Impacts of participants on rbSC performance

Zeliha Banu, Yavuz Pelvan

(Res. Asst. Zirve University, Faculty of Architecture and Design, Gaziantep, Turkey, banu.pelvan zirve.edu.tr)

1 ABSTRACT

As material costs account a high percentage of overall cost, the success of projects are heavily dependent on material related factors and processes. In Turkey because of extensively using in-situ concrete in construction, the supply chain for reinforcement and the concrete became important. One of the components of concrete is "re-bars" and its supply chain, rbSC (rebar supply chain) was used in the scope of subject.

This study aims to analyze the relationships between rbSC participants and rbSC performance. The effect of each participant with its influencing level of rbSC performance was deduced in this study. In this context, a questionnaire survey was administered to the rbSC participants and the data gathered was analysed with structural equation modeling (SEM) rules. LISREL was used and the outputs of LISREL were evaluated to determine the impacts of participants on rbSC performance.

2 INTRODUCTION

The complexities, pitfalls and ordeals of the construction industry at large are only too well known to its practitioners, worldwide. Yet no simple and straightforward means of avoiding these at one go from the onset to the very end has so far been developed and put into effect. As Kalu (2003) pointedly notes, the rate at which the construction industry adopts "modern" management techniques particularly in relation to the planning and execution of large projects continues to be relatively low when compared to other similarly "complex" ones. As with almost all other industries, one innocent obstacle that lies in the way of "progress" here is the diversity of the work force both white and blue collar involved.

One system that has emerged over the last two decades, however, with–according to Fotwe, Thorpe and McCaffer (2001) strong claims to have finally 'fit the bill' especially where the construction industry is concerned has been called Supply Chain Management (SCM). O'Brien (1998) describes this as a system that takes a holistic view of all production activities-including those of autonomous units (sub-contractors and the like) and seeks an overall optimization of these. This is in sharp contrast to the more conventional approaches of planning and contracting that merely seek to optimize individual activities.

Many authors (e.g., Bertelsen & Nielsen, 1997; Othman & Rahman, 2010) concur that for the construction industry at large and for the building industry in particular, material costs account for roughly 50% of overall cost, with labor coming in second at 30%, management and supervision third at 15% and heavy equipment last at 5%. Among the overall cost of all materials as might go into any given building of a utilitarian nature, that with by far the greatest share is devoted to making just one component, which itself also happens to be almost completely hidden from view: The structure in Turkey, with the exception of certain large-scale industrial and public buildings, fire codes prescribe this structure to be in reinforced cement concrete (rcc). Statistical data from the Türkiye İstatistik Kurumu (the Turkish Statistics Agency, TÜİK) shows that this amounts to roughly 98% of all construction in terms of built floor area while of this total, about 93% consists of construction where concrete was placed in situ; in other words, with the supply chain for both the reinforcement and for the `green' concrete of the rcc combination extending all the way to the site.

A perhaps more serious repercussion for the latter case is that the two components are not independent of each other since no concrete can be poured until all reinforcement called 're-bars' for short is in place. An aspect of even greater import in this vein, i.e., use of in-situ concrete, that further extends the rebar supply chain (rbSC) arises from the additional site work brought on by way of what is known as the `bending schedule'.

Even this brief overview immediately suggests that potentially large economies of significant magnitude are to be had by reducing both waste of time and material in the rbSC-and most so for RCC buildings put up using the in-situ method of construction. Be this as it may, a crucial aspect noted by Gunasekaran, Patel &

McGaughey (2004) is that not many construction companies have actually succeeded in fully realizing this potential simply because they have failed to develop the performance measures and metrics needed by the supply chain (SC) system for maximization of both effectiveness and efficiency. Lee & Billington (1992) even earlier observed that the discrete sites in a supply chain cannot contribute to such maximization if each were to pursue goals independent of each other.

Such being the overall situation for RCC, by itself the most costly component of building construction, it seemed only worthwhile to further pursue the matter, in order to first define relevant performance measures and metrics for rbSC. From this would then be developed a more comprehensive checklist to serve as a model for not just rbSC, but also for the general case of all building components. This model would then have to be field-tested in terms of 'real' projects so as to demonstrate the value of rbSC for the building industry in realizing the potential mentioned above. So it was that this study came into being.

