Trust and Collaboration in Interagency Information Technology Projects.[1]

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Abstract

This paper presents a model providing a feedback structure that clarifies the nature of the reinforcing processes involved in the development of trust through collaborating in a project. The feedback structure is grounded in data from a project where a prototype system was built, and it is consistent with the literature on trust, collaboration and diffusion of innovation. Four feedback processes are identified at the core of the development of trust and collaboration, two of them reinforcing in nature, and two of them counterbalancing in nature. Experiments with the model suggest that the initiation of a collaborative project with a new partner has the potential to have a slow start because of the lack of knowledge about the other parties. The initiation of the collaboration could be accelerated by shaping expectations of benefits of the project or by reducing the perception of risk associated with the project.

Introduction

The purpose of this paper is to describe a feedback-based collaboration theory. The paper extends previous theory development about trust and knowledge dynamics (Luna-Reyes *et al.* 2004), further exploring behaviors of the model of trust described previously in the literature, as well as its implications to the management of collaborations in the context of information technology innovations in the public sector.

It is common to find in the collaboration literature textual descriptions describing the positive loop in Figure 1. The loop describes how a group's willingness to collaborate depends on how much they trust on each other. Then, collaboration leads to work done, and one of the results of getting results is the development or confirmation of trust on the group. The present paper extends and explores these relations between trust and the engagement of participants in doing work in a project.

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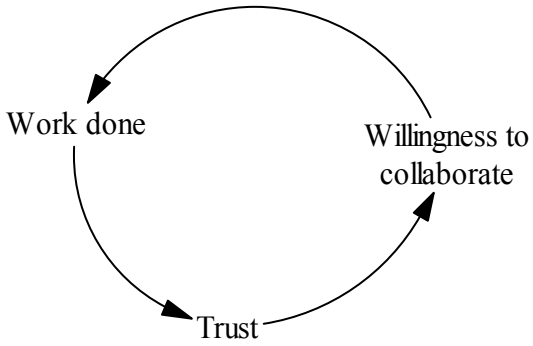

Figure 1. Reinforcing process describing relationships between trust and collaboration.

Specifically, the model presented in this paper describes the efforts of the team from the Bureau of Housing Services and the Center for Technology in Government approaching a group of homeless service providers through an existing network[2] of homeless service providers represented by an Ad hoc Technology Committee. Through a series of general presentations and directed individual conversations, the BHS/CTG team developed the necessary trust for some providers to share their data to build the HIMS prototype, and work in the development of a prototype definition of services and a prototype evaluation model of homeless services. Although BHS had the authority to ask for the providers' data and bring them into the project, they choose not to exercise such authority and instead listened to the needs and concerns of the provider group to create a long-term collaborative relationship with them. BHS's intention to develop this kind of collaboration is well reflected in the initial address of the BHS team leader at one of the workshops with the provider group:

> Our objective – we needed to develop a uniform database to provide management with the information needed to track homelessness and to provide the data necessary to more effectively manage the program. [..] As part of that process I'm being educated by CTG –who said "that's your goal. What about the people you're working with?" And I said, oh, they probably have data needs and information needs. Each has an internal system. I can access things you can't and I know you have data that I don't. So how do we share that information? How do we use technology as a resource to give us information to make decisions at all levels? That's really what our objective is. That's all it is. That's where it came from. [..] All of our direction is not to make additional work for you. Eh, maybe a little. But, it's more like, hey what do you got? Can I borrow it? I'll give it back to you in 20 minutes, and what I want to do is enhance it with stuff that you can't get. Information from other agencies, whether it's client related or at the

[2] The use of the word *network* does not link to the literature in social network analysis. Aggregated models—such as the model described in this paper—include assumptions that are linked to the concept of "network structure" such as "network density". However, the emphasis of this paper is in a different kind of "structure", i.e. the feedback structure of the process instead of the detailed structure of actors (nodes) and relationships (links) that is used in social network analysis.

aggregate decision-based related. We can do what we can do, depending on the confidentiality rules that we have in place out there to try and give you.

The paper is structured in five different but interrelated sections. The first of them includes a brief description of the data used to build the model, followed by literature relevant to the relationships between trust and collaboration, as well as literature relevant to the diffusion of innovation processes. The next section will describe the model structure, which is consistent with the HIMS data and the literature. The fourth section of the paper includes some simulation experiments associated with the feedback processes embedded in the model. Finally, I will finish the paper with a brief summary and some implications of the simulation experiments.

The HIMS Project

This case study follows a project designed to develop a new management information system to be shared between the New York State Bureau of Housing Services (BHS) and state-supervised homeless shelter providers. The system, referred to as the Homeless Information Management System, or HIMS, was intended to support management and evaluation of homeless client service programs. Funding from federal, state, and local government sources for programs for the homeless in New York State totals approximately $350 million per year, $130 million of which is allocated to support services to clients.

The project setting is a mixed multi-government and private sector, interorganizational one. It consists of state, county, and city regulatory agencies and the nonprofit and local government service providers that receive financial support from the State. The State exercises supervisory responsibility over the shelter providers through BHS, which writes regulations that govern the physical, financial, and program requirements for shelters, certifies shelter programs according to these requirements, and conducts periodic inspections. 80 percent of the New York State homeless population resides in New York City, Westchester County, and Suffolk County. The New York City Department of Homeless Services (DHS) shares this regulatory responsibility for those providers that also receive City funding. Most shelter service providers are nonprofit organizations. They range in size from single facility operations that serve a few individuals or families at a time to multi-facility programs of large organizations like the American Red Cross. Outside New York City, the Westchester, Nassau, and Suffolk County social services agencies have similar roles vis-à-vis shelters and service programs.

Project activities were facilitated by the Center for Technology in Government (CTG). CTG receives funding from New York State to assist public agencies in information technology innovation projects. In this project CTG's role was to support and facilitate the collaboration among the participants, and to provide expertise and a development environment for the HIMS prototype, which was a central part of the project. Doing so focused attention on the issues of combining data from multiple existing case management and financial systems. CTG used group facilitation and decision-making support techniques to further support the progress of the project. CTG staff was also engaged in case study research activities in parallel with the project facilitation. These

included direct observation, interviews with participants, and review of project documents and other artifacts.

The collaborative nature of the project activities required participants from the state agency responsible for shelter oversight to work closely with managers from a wide range of homeless shelters in New York City, Westchester, and Suffolk counties. Over a 2-plus-year period, the project participants were able to achieve the necessary collaboration and share highly detailed and complex operational knowledge. The result was the design and development of a successful prototype shared information system.

The participants overcame several significant problems and barriers to collaboration. Implementing the HIMS had substantial threat potential for the shelter providers. The system could provide oversight agencies with enhanced ability to control or even eliminate programs or shelter providers. Providers may also be in competition with each other for funding or clients, so sharing information could place them at a competitive disadvantage. Providers had to develop substantial trust in the oversight agencies and their colleagues to commit to building the proposed system and providing the necessary data. The model presented here represents the dynamics of how this collaboration and trust developed.

The need for trust extended to the technical and design issues in prototype development. Shelter providers do not have standard computing platforms, data definitions, or business practices. Designing a shared information system required the providers to share operational details about each other's business processes and to agree data definitions that were useful and valid across the provider population. Achieving this agreement often involved complex technical and organizational negotiations, knowledge sharing, and collaboration. Observing these processes over the course of the project provided the evidence of feedback and learning that is the basis for the dynamics in a formal model.

Relevant Literature

Trust and Collaboration

The use of technology as a facilitator for collaborative relations and information sharing has promoted the creation of new forms of organization, such as networks (Bensaou and Venkatraman 1996; Dawes 1996; Lewicki and Bunker 1996; Hart and Saunders 1997; Espinosa *et al.* 2003). Researchers have considered trust as an alternative governance mechanism (alternative to price and authority) in most collaborative relations (Zucker 1986; Good 1988; Creed and Miles 1996; Powell 1996; Tyler and Kramer 1996; Kumar *et al.* 1998; Zaheer *et al.* 1998), but especially important in network environments (Bensaou and Venkatraman 1996; Creed and Miles 1996; Lewicki and Bunker 1996; Sheppard and Tuchinsky 1996; Heimer 2001). Some researchers have also discussed the importance and problems associated with the development of trust in interorganizational collaborations in the public sector (Bardach 1998), as well as in cases such as HIMS where the government collaborates with nonprofits to offer a service to the public (Schwartz 2001).

From the point of view of researchers like Hart and Saunders (1997), the use of coercion in partnerships limits the ability of future and more comprehensive ways to collaborate. However, authority or power asymmetries between partners like the ones existent in the HIMS case, lead to the temptation for the more powerful partner to exercise her authority during the collaborative process (Kumar 1996). The BHS team faced this temptation, but following their own conviction and the advice from CTG staff, BHS decided to pay attention to the providers' initial concerns about the confidentiality issues brought into the table.

If we understand collaboration as the process in which two or more parties created a shared vision of a problem or solution on the basis of their particular perceptions of the problem (Gray 1989; Mattessich *et al.* 2001), trust become an important element not only to bring the different parties into a conversation, but also to facilitate the disclosure of the individual points of view to effectively transfer such individual views (Shapiro *et al.* 1992; Szulanski 2000; Levin *et al.* 2002a; Levin *et al.* 2002b; Levin *et al.* 2002c). As pointed out by Shapiro and his colleagues (1992), "[a] willingness to share knowledge about yourself depends on the existence of a deterrent to the other to take advantage of that knowledge. The coexistence of both types of trust allows parties to engage in full disclosure" (371).

Although trust is conceived as an important element to start the collaborative process (Zand 1972; Gray 1989; Bensaou and Venkatraman 1996; Mattessich *et al.* 2001), collaboration constitutes an opportunity to further develop the initial trust in a reinforcing process that constitutes a potential trap or a pattern of positive relationships (Larson 1992; Kramer *et al.* 1996; Rousseau *et al.* 1998; Hardin 2001). In a recent review of the literature on trust and collaboration, Vangen and Huxham (2003) stressed the importance of trust in a "continuous process of nurturing" the collaborative relationship through this reinforcing process (see Figure 2). In their reflection upon this process, they consider as two key elements to initiate the trust-building cycle "the ability to form expectations about the future outcomes of the collaboration and the willingness to take a risk" (Vangen and Huxham 2003). Moreover, on the basis of their experience facilitating collaborative processes they recommend to practitioners interested in building and maintaining higher levels of trust "to pay relentless attention to trust-building activities" (20).

