Group Model Building to Support Interdisciplinary Theory Building

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Abstract

In this paper we describe the initial steps in the development of a theory of the impacts of governance principles such as completeness, openness, relevance and reliability on the adoption of a large-scale interorganizational system to increase supply chain transparency. The research presented here is in alignment with the use of system dynamics models to develop and test theories. Given the interdisciplinary nature of the project, Group Model Building was selected as the approach to build the theory. In this context, the system dynamics model, and other artifacts used during the modeling process work as boundary objects facilitate conversations among researchers from different disciplines.

Introduction

In this paper we introduce the use of System Dynamics Group Model Building as a tool to support interdisciplinary theory-building efforts. Our current research involves the work of an interdisciplinary team of researchers—coming from disciplines as diverse as public administration, public policy, marketing, information science, computer science and information systems—exploring the dynamics of the creation of a socio-technical system and set of standards to build more transparent and sustainable supply chains (Jarman et al., 2011; Luna-Reyes et al., 2009, 2011; Luna-Reyes, Andersen, Andersen, Derrick, & Jarman, 2012; Zhang et al., 2012). Following an approach known in the Information Systems field as Design Science, our work involves the reflective development of a technical artifact, yielding practical and theoretical insights as one of the key products of the design process (Hevner, March, Park, & Ram, 2004; Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007).

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The project has involved the collection and analysis of qualitative data from interviews, secondary sources, a workshop involving main stakeholders in the coffee supply chain, and formal system dynamics modeling. This approach is unusual but not unique in social science research (Luna-Reyes, 2004). In fact, social scientists use a diversity of approaches in building or testing theories. As pointed out by Hanneman (1987), in the attempt to get a better understanding of social phenomena, it is possible to use methods “ranging from deductive reasoning by rules of formal logic to efforts to understand and offer “thick” descriptions of the patterns of meanings and definitions of situations of people in everyday settings” (p.16).

Simulation has been recognized as a useful method to develop and test theories in the social sciences, giving researchers the opportunity of representing their knowledge about a particular phenomenon, and testing for its internal consistency (L. Black, 2002; Hanneman & Patrick, 1997; Hanneman, 1987; Kopainsky & Luna-Reyes, 2008). Given the usefulness of Group Model Building (GMB) as a method to help groups of managers to design and test solutions for real-world problems (Andersen & Richardson, 1997; George P. Richardson & Andersen, 1995; Vennix, 1996), we also have used the method effectively to help a group of researchers to build theory (Luna-Reyes et al., 2006; Luna-Reyes et al., 2004). System dynamics graphs over time and causal diagrams have proven to be effective boundary objects to aid theory building efforts in an interdisciplinary environment. However, using system dynamics as a tool to theory development may call for additional tests for assessing models as has been already suggested in the literature (Luna-Reyes & Kopainsky, 2008).

After this brief introduction, the paper is organized in four additional sections. The next section introduces the context of our current research project, I-Choose. The third section of the paper consists of a review of the literature on GMB and system dynamics as a theory-building method. The fourth section of the paper includes a description of the process of theory development involved in this project, and the last section offers some final reflections and remarks.

The I-Choose Project

I-Choose is a research project with the main goals of developing and testing a data-sharing architecture to provide a wide range of trusted product information to assist better informed consumer choices (Zhang et al., 2012). Our current prototype development efforts focus on coffee produced in Mexico and consumed in the United States and Canada. However, learning from the design process may be extended to other products and markets. Prototype development is being guided by an international network of researchers and key stakeholders from the three countries.

The I-Choose system has three basic components: 1) a set of ontology-based data standards to share information across the supply chain, 2) a set of Application Programming Interface

(API) standards to make it possible for developers and other interested groups to create specific applications to make this information usable by regular consumers, and 3) a governance system, which will be in charge of creating and modifying the standards over time (Luna-Reyes et al., 2012). These three components will make I-Choose an enabling tool for the development of various applications to help consumers make more sustainable purchasing decisions.

Figure 1 shows I-Choose at work. With this architecture, consumers will be able to trace a particular product back through the supply chain. When a consumer wants to find information about a product, all he/she needs to do is to scan the UPC (Universal Product Code) or QRC (Quick Response Code) with his/her mobile device to trace product attributes through the apps developed by consumer advocates such as GoodGuide or others supported by I-Choose. Different stakeholders in the supply chain will periodically share information about the product and processes supported by the first basic component of the I-Choose architecture—an open XML schema based on an OWL-compliant ontology. Using the I-Choose APIs (our second component), consumer advocates will be able to develop applications to trace and extract information from the supply chain in order to make it available to regular consumers. Each of these apps will respond to consumer groups represented by varying consumer advocate interests (Zhang et al., 2012).

