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# Structural equation model for investigating factors affecting delay in Indian construction projects

HEMANTA DOLOI[1]*, ANIL SAWHNEY[2] and K.C. IYER[2]

[1]*Faculty of Architecture, Building and Planning, University of Melbourne, Melbourne 3010, Australia*
[2]*Department of Civil Engineering, Indian Institute of Technology Delhi, New Delhi 110016, India*

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The rapid growth of the Indian construction sector over the last few decades and recurring failure in on-time delivery highlight the need for a systematic analysis of the factors influencing delay. A theoretical structural equation model representing the influence of four key latent variables on project delays in the Indian construction industry has been developed. Data collected from a questionnaire survey and personal interviews, with 77 valid responses from clients, contractors and designers or architects, were used to further formulate and analyse the model. The results of the structural equation model suggest that client's influence is one of the most significant factors affecting time performance on Indian projects. Client's influence is also found to be one of the key contributing factors resulting in lack of commitment and contractor's inefficiency in the project. Lack of efficient construction planning plays the second key role in adverse time performance. While the effect of lack of commitment on contractor's inefficiency is highly significant, neither of these two factors has any direct impact on time delay in projects. Contrary to the notion that the contractor is the only party responsible for delay in construction projects, the results clearly highlight the importance of the role of clients and technical expertise in planning in achieving satisfactory time performance on Indian projects. It is hoped that these research findings will contribute significantly to the Indian construction industry's efforts in addressing the root causes of delay and enhancing the time performance on projects.

*Keywords:* Delay, India, structural equation modelling, time.

## Introduction

The contribution of the Indian construction sector to the growth of the Indian economy and rapid socio-economic development of the entire country over the past few decades is highly phenomenal (Gupta *et al.*, 2009). The construction sector is the second largest economic sector after agriculture with annual contributions of around 6% to 9% to India's GDP over the past five years. As per the Planning Commission of India (2011), the investments made in construction were reported to be approximately US$100 billion in 2008 with a persistent growth pattern expected for much of the next decade. Expenditure of US$1 trillion over the next five years on infrastructure is now being predicted. As per government data, the demand for construction manpower is also projected to grow at a consistent pace of 8%–9%, thereby resulting in an annual addition of around 2.5 million jobs to the existing stock with approximately 125 000 new engineering jobs being added annually. Paradoxically, notwithstanding its economic importance and employment potential, the construction sector is marred by issues such as low productivity, limited mechanization and lack of professionally qualified employees. Government and industry data suggest that up to 60% of projects are currently being plagued by time and cost overruns resulting in loss over US $80 billion in the sector (Gupta *et al.*, 2009). While on average 20% to 25% time and cost overruns are the norm in most building projects, some sectors such as petroleum, power and railways have reportedly been suffering overruns as high as 50% (Ernst & Young, 2011).

While the importance of the Indian construction sector over the past five years has grown significantly,

*Author for correspondence. E-mail: hdoloi@unimelb.edu.au

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lack of sophistication across the construction supply chain is one of the key issues challenging the industry (Sawhney *et al.*, 2011). As evident from numerous publications on the Indian construction sector, projects are reportedly failing across all the key performance measures including cost, time and quality performances. Based on an investigation report by Ernst & Young in February 2011, out of a total of 559 ongoing infrastructure projects in India, 293 were delayed (Ernst & Young, 2011). Out of the delayed projects, 69 were a month to a year behind schedule, while 67 projects were delayed by 13–24 months, 107 by 25–60 months and 37 by over 60 months. With inflationary pressures in the current Indian economy, such time delays in 293 projects potentially added an incremental cost of INR682.7 billion (approx. US $105 billion) amounting to a 22.3% effective cost escalation (Ernst & Young, 2011). In a study comparing the performance of international development projects in India, China, Bangladesh and Thailand, it was reported that construction projects in India showed the worst schedule performance (Ahsan and Gunawan, 2010). The study found that in India average schedule overrun of 55% over planned schedule is the highest compared to the other nations included in the study.

In the wake of the 2010 Commonwealth Games, construction projects, especially infrastructure projects, in India have come intensely under the international spotlight (*Hindustan Times*, August 2009). The current status report published by the Indian Ministry of Statistics and Programme Implementation (MOSPI) highlighted that out of the 951 projects being monitored 309 projects have cost overruns and 474 projects are behind schedule (Kishore, 2004).

While the intrinsic factors affecting the time and cost performance in projects have been widely published within the mainstream construction management research, at least in the Indian context, a clear analysis of this chronic issue of time performance of construction projects is still hard to find. Although many studies have published causes and factors affecting schedule and cost performance using numerous techniques (Odeyinka and Yusif, 1997; Assaf and Al-Hejji, 2006; Jha and Misra, 2007), most of these studies failed to examine how the identified causes work together to influence schedule performance in projects. Moreover, in producing area-specific identification of the causes and factors without understanding the collective influence on schedule performance in quantitative terms, such researches do not provide a very convincing argument for preventing delay in the context of Indian construction projects. With the stated situation in the Indian construction sector, quantification of the relationships among different causes of delay in Indian construction projects is certainly an important topic for investigation. Given this background, the primary objectives of this research are to:

- use data from the Indian projects to identify the key factors for investigating their relationships and collective influence on time delay in Indian construction projects;
- develop a structural equation model to analyse the relationships with quantitative impact value among the identified causes of time delay in Indian construction projects.

Structural equation modelling (SEM) is a tool developed largely by sociologists and psychologists (Yang and Ou, 2008). SEM is a multivariate technique for estimating a series of interdependent relationships among the latent or independent variables quantitatively (Molenaar *et al.*, 2000). Although SEM is widely applied across many disciplines, applications in construction management research are not widespread. In an investigation for quantifying the impacts of factors on contract disputes between owners and contractors in the construction industry, Molenaar *et al.* (2000) asserted that SEM methodology is far more useful over multivariate or logistic regressions especially in the situation of poorly measured variables in the data sample. Analysing the quantitative influence of project environment and organizational related factors on effective project planning, Islam and Faniran (2005) highlighted the effectiveness of the SEM approach in modelling multiple latent factors (Islam and Faniran, 2005). Their study concluded that SEM is highly effective in terms of understanding the direct and relative impacts of latent factors on the measured phenomena (e.g. project planning efforts) in the hypothetical construct. Over past years, numerous empirical studies have demonstrated the usefulness of the SEM method for determining relationships among key correlative factors. Wong and Cheung (2005) demonstrated the SEM approach in examining partner trust level in performance, permeability and relational bonding on partnering success. Investigating the relationship among key causes of delay in Taiwanese construction projects, Yang and Ou (2008) established that SEM is capable of quantifying the comprehensive relationships among latent factors for resolving problems in the construction industry. Doloi (2009b) used SEM in investigating the influence of communication, trust or confidence and joint risk management on relational partnering success. Based on these findings, it is clear that the SEM methodology is suitable for exploring the relationships among multiple latent factors and resolving complex interactions with the measured outcomes within construction practices.

