DEVELOPMENT OF A PERFORMANCE MODEL FOR INTERNATIONAL CONSTRUCTION JOINT VENTURE: A SYSTEM DYNAMICS APPROACH

Muhammad Nateque Mahmood
The University of Tokyo, Tokyo, Japan
nateque@ken-mgt.t.u-tokyo.ac.jp

B.H.W. Hadikusumo
Asian Institute of Technology, Pathumthani, Thailand
kusumo@ait.ac.th

Stephen O. Ogunlana
Heriot Watt University, Edinburgh, UK
S.O. Ogunlana@hw.ac.uk

Azmeri Rahman
Stamford University Bangladesh, Dhaka, Bangladesh
azmeri14@yahoo.com

The uncertain and dynamic nature of International Construction Joint Venture (ICJV) performance is evolved with many critical factors which lead to make partner relationships more complex in respect of making decisions to maintain a cohesive environment. Addressing to the fact, a generic system dynamics performance model for ICJV is developed by integrating a number variables as to get an overall impact on performance of ICJV and to make effective decisions based on that. In order to formulate and validate the model both structurally and behaviourally, both qualitative and quantitative data are gathered by conducting intensive interviews from two ICJVs in Thailand. After conducting intensive simulations of model, three major problems are identified related to negative value gap, low productivity in construction and high rate of ineffective information sharing of both ICJVs. Several policies are suggested and integrated application of these policies provides a maximum improvement to performance of the ICJV.

KEYWORDS: international construction joint venture, system dynamics performance model, joint ventures- Thailand.

INTRODUCTION

Global construction business has moved towards more competitive environment over the past two decades. As local markets erode due to competition, firms need to change their business strategy and expand their traditional markets. According to Yoshino and Rangan (1995), joint ventures (JVs) have emerged as a popular strategy in an environment in which fast access to up-to-date technology and emerging markets is more critical than ever before. The complex and diversified nature of construction industry makes JVs as a vehicle of seeking new opportunities to increase organizational strengths and reduce weaknesses.

Although there is a significant growth of ICJVs, the success rate is not satisfactory (Adler et al., 1992). This success is measured in terms of performance level of joint venture. The performance of ICJVs depends on many factors which affect performance at different stages (selection, formation, operation and dismantle stage) of joint venture. The factors are changing with time and have a dynamic effect on performance of joint venture. ICJVs have become increasingly prevalent in the business environment and the need to understand the dynamics of these emerging organizational forms increase, as managers and researchers struggle to find patterns and indications of how to effectively manage these complex collaborative arrangements. Hence, a better understanding of performance of ICJVs and their dynamic development over time is needed. Modelling relationship dynamics in joint ventures makes interactions visible and thus understandable. Once understandable, managers are positioned to make judgments about the observed patterns and intervene, as appropriate, to increase the likelihood of partnership success. Considering to the dynamic and uncertain nature of the performance of ICJV, the primary objective of this paper is to develop a generic system dynamics model in order to explain how the factors affect the performance of ICJVs and then develop adopted system dynamics models for different cases of ICJVs.

The structure of the paper is as follows. The second section provides a brief review of performance measurement of ICJV. Then in the third section development of system dynamics modelling process is described. Based on a discussion presented in the third section, the final part provides a conclusion and direction on the future research.

PERFORMANCE MEASUREMENT OF ICJV

If one considers inter-partner harmony as a long-term objective of parent firms, a financial or objective measure in itself is unlikely to capture accurately an IJV's relative performance against objectives (Chowdhury, 1992). Moreover, there is also the problem of not reporting financial data concerning joint venture performance (Geringer and Hebert, 1991). Thus, instead of measuring financial performance of the ICJV, project output (time, cost and quality) can be considered as objective measure. The ICJV's performance can be reasonably judged in terms of subjective measure and objective measure. According to Mohamed (2003), the subjective and objective measures representing performance, is measured by three items, namely; (1) *Value* (reflecting the overall business benefit including tangible and intangible gains derived), (2) *Project output* (reflecting project-based tangible gains), and (3) *Satisfaction* (reflecting the organization's willingness, given the opportunity, to have a continued relationship beyond the project under investigation).