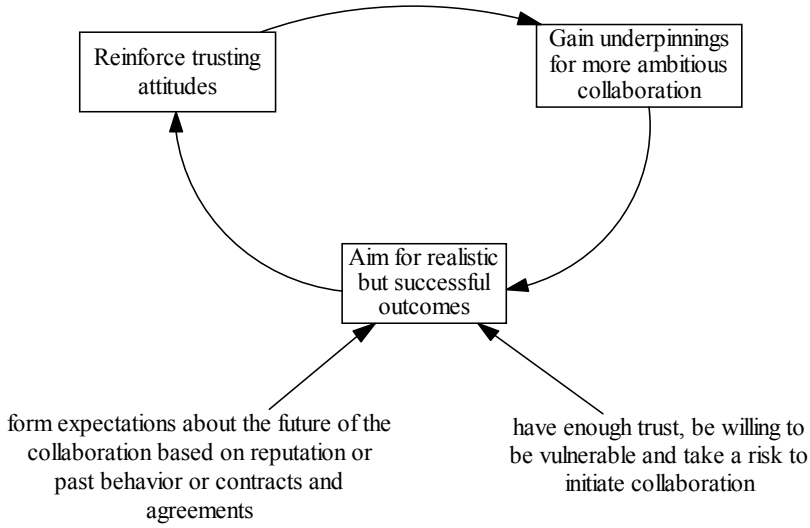

Figure 2. The trust-building cycle. Reproduced from (Vangen and Huxham 2003)

Innovation Diffusion

The collaborative relationship present in the HIMS project belongs to a particular case in which an organization such as BHS recognized the importance of the visions and inputs of a large group of stakeholders. Although most of the stakeholders of HIMS were homeless service providers, other governmental organizations such as the county level departments of social services were also invited to participate. As pointed out earlier in the paper, the BHS/CTG approach consisted of inviting of stakeholders through the use of public forums and personal directed conversations a conversation to further develop the vision of the HIMS project.

Modeling the process of spreading an idea has been of interest to social scientists for many years. Depending on the area of study, the process is known alternatively as epidemic, innovation diffusion, market penetration or technological substitution (Homer 1987). A number of efforts to capture the features of the process consider diffusion as a contagion process characterized by influence and imitation (Strang and Tuma 1993; Abrahamson and Rosenkopf 1997).

Many models of diffusion processes rely on an early contribution (1906) from the area of epidemics known as the “mass action principle” (Morris 1994). The principle defines the dynamics of the epidemic process as the product of three factors, the probability that one person in a contact is susceptible, the probability that one person in the contact is infected, and the number of contacts made by an individual in a time period. This basic formulation relies on the principle of homogeneous mixing. That is to say, every member of the population has the same probability of getting the disease. Additionally, the formulation assumes the need of having at least one person infected to start the process, and the process ends only when all the population becomes infected.

Sociologists and administrators interested in diffusion processes have elaborated this initial formulation to allow some external influence (such as mass media) to start the spreading process (Bass 1969; Strang and Tuma 1993; Abrahamson and Rosenkopf 1997). These "mixed-influence" models (Homer 1987) consider the diffusion process as a "two-step flow" (Abrahamson and Rosenkopf 1997). In the first step, external actors make potential adopters or participants aware of the innovation. Internal forces that follow the basic "mass action principle" persuade potential adopters to get involved in the innovation process or to acquire the new product or service.

The basic "mixed influence" model was made popular in the management literature by Bass (1969), and in the sociology literature by Bartholomew (Strang and Tuma 1993), and consists in a single differential equation that represents the rate of adoption as a fraction of the non-adopters (see equation 1),

$$x_t = a\,(N-X_t) + b\,X_t\,(N-X_t) \qquad (1)$$

where x_t represents the rate of diffusion at time t, a is the parameter associated with the influence of external forces, and b is the parameter associated with the internal process of diffusion through influence or imitation. N represents the total number of people in the population where the diffusion process takes place, and X_t is the number of people who already are "infected," have bought the new product or participate in the innovation process.

The model is interesting to researchers because it constitutes a simple structure consistent with empirical observations of diffusion processes (producing a generalized logistic curve) (Homer 1987), and the theoretical perspectives in diffusion of the innovation (Rogers 1995; Brown and Venkatesh 2003). Although the model solves the problem of the need of an initial innovator to start the process, it still relies on the assumption of homogeneous mixing and in the assumption that every member in the population will eventually adopt.

As pointed out by Homer (1987), "most current diffusion models may be seen as extensions or refinements of the classic 'mixed-influence' model" (197). Extensions in the business literature includes the addition of a model of the decisions of an organization and their influence in the two basic parameters for a monopolistic market (Milling 2001), or for competitive environments (Maier 1998). Other models in the business area add some delays in the perception of the utility of the innovation and its influence on the decision to adopt a new technology (Homer 1987).

On the other hand, researchers interested in epidemics have extended the basic two-population formulation to represent different stages in the evolution and recovery of a disease (Dangerfield *et al.* 2001).

Other approaches in the study of the diffusion of the innovation, mainly from sociology, are concerned about the assumption of the homogeneous mixing that exists in the diffusion models described in the previous paragraphs, and in the nature of the processes of influence or imitation that trigger the diffusion process.

For example, some sociologists have focused their effort in the development of statistical models to identify the impact of characteristics of the social structure (such as similar profiles of relations, power or centrality) in the decision to adopt and the diffusion process (Strang and Tuma 1993; Marsden and Friedkin 1994; Teo *et al.* 2003). These studies conclude that the social structure matters, and thus the assumption of homogeneous mixing does not hold for most diffusion processes. Moreover, the social position and visibility of the initial adopters impact the final number of adopters. On the basis of these reflections and following a simulation approach, some researchers have developed models relaxing the homogeneous mixing assumption (Morris 1994; Abrahamson and Rosenkopf 1997).

Finally, an important concern related to the spreading of an innovation consists in the uncertainty associated with the way in which the innovation will change the social structure and the interaction patterns (Bensaou and Venkatraman 1996). This concern has not been addressed by any of the models presented above.

The model presented in the next section constitutes an extension of the mixed-effects model, including the influence of trust in the decision to join an innovation project: the HIMS project. The model considers some elements of the social structure network that the BHS/CTG team used to approach the provider group.

Model Structure

In the present section I will describe the main feedback processes involved in the process of bringing the main stakeholders into the HIMS work and the way in which this diffusion process integrates to the trust model. In doing so, I will describe the changes done to the trust model to consider the inclusion of people into the model, providers, CTG staff, and BHS staff. The section will finish with an overall picture of the collaboration and trust development depicted as a series of feedback processes.

Bringing Stakeholders into to the HIMS project

The model developed on the basis of the HIMS project assumes the presence of three main actors: a group of people from the Bureau of Housing Services, a group of people from the Center for Technology in Government, and a group of providers. For simplicity, the group of providers includes not only the nonprofits providing services to the homeless population in New York State, but also some other agencies involved in the regulation or provision of those services.

The provider group coming into the project is modeled as an extension of the mixed influence model as the one proposed by Bass (1969). The differential equation (1) can be graphically represented as in Figure 3. The internal forces of the diffusion process follows the mass action principle, and is a fraction of the Providers not involved in the HIMS project proportional to the probability to contact an engaged provider, the probability of talking about the HIMS project, and the average contacts with other providers, per provider per month (feedback loops R1 and B1). This internal process relies on the existence of a previous network represented by the Ad hoc Technology

Committee. According to Powers (2001) informants, this was a dense network in which each member had around 100 contacts with other members per month.

The external influences in the diffusion process are represented in Figure 3 as the counterbalancing process B2. This external influence consisted of a series of public presentations and individual conversations conducted by the BHS/CTG team from July 1998 to March 1999. The external influence is formulated as a function of the capacity of contacting people by the team (which in turn is a function of the team effort in contacting providers), and the providers not yet involved in the HIMS project (2).

People Contacted =
MIN(Capacity to contact people, Max. number of providers contacted by month)[3] (2)

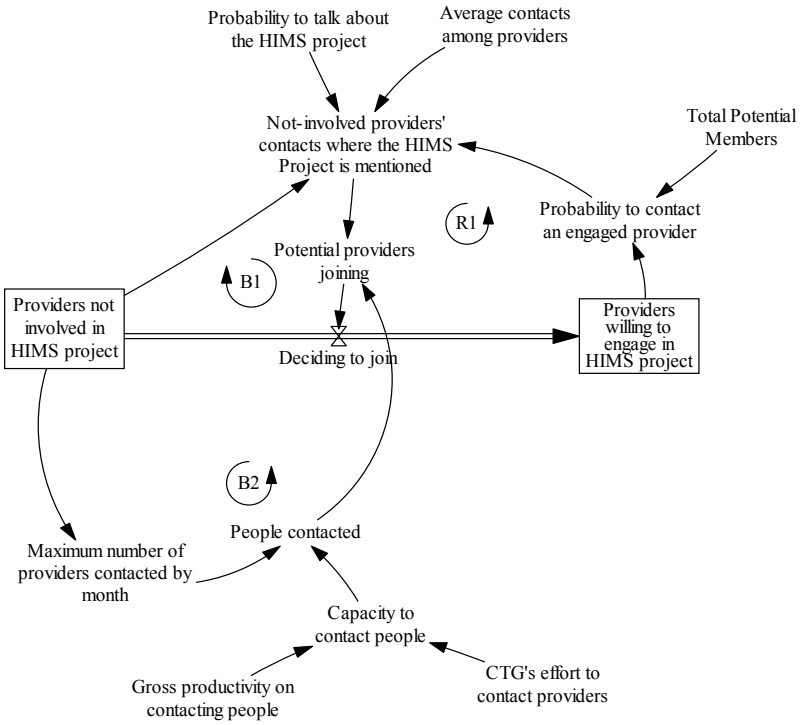

Figure 3. The mixed influence model in the HIMS conceptualization

The basic assumptions from the mixed influence diffusion model are relaxed or extended in two different ways. The first of them is related to the inclusion of the concept of trust into the model (Figure 4). On the one hand, the number of potential providers joining consists of the product of the mass action principle and an effect of the trust of the providers in the project. This effect is a linear function of the providers' trust in BHS normalized with a moderate value of trust (0.5 is used in the model; the trust scale can

[3] The actual formulation in the model is a fuzzy MIN function Sterman JD. 2000. *Business dynamics : Systems thinking and modeling for a complex world*. Irwin/McGraw-Hill: Boston.

take values from 0 to 1). Additionally, the formulation in the model gives the providers willing to engage in the project the capacity to leave, or even deciding not to join as a result of the internal influences in the diffusion process (represented by the outflows *deciding not to join*, and *leaving project*. Leaving the project is a fraction of the providers willing to engage the project that decide to leave after a period of time in which they consider their participation in the project. The fraction is a function of the providers distrust (lack of trust) in BHS. The people deciding not to join is modeled as the product of the mass action principle and the same function of distrust.