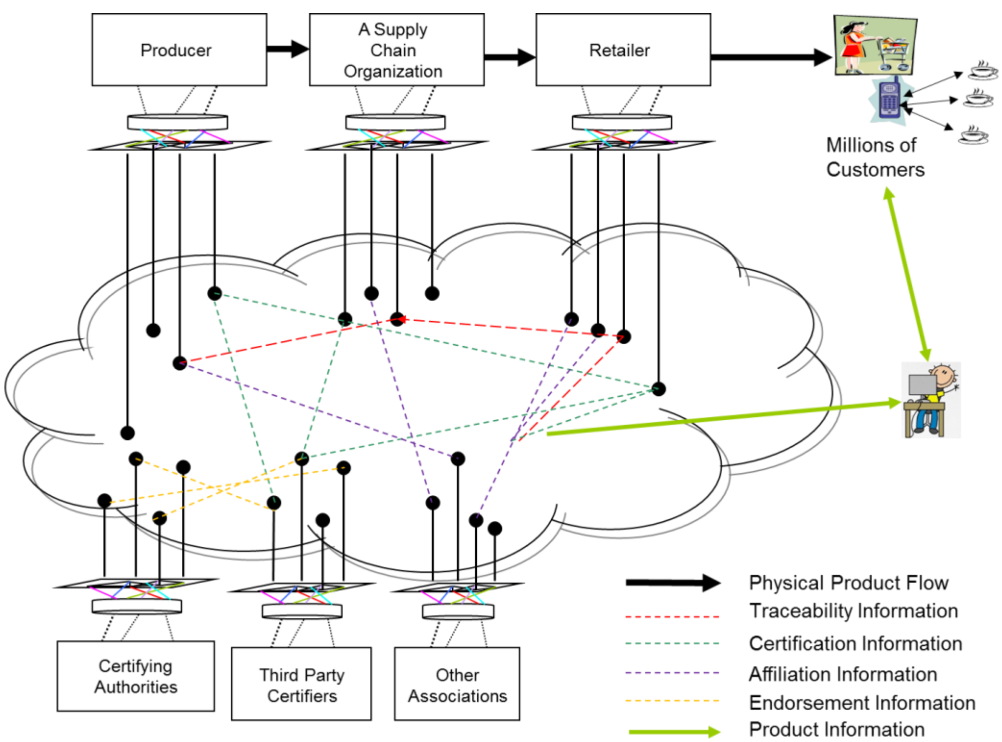


Figure 1. The I-Choose Architecture, Source: (Luna-Reyes, et al., 2011)

Some current systems such as GoodGuide in the United States (www.goodguide.com) or Barcoo in Europe (www.barcoo.com) have already been delivering information to consumers to help them in their decision making. However, an architecture such as I-Choose will provide systems such as GoodGuide and Barcoo with better, more complete and trusted information for consumers and other stakeholders in the supply chain (Luna-Reyes et al., 2011). To accomplish this goal, I-Choose system needs to be able to represent trusted certification and endorsement information. This task entails both presenting certification information for products at different stages, and displaying information that allows the consumer to understand the meaning of seals, and certification norms and standards. Figure 1 also illustrates how these types of certification and endorsing relationships could be handled by the I-Choose system. In the case of fair-trade coffee, along with extracting the origin of the product, an app using I-Choose could also provide the FLO-ID (Fair-trade ID), as well as information regarding the certification status of producer, exporter and importer. Furthermore, consumers might drill down to gain more detailed information they can trust regarding product sustainability (Zhang et al., 2012).

To develop the main I-Choose components described in the previous paragraph, we are involved in a three-year project that follows the principles of the design science paradigm (Hevner et al., 2004; Peffers et al., 2007). The design science paradigm involves the development of innovative artifacts to solve problems. By developing the artifact, researchers not only push forward human and organizational capabilities to deal with a specific problem, but also create new knowledge in that specific problem domain through the design process. The main steps in the design of I-Choose are included in Figure 2.