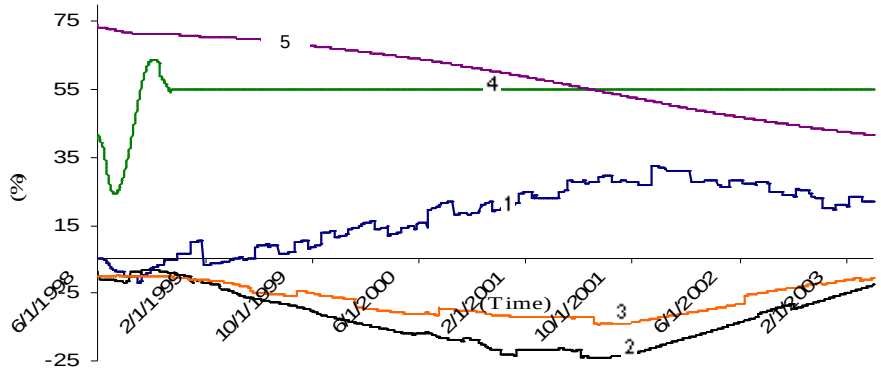
SYSTEM DYNAMICS MODELLING PROCESS

Sterman (2002) proposed a modelling process which has been adopted in this study. First step is to articulate problem to be addressed. Second step is to formulate of dynamic hypothesis or key feedback loops. Third step is to construct a formal model which is incorporating the dynamic hypothesis along with other structural details of the system related to the problem being addressed. Fourth step is to test the model until it satisfies the purpose, and fifth step is to design and evaluate policy for improvement. Powersim® software has been used for the task of system dynamics modelling as building causal loop diagrams, stock and flow maps, an elaborate model, testing, simulation, and policy analysis. In order to develop firstly, reference modes and some key feedback loops, secondly, formulate and validate the model both structurally and

behaviourally and lastly policy formulations both qualitative and quantitative data are gathered by conducting four phases' intensive interviews of 12 key personnel from two ICJVs in Thailand.

One is related to double track railway project. Local company had been at the forefront of this effort, undertaking civil works of approximately 193.5 km starting from June, 1998 to April, 2003 and foreign partner supporting technical part, which is considered as Project A in this paper. Another one is related to instalment of fibre optic cables in the same trench as the product pipe for oil and gas, which is considered as Project B. Foreign joint venture partner joined in this telecommunication project in order to transfer latest technology to the local partner. Local company installed 11,000 km of fibre and around two hundreds of control stations across the country starting from January, 1999 to December, 2002.

The historical data for satisfaction and value from the interview have been developed by the interviewees and then combined as a cumulative average value and develop points for the reference mode for each ICJV in a scale of 0-100% with a range from very low to very high. However, the reference data of project output (time, cost and quality) have been gathered in terms of tabular form. In order to have better understanding of the project output, cost is referred by project cost discrepancy, time is by schedule pressure and quality is by quality discrepancy. The discrepancy is the difference of the actual to the desired one. Due to the space constraint, only the reference modes of Project A are shown in Figure 1.



Legends: 1-project cost discrepancy; 2-schedule pressure; 3-quality discrepancy; 4-value; 5-satisfaction