2. LITERATURE REVIEW

2.1 Supply Chain in Construction

Vrijhoef and Koskela (2000) defined construction supply chain (CSC) with three specific peculiarities. First one is related with the place of the activities materialized - construction factory. Second is about the instability, fragmentation, seperation of the activities (e.g. design and construction process) in the supply chain. The third one is about the procurement system of the supply chain that it is make-to-order supply chain. Construction supply chains characterized by the involvement of many companies from a wide variety of trades (O'Brien, London, Vrijhoef, 2002). A construction project involves a diverse group of participants including contractors, architects, engineers, laborers and developers (Issa, Flood and Caglasin, 2003). A project involves hundreds of different companies supplying materials, components, and a wide range of construction services.

2.1.1 Factors related to rbSC participants and rbSC performance

In this study of determinining the factors that has impacts on the rbSC performance it was focused on the participants of the rebar supply chain. With this point of view there are several factors which are related to participants that affect the rbSC process. The main participants of rbSC are main contractors, who undertake the construction of the project and will referred as contractor in this study; sub-contractors, suppliers and AE companies.

Contractor related factors:

Polat(2005) specified the contents of the activities of rbSC with the designing, detailing, reckoning, milling, fabricating, delivery and assembly. The details that were written under the activities were analysed according to the doer of the activity by the help of the interview performed. The activities of contractors in rbSC can be listed as follows:

- Analyzing the projects (architectural, mechanical, electrical etc.),
- Preparing quantity surveys,
- Prepare the order according to master supply schedule,
- Prepare the procurement process of rebar,
- Negotiate with the rebar fabricator and approve it,
- Control the installed rebar,
- Plan and manage the financial issues about the procurement of suppliers and sub-contractors.

Problems related to managing the flow of materials can be found in every organization. The efficient management of materials play a key role in the successful supply chain so it should be measured as a company & management related factor. Materials account for a big part of products and project costs (Perdomo,2004). Planning, acquiring, storing, moving and controlling materials effectively are the main areas need dealing within material management (Ballot,1971; Perdomo 2004).

Winch (1989) pointed the important point in the production level of construction on that specific environment called the “construction site” was the organization of the activities and the groups work there. For the continues flow of materials, information and money in the rbSC it was a necessity to have the sense of the site management.Project management competency is a key factor for the success of rbSC. Managing the chain with the new systems, maximize the projects success.

Past experience of the contractor is an important variable for measuring performance. Past performance focuses on the quality of the contractor's past work. Holt et al. (1994) specified that contractors past experience in terms of size of the projects completed, play an important role in the overall satisfaction of the client on construction projects.

Problem solving often involves a set of specific knowledge-based abilities to overcome design, production, plant and transport difficulties. Many SME companies, which engage in highly specialized activities, are likely to exhibit strong skills in these areas, but often such skills will have been acquired through learning-by-doing (Briscoe et al., 2000).

Interaction between structural designer and jobsite can be assessed in relation with organization culture. Organization structure is important to form a systems of controlled and coordinated activities that arise when work is embedded in complex structures .

A number of attributes that will affect contractor related factors, including insurance cover, operating and machinery, communication system, efficiency of cash flow methods are related to the economic power of the contractor and have affects on SC success (Chan et al., 2004).

AE company related factors:

Anlayzing technical documents, preparing pre-designs, structural design of the project, prepairing detailed cut and bent rebar drawings were specified as the AE companies workloads in rbSC by Polat (2005). Specialized expertise of design team, their usage of information and CAD technologies, their organizational culture to form a coordination with the other participants and working related with work schedules to prevent design delays were assessed as important points in the survey as Palaneeswaran, Kumaraswamy and Zhang (2000) mentioned in their paper.

Sub-contractor related factors:

Chun et al.(1999) defined project participants as the key players, including project manager, client, contractor, consultants, sub-contractors, supplier and manufacturers. The rebar sub-contractors duty can be summarized as to prepare the rebar according to the technical drawings and place the cut & bent rebar in formwork (Polat, 2005). Their duty starts just after the excavation of the site. Briscoe et al. (2000) explored some skills for the participant of the supply chain for more efficient supply networks. For sub-contractors, skills to increase the efficiency were divided into two main categories: “hard” skills -vocational nature- and “soft” skills which are generic and are applied most commonly in non-manual works. Cutting in required length, percentage of defects, grouping the cut rebar in respect of length and size, ability of reading technical drawings, improved communication and learning skills were used to assess the two types of skills presented above. Labor utilisation, accomodation conditions, standardization of rebar shapes, components, processing area, storage area and transportation of materials are the factors that affect the efficiency of sub-contractor works but should be provided by contractors or AE company. Sub-contractors demand these conditions about the site.