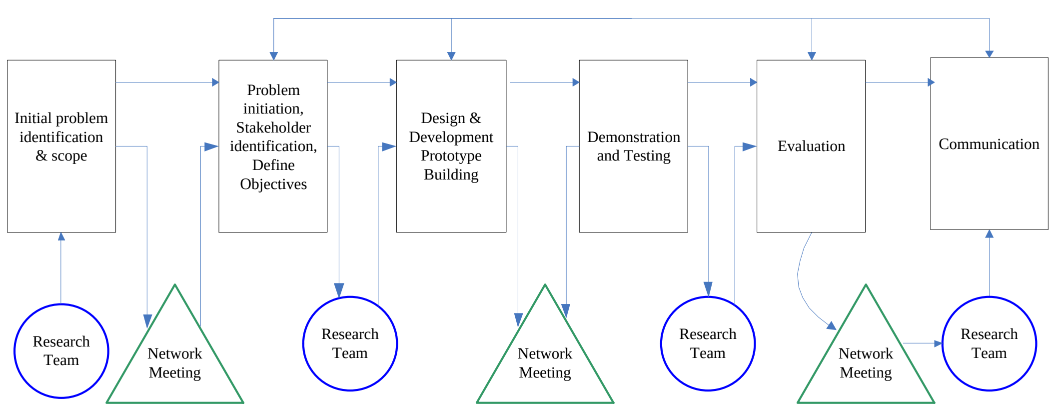


Figure 2. I-Choose Research Design, Source: (Zhang et al., 2012)

Literature Review

In this section of the paper we start with a statement about the value of system dynamics as a theory development method, and continue with a description of some of the complexities of conducting interdisciplinary research and how GMB can facilitate such work.

System Dynamics as a Theory Building Method

System dynamics is a modeling and simulation method that relies on a variety of qualitative and quantitative data sources in the formulation of dynamic theories (Richardson & Pugh, 1981; Sterman, 2000). The premise is that dynamic behaviors (performance over time) are closely linked to an underlying structure of feedback loops. Articulating and understanding linkages between behavior and structure contributes to our understanding of the world, and constitutes a way of creating theories about the word that we call Dynamic Hypotheses.

Similarly to other qualitative theory-building approaches (Eisenhardt, 2002; Glaser & Strauss, 1967; Walsham, 1995), "a formal model is constructed by inferring from data and theoretical statements some hypotheses about causal relationships that generate a particular pattern of behavior over time observed in the case. Model-building proceeds iteratively by representing the hypotheses in a mathematical form, simulating, comparing the model output with observed behaviors, and returning to the observations and theories to refine the hypotheses represented in the model by changing its structure. In this sense, a formal model is a non-textual, mathematical expression of a theory of the cause-and-effect relationships that systematically produce the patterns of behavior observed in the field" (L. Black, 2002, p. 120). The mathematical nature of the method forces the analyst to be "quite exact and specific in attempting to specify causal dynamics that accomplish a satisfactory translation between verbal theory and empirical observations" (Hanneman & Patrick, 1997, p. 457).

Dynamic simulation has been argued to constitute an effective way for building theories about social phenomena. For example, McCaffrey and his colleagues (1985) showed how the use of simulation could contribute to solve apparent contradicting conclusions between regression research and case studies in Public Administration by better understanding the dynamics of key performance variables used in both kinds of research. Sociologists such as Patrick (1995), argues that dynamic simulation helps to get a better understanding of verbal theories and any unexpected outcome obtained from them, with the potential to inform or improve the activities of both, theorists and empirical analyst. More recently and consistent to these views, Davis and his colleagues (2007) also argue for the use of simulation methods as a way to use a synthetic environment to incorporate our knowledge about a particular phenomenon to refine our understanding of the problems and better focus further empirical research efforts.

System dynamics has proven useful for studying complex feedback systems (Richardson, 1996). In the concrete case of theory-building efforts, system dynamics has been successfully used in sociology (Hanneman, 1987; Patrick, 1995), management and organizational theory (Black, Carlile, & Repenning, 2004; Rahmandad, 2008, 2012; Repenning, 2002), information systems (Abdel-Hamid & Madnick, 1990; Duhamel, Gutiérrez-Martínez, Picazo-Vela, & Luna-Reyes, 2012) and public administration (Ghaffarzadegan & Andersen, 2012; Luna-Reyes & Gil-Garcia, 2011).

Group Model Building and Interdisciplinary Research

Doing interdisciplinary research engaging an international group of researchers involves a set of challenges. Eglene and Dawes (2006) reflect that the main challenges in conducting a multinational research project include nonequivalence of key management terms, cultural stereotypes, assumptions of universality, and difficulties in comparative analysis. Managing a team of researchers in a distributed setting has been identified as another important challenge to conduct interdisciplinary international research (Teagarden et al., 1995). In fact, researchers have identified the lack of guidance and standard mechanisms for managing the processes used to conduct research, such as composing, maintaining, and renewing team, providing continued motivation, integrating perspectives, handling diverse level of commitment, or managing the work flow (O'Connor, Rice, Peters, & Veryzer, 2003). Studies on research collaboration often focus on the tasks and processes involved in developing and managing the content and relationships in collaborative research, and prescribes mechanism to handle the tasks in a more effective fashion (Eglene & Dawes, 2006; O'Connor et al., 2003; Teagarden et al., 1995).