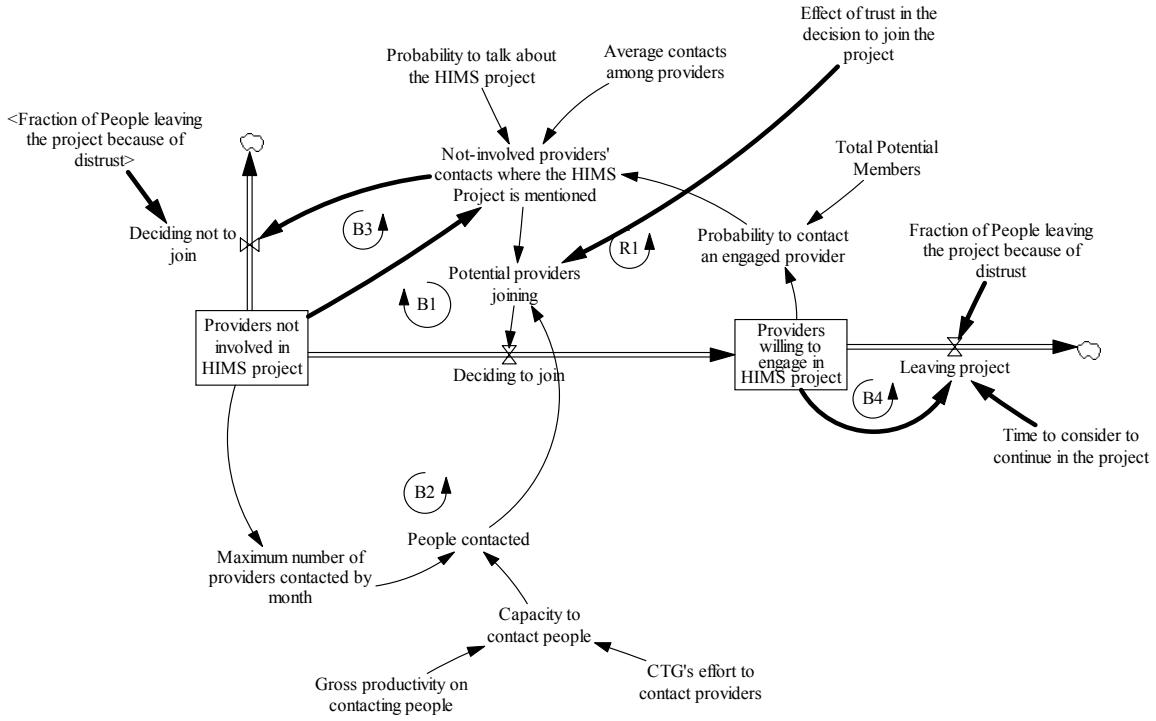

Figure 4. Trust and the mixed effects diffusion model.

The second extension to the basic diffusion model considers the structure of the network, and the results of the stakeholder analysis conducted by the BHS team in previous stages in the project (Figure 5). As part of the BHS work in the UIG project the team went through a careful analysis of the main stakeholders to be included during the prototyping stage of HIMS. Furthermore, during their initial conversations with the providers in July 1998, the team learned about the existence of the Ad hoc Technology Committee and the network of providers represented by the committee. In this way, the model considers that the CTG/BHS team was looking to bring into the project a core group of providers that constituted a critical mass to work in the project. Some of them would provide the data needed for the prototype, most of them would provide knowledge about the provision of services to the homeless, and some of them would provide legitimacy to the process.

Moreover, the decision of the Technology Committee core representatives to participate in the project, and the trust of the rest of the providers in this core group made some providers not to join the conversations because they felt represented in the project by this core group (Powers 2001). In this way, the basic formulation of the diffusion process

divides the potential providers joining into two flows, the ones joining the conversations, and those that opted not to join because they felt represented in the project by the core members of the Technology Committee. Both flows are functions of the number of potential providers joining, and the fraction of the critical mass (core group) willing to join the project. As the fraction of the critical mass approaches one, the effective fraction joining tends to zero, making the flow of people deciding to join also approach zero, and the flow of people opting not to join approach the number of potential providers joining (equations 3 and 4).

Deciding to join=
(Potential providers joining)(Effective fraction of providers joining) (3)

Opting not to join because they feel represented in the conversation=
(Potential providers joining)(1 - Effective fraction of providers joining) (4)

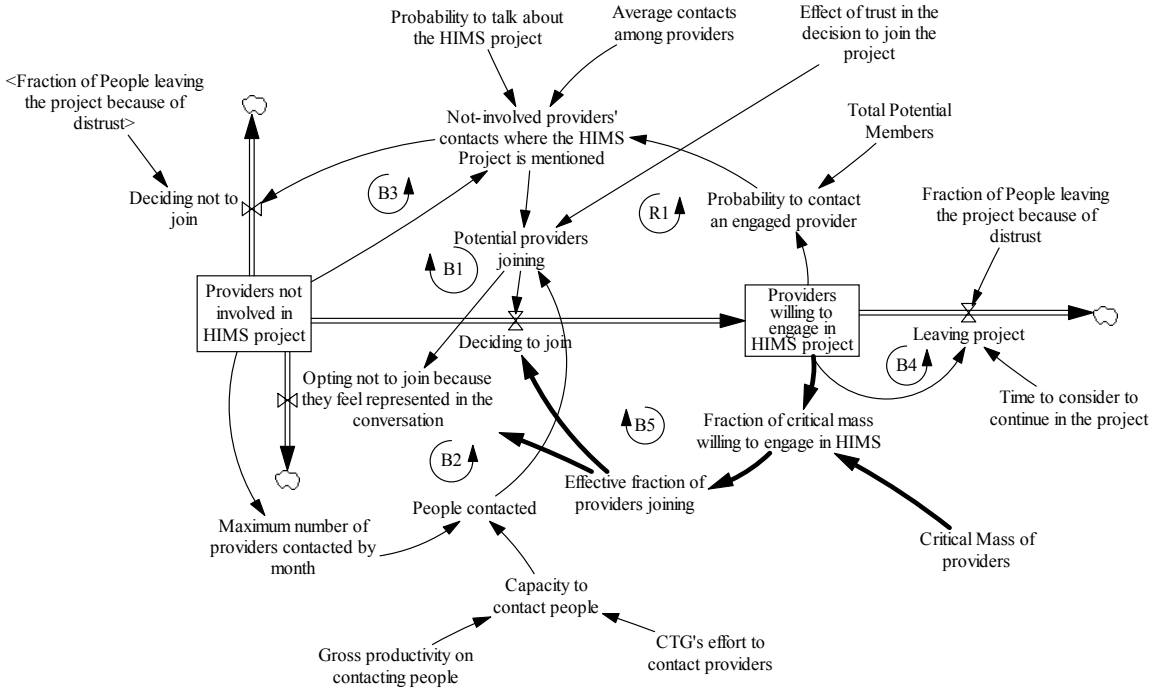

Figure 5. The diffusion model of providers in the HIMS project.

In the case of BHS and CTG teams, the model assumption is much simpler (Figure 6). In both cases, the actual involvement into the project is modeled as a smooth of a desired number of staff involved in the project. The time to move from the previous stage in the project takes into account the overlap between the activities of the UIG project (which concluded in November 1998), and the activities considered as part of the prototyping stage of the project (conversations with providers started in July 1998).

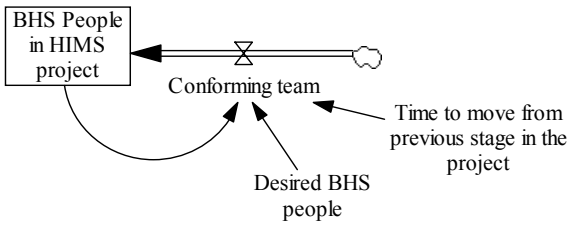

Figure 6. Conforming the BHS team.

The Conforming team rate has the following formulation:

$$\text{Conforming team} = \frac{\text{Desired BHS people} - \text{BHS people in HIMS project}}{\text{Time to move from previous stage in the project}} \quad (5)$$

Linking the Diffusion Process to the Trust Model

The diffusion process presented in the previous section was integrated with the trust model presented previously in the literature [Luna-Reyes, 2004 #537]. That is to say, the stocks of knowledge present in the trust model and their associated feedback loops are linked to the different groups of people that participated in the HIMS project. The group of providers becomes the trustor (the observer) from the trust model, and BHS is considered the trustee in the process.

Two important simplifications are present in the model. The first of them is that BHS trusts the provider group from the beginning of the project. In this way BHS involvement does not depend on its trust in the provider group. The assumption is based on my conversations with participants in the project. One of them commented when we were talking about the trust of BHS in the provider group, "If you need something that I have and you know that you have to engage with me in order to make whatever it is better, you have trust in me, you know you have to work with me." The second simplifying assumption is that CTG trusts the two other parties, and the two other parties trust CTG as a neutral facilitator of the process.

