MODELLING CONTRACTOR'S AND SUBCONTRACTOR'S TRUST: A SYSTEM DYNAMICS APPROACH

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A general mistrust within the contactor and subcontractor companies has identified one of the significant barriers to derive benefits from true downstream supply chain integration. Using the general theory of trust in inter-organizational relations and conducting interviews, this research discusses factors that influence development of trust and cooperation in contractor–subcontractor relationships in construction projects. System dynamics is the simulation method is selected in this theory-building effort, based on qualitative data collected from two projects of a construction company in Thailand. Performance, permeability and system-based trust are found to make significant contributions toward parties' trust level. Three strategic policies such as best value contracting, management of subcontractors as internal team and semi project partnering approach are recommended to stimulate the trust factors as well as cooperative long term relationship.

KEYWORDS: Trust, contractor's and subcontractor's relationship, system dynamics model, construction supply chain management.

INTRODUCTION

The lack of trust between contractor and subcontractor on the adversarial nature of their working relationships has been characterized as a fundamental barrier to the increased understanding of each others' needs and further supply chain integration. This kind of relationship is reflected in projects delays, adversarial attitudes, cost overruns, litigation and a win-lose climate. This appears to be preventing the active involvement of supplier companies to the construction process.

The key barriers to develop trust as well as greater integration seem to stem from the industry's traditional approach of vertically differentiating the construction process, which results adversarial relationships, a lack of transparency and mistrust between the contracting parties (Hinze and Tracey, 1994). Traditional contractual arrangements often generate a climate of mistrust that tends to induce opportunism and hinder co-operative interaction

(Dainty et al. 2001). Moreover, risk is passed down the supply chain, rather than being shared amongst the parties in the spirit of a true partnership. Thus, specialist contractors also identified a lack of risk sharing on the part of the lead contractor as a factor of eroding trust.

From the above statement it can be easily depicted that the fragmented approach of construction project procurement and product delivery process, traditional contractual arrangements regarding payments and retention and information sharing are the main foundation of generating mistrust among the contracting parties. Thus, trust can be regarded as glue that fosters cooperation among organizations and different team members and an essential lubricant that helps to complete the project smoothly (Wong and Cheung, 2005).The primary objective of this study is to address the critical issues in developing trust model for effective supply chain integration between contractor and subcontractor in construction industry using System Dynamics Approach.

The paper is organized is as follows: first, importance of modelling trust as dynamic systems is briefly explained. Then the system dynamics model building steps are described. Due to space constraint, more focus has given on development of dynamic hypotheses. The final section discusses concluding remark and future research scope.

IMPORTANCE OF MODELING TRUST AS DYNAMIC SYSTEMS

In the review of literature, it has been found that researcher in this area have identified several mechanisms associated to trust development such as Institutional trust, calculative trust, knowledge-based trust, and identification-based trust. Institutional trust refers to the existence of an institutional framework that regulates the relationship between the trustor and the trustee (Luna-Reyes et al., 2004). This institutional framework can consist of laws, regulations or certification bodies that provide penalties for a party cheating in the interaction or provide certification of the trustworthiness of the trustee by a recognized third party. Calculative trust refers to the trustee's estimation of the risks and payoffs intertwined in the interaction. Changes in the perception of the institutional framework can result in changed perception of risk, promoting increases in the calculative trust. Knowledge-based trust is related to the ability of the trustor to assess the trustworthiness of the trustee. This assessment of trustworthiness can be based on the recognition of the expertise, the benevolence, ability, and integrity (Mayer et al., 1995), and it is associated with the history or the process of the relationship. Finally, identification-based trust is associated sometimes to emotional bonds, or with the existence of shared values or objectives between the actors. Rousseau et al. (1998), who considers that the calculative trust plays a more important role in early stages of the relationship. This change towards a knowledge-based trust as the relationships matures, and the parties involved develop a history of interactions and get to know each other (Figure 1).