Figure 1: Feedback loops concerning value

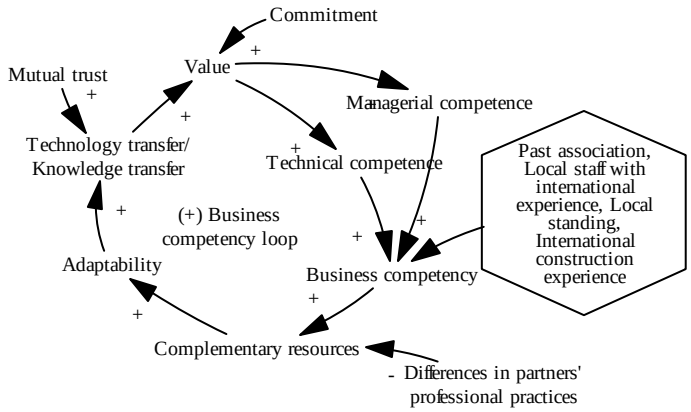
Key Feedback Loops

A set of dynamic hypotheses have been developed in order to investigate the effect of variables on performance of ICJV. The feedback loops have been developed by using the knowledge gained from literature review and interviews conducted with the concerned personnel in the case study joint ventures. The whole causal-effect relationships or feedback loops have been broken down into feedback loops concerning value (Figure 2), feedback loops concerning project output (Figure 3a) and feedback loops concerning satisfaction (Figure 3b).

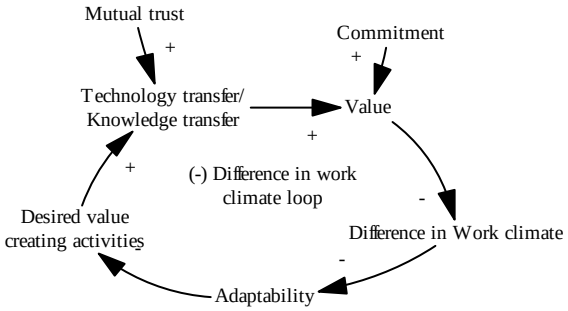
Feedback loops concerning value

Business competency loop: Shenkar and Li (1999) found that partners tend to see that IJVs are the preferred way to gain tacit or embedded knowledge, particularly management skills or intangibles. More explicit knowledge such as marketing and technological may be equally learned by other forms of alliances as by IJVs (Pucik, 1988). The technical and managerial knowledge transfer can be described as 'value'. The 'value' increases managerial as well as technical competency which in turn increase business competency.

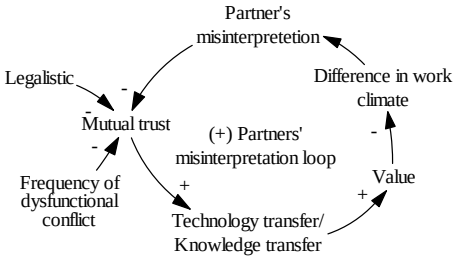
Business competency loop



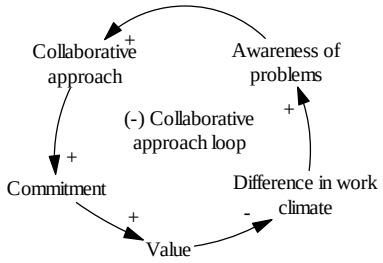
Difference in work climate loop



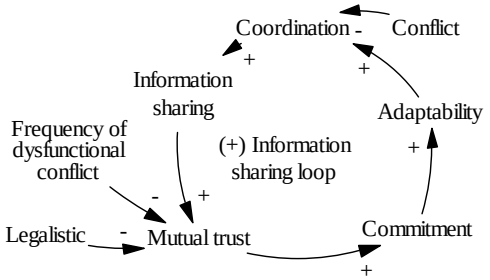
Partners' misinterpretation loop



Collaborative approach loop



Information sharing loop



Legend: ⟶ A causal relationship; + (-) signs at the arrowheads indicate that the effect is positively (negatively) related to the cause