Methods for Group Model Building (GMB) have been developed at the University at Albany to enable the integration of decision conferencing and system dynamics practices (Andersen & Richardson, 1997; Reagan-Cirincione, Schuman, Richardson, & Dorf, 1991; George P. Richardson & Andersen, 1995; Zagonel, Rohrbaugh, Richardson, & Andersen, 2004). These methods employ decision conferences as a particular kind of group decision support activity in which groups create and refine system dynamics models. Instead of the computer-mediated collaboration typical of group decision support systems, however, these GMB methods employ face-to-face meetings in which "verbal and nonverbal communication takes a completely connected, 'each to all' pattern enhanced by the presence of a group facilitator" (Schuman & Rohrbaugh, 1991, p. 148). These meetings use a combination of group facilitation techniques linked to projected computer models in the room to support the model development, building on the larger body of literature in GMB (Ackermann, Andersen, Eden, & Richardson, 2010; Rouwette, Korzilius, Vennix, & Jacobs, 2011; Vennix, 1996).

GMB has been based on a series of structured divergent and convergent activities called scripts (Andersen & Richardson, 1997). These activities have the potential of facilitating collaborative planning, addressing some of the cultural and ideological barriers involved when working with diverse groups (Hovmand et al., 2012). Moreover, visual representations and other objects used in this facilitated conversations have been characterized as "boundary objects," which may also contribute to improve cross-boundary conversations when used properly (Black & Andersen, 2012). Because of these basic characteristics, we are convinced that System Dynamics GMB has the potential to contribute to some of the problems identified in the context of conducting interdisciplinary and international research like the one involved in I-Choose. GMB has been already used in the context of theory development in a successful way (Luna-Reyes et al., 2006; Luna-Reyes et al., 2004). In these previous experiences, the team involved in the GMB sessions included researchers involved in action research projects to understand the development of large-scale information systems to support collaboration in the public sector. The following section of the paper includes a description of our current work in developing a theory of public-private collaboration to build more transparent and sustainable supply chains.

Modeling Processes

In this section of the paper, we describe the processes involved in the development of a preliminary theory for governance and market penetration for the I-Choose system reported elsewhere in this proceedings (Ran et al., 2013). As described in previous sections, the modeling team included researchers involved in the I-Choose project who have been involved in the design and data collection processes. Overall, our research progressed through three methodological phases: (1) A large-scale concept elicitation meeting with stakeholders in the I-Choose supply chain, (2) A smaller-scale and more formal group model building project involving only team researchers who had been present at the larger stakeholder meetings, and (3) The creation of a simulation model. As in many other simulation projects, initial modeling attempts involved a larger model that later was reduced to a smaller, more parsimonious version.

Concept Elicitation with Stakeholders in the I-Choose Supply Chain.

One main component of the project has been to create a network of researchers and key stakeholders of the coffee supply chain to understand the main requirements of a system like I-Choose. A core group of researchers from this network has been meeting regularly in a combination of face-to-face and electronic meetings for the last two years. This core group organized a workshop with a wider representation of stakeholders in a two-day meeting in August 2011. The goals of the workshop were to understand which were the main stakeholders of a system like I-Choose, and what were the key issues to be considered in the development of the system (Zhang et al., 2012). The workshop involved a series of brainstorming and discussion sessions about main issues and stakeholders. Figure 3 shows one of the products of the meeting, in which participants identified and ordered key stakeholders according to their power and interest in I-Choose.