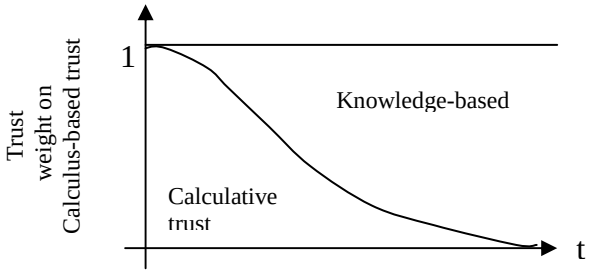

Figure 1: Change over time of the character of trust in an interpersonal relationship. Adapted from Rousseau et al., (1998).

The assumption about the shift from calculative trust to knowledge-based trust is also supported by the observations of reference mode, and from the interview of contractor and subcontractors.

As trust is dynamic e.g. if either one deteriorates, this will have a negative impact on the other, thus a system dynamics model related to trust in creating project team can help to make decisions effectively and encounter the problems related to parties' relationship as it involves two major characteristics: 1) changes over time and 2) allows feedback. System dynamics model are well suited to representing multiple interdependencies, to deal with dynamics nature and involved in significant feedback processes (Ogunlana et al., 1998). This study focuses to develop a system dynamics model of trust from both contractor and subcontractor point of view in order to experience the impact of factors on trust.

METHODOLOGY

System Dynamics is a way of analyzing the behaviour of complex socioeconomic system to show how organization and policy influence behaviour. Several types of model building steps have been described by different authors at different times. For this study, five stages of model building process have been adopted (Sterman, 2002). First step is to identify the problems and goals for the study and to organize historical information into a reference mode. The reference mode leads to formulation of dynamic hypothesis in terms of causal feedback loop existing among the decision elements in the system. In second step, a formal model is constructed which incorporating the dynamic hypothesis along with other structural details of the system related to the problem being addressed. After a model is formulated, simulation aided by computer then can be done. Thus, the fourth step is to test the model until it satisfies the purpose. Final step is to design and evaluate policy for improvement. Powersim ® software has been used for constructing loop diagrams, simulation and policy analysis in this research.

Dynamic modeling of contractor's and subcontractor's trust requires mental data (qualitative data) to gather at different stages of model building. However, expert opinions are also required for several times such as to identify and clarify the problem, to develop the formal model and to validate the model.

The study has been conducted in Thailand in a contractor company, which generally performs the work by subcontracting their work. Information has been obtained through personal interviews of contractor's site manager and some selected subcontractors from two ongoing projects, Project A and Project B. Both of the projects were related with same type of construction work (villa or resort) on the top of hill beside the sea but the client was different. Most of the subcontractors were from the local area. During data collection, 90% of the work of project B and 60% of the work of project A had been completed. Unstructured interview have been conducted that addressed topics related with trust issues such as background information of both subcontracting and contracting firm, practices related to bidding on subcontracted work, practice related to problem in current project progress and practice related to the general contractors' administration of subcontracts.

Trust reference mode has been plotted from the historical and present time data from the view point of contractor and subcontractors. The trust behaviour over time has been plotted in a scale of 0% to 100 % with a range of very poor trust relationship to very good trust relationship by the interviewees.

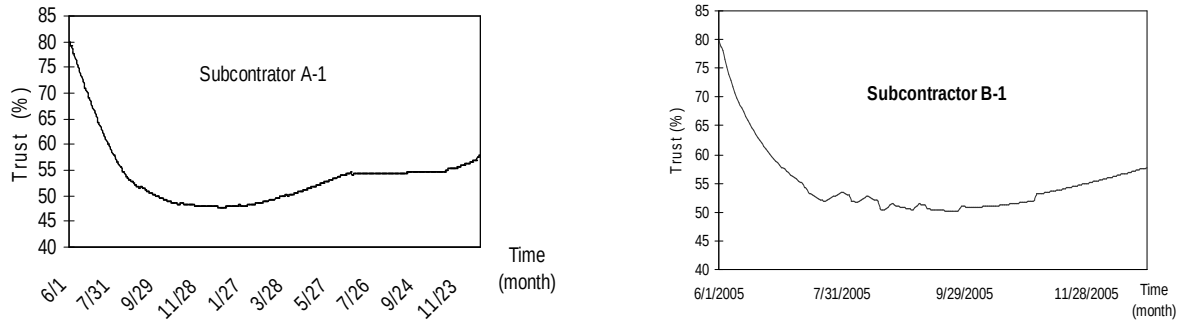

Figure 2: Reference mode (A-1: Project A; B-1: Project B)