By applying the SEM methodology, the research extends the knowledge contributed in a previous study on the Indian construction industry (Doloi *et al.*, 2012) that investigated the causes of construction delay using a structured questionnaire survey. The findings of the study established some of the root causes of delay in Indian construction projects based on factor analysis and regression modelling. The focus of this investigation is to provide a further insight into the influence of four hypothesized latent variables and their underlying attributes on construction delays. This study is significant because of the recurring failure of Indian construction projects to meet time schedules and the lack of clarity as to the root causes of delay in the construction value chain. In the event of a construction boom, such chronic problems must be addressed by highlighting the key issues against the perceived concerns among the construction professionals so that the appropriate industry standards can be developed for achieving success across the industry sector. The research also contributes to the methodological construct by describing the application of structural equation modelling in the problem domain and putting forward a precise framework for understanding the complex interactions of the latent factors within the construction domain.

## Literature review

Time performance of construction projects has been a research topic for several decades, with equal attention being paid to the topic by practitioners. Some country- or region-specific work related to delay analysis reported by El-Razek *et al.* (2008), Sambasivan and Soon (2007) and Iyer and Jha (2005) has highlighted the complexity of this issue across many countries (Sambasivan and Soon, 2007). An extensive body of literature on this subject exists and is summarized below with the aim of documenting the current state of the art.

Arditi *et al.* (1985) studied the causes of delay in Turkish public sector construction projects in the 1970s and 1980s by surveying public agencies and contractors involved in public sector projects. This study divided the identified factors into those that are influenced by national policies and those that can be controlled by public agencies and contractors. The findings suggested that the effects of construction delay are not always confined to the construction industry but influence the overall state of the economy of a country as well. Thus the causes of delay should be understood and analysed from the perspectives of both public agencies and contractors so that management responsibility can be appropriately shared for an effective outcome in the project. Investigating the factors causing delay in construction projects in the United Arab Emirates (UEA), Faridi and El-Sayegh (2006) reported that over 50% of construction projects experience delays due to factors such as delay in approval of construction drawings, poor preplanning and a slow decision making process. Comparing the key factors of construction delay across UAE, the Kingdom of Saudi Arabia (KSA) and Lebanon, the research established that delay in approval, owners' slow decision making and material shortages are common causes of construction delay across the region. However, the finding that certain high ranked factors in UAE had no significant impact on KSA construction projects clearly highlights the fact that factors causing construction delay cannot be considered common across countries. Supporting the findings by Arditi *et al.* (1985), the need for effective management of time performance by addressing the root causes of delay associated with the specific location and underlying cultural issues across the construction industry was suggested. This clearly shows the need for understanding the critical factors for addressing the chronic issue of construction delay in the Indian context.

Based on a survey by Al-Khalil and Al-Ghafly (1999) in the Eastern Province of Saudi Arabia it was reported that 59% of projects completed during the period of 1985–90 were delayed. One of the key reasons for delay was lack of agreement between project stakeholders across most construction projects (Al-Khalil and Al-Ghafly, 1999). Carrying out a similar study in Saudi Arabia examining seven key sources of delay, namely client, contractor, consultant, materials, labour, contract and relationship related causes, Al-Kharashi and Skitmore (2009) reported that the lack of qualified and experienced personnel was one of the most influential causes of delay. The particular cause was reportedly attributed to a considerable amount of large, innovative, construction projects and associated current undersupply of manpower across the industry. Emphasizing the controlling aspects of construction projects, Olawale and Sun (2010) conducted a study in the UK to determine inhibiting factors and mitigating measures in practice relating to time and cost overruns. Based on a survey of 250 construction project organizations, this research reported management strategies of five key inhibiting factors such as design changes, risk and uncertainties, inaccurate estimation, complexities and non-performance of subcontractors within four key principles namely preventive, predictive, corrective and organizational support. While identification of such management measures was an interesting contribution, lack of quantification of impacts of the inhibiting factors on the cost and time performance made the research inconclusive in the context of appropriateness and effectiveness of such measures in reality. Based on the responses to a questionnaire survey received from 29 construction firms, Nkado (1995) prioritized the issue of time performance of construction projects in the UK from the contractors' perspective. The findings were that the top order issues are much more technical and can be well controlled by contractors in most projects. However the bottom order issues are usually not assessed explicitly and do not fall under the direct control of the contractors. Following an interview-based questionnaire with 10 Singaporean firms operating in the Indian market, Ling and Hoi (2006) provided time performance guidelines for Singaporean contractors working in India. Among the findings, one of the key factors identified was the requirement for careful planning and management with appropriate support from local experts. Cultural diversity was considered to be an important consideration in achieving success in projects.

El-Razek *et al.* (2008) identified the main causes of delays in Egyptian construction projects. They used an importance index and Spearman's rank correlation similar to Assaf *et al.* (1995) and concluded that different construction stakeholders don't agree on the relative importance of various factors of delay, mostly blaming each other for delays. It was established that the most important causes of delay were contractor's cash flow, payment by owner to contractor, design changes by owner and non-professional construction personnel and contract administration. While a team-based effort for management of these issues was suggested, lack of understanding of the influence of these causes on project delay failed to reveal the acceptance of responsibilities among the parties in the project. Investigating the causes of delay in Hong Kong construction projects, Lo *et al.* (2006) analysed 30 attributes divided into seven categories, namely client related, engineer related, contractor related, human behaviour related, project related, external factors and resource related. Using rank agreement factor (RAF), percentage agreement (PA) and percentage disagreement (PD) the differences in perceptions of various construction practitioners on causes of delay were discussed. The results revealed that while the clients and consultants admit to their own faults and are often responsive to effective mitigation measures, contractor groups tend to interpret the issues quite differently (Lo *et al.*, 2006). However, that the third cause in the top 10 significant causes of construction delay is 'contractor's low bid' was agreed by clients, consultants and contractors.

In Nigeria, Aibinu and Odeyinka (2006) identified 44 factors of delay under nine categories based on the work of Bramble and Callahan (1992) and Odiyenka and Yusif (1997). Based on covariance analysis and Pareto analysis, it was found that 88% of the factors contribute to 90% of delays and the authors thereby concluded that there is no discernible difference among the different delay factors and none of them really stands out as the largest contributor to the problem. Adopting a questionnaire survey approach for understanding the causes and effects of construction delays in Malaysian construction projects, Sambasivan and Soon (2007) identified 10 important causes and six main effects of delays using a relative importance index and Spearman's rank correlation (Sambasivan and Soon, 2007). Among the 10 causes, eight of them were related to contractor's inability to plan and manage the project across all phases of construction. The assertion of client being responsible for inadequate finance and poor communication in project does not support in the findings by a number of researchers including Aibinu and Odeyinka (2006), El-Razek *et al.* (2008), Lo *et al.* (2006) and Kharashi and Skitmore (2009). While this research highlights some of the obvious effects of time delay, a clear linkage between the causes and effects in terms of quantification of impacts meant that the research was not comprehensive.