Figure 2: Feedback loops concerning value

Business competency is also positively affected by local staff of international experience, past association, local standing and international construction experience. However, differences in partners' professional practices induce negative impact on complementary

resources as there are differences of using functional practices such as dissimilarity in using technical specifications, codes and different management system (i.e., accounting system, cost control system, quality control system, human resource management system etc.). Higher business competency enhances the chance to share resources as a part of complementary and which positively affects adaptability. The 'value' can be extended to include the cases in which the knowledge in question is itself a set of learning skills constituting of firm's adaptability or absorptive capacity. This capacity increases as a function of previous experiences through sharing of complementary resources, its learning processes, and the need for information that the partners consider lacking in order to attain its strategic objectives (Huber, 1991). The partner's ability to monitor, process, integrate and deploy new flows of knowledge will depend, among other things, on its ability to link this knowledge to its existing knowledge base. Furthermore, Huber (1991) also found that partners are more likely to search for partners with complementary knowledge, e.g., a managerial skill base complemented by a technological or marketing skill base. However, the level of expertise that a firm may actually gain through a technology transfer will vary. Leonard and Barton (1992) suggested that a higher adaptability will increase the technology and knowledge transfer and which lead more value added to the IJV.

Difference in work climate loop: The deep level of technological and managerial knowledge transfer (higher value) enhances the adaptability and competitiveness of the firm in a changing environment by reducing the difference in work climate. The higher 'value' of IJV means that the partners have adopted similar measurement and functional control systems and so the partners reduce desired 'value' creating activities. As the desired 'value' creating activities decreases, the level of 'value' of the IJV will be static or decrease. The decrement of 'value' level may be due to the adopted systems do not serve as efficient system and in addition to that changes in project scope may require more technical and managerial knowledge transfer.

Partners' misinterpretation loop: Higher difference in work climate increases misinterpretation between partners and consequently decreases mutual trust. The lower is the mutual trust; the lesser will be the technology/knowledge transfer. However, lower technology and knowledge transfer decreases 'value', problem solving as the partners are not willing to share knowledge due to lower trust level. So, lower value can not minimize the difference in work climate.

Collaborative approach loop: If companies are not aware of (the extent of) differences between partners, functional management tasks may not be carried out efficiently and tasks may be duplicated or tackled in incompatible ways. If differences become apparent through misunderstandings and conflicts, partners need to evaluate different approaches, which take longer the more dissimilar the approaches are. Sometimes, difference in work climate leads to increase awareness regarding the negative impact between the partners and try to minimize the difference by introducing collaborative approach. This collaborative approach will increase the commitment for long term relationships. As commitment increases, 'value' is also stimulated and in turn reduces the difference in work climate of the joint venture

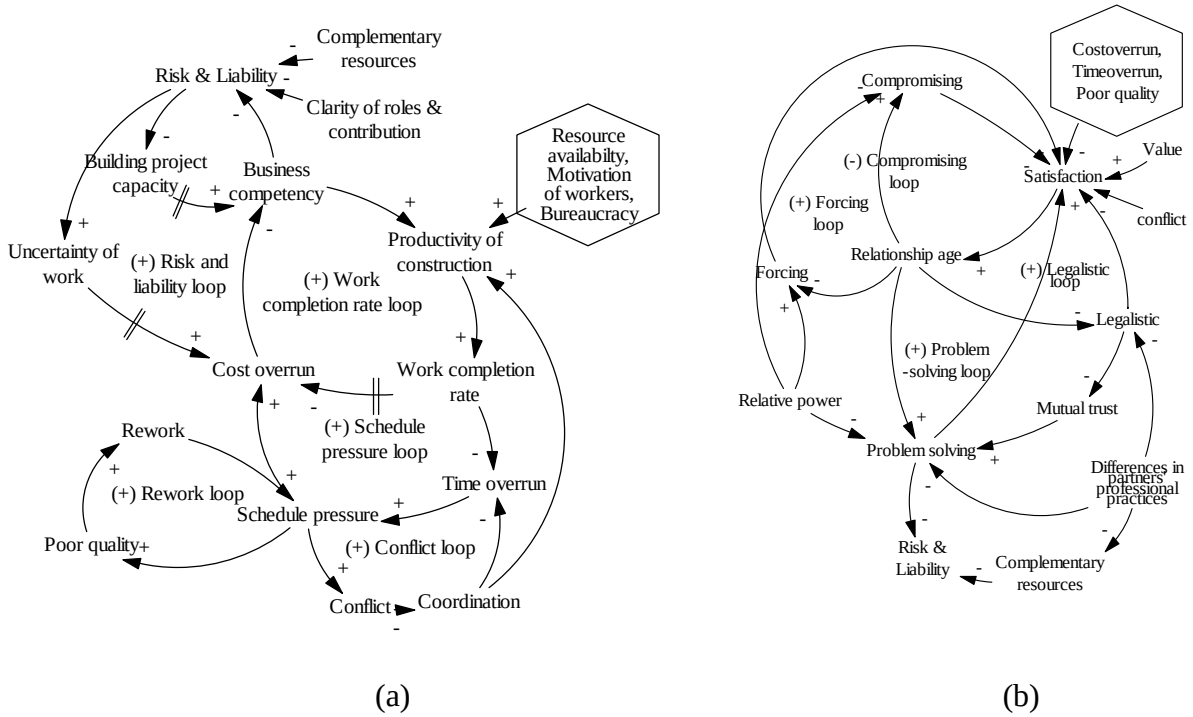
Information sharing loop: If the adaptability is higher, there will be more coordination among the different functional units due to less learning gap. Coordination induces an environment of openness which leads to increases information sharing among the project participants. Effective information sharing stimulates mutual trust as it reduces operation process delay.