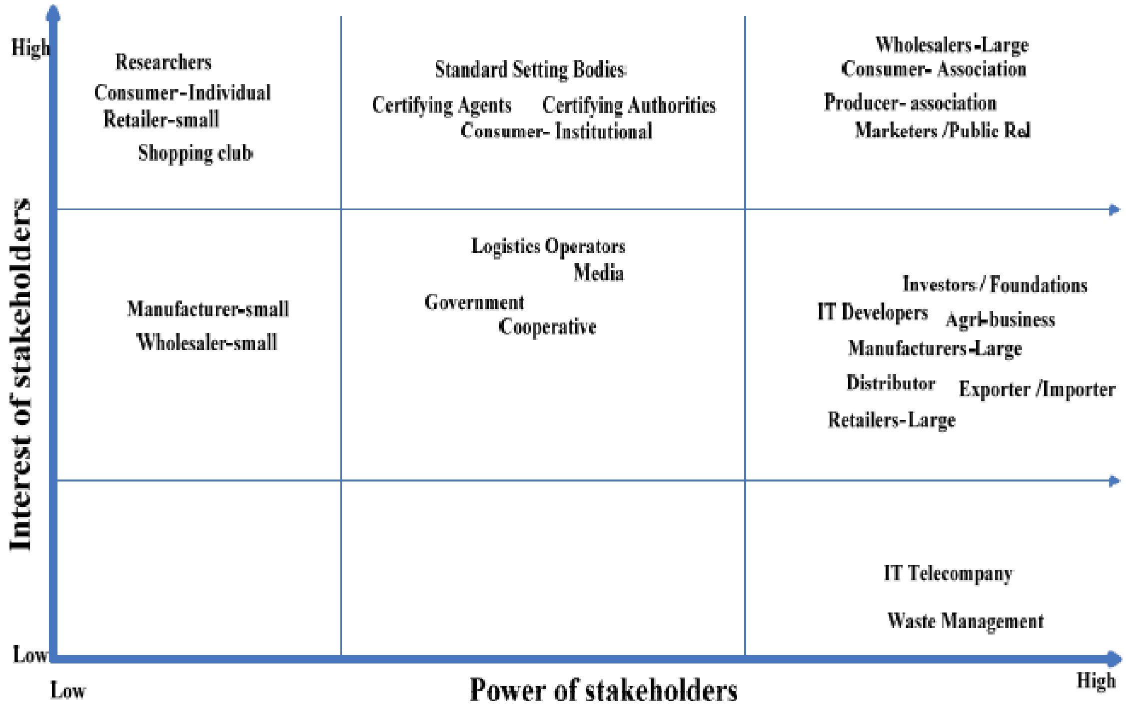


Figure 3. Stakeholder Map from the Workshop

The theory-building process reported in this paper has been informed by this workshop, and by a series of follow-up interviews with stakeholders that members of the core team have done during the last two years.

<u>Group model building exercise with research team as clients</u>

The second stage of our project has involved a series of formal and informal meetings to discuss and refine both model structure and behavior. Similar to many other GMB projects, we had a series of small scoping meetings with the small team of researchers working in the simulation model. As described in the literature, many different visual representations have been used during these meetings as boundary objects (Black & Andersen, 2012). These objects have helped this interdisciplinary team to communicate and work together sharing meanings and ideas. Figure 4 below shows what we understand as the root documentation of this project. The drawing represents I-Choose as an umbrella concept involving many components: supply chain participants joining an initiative, sharing data through a structure called the data commons, and building a set of APIs to make it possible for developers to create applications for consumers to use through mobile devices. Governance was considered in this preliminary drawing as a component that builds trust in the system.

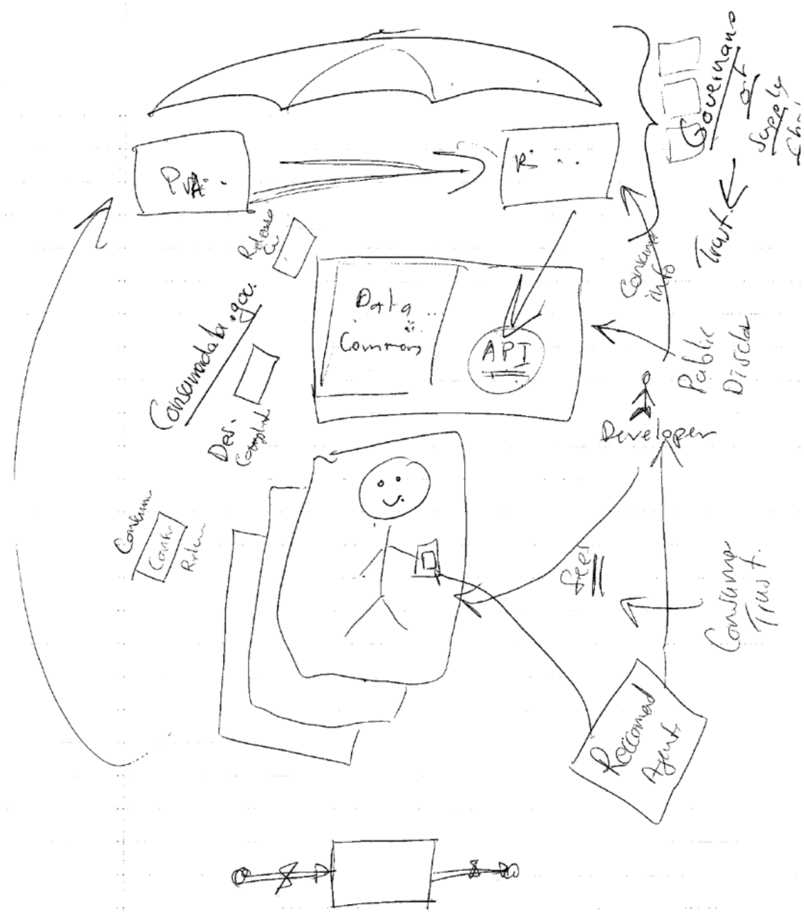


Figure 4. Preliminary Concept Drawing for the I-Choose Simulation

Following these series of scoping meetings, we conducted a group model building exercise where members of the research team served as the clients participating in the group modeling project. The purpose of this stage was to create a dynamic theory of the growth of a market for “Green” product identification systems such as I-Choose. Each participant was asked to identify key variables in the I-Choose socio-technical system and draw possible variable behaviors. Model variables were then selected based on participant votes and grouped into different clusters, these clusters of variables and behaviors over time were used to build a sector view of the I-Choose system conceptual model. Figure 5 shows a picture of the clusters of variables and behaviors over time created during the meeting. The center of the figure includes the sector view created from the clusters.