Dynamic Hypotheses

The knowledge gain from the literature review, information gathered from the real system and interviewed data has helped to formulate key feedback loops regarding development and diminish of trust between main contractor and subcontractor way of collaboration.

As the main concern of this study is related with observation of trust pattern either developing or diminishing with respect to project progress, thus knowledge based trust and system based trust put greater contribution in developing hypothesises. According to literature, knowledge based trust can be attained with the maturation of relationship which is influenced by performance and permeability and is affected by institutional framework. Therefore to get a better understanding about the causal relationships the feedback loops has been classified in the following three major categories:

- Feedback loops concerning permeability (PL1, PL2 and PL3) (Figure 2)
- Feedback loops concerning performance (PF1, PF2, PF3 and PF4) (Figure 3)
- Feedback loops concerning system based trust (SB1, SB2 and SB3) (Figure 4)

These causal-effect relationships according to their major groups are described in the following sections.

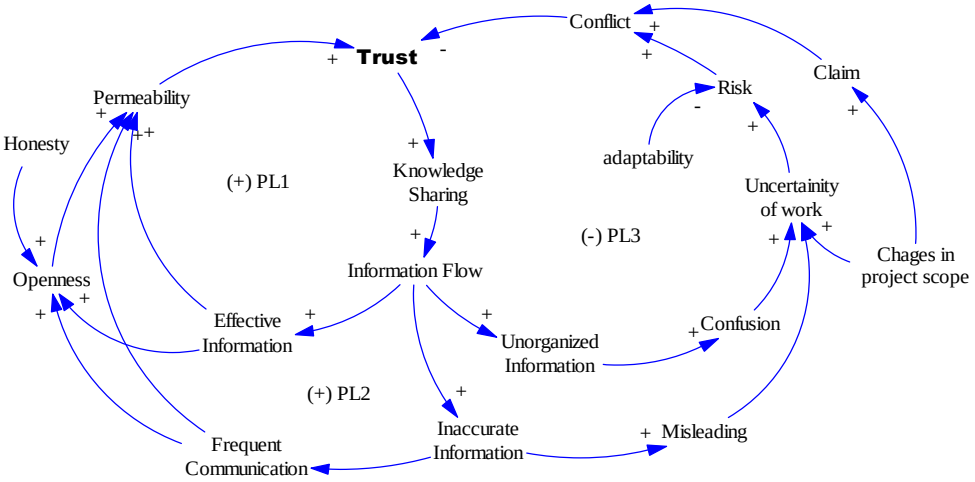

Figure 3: Feedback loops concerning permeability

Permeability involves being open in sharing and receiving information and dealing with others in a straightforward manner (Wong and Cheung, 2005). It represents the level of transparency of the relationship among the contractual parties. *Loop PL1:* Knowledge sharing and trust can interact in a collaborative process. According to Gherardi and Nicolini (2000), knowledge "resides on a team of individuals sharing common experiences". Working together builds knowledge of one's own work as well as knowledge of the other's work; as one knows the other better, it is possible to trust the other more; and as trust is built, parties share more information, making their collaborative work more effective. Effective and sufficient information flow represents openness as well increase permeability. Openness is affected by honesty and provides an access to a greater number of information sources, forces the development of mechanisms that facilitate the information. *Loop PL2:* According to Lau (1999), it is not easy to tell whether trust leads to communication or communication leads to trust. In most of the case, the accuracy rates of information provided by the subcontractors are quite low. This inaccurate information requires more communication as to continue the work. Consequently, open and frequent communication and open-door policies to each other, results from willingness of partners to create transparency in relationship. *Loop PL3:* The inaccurate and unorganized information mislead and create confusions to the decision makers to make an effective decision. However, delayed decision or situation