Commitment for long term relationship is affected by the mutual trust between the partners. If the mutual trust is high, commitment will be high.

Feedback loops concerning project output

Work completion rate loop: If the business competency is high, then productivity of construction will be high due to intervention of new technology, and higher efficiency in operational control. Productivity of construction is also positively influenced resource availability, motivation of workers, coordination and negatively influenced by government bureaucracy for getting permit. Higher productivity increases work completion rate and higher work completion rate decreases cost overrun. As there is less chance of cost overrun, the business competency will be increased due to higher profitability.

Schedule pressure loop: On the other hand, if the work completion rate is lower, the probability of time overrun of the project will be more likely. Schedule pressure is affected by time overrun and it affects cost overrun due to overhead cost. Sometimes cost overrun creates financial instability which in turn negatively effect business competency.



Legend: ⟶ A causal relationship; + (-) signs at the arrowheads indicate that the effect is positively (negatively) related to the cause; ⫽⟶ Delay sign

Figure 3: (a) Feedback loops concerning project output; (b) Feedback loops concerning satisfaction

Rework loop: When the schedule pressure continues to increase as a result of an increase in aggressive scheduling it can bring about other negative effects on the work site. First, the higher the schedule pressure the greater will be the amount of work performed out of sequence. Second, workers may intentionally try to cope with schedule pressure by cutting corners. Third, an increase in schedule pressure may increase the number of work defects through the selective use of information, which, unlike the previous effect, can occur

unintentionally. This situation is due to the fact that under high-pressure conditions, site staff and workers are likely to engage in activities that make progress even though not all the prerequisite information is available. All these phenomena—working out of sequence, cutting corners, and work defects—are responsible for increasing the amount of rework. The increase in rework on construction sites is arguably a quality problem.

Conflict loop: Conflict may arise due to increase in schedule pressure and which leads to decrease in coordination of work in the project. As the coordination decreases, the process time will increase which in turn increase schedule pressure.

Risk and liability loops: If the company has higher business competency, then the probability of managing risk will be higher. The company increases their project capacity as there is less risk involved by investing more on similar type of project. On the other hand, if the risk is more, the uncertainty of work will be more. Uncertainty of work increases cost overrun due to more time is required to response the unexpected situation.