Supplier related factors:

Suppliers play important roles in supply chains. Perdomo (2004) specified the relationship between contractor and supplier crucial for the success of a project. He added that the good relationship with the suppliers, increase the expectation of better prices and more reliable delivery dates. Companies that have good relations wih suppliers could be more successful in attracting customers than companies that have bad relations. When a company has good relations with its suppliers it could benefit from cost , cooperative environment from the employeesof the supplier, and willingness to help with materials ordered. When a company has bad relations with its suppliers it might be possible that it experiences late deliveries or wron materials delivered. This will have an impact on the total cost of the product, delaying the completition of the final product. Additionally, Agopiou (1998) mentioned on the importance of reliability, credit facilities for payment, product knowledge, location of the supplier as used supplier related factors content of rbSC performance model.

rbSC performance:

As the efficiency of the process is one of the key factors of SC, the amount of Missing//damaged/defective products are important to minimize the unit cost of the product. To increase the profitability of the project the amount of missing/wrong/damaged/defective products should be low. This indicator is quantitative and qualitative. Qualitative indicators are mostly related to the customer satisfaction level. These indicators not only deal with the quality of the product but also the services provided. Responsiveness to customers is about the time between the demand and its delivery to the customer. It is important for customer satisfaction and schedule performance of the project. Supply chain flexibility is vital to the success of the supply chain since the supply chain exist in an uncertain environment.

Good communication and information flow are the keys to the effectiveness of the execution of integration. rbSC integration is important for measuring the level of the SC strategy perception. As it is difficult to implement a SC system with its rules, competitive advantage through other companies in the sector will be the result. Without integration, each company will continue to maximise the achievement of its own objectives.

2.2 Structural Equation Modeling

Mac Callum and Austin (2000) defined structural equation modeling (SEM) as a technique used for specifying and estimating models of linear relationships among variables. It recognizes the measurement error, and further offers an alternate method for measuring prime variables of interest through the inclusions of latent variables and surrogate variables (Kline,1998).

SEM is a multivariate analysis method that was developed to examine causal relationships in the social sciences, which use mainly qualitative analysis (Hair et.al., 2006). Cho et al.(2009) emphasized benefits of SEM with three characteristics which were defined by Hair et al.(2006) as follows:
(i) having the ability to estimate multiple and interrelated dependence relationships;
(ii)having the ability to represent unobserved concepts in these relationships and correct measurement errors in the estimation process;
(iii) having the ability to define a model explaining the entire set of relationships.

SEM is used to examine patterns of relationships among constructs. The constructs used in SEM are usually measured by multi item scales. Several options can be used to specify the constructs in SEM. Using parcels as indicators of latent variables, where parcels are aggregations (sums or averages) of individual items is one of these options. Total disaggregation, partial disaggregation and total aggregation are several aggregation levels of latent variable indicators that can be used in a construct measured by a scale with multiple items (Coffman and MacCallum, 2005). Partially disaggregation was used in this study and several items are parceled by using average values of items. Then these parcels are used as indicators of participant related constructs.

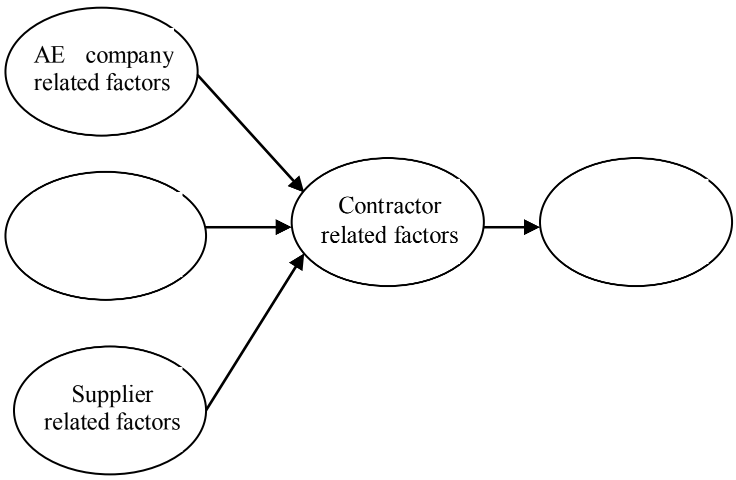
The most important advantage of using parcels as indicators of constructs is that parcels generally have higher reliability than single items (Coffman and MacCallum, 2005). Secondly models with parcels as indicators are likely to fit better than models with items as indicators because the order of the parcel correlation matrix is much smaller than the order of the item correlation matrix. Third advantage specified for using parcels, is that they can be used as an alternative to data transformations or alternative estimation techniques when working with nonnormally distributed variables.

