answer a specific research question"* (Brower et al., 2000, p. 386). In order to answer a specific research question, a researcher may make it explicit as early as possible, so relevant data sources can be accordingly chosen. Otherwise there is a risk of *"wasting time gathering unusable data and arriving at various research dead ends"* (ibid).

This first step of this research design corresponds to the problem articulation step of the system dynamics modeling process. Having a similar iterative approach to grounded theory, system dynamics models are also grounded on the data. Additional to the research problem and question definition, system dynamics researchers also search for key variables and concepts, the time horizon of the problem, and reference modes (historical and predicted future behavior of the key concepts and variables). In the modeling process, *"results of any step can yield insights that lead to revisions in any earlier step"* (Sterman, 2000, p. 87). Similar to grounded theory, these insights emerge throughout the research process.

The goal of extending and elaborating upon the theory the WTC research requires delicate handling of the heuristic concepts and propositions of the generic dynamic theory at the beginning of the research. Following the fundamentals of grounded theory (Strauss & Corbin, 1998), as part of theory extension and elaboration, heuristic concepts of the III Theory were carried into the data analysis at the beginning of the research. These heuristic concepts with low empirical content are grand concepts and abstract theoretical concepts derived from the generic dynamic theory. The generic dynamic theory explains the interaction of social processes and accumulations in an interagency information integration initiative. The description of generic processes creating technical artifacts in a social process (Figure 7) became the base for developing heuristic concepts and dynamic hypotheses in the WTC research.

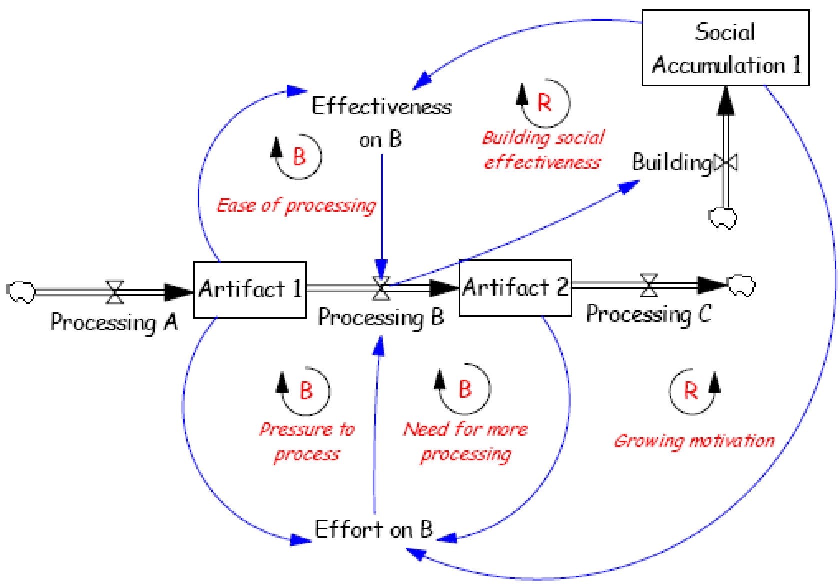

Figure 7 - Generic processes creating technical artifacts in a social process (Luna-Reyes et al., 2004)

An interactive process of developing the research question with the existing theory and the literature leads the development of heuristics concepts (Box 1). Having a generic dynamic theory prevents forcing the data into a Procrustean bed and enables emergence of theory relevant concepts from the qualitative data.

The generic dynamic theory's dynamic hypotheses with high empirical content (herein, called '*propositions*') are also available for the analysis. The dynamic hypothesis concept comes from the system dynamics approach where it describes *"a theory about what structure exists that generates the reference modes" (a pattern of behavior over time). "A dynamics hypothesis can be stated verbally, as a causal loop diagram, or as a stock and flow diagram"* (VENSIM, 2009). In the generic dynamic theory, dynamic hypotheses are derived from the generic processes causal loop diagram (Figure 7). In order to avoid confusion, these dynamic hypotheses are called ‘proposition’ in this research consistent with the qualitative approach to emphasize their difference to the hypothesis concept in the quantitative approach (Kelle, 1997).