Figure 5. Model Variables and a Preliminary Sector View from the GMB session

Based on selected key model variables, participants were asked to identify stocks and flows in the system, and add causal relationships among these variables. The final product of this exercise is a preliminary conceptual model of the I-Choose socio-technical system (see Figure 6).

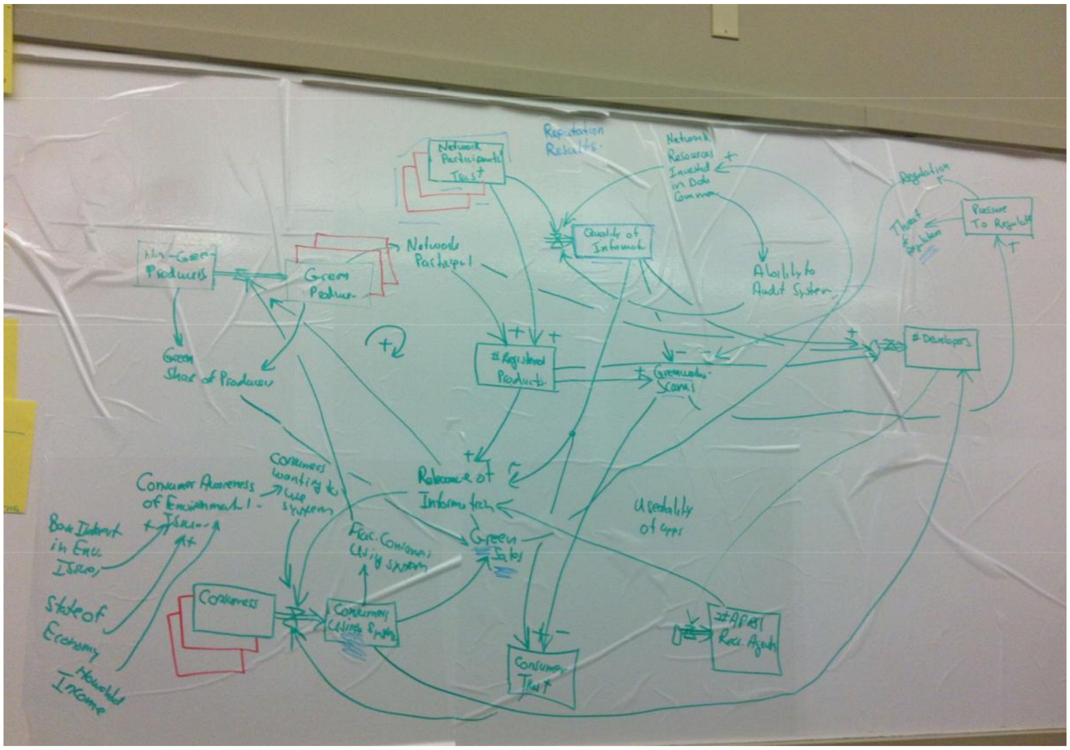
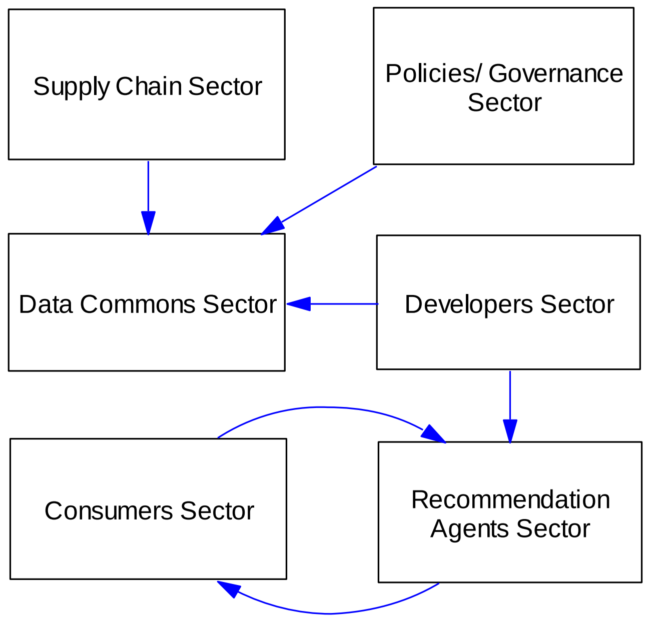