3 METHODOLOGY

The study of finding the impacts of supply chain participants on rbSC performance face to face interviews with three firms act as general contractor in the supply chain were made to analyse the rebar supply process. The questionnaire was developed according to the information gathered from literature survey and informal face-to-face interviews. The questionnaire consists of information about the respondent companies, information about the projects that they filled for, the ratings and performance levels of the rbSC determinants and indicators. It was administered to 33 construction contractors selected from the same list obtained from Gaziantep Chamber of Commerce and different from the ones whom the informal face to face interviews were carried out. Each contractor company asked for AE companies, sub-contractors that they used for laboring of rebar cut&bent and assembly and suppliers that they supply the rebar from. Some of the names obtained for these participants are same. At the end it was reached to the number of 33 for main contractors, the number of 20 for AE companies, the number of 16 for sub-contractors and the number of 9 for suppliers. Totally 78 company filled 115 questionnaires.

3.1 Proposed Model

A theoretical model was developed based on a comprehensive literature review and informal face-to-face interviews, to understand the relationships between the participants and rbSC performance..The theoretical model is presented in Figure 1 depicts the relationships among contractor related factors, AE company related factors, sub-contractor related factors, supplier related factors and rbSC performance.



3.2 Development of rbSC Performance Indicators and Determinants

In the study of finding the impacts of participants on rbSC performance, there were some factors gathered from the literature survey in detail that influence the rbSC performance. The determinants can be classified as sub-contractor related factors, supplier related factors, AEcompany related factors and contractor related factors. All these topics can be defined with tangible and intangible sub items listed in Table 1.

Architecture/Engineering related factors	Contractor related factors
AE1 Design information flow	CON1 Materials management competency
AE2 Design integration	CON2 Site management competency
AE3 Design changes	CON3 Project management competency
AE4 Standardization of rebar shapes, components	CON4 Organization culture of the contractor
AE5 Delay in design definitions and approval	CON5 Organization structure of the contractor
AE6 Internet technologies	CON6 Insurance cover
AE7 CAD software usages	CON7 Past experience of the contractor
	CON8 Operating and machinery
	CON9 Trouble shooting and problem solving
	CON10Communication system of the contractor
	CON11 Interaction between structural designer and jobsite
	CON12 Efficiency of cash flow method
Supplier related factors	Sub-contractor related factors
SUP1 Delivery speed dependability	SCON1 Improved communication and learning skills
SUP2 Delivery reliability performance	SCON2Labor utilization (planned,weekly working schedules)
SUP3 Supplier responsiveness	SCON3 Accomodation conditions on site
SUP4 Price of the material	SCON4 Education level of the workers
SUP5 Location of the supplier	SCON5 Ability of reading technical drawing
SUP6 Financial stability	SCON6 Standardization of rebar shapes, components
SUP7 Writing and reading skills of contract and tech. doc.	SCON7 Grouping the cut rebar in respect of length and size
SUP8 Supplier/contractor relationships	SCON8 Processing area on site
SUP9 Number of faultless delivery	SCON9 Storage area on site
SUP10Quality of the material	SCON10 Team relationships
SUP11Warranties given by the supplier	SCON11 Transportation of material on site
SUP12 Product knowledge	SCON12 Percentage of defects
	SCON13 Cutting rebar in required length

Table 1: List of determinants of rbSC performance

On the other hand rbSC performance as the indicator of the model was represented with four sub tems listed in Table 2.

rbSC performance
RB1 Missing/wrong/damaged/defective product/production
RB2 Responsiveness to customers
RB3 Supply chain flexibility
RB4 rbSC integration

Table 2: Indicator of the model with its sub items

3.3 Definition of constructs

The main types of variables that were used in SEM were described as follows:
Observed (Measured) variables: Sub items of rbSC performance determinants 48 observed variables were used in this study.
Latent variables: They were theoretical constructs that were inferred from the observed variables. Contractor related factors, AE company related factors, supplier related factors, sub-contractor related factors and rbSC performance were the latent variables in this study.

3.4 Test of hypotheses

There are 4 hypotheses which are presented in detail in the following paragraphs were tested. SPSS 11® software for Windows®, and Lisrel program were used to test these hypotheses.