ineffective decisions stimulate work uncertainty as well as risk. The higher the uncertainty or risk, the more a cohesive working relationship is required (Lau, 1999). This allows solving problems in an efficient way, which enhances the adaptability of subcontractor. Moreover, adaptability of subcontractor may help the contractor to manage the risk together. Frequent changes of project scope further increase the uncertainty of work as well as additional work, are likely to generate more claims from subcontractor. Consequently, risk and claim can generate conflicts between the parties. The impact of conflict resolution can be either productive or destructive (Mohr and Spekman, 1994). Such conflict resolution techniques as coercion, confrontation, and outside arbitration are counterproductive and fail to reach a win-win situation often generate distrust between the parties. However, problem solving and compromising attitude bring trust among the parties. Thus, working through the conflict may increase trust. When it gets out of hand it will destroy trust.

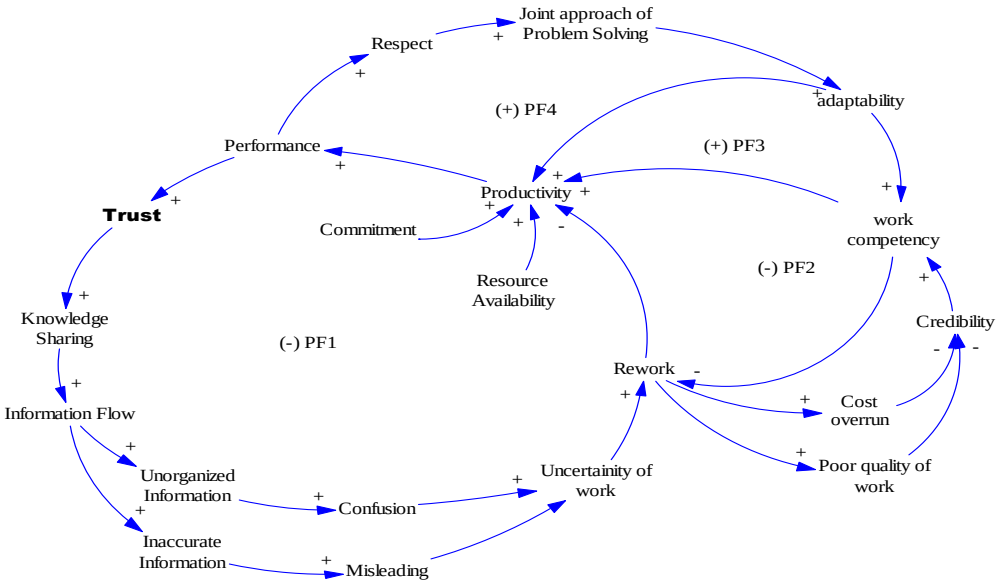

Figure 4: Feedback loops concerning performance

The team members of project will trust each other if both their "behaviours" and "outcomes" are competent. Productivity, work competency, adaptability and rework produce greater influence on performance as indicated in Figure 3. *Loop PF1:* The more uncertain the work, the higher will be the possibility of rework. Rework has a negative effect on productivity. However, more commitment and resource availability increase the productivity level. Alternatively, higher productivity means high performance which has a greater impact on developing trust level. *Loop PF2:* Reworks very often generate poor quality of work and cause cost overrun. Poor quality of work and cost overrun has negative impact on subcontractor's credibility as well as deteriorate its competency. Moreover, lack of competency causes more rework. Conversely, work competency positively stimulates productivity level. The higher competency level of parties represents high management competency, technical skills and stable financial condition of the parties. *Loop PF3, PF4:* Higher performance of subcontractor attains mutual respect between contractor and subcontractor. Furthermore, this mutual respect enhances them to solve any problem jointly rather than doing it individually. Joint approach of problem solving facilitates the subcontractor to be adaptable to the contractor's policies and working in unfavourable environment. Moreover, during joint problem solving, parties gather together and share with each other their own views on the conflict issues and their resolving tactics. Such a high level of participation among parties encourages them to keep a commitment to the mutually agreed solution. In addition, adaptability increases their competency as well as productivity.