In the process of linking these two models, three main changes were done to the basic structure of the trust model. The first of them is related to the theory of knowledge present in the trust model. The second is related with the risk and desirability associated with the collaboration between the two parties, and the last one is related to the assumptions about the intensity of the interaction between both parties.

Trust is "learned and reinforced, hence a product of ongoing interaction and discussion" (Powell 1996), and the main accumulations of the trust model are still different kinds of knowledge accumulated during the interaction. However, these accumulations of

knowledge are now linked to the actors in the project (see, for example, Figure 7). The knowledge represented in the figure is measured in terms of requirements for the HIMS prototype.

As shown in Figure 7, actors in the HIMS project such as providers bring with them into the project knowledge accumulated from their previous experiences, and they take with them some of the accumulated experience when they decide to leave the project. The rate of providers' previous experience is a function of the number of providers joining per period of time and the knowledge about their information needs and concerns that each of them bring with herself (see equation 6).

Providers previous experience= (6)
Deciding to join*Knowledge about providers' information needs per provider participant

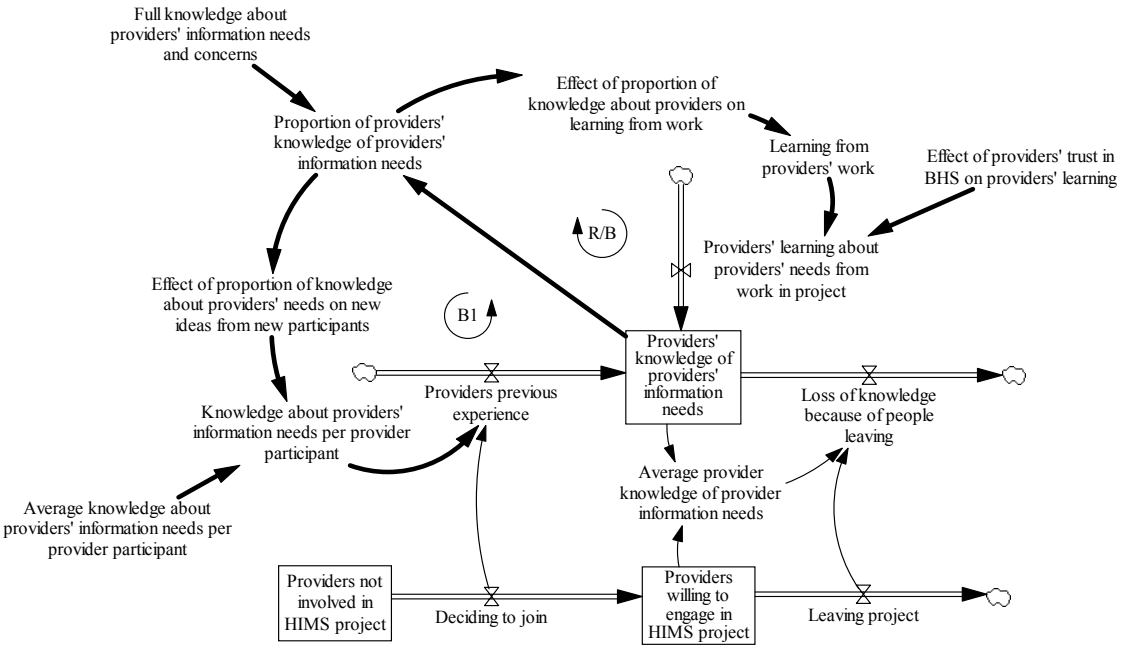

Figure 7. Providers' knowledge of their own information needs and concerns.

The conceptualization in the model assumes there exists a maximum level of knowledge from the provider group (i.e. a maximum level of requirements associated to the providers' work). In this way, the marginal contribution of knowledge that each additional provider participant brings into the project is subject to diminishing returns. This phenomenon is represented in the figure by the balancing process B1.

The loss of knowledge because of providers leaving the project, on the other hand, is calculated as the product of the number of providers leaving, and the average knowledge per provider participant (equation 7).

Loss of knowledge because of people leaving=
Leaving project*Average provider knowledge of provider information needs (7)

Finally, it is assumed that the provider group learns about its own information needs through its work in the project defining requirements. This learning preserves the same characteristics that the learning in the simple trust model (represented in the figure as the loop R/B). In the early stages of the learning process, acquired knowledge facilitates learning with increasing returns. In a second stage, as the group gets to know more and more about its information needs, the initial increasing returns from the previous knowledge change into decreasing returns up to a maximum point. In the final stage, as knowledge reaches a saturation point, the effect of the previous knowledge becomes negative, reducing their ability to learn gradually to zero. However, the learning rate is affected by the trust of the providers in BHS, given that lower levels of trust will limit the effectiveness of the communication process, and their ability to learn about themselves.

In order to make the representation of the model simpler, this structure will be represented in some other figures as a box of knowledge.

The second adjustment to the model is related to the project's risk and desirability. In the model presented in the literature both were parameters that remained constant along the simulation, and in the present model both have dynamic characteristics similar to the ones observed in the HIMS project.

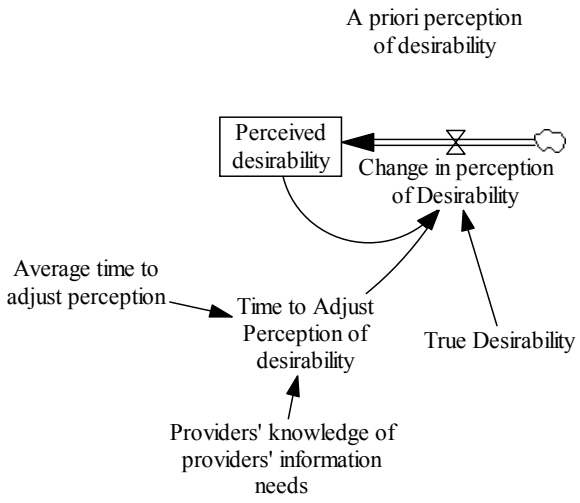

Figure 8. Providers' perception of project desirability

As shown in Figure 8, providers' perceived desirability of the HIMS project is modeled as a smooth of a true desirability intrinsic to the project. The formulation can be interpreted as a weighted average[4] of this true desirability and the initial value in the

[4] From the differences equation of the Perceived desirability, it is possible to obtain the following expression, in which the smooth formulation is represented as a weighted average. As the time to

stock, which is set equal to an a priori perception of desirability. As time goes by, the perception of the project's desirability approaches the true desirability value. The main factor in the weight of the averaging process is the Time to Adjust Perception of desirability, which is considered a function of certain average time and the providers' knowledge about their own needs and concerns. The assumption is that as knowledge increases, the time to perceive the true desirability decreases, speeding up the averaging process to make the perceived desirability approach the value of the true desirability of the project.

Providers in the HIMS project had a low a priori perception of desirability. During a meeting on January 1999, they actually commented that they were clear about the benefits of the project for BHS, but they also asked "What's in it for us?" However, as they got involved in the project, they learned about the potential benefits to them, as a tool to benchmark their services, and improve them through the identification of best practices.

It is possible to identify at least two different kinds of risks associated with the project. Early in the project, the provider group expressed the risk of disclosure of confidential information from case data. As they learned about the potential use of HIMS as a benchmarking tool, they also recognized the risk of using the same information in the funding process. In this way, the model assumes the existence of both kinds of risk in the project (Figure 9).

According to the case data, the perceived risk of disclosure of confidential information was one of the main concerns preventing the development of the prototype and the project itself. In this way, the assumption in the model is that providers have an a priori perception of such risk (very high in the model). However, the CTG/BHS team worked with the provider group to clarify the existence of the regulations to protect the confidentiality of the clients, but most important, to confirm the commitment of the State to protect the confidentiality rights of the providers' clients reflected in the letter of the commissioner of February 1999. In the model, the perception of the risk of disclosure is "drained" as a function of the effort of the BHS/CTG team in contacting providers to invite them to share their data and to join the project, and the knowledge of the team about the providers' needs and concerns (left side of Figure 9). In this way, as they learned about the providers' concern of the confidentiality of the case data, a fraction of their effort in contacting them had an effect on the reduction of the perception of this risk (through their work in clarifying the regulatory framework and the state's commitment to such framework).

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perceive τ increases, the weight to the previous perception of desirability is bigger, taking more time for the averaging process to approach the value of the True desirability. Given that the initial value of Perceived desirability is the A priori perception of desirability, the smooth formulation can be interpreted as a weighted average of both the a priori perception and the true desirability.

$$\text{Perceived desirability}_t = \left(1 - \frac{\Delta t}{\tau}\right)\text{Perceived desirability}_{t-1} + \left(\frac{\Delta t}{\tau}\right)\text{True desirability}$$

On the other hand, the perception of the risk of using HIMS for funding decisions was discovered during the development of the project. In the model, this discovering process is formulated in the same way that the perception of desirability of the project by the use of a smooth (lower right part of Figure 9). In this case, the a priori value starts low, reflecting the lack of awareness about this risk, and finishes at a higher level, reflecting the true value of this risk. The total perception of risk is formulated as in equation 8, assuming that the bigger of the two perceived risks will dominate the total perception of risk.

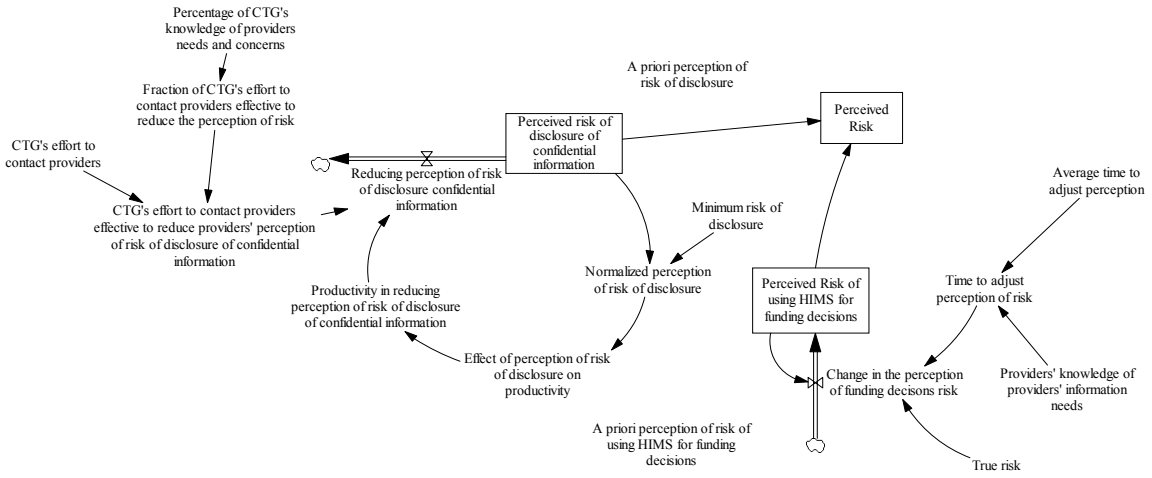


Figure 9. Providers perception of project risks.