Feedback loops concerning satisfaction

Problem-solving loop: As a conflict resolution strategy, problem-solving approach tends to make a relationship more satisfying, since it aims at achieving positive outcomes for both partners (Campbell et al., 1988). So, the relationship age would be last long. As a relationship endures, shared experience may facilitate an open problem-solving approach to resolve conflicts. An ICJV partner can use its relative power as a mechanism to coordinate and integrate the activities of the two ICJV partners. But unbalanced power relations provide an incentive to less integrative behaviour when conflicts need to be resolved. The more powerful an ICJV partner, the more likely it is that a lengthy problem-solving process can be avoided, especially during the formative stage of an International Joint Venture (Friedmann and Beguin, 1971) that means higher difference in relative power reduce the probability of using problem-solving as a negotiation strategy.

Compromising loop: Compromise approach tends to make a relationship less satisfying and is likely to be observed in short term relationships, since long term partner often understand better that short-term asymmetries in bargaining outcomes are likely to balance out in the long run (Dwyer et al., 1987). The more powerful an ICJV partner, the more likely it is for the partners not to seek compromise, since their powers offer them leverage with which they can make their preferences prevail.

Forcing loop: In general, power asymmetries induce more chance for partner to engage in more demanding coercive behaviour (i.e., forcing). The tendency to be forceful during a conflict may decline with IJV age, since partners are more likely to become concerned with the other party's interests.

Legalistic loop: A party's reliance on legal mechanisms may decline as an IJV ages, since uncertainties regarding the other party's competence, reliability, and other qualities tend to decrease over time. When IJV partners view one another regarding difference in professional practices, the feeling of a lack of common ground may result in higher degree of perceived behavioural uncertainty. As a consequence, the parties may be more likely to place their trust in legal and written documents and hence to rely upon legal mechanism for resolving conflicts which tend to make a negative impact on satisfaction when more legal changes are occurred.

Model Formulation

The structure of the generic model has been developed based on the aggregated views and opinions of the interviewees. The generic model is preliminarily divided into three subsystems (value, project output and satisfaction). Also, each subsystem can be divided into sectors. While implementing in real case studies, the generic model has been modified into two different models for two different ICJV projects. In the modified models only the input values are different but the structures are same as generic model. The modified model's scope and focus are reflected in the model boundary as shown in Table 1. The modified model consists of various variables. The interrelationships among the variables have been translated in terms of equations and graphical representations. The details of the model formulation and output of the simulations are somewhat large in volume. The whole set of representations related to model formulation can be provided upon request.

Table 1: Model boundary chart

Endogenous	Exogenous	Excluded
Mutual trust, Partner's commitment, Difference in work climate, Conflict resolution procedure, Communication and information exchange, Legalistic, Managerial competence, Technical competence, Financial status, Business competency, Complementary resources, Productivity in construction, Project scope, Coordination, Frequency of negotiation, Conflict, Project scope, Project output	Local standing, Past association, Prior ICJVs experience, Local staff with international experience, Fluctuations in exchange rate, Change in material price, Difference in partners' professional practices, Bureaucracy, Resource availability, Relationship age, Relative power, Clarity of roles and contribution	Changes in policies, Inconsistencies in laws and regulations Corruption and bribery, Cash flow problems, Incompetent suppliers or subcontractors, Local business environment, Market contacts and knowledge

Model Behaviour, Validation and Sensitivity Analysis

The model has been validated in terms of structurally and behaviourally. Structural validation includes structural assessment test and dimensional consistency check. Structural assessment test is related to check interrelationship among variables. In the second phase interviews, all the equations and graphical relationships have been checked thoroughly by the interviewees and rectified any corrections at the same time. Dimensionally consistency check is automatically tested by the inherent function of Powersim®. Behavioural validation can be done by comparing base run with reference mode and also by parameter sensitivity analysis. While comparing base run (Figure 4a) with historical data (Figure 1), the output of the model replicates historic data well. Parameter sensitivity is usually performed as series of tests in which the modeller sets different parameter values to see how a change in the parameter causes a change in the dynamic behaviour of the model. The sensitivity analysis has been done for the model and it has been found that the model is numerically, behaviourally or policy sensitive.