Grand Theory and Abstract Theoretical Concepts

- Process, social process, practice, social practice
- Social accumulation
    - Social Capital
    - Symbolic Capital
    - Cultural Capital
    - Individual understanding
    - Individual commitment
    - Shared understanding
    - Group engagement
- Social group efficiency
- Social group effort
- Feedback loop, causal relationship
- Artifacts

Box 1 – Grand Theory and Abstract Theoretical Concepts developed based on the existing theory

The III theory has ten propositions:

P1: Social practice causes social accumulation.

P2: A reinforcing feedback loop exists between social practice and social accumulation through individual/group effectiveness that builds social effectiveness.

P3: A reinforcing feedback loop exists between social practice and social accumulation through individual/group effort that grows motivation.

P4: A balancing feedback loop exists in that, as social practice changes Artifact 1, these changes affect social practice back through individual/group effectiveness.

P5: A balancing feedback loop exists in that, as social practice changes Artifact 1, these changes affect social practice back through individual/group effort.

P6: A balancing feedback loop exists in that, as social practice changes Artifact 2, these changes affect social practice back through individual/group effort.

P7: A feedback loop exists in that, as social practice changes Artifact 2, these changes affect social practice back through individual/group effectiveness.

P8: Independently accumulated social accumulations affect social practices through individual/group effectiveness.

P9: Independently accumulated social accumulations affect social practices through individual/group effort.

P10: Social accumulations have initial values that accumulate independent of subjected social practice.

Having propositions with high empirical content creates a risk of forcing data initially into a Procrustean bed. To avoid this risk, the propositions should not be employed or considered in the analysis. Once relevant concepts and hypotheses emerged and were validated against data, these propositions can be introduced in order to compare them to the emerging findings and hypotheses to increase understanding of the phenomenon (Strauss & Corbin, 1998).

6.2 Data Analysis

Grounded Theory techniques are used in this stage. Theoretical sampling process starts based on the research question and heuristic concepts. *"Theoretical sampling is the process of data collection for generating theory whereby the analyst jointly collects, codes and analyses the data and decides what data to collect next and where to find them, in order to develop the theory as it emerges"* (Glaser & Holton, 2004, p. 51).

The available number of samples (interview transcripts in the WTC case) is an important restriction in secondary data analysis. As noted by the grounded theorists, it is possible to reach theoretical saturation before analyzing all the interview transcripts. But an opposite scenario is also possible with a limited size of data that theoretical saturation may not be reached with the given dataset.

The coding processes are *"the analytic processes through which data are fractured, conceptualized, and integrated to form theory"* (Strauss & Corbin, 1998, p. 3). Open, axial and selective coding procedures are discussed in details in the literature (Strauss & Corbin, 1998).

Iterative coding processes lead development of categories and their properties, relationships between categories, and causal understanding of the phenomenon along with memos, diagrams and modeling information. This iterative process helps researcher to accumulate a causal understanding of the phenomenon. Causal understanding grounded on empirical evidences is critical in the substantive theory development process. The substantive theory answers the research questions that evolved throughout the research steps based on emerging themes.

6.3 Theory Development

After this step it is possible to complete the research process with a substantive dynamic theory for qualitative researchers. Some of the system dynamics researchers (Coyle, 2000; Wolstenholme & Coyle, 1983) also settle at this stage by developing causal loop maps to describe the phenomenon, if they do not have enough modeling information. Despite the challenge and risks of quantification process, many system dynamics researchers (Homer & Oliva, 2001; Richardson, 1999; Sterman, 2002) find the actual value by formulating a simulation model.

Formulating of a simulation model step follows the decision to quantify the causal understanding of the phenomenon. Formalization helps *"to recognize vague concepts and resolve contradictions that went unnoticed or undiscussed during the conceptual phase"* (Sterman, 2000, p. 103). Recognizing the missing information, researcher can go back to data to gather more data and develop more accurate dynamic description of the phenomenon.