Assaf *et al.* (1995) identified 56 causes of delay under nine major groups and evaluated their relative importance by a questionnaire survey and an importance index. Using Spearman's rank correlation, it was concluded that contractors, owners and architects in general agree to the ranking of individual delay factors while contractors and architects substantially agree with ranking of groups of delay factors, but contractors and owners, and architects and owners don't agree (Assaf *et al.*, 1995). In a separate study, based on a field survey of 23 contractors, 19 consultants and 15 owners in the Saudi construction industry and using a frequency index (FI) and a severity index (SI), Assaf and Al-Hejji (2006) later identified that the most common cause out of 73 listed causes of delay is the change orders by the owner during construction. The contrast in findings of these two studies by the same authors highlights the fact that a general consensus of the delay issues in Saudi construction practices could not be achieved.

Focusing on the Indian construction industry, Iyer and Jha (2005) identified project success and failure attributes and their latent properties. While the success factors are generally linked to competent personnel and good management practices, failure attributes are predominately linked to the cost and time performance of projects. The identified failure attributes were conflict among project participants; ignorance and lack of knowledge; the presence of poor project-specific attributes and the non-existence of cooperation; hostile socio-economic and climatic conditions; reluctance to make timely decisions; aggressive competition at the tender stage; short bid preparation time (Iyer and Jha, 2005). While identification of these empirical attributes has revealed some of the underlying issues in the Indian construction industry, the exclusion of scope for any further investigation in understanding the quantitative influence on cost and time performance meant that this research was not comprehensive.

Employing a questionnaire-based approach in the Hong Kong construction industry, Kumaraswamy and Chan (1998) examined 83 delay attributes grouped under eight categories: project related factors, client related factors; design team related factors; contractor related factors; materials; labour; plant and equipment; and external factors. Based on the relative ranking index of these attributes reflecting the perceptions of three key stakeholders namely clients, consultants and contractors, the findings confirmed that higher productivity and effective communication are the two most significant factors influencing time performance in projects. However, in a previous study on the same groups of attributes, Chan and Kumaraswamy (1997) highlighted five principal delay factors, namely poor site management and supervision, unforeseen site conditions, slow decision making involving variation, client initiated variation works and necessary variations of works (Chan and Kumaraswamy, 1997). While perceptive judgement based on the relative importance index of the delay attributes is clearly reported in both these studies, objective assessment of the collective impact of these factors on time performance in projects has not been reported comprehensively

Odeyinka and Yusif (1997) reviewed the causes of delays in housing projects and identified the main categories as: client-, consultant- and contractor-caused delays, and extraneous factors in Nigeria. The research established that client-caused delays predominately arise from design variation in projects. Mansfield *et al.* (1994) reviewed the causes of delays and cost overruns and found that there was a very good agreement between the respondents on those factors that could cause delays and cost overruns. The four most important items agreed on by the contractors, consultants and public clients surveyed were found to be the financing of and payment for completed works, poor contract management, change in site conditions, and shortages of materials.

Based on a questionnaire survey in the Taiwanese construction industry and SEM analysis results, Yang and Ou (2008) asserted that non-human related causes play a significant role in achieving time performance in projects. Among the six key factors across the project development environment, unforeseen site conditions was presented to be the most critical non-human related factor in Taiwanese construction projects. Site conditions being a localized cause associated with specific projects, the assertion at to the criticality resulting from this research however could not be considered conclusive in a generic project context.

From the above selected literature review, it is apparent that in most studies, priority has been given to identifying the critical causes based on perceptions of different parties in construction. However, quantification of the dependencies of one factor on another and their relative impacts on construction delay in the context of project outcome being influenced by the factors collectively has not been found in many studies. Hence it is important to identify the precise relationship between various key factors of delay and their interactions in relation to overall delay in projects. Research is yet to be conducted in identifying the relationship between the relative importance of delay factors when these factors are present in groups and developing some sort of capability for explaining the quantitative impacts on delay.

## Selection of the key factors and rationalization

In the construction domain, the causes for delay in completion of any activity over the construction phase and that subsequently affect the completion time are known as delay factors (O'Brien and Plotnick, 1999). Research published over the past few decades has identified numerous factors affecting delay in construction projects. While there is a high degree of similarity in the delay factors across many projects, the factors associated with the Indian construction industry do not necessarily follow suit (Ernst & Young, 2011). A number of studies conducted in the Indian context have established that the primary reasons for time overruns in Indian construction projects are inadequate design and planning coupled with scope creep and regulatory hurdles (Singh, 2010; KPMG and PMI, 2012). As reported earlier, while a recent study by Doloi *et al.* (2012) revealed some of the unique characteristics of the factors affecting time performance in the Indian construction context the investigation did not cover the direct and relative impacts of such factors on time delay. This study is an extension of the previous study. Based on a questionnaire survey and factor analysis method, the previous study identified seven key factors affecting time delay in Indian construction projects (Doloi *et al.*, 2012). Upon presenting the findings and discussion with five scheduling experts and senior project managers, a total of four factors have been confirmed as most common in the majority of Indian projects. The four factors are contractor's inefficiency (CNI), lack of commitment (LC), improper planning (IP) and client's influence (CI). While the bulk of the underlying attributes grouped under these four latent factors have been selected as measured variables, based on the expert consultations, two attributes, namely 'use of obsolete construction methods' and 'improper material storage' have been removed. However, three additional attributes namely 'poor site management and supervision', 'delay in approval of completed work by client' and 'poor organisational structures for client or consultant' have been added in the total of 19 measured variables. Table 1 shows the four latent factors and the respective measured attributes in the hypothetical construct of the research.

Linking contractor's poor performance to the time delay, many researchers have identified estimation ambiguity and misunderstanding of the project specification at the pre-tender stage as among the key attributes causing failure of contractors in most projects (Satyanarayana and Iyer, 1996; Iyer and Jha, 2005). Contractor's inefficiency is characterized by ambiguity in estimations, lack of relevant experience, poor onsite productivity and lack of control over subcontractors. Lack of relevant experience and poor control of onsite resources and performance of subcontractors have been known to hinder a contractor's success in a project (Sambasivan and Soon, 2007). Lack of commitment is usually evident from the practices of poor site management, delay in material delivery, frequent occurrence of accidents due to lack of safety measures and lack of enthusiasm and motivation in the project (Satyanarayana and Iyer, 1996; Chan and Kumaraswamy, 1997; Doloi *et al.*, 2012). Improper planning has reportedly been the result of poor coordination among parties in relation to their understanding of the job, roles and responsibilities in the project (Doloi *et al.*, 2012). Delay in delivery of materials and inefficient use of construction equipment have been found