Perceived Risk=
MAX(Perceived risk of disclosure of confidential information, Perceived Risk of using HIMS for funding decisions) (8)

The last adjustment to the trust model consisted of extending the assumptions about the intensity of the interaction to make them consistent to the HIMS case data. The assumption about the intensity of the interaction in the simple trust model is that the two actors interact in a regular basis with a constant frequency of interaction. However, in the HIMS project, and in similar project collaborations, the actors in the project does not collaborate in a regular basis, but they decide to participate or not in the project, as described in the diffusion process present in the case.

The intensity of the interaction between the providers and BHS comes from their actual effort on the project work. As it is shown in Figure 10, this effort is the product of the potential provider effort and the fraction of provider involvement in the project. The potential provider effort is the product of the number of providers willing to engage in the project and certain effort that each provider is willing to invest, measured in hours/month. On the other hand, the fraction of provider involvement is a function of the fraction of critical mass willing to engage, and the fraction of CTG's effort working with them. Making the actual fraction of effort a function of the fraction of the critical mass reflects

the fact that most of the work with the providers in the project was done in a series of workshops held from May to July 1999. In this way, only when the facilitator (CTG) considered that there was enough critical mass to have the workshops, they decided to organize them. Additionally, and as one of the members of the facilitator group expressed in one of the interviews, "Engagement of actors did not occur at any point without facilitator inputs." That is to say, the facilitator always initiated the collaborative process in this stage of the project, making the fraction of involvement from the provider group also a function of the involvement of the facilitator in the process.

Finally, the work with the providers in the project had a specific purpose associated with the elaboration of a prototype set of standard definitions of services, a prototype evaluation model, and an assessment of the initial HIMS prototype. In this way, as providers got engaged in the project, their effort was an important input to accomplish that part of the work in the project. When they finished that work, their level of engagement was reduced for this phase of the project (reflected in the balancing process labeled as B in the figure).

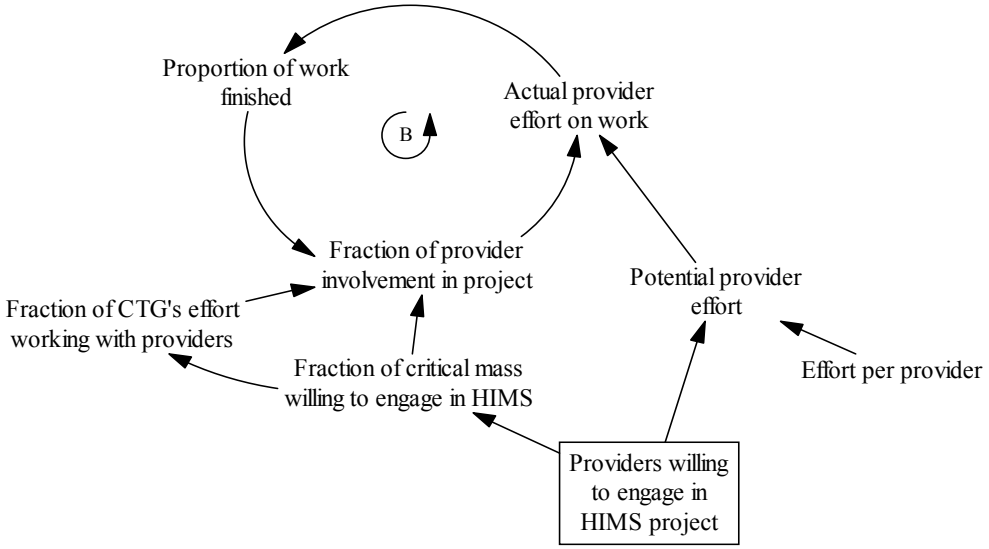


Figure 10. Feedback structure of the Intensity of the Interaction

Collaboration and Trust Development, an Overall Picture of the Model

Figure 11 constitutes a simplified, overall picture of the feedback processes represented in the model of the collaboration and trust development in the HIMS case. The core processes conceptualized in the collaboration literature as the simple loop in Figure 2 are highlighted in the picture with thicker lines (feedback loops labeled as R1, R2, B1, and B2). The reinforcing processes R1 and R2 are the main contributors to the concept of collaboration being an opportunity to trust and to further develop this initial trust. R1 is the reinforcing process associated with the calculative component of trust, and R2 is associated with the knowledge-based component of trust, which relies on the ability of the providers to assess BHS's trustworthiness.

However, these reinforcing processes can work either way, increasing the level of trust and promoting further collaboration, or limiting the opportunities to collaborate, and the development of trust in the interaction. The counterbalancing feedback processes B1 and B2 play an important role in the direction of the reinforcing processes. That is to say, if the collaboration process leads to the discovery of high levels of risk, or the accumulation of bad experiences in the interaction that contribute to the development of a perception of BHS as an untrustworthy party, the reinforcing processes will eventually work in the opposite direction, eroding both trust and collaboration. These four feedback processes play an important role increasing or limiting the strength of the internal forces of diffusion in the providers' network. The external influence in the diffusion process is represented by the feedback loop B3.

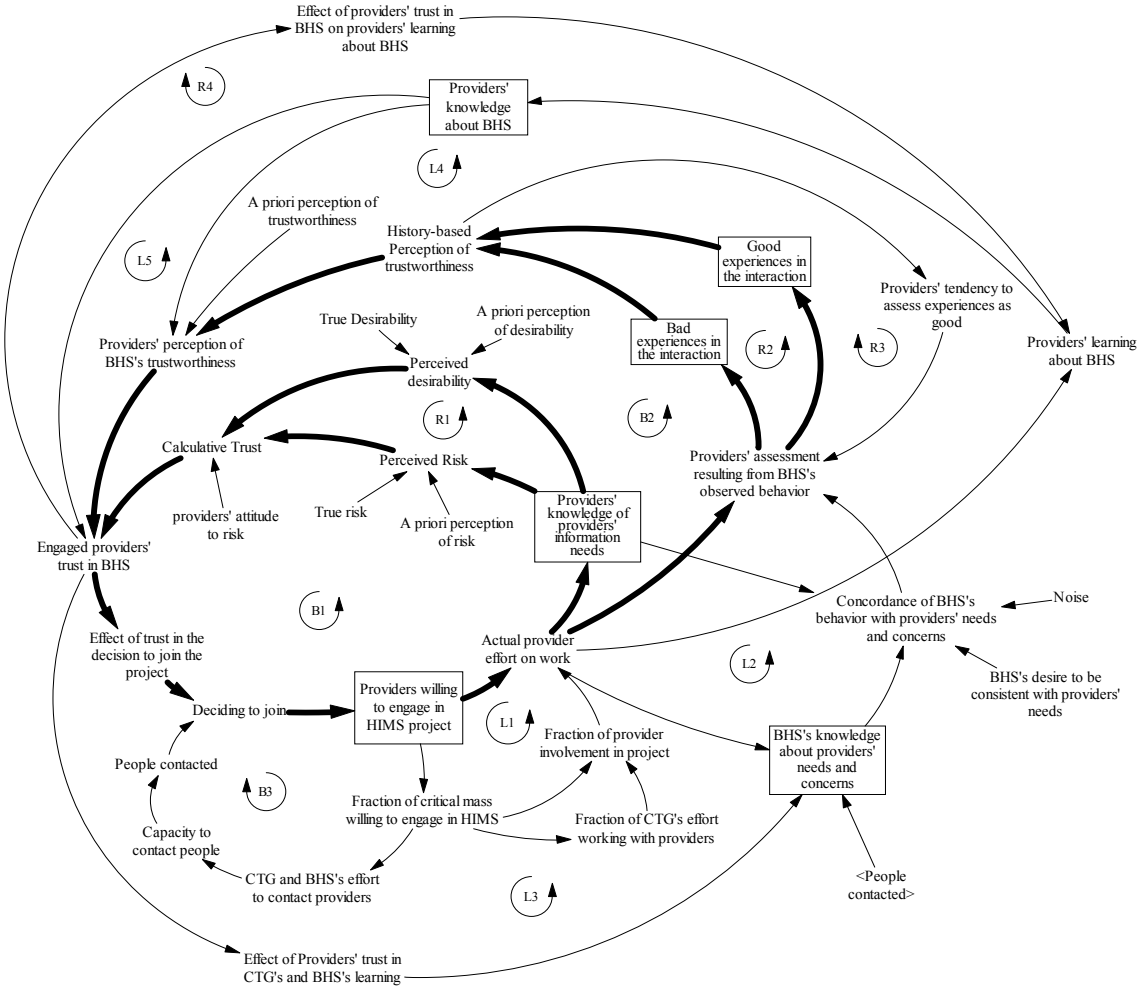


Figure 11. Feedback structure of the Collaboration-Trust structure

The feedback processes labeled as R3 represent the bias in the providers' perception of BHS's trustworthiness. As the number of good experiences in the interaction increase relative to the number of bad experiences, providers will tend to overlook bad experiences. If, on the contrary, the number of bad experiences starts to increase relative to the number of good experiences, providers will tend to fail to see the good experiences

in the interaction. These feedback processes are at the heart of the path dependence process of trust development.