Given the collected data, researchers begin to develop a dynamic hypothesis to account for the phenomenon during the dynamic hypothesis formulation stage. The hypothesis is called dynamic, because it explores and explains the dynamic nature of the phenomenon by characterizing the underlying feedback, and stock-and-flow structure. Although a dynamic hypothesis is a working theory of the phenomenon, it is a hypothesis due to its provisional nature. It is revised or abandoned throughout the research process based on the information gathered from the modeling process and from the real world (Sterman, 2000, p. 95). Initial or emerged heuristic concepts, categories and their properties are used to define key variables in the system dynamics model. The time horizon and reference modes are critical category properties for building a system dynamics model that aimed to be extracted in the coding process. Causal relationships between categories and memos help to reflect causal understanding of the phenomenon in the mapping process. Maps of causal structure are developed *"based on initial hypotheses, key variables, reference modes and other available data using tools such as model boundary diagrams, subsystem diagrams, causal loop diagrams, stock and flow maps, policy structure diagrams and other tools"* (Sterman, 2000, p. 86).

Based on the knowledge gathered from the substantive theory and substantive dynamic theory, research can revisit the propositions of generic dynamic theory and offer changes to extend and elaborate the theory or the generic structure.

7. Conclusion

Since its introduction in mid-1950s, System Dynamics approach has been using qualitative data to study complex social systems. Despite the central role of qualitative data in system dynamics model development process, System Dynamics field does not have detailed protocols to describe the use of qualitative data or qualitative research methods in the modeling process (Luna-Reyes & Andersen, 2003). The Grounded Theory approach is a popular methodology in qualitative data analysis and it is being used by researchers in System Dynamics modeling. This article discusses the methodological issues in mixed use of Grounded Theory and System Dynamics approaches by referring a research experience based on secondary analysis of qualitative dataset.

The first issue deals with the use of existing literature and generic dynamic structures (archetypes) in a research project. The Grounded Theory field has been discussing the role of existing literature or preconceptions in the data analysis phase. Several different versions of Grounded Theory evolved in time and they have different approaches to operating in this role.

This is a critical issue for System Dynamics field too, because generic structures play important role during the research phases. Based on the discussions in the Grounded Theory field, we concluded that generic structures can be used as heuristic concepts. But these heuristic concepts should be low in empirical content, so that they will not force the data into a Procrustean bed. Any concept with high empirical content coming from generic theories can be used after theoretical saturation is reached.

The second issue is focused on the mixed method's ability to extract the necessary modeling information from a qualitative dataset. Existing examples from System Dynamics field shows that the mixed method successfully delivers enough modeling information. But our focus in this issue is more of secondary use of qualitative data to build system dynamics models. Secondary data analysis restricts researcher to a predefined number of materials. While the question comes to the quantity of information needed for model building, qualitative vs. quantitative modeling discussions in System Dynamics field indicate that many researchers find additional value of developing simulation models even under uncertainties.

The third issue is potential outputs of a research project using the mixed method. These outputs are (1) substantive theories to explain specific cases, (2) causal loop diagrams, (3) reference modes, (4) fully developed system dynamics models with dynamic hypotheses, and (5) extended and elaborated generic structures. If we put aside the expectations from System Dynamics perspective, the mixed method can deliver similar result in Grounded Theory research at least. This result is a substantive theory explaining the problem in question. After gaining causal insights about a problem, a researcher can describe her understanding in a causal loop diagram. Again revisiting the qualitative modeling issue in System Dynamics field will show that some researchers can be satisfied with such a result under some conditions. Another set of important artifact in the field consists of reference modes. Reference modes are building blocks of system dynamics models. But they are also very useful tools to describe and discuss dynamic behaviors. Although examples are comparably very rare, several researchers outside the system school construct reference modes to explain dynamic behavior in problem domains. The mixed method can also help a researcher to develop reference modes grounded on qualitative data. Finally a much sought result by researchers, developing a simulation model, can also be reached with the mixed method as it is discussed under the second issue. Parallel to the enthusiasm of using generic structures or archetypes in research, researcher should also revisit relevant generic structures and offer changes based on his findings, where necessary.

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