**Table 1** Constructs and measurements

| Factors | Attributes/indicators | Source reference |
|---|---|---|
| Contractor's inefficiency (CNI) | Ambiguity in estimations (N1)<br>Inadequate experience of contractor (N2)<br>Poor labour productivity (N3)<br>Lack of control over subcontractor (N4) | Satyanarayana and Iyer (1996); Sambasivan and Soon (2007); Odeh and Battaineh (2002) |
| Lack of commitment (LC) | Poor site management and supervision (L1)<br>Delay in material delivery by vendors (L2)<br>Site accidents due to lack of safety measures (L3)<br>Lack of motivation for contractor (L4) | Chan and Kumaraswamy (1997); Satyanarayana and Iyer (1996) |
| Improper planning (IP) | Poor coordination among parties (P1)<br>Delay in material procurement (P2)<br>Inefficient use of equipment (P3)<br>Lack of skilled operators for specialized equipment (P4)<br>Extreme weather conditions (P5) | Lo *et al.* (2006); Assaf *et al.* (1995); El-Razek *et al.* (2008); Ahsan and Gunawan (2010) |
| Client's influence (CI) | Delay in approval of completed work by client (C1)<br>Frequent change of subcontractor (C2)<br>Increase in scope of work (C3)<br>Rework due to errors in execution (C4)<br>Rework due to change of design (C5)<br>Poor organizational structures for client or consultant (C6) | Semple *et al.* (1994); Aibinu and Odeyinka (2006); Odeh and Battaineh (2002); Al-Kharashi and Skitmore (2009) |

highly significant in terms of maintaining the planned progress and meeting the targets in the project schedule. Extreme weather conditions and geographical location further increase the complexity in maintaining the planned schedule in projects (Assaf and Al-Hejji, 2006; Lo *et al.*, 2006). As far as the client is concerned, lack of proactive influence of clients in terms of delay in the approval process has reportedly been a key cause of construction delay. Clients' requirements in terms of frequent change of contractors or subcontractors, change of scope or change of design are reported to be common causes of delay across many projects. Lack of an organizational structure and communication and reporting protocol between clients and consultants impedes contractors' performance in achieving time performance in large projects (Semple *et al.*, 1994; Aibinu and Odeyinka, 2006).

## Theoretical framework

The above review provides the theoretical basis to develop the research framework for this study. It is hypothesized that contractor's inefficiency (CNI), lack of commitment (LC) of contracting parties, improper planning (IP) and client's influence (CI) collectively affect the time performance in projects.

In order to explore the influences of these four key latent factors on construction delay, the research sets out four hypotheses as follows:

*Hypothesis 1*: Frequency of occurrence of inefficient contractor (CNI) influences overall impact on construction delay (CD).

*Hypothesis 2*: Frequency of occurrence of lack of commitment (LC) influences overall impact on construction delay (CD).

*Hypothesis 3*: Frequency of occurrence of improper planning (IP) influences overall impact on construction delay (CD).

*Hypothesis 4*: Frequency of occurrence of lack of proactiveness or initiative from client (CI) influences overall impact on construction delay (CD).

While testing the direct influences of the above key factors on construction delay, the interdependence of one factor with another in the structural model is also an important aspect for investigation. The interdependent relationships of these factors and their potential influence on one another have been reported in numerous other research works (Odeh and Battaine, 2002; Kumaraswamy *et al.*, 2005; Lo *et al.*, 2006). Thus the following additional hypotheses have been further developed to test the relative impacts of factors on one another:

*Hypothesis 5*: Frequency of occurrence of lack of commitment (LC) triggers the frequency of occurrence of inefficient contractor (CNI).

*Hypothesis 6*: Frequency of occurrence of lack of commitment (LC) triggers the frequency of occurrence of improper planning (IP).

*Hypothesis 7*: Frequency of occurrence of lack of proactiveness or initiative from client (CI) triggers inefficient contractor (CNI).

*Hypothesis 8*: Frequency of occurrence of lack of proactiveness or initiative from client (CI) triggers lack of commitment (LC).

*Hypothesis 9*: Frequency of occurrence of lack of proactiveness or initiative from client (CI) triggers improper planning (IP).

*Hypothesis 10*: Frequency of occurrence of inefficiency in contractor (CNI) triggers improper planning (IP).

A hypothetical diagram of the structural model is presented in Figure 1. The arrow represents the direction of hypothesized influences in the structural model.

### Research method

For this research, a quantitative approach has been adopted to test the conceptual model in the Indian construction context. In order to collect the data on the measured attributes, a questionnaire survey was designed. The respondents were asked to assess the perceived influence of the measured attributes in the form of an affirmative question by selecting one of the projects in which they had participated. A five-point Likert scale (1= strongly agree, 2 = agree, 3 = neither agree/nor disagree, 4 = disagree and 5 = strongly agree) was adopted for guiding the participants to provide their objective responses with varying degrees of agreement or disagreement.

### Preparation of the questionnaire

Identification of the measured attributes for the study and preparation of the questionnaire are crucial steps for the success of the research. A significant amount of work has already been done on the causes of construction delay and there is a well-documented

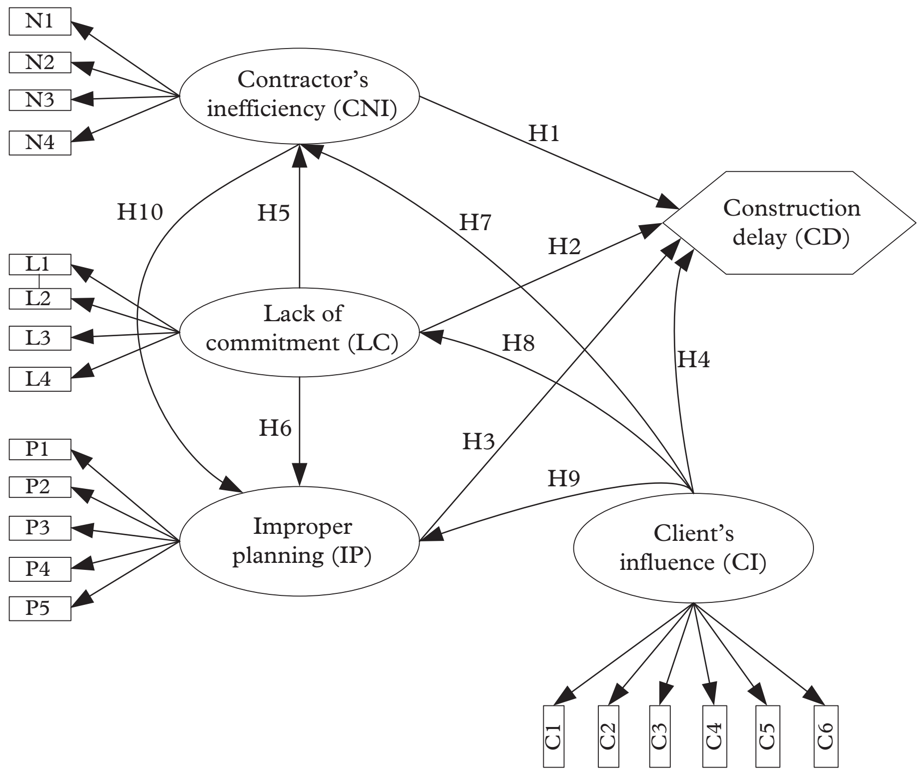


**Figure 1** Hypothetical model of the factors influencing construction delay

and peer-reviewed set of delay attributes available in the literature. For this research, the questionnaire has been prepared by incorporating the key delay attributes representing the four dependent constructs reported in the literature (Semple *et al.*, 1994; Satyanarayana and Iyer, 1996; Odeh and Battaineh, 2002; Lo *et al.*, 2006; Doloi *et al.*, 2012). To reflect a cross-section of the already available delay attributes in the Indian context and validate the selection of the measured attributes, personal interviews were conducted with a focus group of five experts from the Indian construction industry. Before undertaking the industry-wide survey, the final questionnaire was then further refined by reflecting the feedback received.