The rest of the feedback processes in the figure (L1 to L5) represent multiple feedback processes that increase or decrease the relative importance of the four basic loops R1, R2, B1, and B2 in the collaboration dynamics. For example, L1 represents the process by which CTG decides about the level of engagement from the providers. If they do not initiate the work, none of the four basic feedback processes is actually active. The feedback processes labeled as L2 and L3 are closely related with ability of BHS to build a reputation as a trustworthy party by acting in concordance to the providers' information needs and concerns. BHS's ability to act in concordance to the providers' concerns is a function of both BHS and providers' knowledge of providers' information needs, and the intention of BHS to act in concordance to its knowledge of those needs and concerns. The intention and ability to build such a reputation operates mainly through the feedback loops R2 and B2. Finally, the feedback processes label as L4 and L5 control the different weights to each of the components of the trust construct on the basis of the accumulation of providers' knowledge about BHS. Low levels of knowledge will assign a high weight to the a priori perception of trustworthiness, limiting the importance of the processes R2 and B2 in such perception, and will give more importance to the calculative component of trust, making R1 and B1 more important to the trusting behavior in early stages in the interaction. As the level of knowledge grows, R2 and B2 become more important to the trusting behavior.

The next section includes some simulation experiments developed with the feedback structure described so far.

Model Behavior

The structure described in the previous section has the capability to reproduce the qualitative behaviors present in the HIMS case related to the development of trust, and providers' engagement in the collaboration subject to reasonable assumptions in the parameters and initial conditions in the model. To describe and explore such behavior, the current section is organized in two main parts. The first one describes the main parameters of the HIMS scenario, showing some of the qualitative behaviors of the model under these conditions. The second section consists of some additional simulation experiments with some of the basic parameters in the model.

The HIMS Scenario, Parameters and Behavior

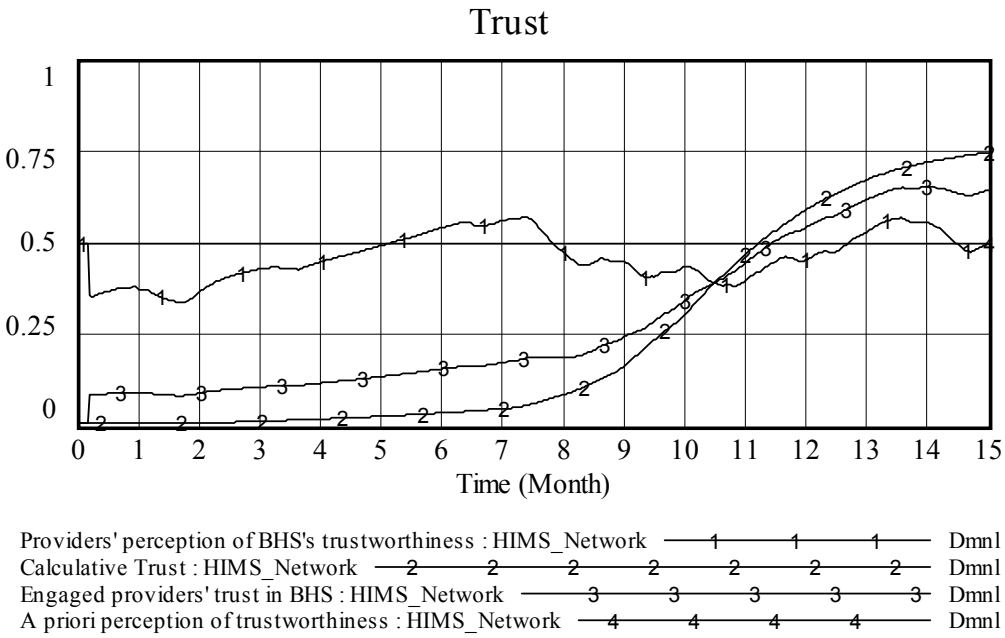
Some of the relevant parameters to explore in the current portion of the model are those related to the four basic reinforcing processes associated with the internal forces of the diffusion process, and the calculative and knowledge-based components of trust.

In terms of the parameters associated with the calculative component of trust, the initial or a priori risk of disclosure of confidential client information starts at the level of 1 in the model (risk and desirability parameters are measured in an arbitrary scale bounded between 0 and 1, including 0 and 1). The risk associated with the use of HIMS for

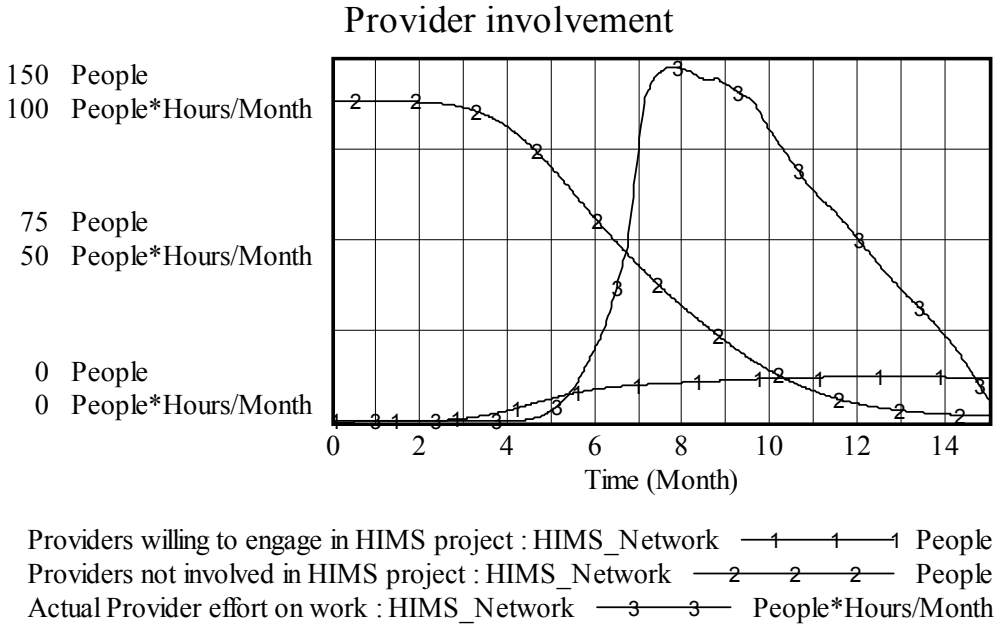
funding decisions starts at 0, given that providers did not realize about this risk until they increased their understanding of the implications of the project. The minimum value for the risk of disclosure is 0.3, considering that there is always a risk associated with the mishandling of the information in spite of the regulations protecting the clients' rights. The true risk of the project (associated with the use of HIMS data to funding decisions) has a moderate value of 0.5. The a priori value of desirability, on the other hand, is equal to 0.1, reflecting the lack of understanding of the provider group about the benefits of the HIMS project. However, the true value of desirability is equal to 0.9, reflecting the assumption that the HIMS was a project from which providers could get important benefits.

In terms of the knowledge-based component of trust, the model assumes an initial small ratio of good experiences relative to the memory of the experiences that providers brought with them into the project, given that they had as an immediate reference the ANCHoR project. The previous bad experiences that each provider member brings with herself are equal to 20, and the previous good experiences are equal to 5, yielding a 0.2 ratio of good experiences relative to the total experience, and a low level of history-based perception of trustworthiness. BHS is assumed to be committed to listen and be coherent with the providers' needs and concerns. In this way, the BHS's desire to be coherent with those needs is set at its maximum value of 1 (again, the parameter values range from 0 to 1). Given that the providers had some previous experience interacting with some of the members of the BHS team, providers' previous knowledge of BHS (the amount of knowledge that they bring with them into the project) has the value of 0.225.

Figures 12a and 12b show the basic behavior of providers' trust and engagement under these basic assumptions. Figure 12a shows the behavior of trust and its two main components. The calculative component of trust starts at a low level, given the initial conditions of trust and desirability. As the provider group gets involved in the project and discovers the true values of trust and desirability, this calculative component increases over time. The knowledge-based component of trust also starts at a low level given the initial bad experiences that the provider group had in previous interactions working with projects similar to HIMS (ANCHoR). However, given the commitment of BHS to attend to the providers' concerns, the providers' perception of BHS's trustworthiness also increases over time through the accumulation of positive experiences in the interaction. The behavior of the providers' trust in BHS is more similar to its calculative component in the early stages in the project, given that the provider group has a limited knowledge of BHS in this particular context. However, as they get to know better the interest to establish a collaborative relation from the BHS group, the knowledge-based component become more important in the determination of the trusting behavior.



(a)



(b)

Figure 12. Behavior of the model under the HIMS assumptions.

Figure 12b shows the behavior of the engagement of the provider group in the HIMS project. The number of providers willing to engage starts at zero, and grows up to the number of providers in the CTG/BHS team target. The number of providers not involved

in the project starts at a level of 132,[5] declining to almost zero at the end of the simulation. Only about 20 of those providers are making the decision to join the project. The rest of them decide not to join because of lack of trust in the project, or decide not to join because they feel represented in the project by the core group targeted by the BHS/CTG team. The last curve in the figure shows the actual engagement or effort of the providers in the HIMS project. This level of engagement increases according to the level of engagement with CTG and BHS, and according also to the fraction of the critical mass willing to engage in the project. Once the group finishes the work in the project, the level of engagement decreases again to zero.

Table 1. Parametric changes in the 5 experiments conducted with the model.

Variable	HIMS Network	No previous Knowledge	High to Low Desirability	Low to High Risk	H to L Desirability L to H Risk	Little Care Trust
Previous bad experiences	20	20	20	20	20	20
Previous good experiences	5	5	5	5	5	5
A priori perception of risk of using HIMS for funding decisions	0	0	0	0	0	0
True risk	0.5	0.5	0.5	**0.8**	**0.8**	0.5
A priori perception of risk of disclosure	1	1	1	**0.3**	**0.3**	1
Minimum risk of disclosure	0.3	0.3	0.3	0.3	0.3	0.3
A priori perception of desirability	0.1	0.1	**0.9**	0.1	**0.9**	0.1
True Desirability	0.9	0.9	**0.1**	0.9	**0.1**	0.9
BHS's desire to be consistent with providers' needs	1	1	1	1	1	**0**
Providers' previous knowledge of BHS	0.225	**0**	0.225	0.225	0.225	0.225

Some Simulation Experiments

After exploring the behavior of key variables by systematically testing its sensitivity to changes in all the constant parameters in the model, I developed a series of experiments

[5] The number of 132 providers was obtained in one of the modeling sessions in early stages of this project (April 13, 2001). The number is consistent with the information in the project documentation.

that show interesting behaviors produced by the model structure. These experiments were designed to explore the ways in which alternative scenarios affected the overall behavior of the model. The scenarios were designed by changing the values of risk, desirability, level of provider's knowledge about BHS, and BHS's care in attending to providers' needs. I designed and tested five alternative scenarios to the HIMS project. The main changes in parameters for the five scenarios are summarized in Table 1.