Figure 6. A Preliminary Conceptual Model from the GMB session

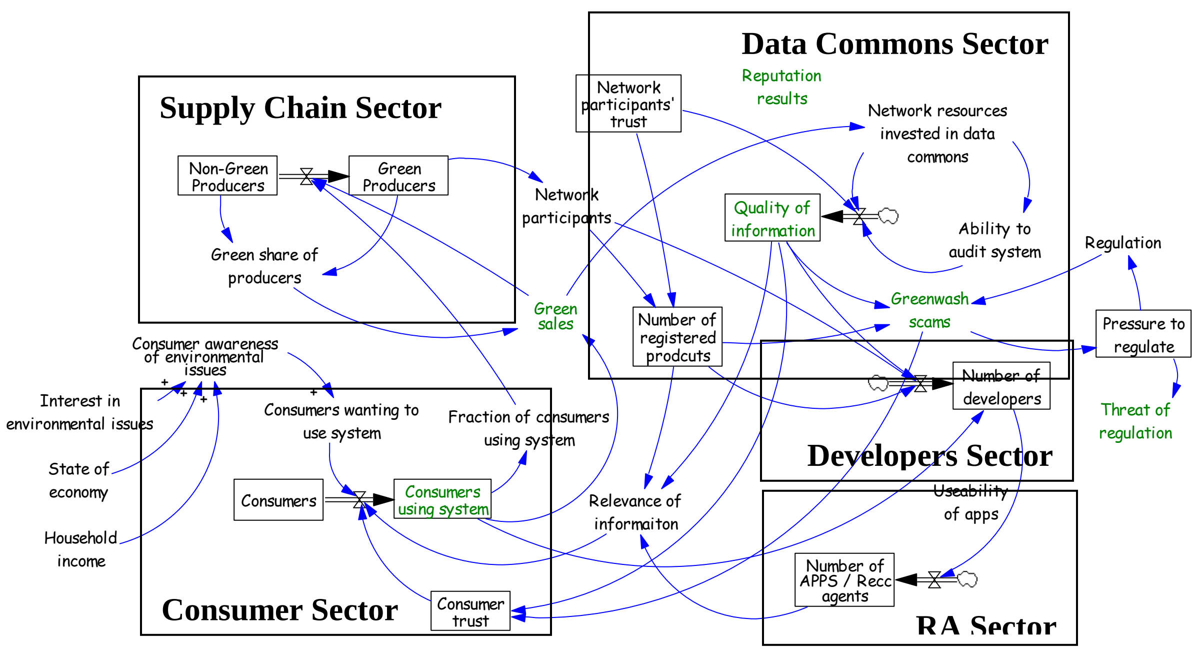
Figure 7 shows a clean version of some components of these two pictures. Figure 7(a) has a clean version of the sector view in the center of Figure 5. The initial sector view considers also main causal relationships among these sectors. These main sectors were also reflected in the preliminary map from Figure 6, and Figure 7(b) shows a Vensim version of the picture in the board, including also the main areas showing main sectors in the model.

After eliciting the initial conceptual model –and recognizing the importance of the concept of governance—the group started a conversation around the concept, looking for important variables and concepts that could help to build an operational view of the concept. The group agreed on four important assumptions related to governance:

- Completeness: data should be complete and high quality
- Openness: data should be accessible and processes transparent
- Relevance: data should be relevant to the needs of consumers
- Reliability: data should be accurate and the system reliable



(a)



(b)

Figure 7. Model Sectors

Model Formulation and Analysis

With the products from the group model building exercise, we formalized the theory using mathematical formulas in Vensim. This process involved some additional thinking to make the conceptual thought operational, yielding a first running simulation model. We refined the preliminary conceptual model, identified key causal loops, and drew a system map, which provided guidance through the rest of the model building process. Figure 8 shows one of these maps, with a more detailed and operational form of the Information Commons. As it is possible to see in the figure, some of the basic assumptions of governance were introduced into the conceptualization. These more operational conceptual models were refined and improved during a couple of scoping meetings.