## Respondents' profiles

Respondents for this study are selected from a range of professionals engaged in the Indian construction sector (contractors, clients and engineers). All the respondents identified for this study had experience on relatively large construction projects in India, with a rich mix of professionals from owners, architects or designers and head contractor organizations. Table 2 provides the descriptive statistics of the respondents' profiles in terms of their professional roles and experience in the industry. In order to seek the best possible response for this study, introductory conversations and e-mail contacts were made with each respondent to explain the objectives of the research. Despite numerous attempts to recruit a much bigger sample (with a target of over 250) for the study, confirmation of willingness to participate was received from only 110 respondents spanning 86 firms. During the conduct of the survey, all the respondents were actively involved in medium (Rs.500Crores ~ US$100M) to large (Rs.3000Crores ~ US$600M) sized construction projects. Thus a total of 110 questionnaires were sent to these pre-identified groups of respondents located in 86 firms. Of 110 questionnaires, only 77 responses were valid, representing a response rate of 70%. Much missing or incomplete data made the rest of the questionnaire responses invalid. Though the sample size is relatively small, the quality of the responses was considered highly reliable for the analysis because of the respondents' relevant industry experience, personal interactions and clear understanding of the questionnaire (Vaus, 2001).

Usually, the covariance-based SEM methodology requires a relatively large sample size owing to its underlying objective of a hypothesized model being validated in the analysis. However, there is a significant disparity in use of the term 'large' among the researchers across a range of disciplines (Tenenhaus, 2008). While a rule of thumb suggests the data size for covariance-based SEM to be in the order of 10 to 20 times

**Table 2** Summary of respondents' profiles

| Nature of work | Experience (years) <5 | 5–10 | 10–20 | >20 | Total in each category | % role of profession |
|---|---|---|---|---|---|---|
| Client | 3 | 3 | 2 | 8 | 16 | **21** |
| Contractor | 15 | 16 | 12 | 8 | 51 | **66** |
| Designer/Architect | 4 | 4 | 2 | 0 | 10 | **13** |
| Total | 22 | 23 | 16 | 16 | 77 | – |
| % by experience | **29** | **30** | **21** | **21** | – | – |

the model parameters, the existence of numerous exceptions in the mainstream literature highlights the lack of a clear consensus on any acceptable numbers. For instance, based on 61 valid datasets collected from 52 construction firms, Islam and Faniran (2005) presented an assessment model for quantifying the influence of project planning effectiveness in the Australian construction industry. Using the SEM methodology on 87 responses, Eriksson and Pesamaa (2007) successfully unveiled some of the key issues of procurement effects on cooperative arrangements within construction organizations. An investigation carried out by Jin *et al.* (2007) for understanding the relationship-based determinants of building projects was based on 116 responses collected from the Chinese construction industry. Doloi's (2009b) finding that communication is the key factor in relational partnering success used 97 targeted responses in an SEM analysis based on Australian construction projects. Investigating the factors affecting lean manufacturing practices across different industries, Vinodh and Joy (2012) applied the SEM approach based on 60 valid responses collected from 60 manufacturing firms in India. As evident from the above review, the prescriptive requirement of the sample size in relation to measured parameters used in SEM analysis cannot be generalized. The 77 responses, by virtue of being highly reliable, collected from pre-selected respondents with a relevant professional background and clear communication of research intents, were thus considered to be appropriate for SEM analysis in the research.

Among the 77 respondents, the highest proportion (66%) was from the contractors involved in construction activities followed by the clients (21%). Respondents from the roles of architects and design managers accounted for 13%. The average experience of the respondents was about 15 years with 21% having over 20 years. The high percentage of contractors compared to clients in a typical sample of the Indian construction industry is due to the fact that most of the clients are usually government agencies involved as principals in the projects. After retirement, most principals usually join the construction industry as contractors. Thus the views expressed in the questionnaire survey by the contractors potentially reflect both the client's and contractor's perspectives without any prejudice.

### Preparation of the dataset for analysis

The research was designed to be used with the covariance-based structural equation model. The structural equation model calculates the path coefficients by minimizing the differences between sample covariance and those predicted by the theoretical model. Thus the model fit in covariance-based SEM makes use of the maximum likelihood estimation approach which is based on the multivariate normality reflecting the true measure of relationships among the latent variables. Ensuring multivariate normality in the perception and attitude based survey dataset is a challenging task as such data may be biased by a 'consistency motif' of the respondents (Sambasivan and Soon, 2007). Furthermore, in the case of single responses collected from different projects, there may be the common variance or communality issues in the dataset as well (Campbell and Fiske, 1959; Field, 2005).

Addressing the issue of consistency motif in the research, the heterogeneity in the survey sample was maintained by approaching the selected group of respondents representing the key industry roles across the construction sector (Field, 2005). In order to address the common variance issue, factor analysis is quite useful to find out the extent of the common variance in the sample. To do this, un-rotated principal component factor analysis was performed in SPSS version 13.0 using the entire dataset across all four latent constructs. The results depict the existence of more than one factor which suggests that common variance was not an issue in the dataset (Schriesheim, 1979). In order to test the reliability of the measured variables in the sample data, Cronbach's alpha coefficient was used. In general, the value of Cronbach's alpha coefficient closer to 1.0 with a threshold of 0.70 is a good depiction of reliability in the dataset (Nunnally and Bernstein, 1994). The values of alpha coefficients for all 19 measured attributes (Table 1) were found to be in the range of $0.8143 \leq \alpha \leq 0.9022$.

## Analysis of the structural equation model

The structural equation models have two components, a measurement model and a structural model. The measurement model is concerned with how well various exogenous variables measure latent variables, as described previously. A classical factor analysis is a measurement model that determines how well various variables describe a factor or factors, or latent variables. The measurement models within a structural equation model incorporate estimates of errors of measurement of exogenous variables and their intended latent variable (Green, 1990). The second component of a structural equation model is the structural model. The structural model is concerned with modelling the relationships between latent variables. Structural equation models allow for direct, indirect and correlative effects to be explicitly modelled, unlike standard regression models, which allow for explicit modelling of direct effects only. It is the structural component of structural equation models that enables the analyst to make substantive statements about the relationships between latent variables and the mechanisms underlying a process or phenomenon. The structural component of structural equation models is akin to a system of simultaneous regression models (Meyers *et al.*, 2006).

For establishing a final structural model, Molenaar *et al.* (2000) suggested that the initial structural quation model that is usually based on theoretical expectations and past empirical findings may be premature without meeting the standard indices of model fit (such as t-statistics and R-squares for model equations). A feasible model should be selected based on the recommended goodness of fit (GOF) measures and the model that satisfies both theoretical expectations and GOF is finally selected for SEM analysis (Molenaar *et al.*, 2000). Thus, in this research, by employing the GOF measures, the model refinement was performed to improve the fit to its recommended levels as shown in Table 3.