The first of these scenarios assumes no previous knowledge about BHS in the provider group. In the second scenario, the assumptions about the project desirability are reversed, making it highly desirable a priori, but with low true desirability. The third experiment inverts the assumptions related to the risks in the project, starting with a low a priori perception of risk, and a high true risk. The fourth experiment constitutes a combination of the previous two. This fourth experiment represents the opposite to the HIMS scenario, where the provider group started with a high a priori perception of risk and a low perception of desirability. The last experiment assumes that BHS had no interest in promoting a trusting environment in the collaboration.

Figures 13 to 18 show the comparative behaviors of some key variables of the model for each of the scenarios summarized in Table 1 (the HIMS scenario is included for comparison purposes).

Figure 13 shows the behavior of the engaged providers' trust in BHS, which shows an increasing behavior in four of the six scenarios. The two scenarios where trust decreases share the characteristic that desirability starts high and ends low. The scenario in which trust ends at the lower level is that one in which both risk and desirability goes from high to low. The case in which desirability goes from high to low, but risk goes from low to high shows an initial decline continuing with a more or less stable behavior just above a moderate level of trust (0.5). The declining of trust in both cases is mainly explained by the decline in the calculative component of trust (Figure 14). However, the final value of calculative trust is higher in the case in which trust ends at the lower level (where both desirability and risk goes from high to low). The difference between the two scenarios is explained by the knowledge-based component of trust, reflected in the providers' perception of BHS's trustworthiness (Figure 15), but also explained by the knowledge about BHS (Figure 16) from a higher initial involvement of providers in the project (Figure 17 and 18). The early involvement in the project promotes a higher accumulation of provider knowledge about BHS, and a better perception of their intention to pay attention to the providers' concerns. In this way, the providers from the scenario where risk goes from low to high not only end up with a higher level of perceived trustworthiness, but this component of trust is also weighted higher because providers have a higher level of knowledge about BHS. In spite of the differences, both scenarios show a declining number of providers willing to engage in the late stage of the simulation (Figure 17).

The scenario in which both the level of trust (Figure 13) and the number of providers willing to engage (Figure 17) ends at the higher level is that one in which risk and desirability goes from low to high. In this scenario, the calculative (Figure 14) as well as the knowledge-based (Figure 15) components of trust increase as the simulation time

progress. The growth in the calculative component is explained mainly because of increases in the perception of desirability. Calculative trust stops growing at the initial speed when the perception of the risk of using HIMS in funding decisions becomes bigger than the minimum risk of disclosure (before that point, the perception of risk is constant, and has the value of that minimum value of the risk of disclosure because of the MAX function used in the formulation of risk). The early engagement of providers in the project (Figure 18), promoted by the faster growth of trust, increases the level of providers' knowledge about BHS, which makes the final value of trust more similar to the knowledge-based component than to the calculative one.

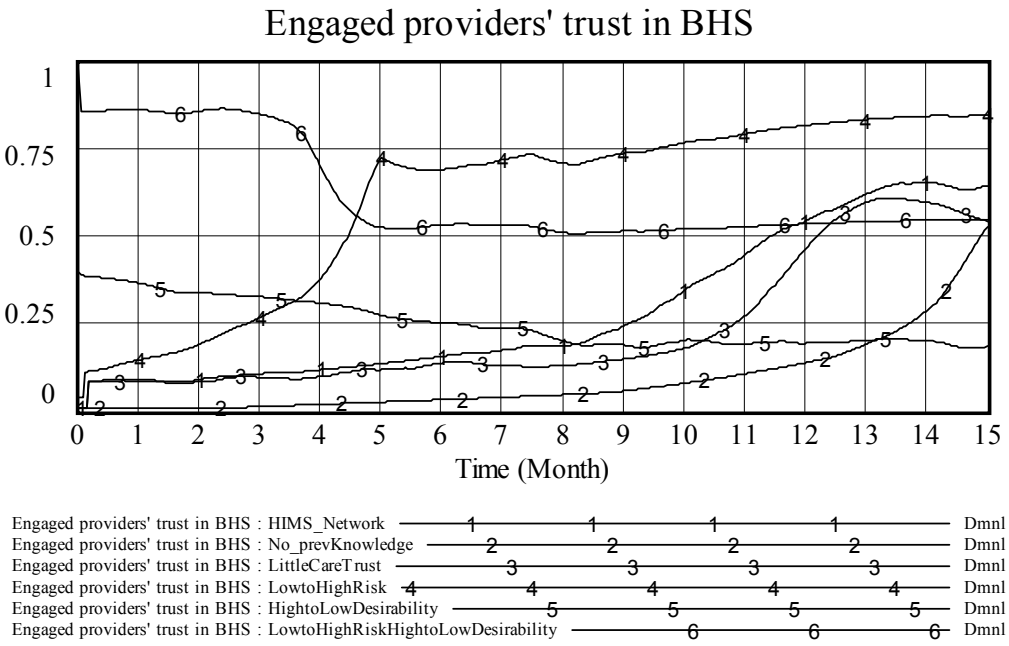


Figure 13. Behavior of Providers' trust in BHS under the 5 scenarios

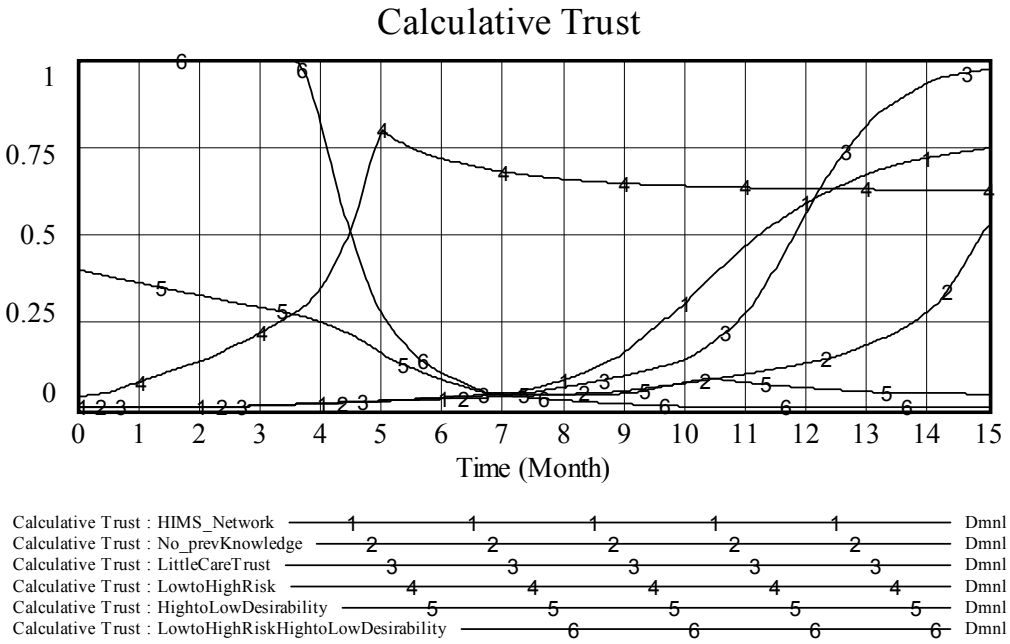


Figure 14. Behavior of calculative trust under the 5 scenarios

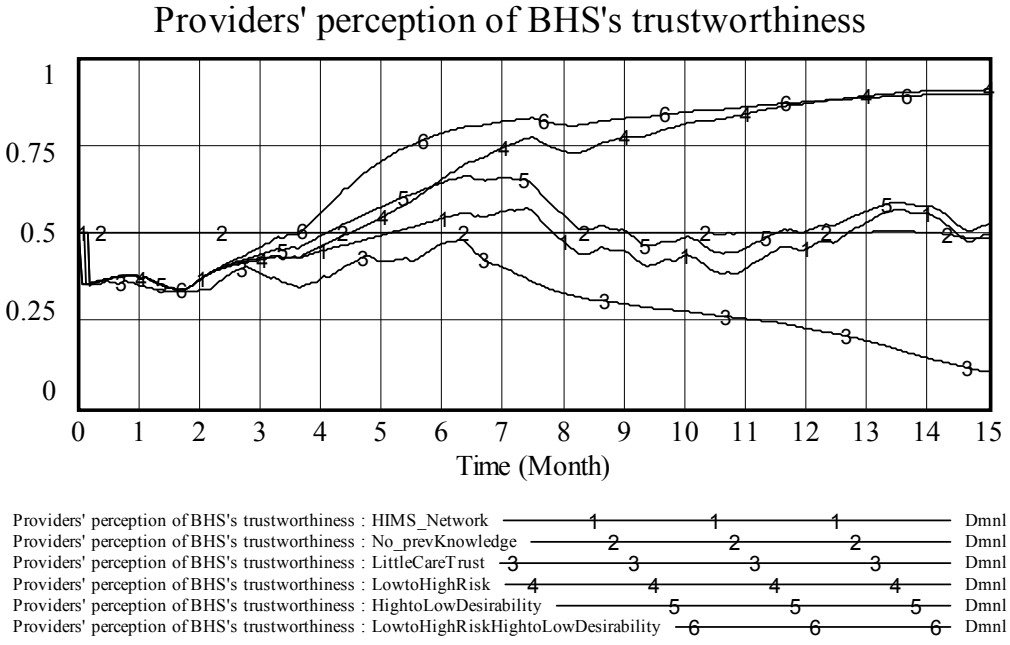


Figure 15. Behavior of providers' perception of BHS's trustworthiness under the 5 scenarios