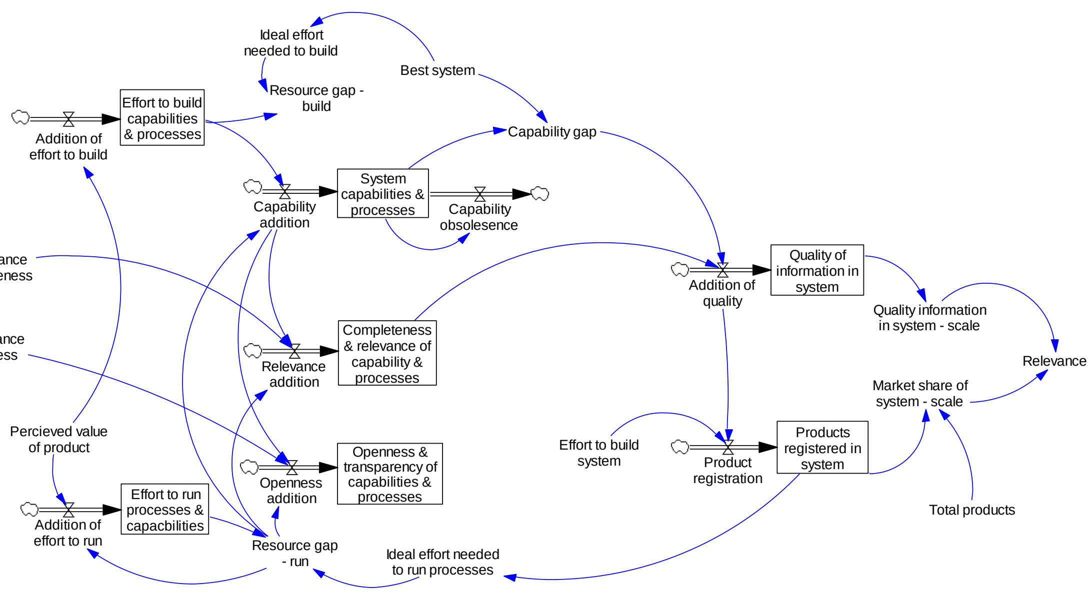


Figure 8. System Map: Sector I – Information Commons

While a running simulation model did emerge quickly from these sketches, its dynamics proved to be too complex or elusive for us to readily understand what was going on in the model. A persistent problem with these early attempts at simulating market growth and expansion was that the positive loops that we knew would dominate market growth seemed to be a too strong trap before the initial take-off. We initially diagnosed this failure to take off as related to formulation problems in the Information Commons as shown in Figure 8. These initial formulations had failed to reveal what resources would be used to actually construct "System Capabilities and Processes".

Tinkering with formulations for where the needed resources to build capability would come from led us to "back into" an assumed business model stating that producers (who would benefit financially from the operation of such a system) would supply the resources to construct system capability. Producer adoption was conceptualized to be the result of tracking the benefits and costs of the system, but in order to get serious about how such adoption could yield a resource base, we needed to expand those equations in the model.

And so step-by-step the detail complexity of the proposed simulation model grew. But still the reformulated simulation seemed to be unwilling to create a self-sustaining take-off. We had modeled consumer adoption as a more or less standard Word-of-Mouth innovation adoption with an initial “boost” from marketing. We discovered that a large enough marketing budget could force a consumer “take-off”, but without some large source of external resources, the model did not easily kick into a self-sustaining market growth. We decided to pay attention to the general admonition that “small models are beautiful models” (Ghaffarzadegan, Lyneis, & Richardson, 2011) and drop back and formulate a smaller reduced form model to get a better handle on overall model dynamics. The model in its current stage is being reported elsewhere in these proceedings (Ran et al., 2013).

Discussion and Final Remarks

In this paper we have presented our work in using system dynamics as a method to build theories and GMB to help interdisciplinary groups of researchers in theory building processes.

Our project touches on a core aspect of GMB, the tension inherent in simultaneously trying to achieve interdisciplinary consensus while making the model as parsimonious as possible in order to increase its generalizability and explanatory power. In earlier stages of the process, the group realized that governance was an important element, but the concept remained very much a ‘black box’, largely exogenous to the other aspects of the model. Governance is a broad concept used in many disciplines in context-specific ways, and so determining what is ‘good’ or ‘high quality’ governance in a way that satisfied all of the team members proved difficult. By finally breaking the concept of ‘governance’ down into four smaller, more quantifiable assumptions, we found we were able to increase buy-in and trust in our model among the disciplines engaged in our GMB process. Our assumptions of completeness, openness, relevance, and reliability represent generalizable governance principles that are applicable to many policy contexts in which the desired goal is to incentivize certain behavior via information disclosure.

However, the cost of introducing these elements into the model was greater complexity, and interpretation became subsequently more difficult. As such, our model proved to be a useful challenge to the validity of relationships that are frequently assumed by studies of governance, and government policy itself, to be true. From this perspective, we anticipate that there is much to be gained in using models like ours to unpack the assumptions inherent in the many and frequent reports and articles which call for ‘good governance’ in the context of digital information. We believe that our GMB process has contributed to our wider project in these important ways, and will continue on the refinement of more specific recommendations for other groups of researchers in the ways of effectively implementing it.

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