The initial hypothesized model (Figure 1) was analysed using AMOS 19.0.0. Based on three trials and through the elimination of two measured attributes, the GOF measures of the final model achieved the recommended levels. The two eliminated attributes were *lack of skilled operators for specialized equipment (P4)* and *poor organizational structures for client or consultant (C6)* which showed reasonably low correlations (loadings) with their latent factors in the SEM.

As seen, the final model fitting for construction delay based on the essential GOF measures is supported satisfactorily. The ratio of $X^2$/degree of freedom, 1.91 and the goodness of fit index (GFI) index value of 0.91, both indicate an acceptable fit to the data. The root mean square error of approximation (RMSEA) value of 0.07 at $p < 0.05$ indicates that the final model cannot be rejected at a high level of confidence. Furthermore, all other essential indices such as comparative fit index (CFI = 0.89), Tucker-Lewis index (TLI = 0.92), normal fit index (NFI = 0.85) and incremental fit index (IFI = 0.94) values provide evidence that the fit between the measurement model and the data is certainly acceptable (Molenaar *et al.*, 2000).

## Reliability of constructs

In order to evaluate the adequacy of the model in relation to the relationships between the latent variables and the underlying measured attributes, three different tests were performed. The tests are reliability analysis of the measurement variables (Field, 2005), convergent validity of the measures associated with the latent variables (Carmines and Zeller, 1979) and discriminant validity of the measurement model (Campbell and Fiske, 1959). Reliability analysis of

**Table 3** Result of GOF measures (adapted from Molenaar *et al.*, 2000)

| Goodness of fit (GOF) measure | Recommended level of GOF measure | Starter structural equation model | Final structural equation model[a] |
|---|---|---|---|
| $X^2$/degree of freedom | 1 to 2 | 2.08 | 1.91 |
| Goodness of fit index (GFI) | 0 (no fit) – 1 (perfect fit) | 0.77 | 0.91 |
| Root mean sq. error of approx (RMSEA <0.05) | <0.05 (very good) – 0.1 (threshold) | 0.11 | 0.07 |
| Comparative fit index (CFI) | 0 (no fit) – 1 (perfect fit) | 0.71 | 0.89 |
| Tucker-Lewis index (TLI) | 0 (no fit) – 1 (perfect fit) | 0.68 | 0.92 |
| Normal fit index (NFI) | 0 (no fit) – 1 (perfect fit) | 0.74 | 0.85 |
| Incremental fit index (IFI) | 0 (no fit) – 1 (perfect fit) | 0.70 | 0.94 |

*Notes*: [a]Attributes P4 (Lack of skilled operators for specialized equipment) and C6 (Poor organizational structure for client or consultant) have been removed in the final structural equation model.

the measurement attributes shows the strengths of the measurement of the latent variables using the subjective scale relative to the error in the judgemental preferences. It is the correlations of the attributes with their respective latent variables and the standardized loadings of the measurement paths in the SEM analysis is usually a reasonable assessment of the reliability measure. A threshold of 0.7 has been widely used as an acceptable level. Since the loadings are correlations, a loading of 0.7 implies that about 50% of the variance in the measured attributes is due to the latent variables. Following the final structural equation model depicted in Figure 2, almost all path loadings of the measured attributes are above 0.70 at a significant level except variables N3 (0.65) and L2 (0.66) which clearly implies a satisfactory level of individual variable reliability in the model.

Convergent validity is a measure of the internal consistency which is estimated to ensure that the measurement variables provide the true measures of the respective latent variables in entirety. In this research, the consistency of the measurement model was therefore established by performing Cronbach's reliability test (Field, 2005). For Cronbach's alpha, a cut-off value of 0.7 is used to indicate the acceptable level of initial consistency. As seen from Table 4, the attributes measuring all four latent variables in the final structural equation model resulted in a high degree of reliability above the cut-off value.

In order to establish the extent to which a given latent variable is different from another, a discriminant validity test is necessary (Campbell and Fiske, 1959). In this research, cross-loadings analysis was performed to test the discriminant validity of the measurement model. The analysis of cross-loadings should result in higher correlation between the measurement variables and the relevant latent variables. The cross-loadings analysis was performed by computing the Pearson's coefficients (using SPSS) of the standardized scores of all 17 measurement attributes and four latent variable scores (using AMOS 19.0.0). Table 5 shows that all measurement attributes have loaded with higher correlations on the respective latent variables in the model which resulted in a distinct demonstration of the discriminant validity of the four latent variables in the construct.

## Results of the SEM and hypothesis testing

Figure 2 shows the final structural equation model with standardized path coefficients on the structure paths corresponding to the hypothesized model (in