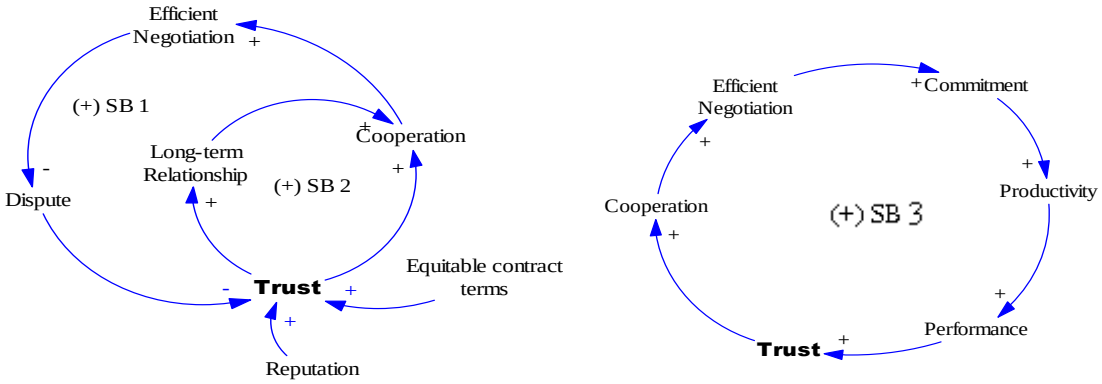

Figure 5: Feedback loops concerning system based trust

Satisfactory contract terms, negotiation process, commitment towards work and dispute solution process normally affect the system based trust as found in literature review. *Loop SB3:* Trust can stimulate a better cooperation. During a negotiation process, a cooperative attitude result efficient solution of problems. Efficient negotiations further motivate the subcontractor to be more committed to their work and consequently increase productivity as well as performance. Develop positive attitude towards other and commitment to the work responsibility; establish a climate of trust and confidence and a sense of responsibility for achieving goal (Lau, 1999). *Loop SB1 and Loop SB2:* Efficient negotiation helps to reduce the conflict between the parties; otherwise it will reach a level capable of generating dispute by eroding trust. On the other hand, companies with higher reputation are more trustworthy as they (contractor company) do not want to lose their valuable asset (Gambetta, 1998). Equitable agreements or contract terms enhance contracting parties establish trust and sustain

cooperation since their perceived benefits are secured (Wong and Cheung, 2005). If the contract parties are able to maintain their trustworthiness at high level during the project and up to the end of project, this establishes long-term relationships between them. This long-term relationships among parties will also lead to trust.

Formulation of System Dynamics Model

The complex system described in the reference mode and dynamic hypothesis has been developed in the form of a system dynamics model in Powersim® software, based on the model boundary as shown in Table 1. Due to the level of details covered in the system boundary, the model used us somewhat large. Further details and a machine readable listing of the model written in Powersim® are available from the writers on request.

Table 1: Model Boundary

Exogenous	Endogenous	Ignored
Equitable contract agreements, Management competency, Financial status, Technical skills, Honesty, Reputation, Resource availability, Negotiation process, Changes in project scope, Past experiences	Knowledge sharing, Communication, Openness , Information flow, Permeability , Respect, Commitment, Problem solving, Work uncertainty, Rework, Work competency, Adaptability, Productivity, Performance, Risk, Claim, Conflict, Dispute, Relationship, Cooperation	Dispute Resolution technique, Organizational structures, Compatibility