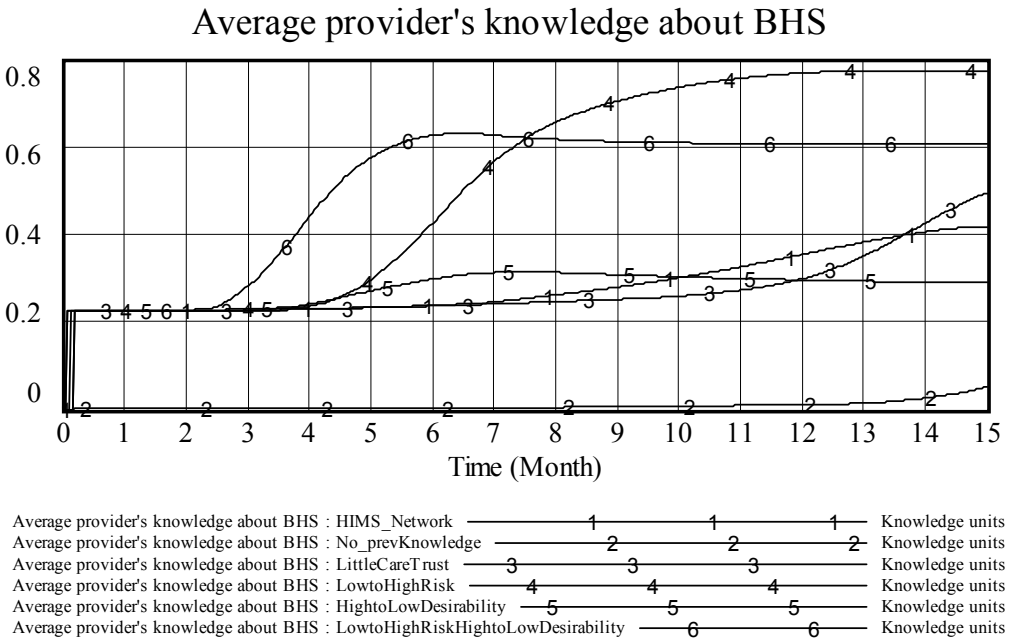


Figure 16. Behavior of Average providers' knowledge about BHS model under the 5 scenarios

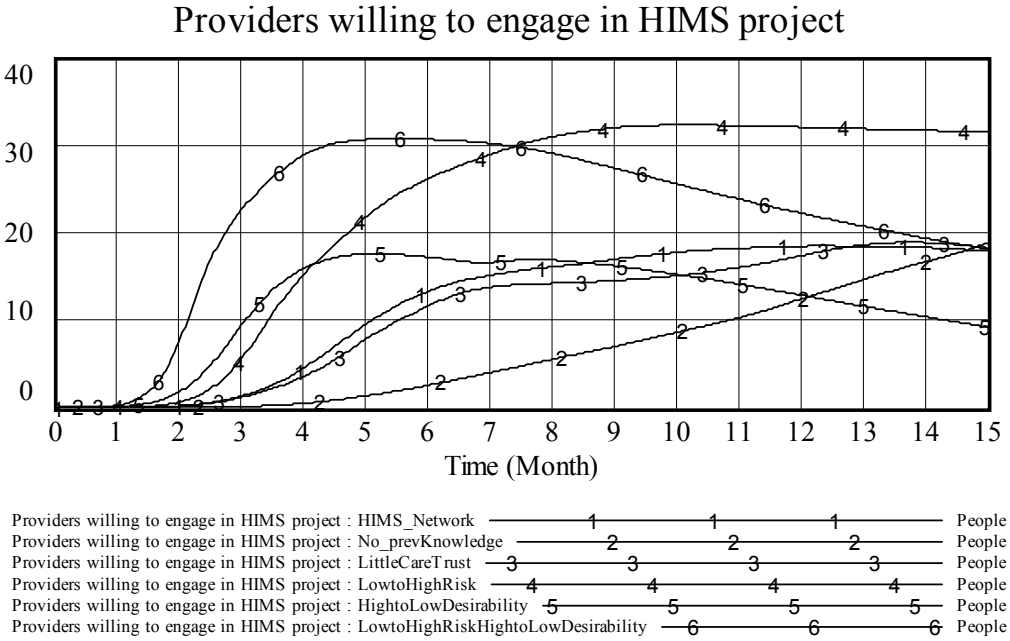


Figure 17. Behavior of providers willing to engage in HIMS under the 5 scenarios

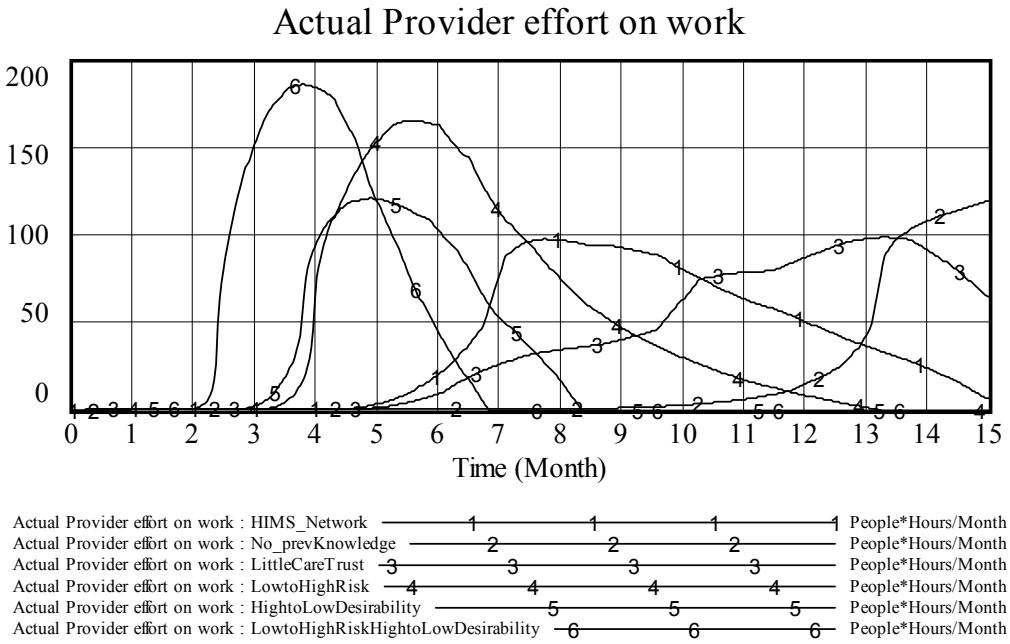


Figure 18. Behavior providers' effort on work under the 5 scenarios

The scenario in which no previous provider knowledge about BHS is assumed also shows some interesting characteristics. As it could be expected in this scenario, trust takes longer to develop (Figure 13). The team is "trapped" in the reinforcing process of trust and collaboration, being unable to build any of them for a longer time. However, the same reinforcing process operates faster once the group overcomes this initial trap. Because of the low level of providers' knowledge about BHS, most of the trust developed is explained by its calculative component. In fact, the providers' perception of BHS's trustworthiness remains almost constant, and at the same level of the a priori perception of trustworthiness (equal to 0.5 in the model). The low levels of trust in the early stages of the simulation require more effort from the CTG/BHS team to bring providers to the project (external influences of the diffusion process). This additional effort of the team causes a bigger reduction in the perceived risk of disclosure, promoting the fast increase in trust towards the end of the simulation.

The last scenario (little care about trust) shows some interesting behaviors, to some extent counterintuitive. Although the providers' perception of BHS's trustworthiness (Figure 15) declines over time once the providers start their involvement into the project (Figure 18), the slight difference in trust when compared to the HIMS case (Figure 13) requires from the CTG/BHS team additional effort to bring providers into the project. This additional effort causes a bigger reduction in the perception of risk of disclosure of client information, increasing the values of the calculative component of trust, and compensating for the lower values on the perception of trustworthiness. The same difference in the values of trust limits the learning of providers about BHS, increasing the weight in the calculative component of trust and contributing to the compensation process. In this way, trust grows until month 13, when reaches a maximum and starts to

decline. The number of providers willing to engage in the project increases following a pattern similar to the HIMS scenario. However, people start to leave at the very end of the simulation, when the reinforcing processes of trust and collaboration start operating in the opposite direction (I tested this interpretation by increasing the simulation duration). The results of this experiment may suggest that for small projects, there is not enough time for the group to develop a knowledge-based trust, relying mainly on the calculative component of trust or in other mechanisms not present in this model.

Conclusion

The model presented here is relevant to the collaboration research and practice by providing a feedback structure that clarifies the nature of the reinforcing processes involved in the development of trust through collaboration in a project. The feedback structure is grounded in the HIMS project data, and is consistent with the literature on trust, collaboration and diffusion of innovation.

Four feedback processes were identified at the core of the development of trust and collaboration (see Figure 11), two of them reinforcing in nature, and two of them counterbalancing in nature. Moreover, two of them are associated with the calculative component of trust, and two of them are associated with the knowledge-based component of trust. The two reinforcing processes appear to be related to behaviors characterized in the literature as spiral patterns of reinforcement of either the development of trust or distrust. The counterbalancing processes appear to have an influence in the direction of the pattern, and also in shifts in direction during a particular collaboration.

Experiments with the model suggest that the initiation of a collaborative project with a new partner has the potential to have a slow start because of the lack of knowledge about the other parties. The initiation of the collaboration could be accelerated by shaping expectations of benefits of the project or by reducing the perception of risk associated with the project.

Under the assumptions and constraints built into the model, reductions in the perception of risks appear to be more effective than the formation of expectations about the benefits of the project. In this way, a strategy that involves starting a collaboration effort with activities that involve low levels of perceived risk could be more effective than a strategy that emphasize in the expected benefits of the initial interaction.

Finally, the experiments also suggest that in projects of short duration, the calculative component of trust could play a more important role than the knowledge-based one, which affects the relation in the long run (unless there is previous knowledge between the parties in the collaboration). Alternatively, it is possible that different processes explain the behavior of trust in such short duration projects as suggested by some researchers (Meyerson *et al.* 1996).

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