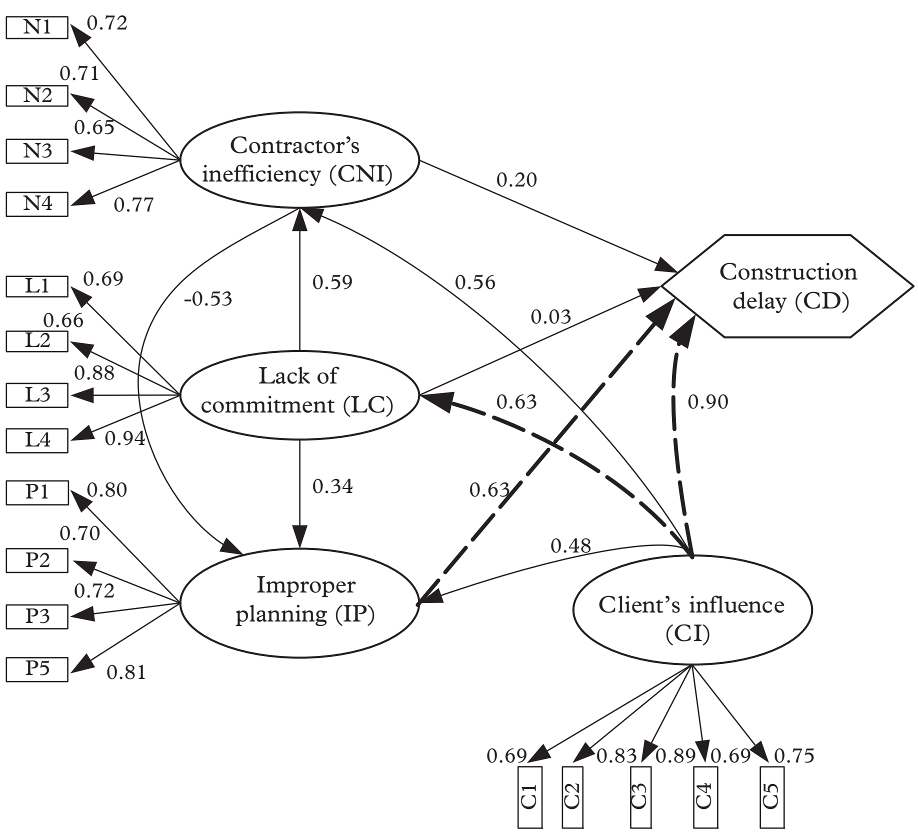


**Figure 2** Final structural equation model of the factors influencing construction delay

**Table 4** Reliability testing of the final structural equation model

| Variable | Indicator/Code | Cronbach alpha (α) value |
|---|---|---|
| Lack of commitment (LC) | Poor site management and supervision (L1) | 0.903 |
| | Delay in material delivery by vendors (L2) | |
| | Site accidents due to lack of safety measures (L3) | |
| | Lack of motivation for contractor (L4) | |
| Contractor's inefficiency (CNI) | Ambiguity in estimations (N1) | 0.893 |
| | Inadequate experience of contractor (N2) | |
| | Poor labour productivity (N3) | |
| | Lack of control over subcontractor (N4) | |
| Improper planning (IP) | Poor coordination among parties (P1) | 0.942 |
| | Delay in material procurement (P2) | |
| | Inefficient use of equipment (P3) | |
| | Extreme weather conditions (P5) | |
| Client's influence (CI) | Delay in approval of completed work by client (C1) | 0.906 |
| | Frequent change of subcontractor (C2) | |
| | Increase in scope of work (C3) | |
| | Rework due to errors in execution (C4) | |
| | Rework due to change of design (C5) | |

**Table 5** Cross-loading analysis

| | Correlations with respect to the latent variables[a] | | | |
|---|---|---|---|---|
| Measured variables[b] | CNI | LC | IP | CI |
| N1 | **0.693** | 0.218 | 0.367 | 0.261 |
| N2 | **0.784** | 0.389 | –0.258 | –0.030 |
| N3 | **0.659** | 0.295 | 0.379 | 0.085 |
| N4 | **0.802** | 0.135 | –0.095 | 0.376 |
| L1 | 0.133 | **0.673** | 0.184 | –0.278 |
| L2 | –0.120 | **0.688** | –0.086 | 0.480 |
| L3 | 0.094 | **0.863** | 0.289 | 0.391 |
| L4 | 0.120 | **0.978** | 0.381 | 0.292 |
| P1 | –0.133 | 0.353 | **0.867** | –0.052 |
| P2 | –0.024 | 0.327 | **0.789** | 0.343 |
| P3 | –0.010 | 0.047 | **0.778** | 0.072 |
| P5 | 0.307 | –0.101 | **0.876** | –0.107 |
| C1 | 0.341 | –0.352 | –0.067 | **0.753** |
| C2 | 0.118 | –0.048 | 0.078 | **0.849** |
| C3 | 0.337 | –0.027 | 0.109 | **0.926** |
| C4 | –0.109 | –0.013 | –0.109 | **0.763** |
| C5 | –0.037 | 0.024 | 0.122 | **0.801** |

*Notes*: [a]The highest Pearson correlation coefficients ($p < 0.05$) are highlighted in bold.
[b]Refer to Table 1 for the description of the variables.

Figure 1). A summary of standardized coefficients, standard errors and signs of the hypothesized paths with reference to the 10 hypotheses is shown in Table 6. The significance of the path coefficients has been tested by analysing the t-values, standard errors and their corresponding one-tailed significance. The one-tailed significance ($p < 0.05$) is used to study the one-way impacts of one factor over another (Field, 2005).

As depicted in Figure 2, the most significant paths in the construct have been highlighted in dotted lines. As seen, out of four primary hypotheses, only two hypotheses (H3 and H4) were supported at the acceptable significance level of $p$ being less than 0.05. The path between *lack of commitment* (LC) to *construction delay* (CD) with statistically significant ($p = 0.008$) coefficient of 0.03 does not support the hypothesis. The hypothetical path between *contractor's inefficiency* (CNI) and *construction delay* (CD) with relatively smaller path coefficient (0.20) at an acceptable significance level ($p = 0.046$) does not support the hypothesis either. Among the additional six hypotheses (H5–H10) in the construct, four hypotheses (H5, H7, H8) are supported in full, one hypothesis is supported marginally (H9), one is supported in reverse order (H10) and one was not supported at all (H6). The link between the *contractor's inefficiency* (CNI) and *improper planning* (IP) was found to be supported in reverse order with a statistically significant negative path coefficient (–0.53). The path between *lack of commitment* (LC) and *improper planning* (IP) with a moderate positive path coefficient of 0.34 is found to be statistically insignificant and thus hypothesis H6 is not supported. The path from *client's influence* (CI) to *improper planning* (IP) with a path coefficient of 0.48 was found to be marginally significant at a $p$-value of 0.052.

**Table 6** Standardized coefficient estimates ($p$-value) of the final structural equation model

| Hypothetical paths and expected influences | Path coefficient[a] | t-value (1-tail) | Sig. (p) | Std. error ($\varepsilon$) | Interpretation |
|---|---|---|---|---|---|
| H1: CD ← CNI (expected influence, +ve) | +0.20 | 1.234 | 0.046 | 0.087 | Not supported |
| H2: CD ← LC (expected influence, +ve) | +0.03 | 2.345 | 0.008 | 0.104 | Not supported |
| H3: CD ← IP (expected influence, +ve) | +0.63 | 3.112 | 0.003 | 0.145 | Supported |
| H4: CD ← CI (expected influence, +ve) | +0.90 | 3.106 | 0.000 | 0.083 | Supported |
| H5: CNI ← LC (expected influence, +ve) | +0.59 | 2.679 | 0.022 | 0.067 | Supported |
| H6: IP ← LC (expected influence, +ve) | +0.34 | 1.309 | 0.061 | 0.027 | Not supported |
| H7: CNI ← CI (expected influence, +ve) | +0.56 | 2.102 | 0.045 | 0.170 | Supported |
| H8: LC ← CI (expected influence, +ve) | +0.63 | 4.912 | 0.000 | 0.295 | Supported |
| H9: IP ← CI (expected influence, +ve) | +0.48 | 2.482 | 0.052 | 0.126 | Marginally supported |
| H10: IP ← CNI (expected influence, +ve) | –0.53 | 4.303 | 0.022 | 0.209 | Supported but inversely |

*Note*: [a]All standardized path coefficient estimates are expected to be significant at $p < 0.05$.

## Discussion of results

The final SEM results suggested that only one key factor, client's influence, has a significant impact on time performance in the Indian construction industry. Comparing the findings by Iyer and Jha (2005), owner's competence was reported to be one of the key factors in terms of understanding scope of work, managing contractors, monitoring progress, controlling budget and quality. However, the assertion by Chan (2001) that the owner's influence is important in design and build projects presents a contrast to the findings that project type may not be the key consideration at all. Furthermore, a strong positive path coefficient (β) for client's influence suggests the probability of occurrence of this particular factor has a significant influence on overall impact of delay (Odeh and Battaine, 2002). The second significant factor impacting on construction delay is improper planning with a β value of 0.63. This finding is consistent with the past findings that accurate technical planning plays a critical role in achieving successful project outcome (Sambasivan and Soon, 2007; Doloi, 2009a; Doloi *et al.*, 2012). Time being one of the key success factors in most projects, this finding highlights a useful link between improper planning and construction delay.