Model boundary shows the primary features included (endogenous), assumed (exogenous) and excluded from the model. The exogenous factors such as past experiences, management competency, technical skills and the reputation of the organization act as the bases of calculative trust at the early stages of project. Equitable or satisfactory contract terms affect system based trust. On the other hand, honesty, changes in project scopes, these external factors are experienced during project life which has greater impact on knowledge based trust development. Mostly, all of the endogenous factors affect on knowledge based trust as this type of trust has developed during working together. The origin of this type of trust can be measured under two headings such as permeability and performance. Permeability is measured by the degree of willingness of knowledge sharing, openness, information flow and frequent communication. Conversely, respect, commitment, problem solving attitude, work competency, and adaptability, these endogenous factors has positive impact on productivity as well as performances improvement. During negotiation, the way of the parties to negotiate (problem solving, forcing) has greater impact on problem or conflict resolution as the forcing attitude during negotiation may arise dispute between the parties and the problem solving approach may increase the satisfaction of both parties as well as improving trust level. On the other hand, the organizational structure is ignored as vertical trust is not significant in developing trust between contractor and subcontractor. As contractor and subcontractor are assumed to work in the same region thus differences in compatibility is not included in the model boundary. Moreover, adoption of detail dispute resolution techniques is also overlooked here.

The model is preliminarily divided into three sectors as permeability, performance and system; depend on the model boundary, literature review, information gathered from the real

system, and interviews conducted with decision makers in the organization. Each sector can be further divided into sub sectors or sections. These subsystems and sectors are interrelated in the form of shared parameters. Information flow, openness and communication can be grouped into permeability subsystem because they have a special interrelation. When a project work is performed, rework which in turns effect credibility of performer by reducing their work competency. Resources consist of manpower, equipment, and material. Productivity is affected by resource availability, work competency, commitment, rework and adaptability and all of these are grouped into a subsystem—performance. Equitable contract terms, negotiation process, conflict and dispute resolution process are grouped into the other sub system- system.

Model Behaviour and Validation

As it is widely stated among modellers, "there is no correct model but there are useful models!" The closer the model represents a real world system, the more accurate decisions can be made by the users. Hence, Forrester and Senge (1980) define validation for system dynamics models as a "process of establishing confidence in the soundness and usefulness of a model." In this paper, both structural and behavioural validation tests have been performed for building confidence in the model. The useful time period of the model simulation has been vary from subcontractor to subcontractor for both of the projects. The results from the baseline of the model are shown in Figure 6. It is seen from the figure that the model replicates the reference mode (Figure 2) very well.

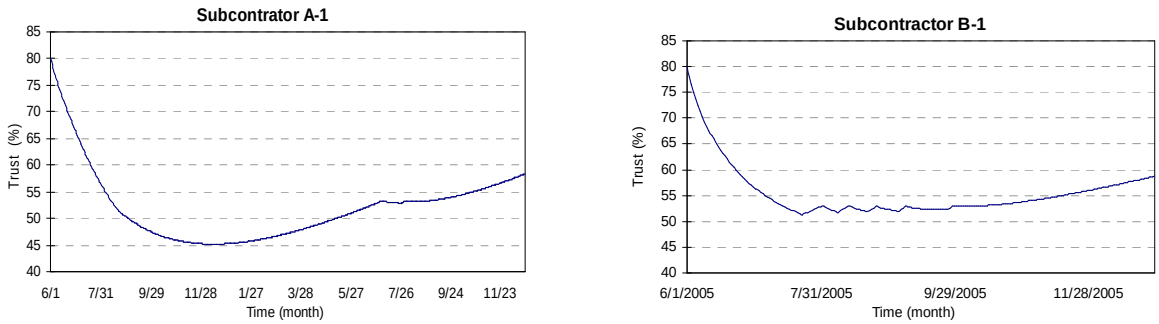

Figure 6: Base run of model (A-1: Project A; B-1: Project B)

In modelling trust, the initial value of each parameter has been established based on the interview from the selected project members. For each important relationship and major assumption, sensitivity analysis has been made. In the sensitivity analysis, the variables that are described with a single numerical value at any time and more complex variables such as task dependencies are investigated. Each simulation with the changed parameters and changed slope of the non linear relationships has been compared with the base run simulation. This extensive process of simulation comparison showed that the model is structurally and behaviourally valid.