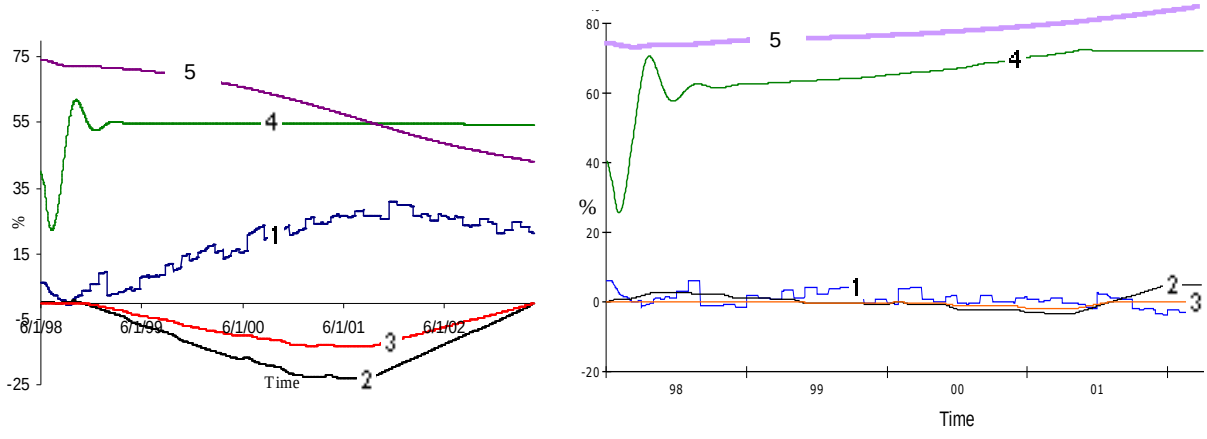
Formulation of Policies

While simulating the model, three major types of problems have been identified for both the projects as shown in Table 2. In order to identify a set of effective and implementable policies in order to improve performance of ICJV, extensive model simulations have been made. In these simulation runs, certain parameters value used for the degree of importance of the specific variables do not necessarily show the exact numerical values rather emphasis is given on the degree of importance of these variables.

Table 2: Policy formulation

Problems	Policy	Remarks
Delay, cost overrun and poor quality: Low productivity (unavailability of skilled labour and lack of motivation)	Performance based incentive,, Problem solving team, Multiple skilled training of workers(Policy I)	Apart from improvement in project output, significant positive changes observed in business competency for project A and satisfaction level in project B.
Negative value gap (difference between desired value and actual value) due to low adaptability	Training, Workshops, High performance team (Policy II)	Policy has made a significant impact on mutual trust, business competency and satisfaction level for both Project A and Project B
Ineffectiveness of information sharing	Integrated proactive team, 'Project web' (Policy III)	Policy has made a significant improvement in trust level for both project A and B

Initially, three policies are addressed as to improve performance components rather than whole performance and identified evolutionary change in the behavioural sensitive parameters but later on integrated all three policies to get the maximum performance improvement (Figure 4 b).



(a) (b)

Legends: 1-project cost discrepancy; 2-schedule pressure; 3-quality discrepancy; 4-value; 5-satisfaction

Figure 4: (a) Base run; (b) After implementing integrated policy

CONCLUSION

The paper explores the dynamic behaviours of ICJV performances by developing generic performance model. While calibrating and testing of the generic performance model with data from two ICJVs in Thailand, the simulated behaviour (base run) of the adopted model has been replicated with the historic behaviour (reference mode) for both cases. This implies that the generic system dynamics performance model can be able to facilitate managers of an ICJV to identify the factors and causes of problems related to performance gap by adjusting inputs of exogenous variables with their real scenario. Based on the case studies, three policies are suggested in order to improve ICJV performance level and integration of these three policies result maximum improvement of performance level. The future research directions related to this study are suggested to incorporate more government related (changes in government policies and inconsistencies in laws and regulations) and project related factors (incompetent suppliers or subcontractors and local business environment) in the performance model.

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