In contrast to past findings by Iyer and Jha (2005), the influence of lack of commitment among the contracting parties on project delay is found to be significantly minimal. Rather, lack of commitment was found to be significantly influenced by the client's influence in the project. Similarly, client's influence exerts a significant impact on contractor's ability and performance in projects. The revelation that contractor's inefficiency (CNI with β = 0.20) does not have direct significant impact on construction delay is a paradigm shift in the strongly endorsed assertions within the bulk of construction management literature (Al-Khalil and Al-Ghafly, 1999; Aibinu and Jagboro, 2002; Aibinu and Odeyinka, 2006; Ahsan and Gunawan, 2010). While contractor's inefficiency (CNI) may contribute to construction delays, the same is rather an outcome of the two important and interrelated factors namely client's influence (CI with β = 0.63) and lack of commitment (LC with β = 0.59) in the project. However, the impact of lack of commitment (LC) on improper planning (IP) has not been revealed in the model with any statistically significant path coefficient (β = 0.34). The hypothesis that contractor's inefficiency directly affects the planning process of the project has been found untrue with a negative path coefficient value (β = –0.53) in the SEM results. Contrasting with past findings, the effect is found to be the opposite instead (Arditi *et al.*, 1985; Satyanarayana and Iyer, 1996; Chan and Kumaraswamy, 1997; Assaf and Al-Hejji, 2006).

## Conclusion

Numerous studies published on the factors affecting construction delay (Arditi *et al.*, 1985; Odeyinka and Yusif, 1997; Iyer and Jha, 2005; Assaf and Al-Hejji, 2006; Jha and Misra, 2007; Sambasivan and Soon, 2007; El-Razek *et al.*, 2008) identified many common factors including clients' delay in approval (Faridi and El-Sayegh, 2006), lack of agreement between project stakeholders (Al-Khalil and Al-Ghafly, 1999; Al-Kharashi and Skitmore, 2009), client initiated variations (Lo *et al.*, 2006), conflict among project participants and lack of commitment (Iyer and Jha, 2005; Doloi *et al.*, 2012), poor risk management (Chan and Kumaraswamy, 1997), inadequate design and planning coupled with scope creep and regulatory hurdles (Singh, 2010; KPMG and PMI, 2012). Based on these known causes in generic terms, this research looks into schedule performance in terms of the collective impacts of the factors focusing on Indian construction projects. Extending the findings from a previous study by Doloi *et al.* (2012), the effects of four latent factors namely contractor's inefficiency, lack of commitment, improper planning and client's influence were investigated.

A questionnaire was prepared by incorporating the key delay attributes representing the four dependent constructs reported in the literature. A total of 110 questionnaires were sent to the pre-identified respondents located in 86 firms. Of these 110 questionnaires, only 77 valid responses were analysed using structural equation modelling and a final structural model was derived based on the satisfactory criteria on GOF measures.

Findings of the structural equation model reveal that one of the most significant factors inducing construction delay is the client's influence. Client's influence is found to be due to delay in approval process, design and scope changes, lack of stringent organizational protocol and even change of subcontractors in the project. Owing to the lack of a clear project charter and to aggressive competition at the tender stage, these issues are well evident in most construction projects in India (Singh, 2010). This finding is indeed similar to the findings of Iyer and Jha (2005) and Odeh and Battaineh (2002). Traditionally, contractor's efficiency in terms of attributes such as financial strengths, efficient site management, relevant training and experience have been heavily weighted for achieving success in most projects (Sambasivan and Soon, 2007; Olawale and Sun, 2010). However, the finding that the contractor's inefficiency does not have a direct impact on time performance of projects is a clear shift in perception within the Indian construction environment.

Improper planning is found to be the second most significant factor affecting schedule performance in Indian construction projects. As far as the planning is concerned, significant responsibility lies with the head contractor, in respect of technical competency in the context of reflecting the realistic planning of construction coordination, procurement schedule, maintaining high labour productivity and factoring in the extreme weather conditions relative to the job site. While contractor's financial position, past experience and risk management capability have been heavily weighted in awarding the contract in most projects (Mansfield *et al.*, 1994; Chan and Kumaraswamy, 1997; Al-Kharashi and Skitmore, 2009), this finding clearly shifts the emphasis to the technical ability of contractors in relation to effective planning and controlling of projects. The path coefficient between improper planning and client influence in the final structural equation model suggests that contractor's inability in accurate planning is significantly impacted by the client's influence. This finding is clearly evident in a few observations reported on Indian construction practices (Ernst & Young, 2011; MOSPI; KPMG and PMI, 2012). One of the key conclusions from the research is that contractor's inefficiency is not the direct outcome of poor planning practices in projects as perceived by the clients and consultants. Rather, accurate planning is a direct result of the client being supportive in the project.

While the research community has a clear understanding of the impact of client's influence and lack of appropriate project planning on the time performance of projects, a holistic attempt to address this chronic issue of time overrun is yet to materialize among practitioners in the Indian construction industry. Traditionally, the approach to managing construction is quite ad hoc on Indian projects and the need for adopting a systematic approach has not been realized across the board. This became evident on the world arena during the execution stage of programmes and projects during the recently concluded Commonwealth Games 2010. With the advent of rapid urbanization and fast growth in the construction industry, the criticality of the factors revealed in this research must be considered and well integrated in the mainstream construction processes for improving industry practices across construction projects. Consequently it is hoped that these findings will be significant contributions to the Indian construction industry in controlling the time overruns on construction projects.

Based on the SEM results, it may be concluded that time performance can be improved by demarcating clear roles and responsibilities between clients, contractors and consultants in Indian construction projects. Positive client support can have a significant influence on enhanced commitment among the participants and potentially assists contractors to increase efficiency in projects. Thus the practical implication of the findings for construction clients is that they should focus more on how to positively perform the role and assume legitimate responsibility that eliminates tensions among the project participants and enhances a positive working environment. The findings highlight the need for construction professionals to reallocate the weightings from the traditional contractor's blaming mentality to the most influencing factors such as client's influence and appropriate planning for achieving success in time performance. The result of the structural equation model establishes that the most important factors such as commitment of contracting parties and contractor's efficiency can be influenced by the client's interventions. Thus the role of clients and their communication protocols should be clearly formalized for achieving time performance and overall positive outcomes in Indian construction projects.

Though best efforts were put into this research and findings to make a significant contribution for industry, this research has some limitations. First, the sample data size of 77 responses is considered to be too small for covariance-based SEM analysis presented in this research. Further investigation should be carried out with a larger sample size for validating the model. Second, the bulk of the respondents in the sample represent public owners, contractors and consultants operating in current Indian projects. A similar research based on private participants in all three categories may yield different outcomes. Third, the SEM analysis entirely relied on the survey data which is partly opinion based rather than factual project-based documentary evidence. The relationship between various reasons for delay and their impact on overall project delay may be further tested using project-specific hard data. A similar study on the national and international levels with a large sample size would be also a meaningful contribution within the existing body of knowledge in the field.

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