Formulation of Sustainable Policies

The prime objective of this research is to formulate of an effective set of policies for increasing trust level as well as improved organizational performance between contractor and subcontractor. Extensive model simulations are made in order to identify a practically effective and implementable policy. Three sets of policies are selected here for an improved

and sustained behaviour as shown in Table 2. The policies are generic. From the simulation result (Figure 7), it is concluded that integrating subcontractors into semi-project partnering approach, is a very effective way for stimulating trust level. Partnering aims to reduce the adversarialism which is said to be typical in the industry and which has confounded previous attempts to encourage better integration and cooperation between contractual partners (Kumaraswamy and Mathews, 2000).

Table 2: Policies Considered and their Results

Policy goal	Policy	Remark
Increasing performance as well as productivity, reducing claim and risks	Best value contracting (Policy 1) (Thomas, Skitmore and Chung, 2003)	Shifting from ‘‘Price Only’’ single criterion to multiple performance criteria.
Improving collaboration and quality of human resources.	Management of Subcontractors as Internal Team (Policy 2)	Prevents the sense of alienation of the contracting parties
Maximizing resource sharing and increasing commitment	Semi-project partnering (Policy 3) (Kumaraswamy and Mathews, 2000)	A limited form of “competitive” tendering is applied

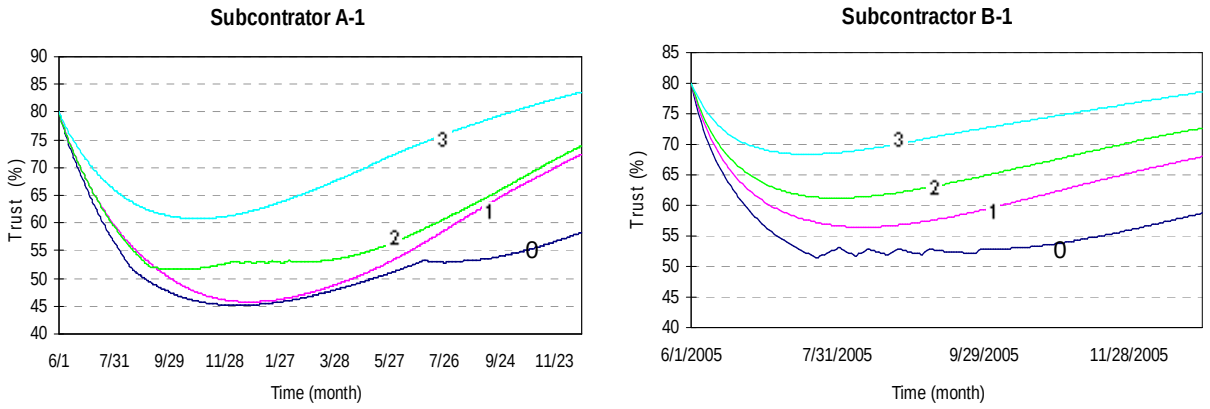

Figure 7: Comparative behaviour of model after implementation of three policies [A-Project A; B-Project B]; Reference – 0; Policy 1-1; Policy 2- 2; Policy 3- 3;

CONCLUSION

As trust is path dependence phenomenon, thus it is extremely difficult to capture the behaviour of trust in a construction project relationship at a holistic view. Therefore, by adopting system dynamics approach, a generic trust model has been formulated in order to facilitate the contractors and subcontractors in understanding trust related issues. This model may help them to attain high level of performance and competitiveness of the construction industry and can bring long term benefits during their contact period. According to the model, three trust factors have significant enhancement on contractor and subcontractors’ trust building: participants’ performance, participants’ permeability and system based trust.

Best value contracting, management of subcontractors as internal team and semi-project partnering-these three policies are suggested for improving trust level bases on the case studies. As the interview companies resolve their dispute by mutual understanding thus impact of several dispute arising in large scale projects and their detail resolution techniques such as litigation, arbitration has not been included here. Thus, the research area could be extended in future for the investigations of detail modelling of contractual agreement.

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