H1: “Contractor related factors “ has a direct affect on rbSC performance.
H2: “Ae company related factors” has a direct affect on contractor related factors.
H3:“Subcontractor related factors” has a direct affect on contractor related factors.
H4: “Supplier related factors” has a direct affect on contractor related factors.

4 RESULTS AND DISCUSSION

4.1 Confirmatory factor analysis of the observed variables

Confirmatory factor analysis was performed to check if any item is inconsistent with the averaged behavior of the others, and thus can be discarded. By the way the observed variables that represent the construct was determined. LISREL 8.51 was used to purify the constructs. The model fit indices for each construct was assessed through the ratio of χ^2/dof, the root mean square error of approximation (RMSEA), goodness of fit index (GFI), comparative fit index (CFI), non-normed fit index (NNFI).

Participant related factors that impact rbSC performance was represented by contractor related factors (CON) (12 observed variables), AE company related factors (AE) (7 observed variables), subcontractor related factors (SCON) (13 observed variables) and supplier related factors (12 observed variables). On the other hand rbSC performance construct consists of 4 observed variables. To reach the fit indices in the allowable range for each construct 6 variables under contractor related factors, 5 variables under subcontractor related factors and 4 variables under supplier related factors were removed. Also one of the four observed variables related to rbSC performance was deduced from the construct to increase the meaning of averaged measure. The GOF indices of each construct after removing the inconsistent observed variables can be seen in Table 3-7.

In the study of finding the impacts of participants on rbSC performance to reach the fit indices within the allowable range, the indicators were parceled according to their conceptual relations. For contractor related factors items CON1, CON3, CON4 were summed to create a total scale score for a new item called CONA and CON7, CON8, CON10 were summed to create a total scale score for a new item called CONB. AE company related factors parceled into three items called AEa (create by summing up AE1, AE2, AE3), AEb (create by summing up AE4, AE5), AEc (create by summing up AE6, AE7). SCON3, SCON6, SCON8, SCON11 as the indicators related to subcontractors were summed up to create a total score for a new item called SCONA and SCON2, SCON4, SCON5, SCON10 were summed up to create a total score for the second new item for subcontractor related factor with the name of SCONB. Supplier related factors parceled into two due to the logical relations between the items. For this reason SUP1, SUP3, SUP6, SUP9, SUP11 were summed up to create SUPA and only SUP4 and SUP10 were summed to create SUPB. As it is described above there were two parcels created for each participant except AE company related factors which had three parcels.

Goodness-of-fit measure	Allowable range of GOF measure	Final
χ^2/dof	< 3	2.49
RMSEA	< .01	0.10
GFI	0 (No fit) – 1(Perfect fit)	0.943
CFI	0 (No fit) – 1(Perfect fit)	0.956
NNFI	0 (No fit) – 1(Perfect fit)	0.927

Table 3: Model fit indices for contractor related factors

Goodness-of-fit measure	Allowable range of GOF measure	Final
χ^2/dof	< 3	0
RMSEA	< .01	0
GFI	0 (No fit) – 1(Perfect fit)	0.987
CFI	0 (No fit) – 1(Perfect fit)	1
NNFI	0 (No fit) – 1(Perfect fit)	1

Table 4: Model fit indices for AE company related factors

Goodness-of-fit measure	Allowable range of GOF measure	Final
χ^2/dof	< 3	1.91
RMSEA	< .01	0.085
GFI	0 (No fit) – 1(Perfect fit)	0.925
CFI	0 (No fit) – 1(Perfect fit)	0.957
NNFI	0 (No fit) – 1(Perfect fit)	0.940

Table 5: Model fit indices for sub-contractor related factors

Goodness-of-fit measure	Allowable range of GOF measure	Final
χ^2/dof	< 3	1.17
RMSEA	< .01	0.072
GFI	0 (No fit) – 1(Perfect fit)	0.935
CFI	0 (No fit) – 1(Perfect fit)	0.960
NNFI	0 (No fit) – 1(Perfect fit)	0.943

Table 6: Model fit indices for supplier related factors

Goodness-of-fit measure	Allowable range of GOF measure	Final
χ^2/dof	< 3	0
RMSEA	< .01	0
GFI	0 (No fit) – 1(Perfect fit)	1
CFI	0 (No fit) – 1(Perfect fit)	1
NNFI	0 (No fit) – 1(Perfect fit)	1

Table 7: Model fit indices for rbSC performance

4.2 Analysis of the structural model with SEM

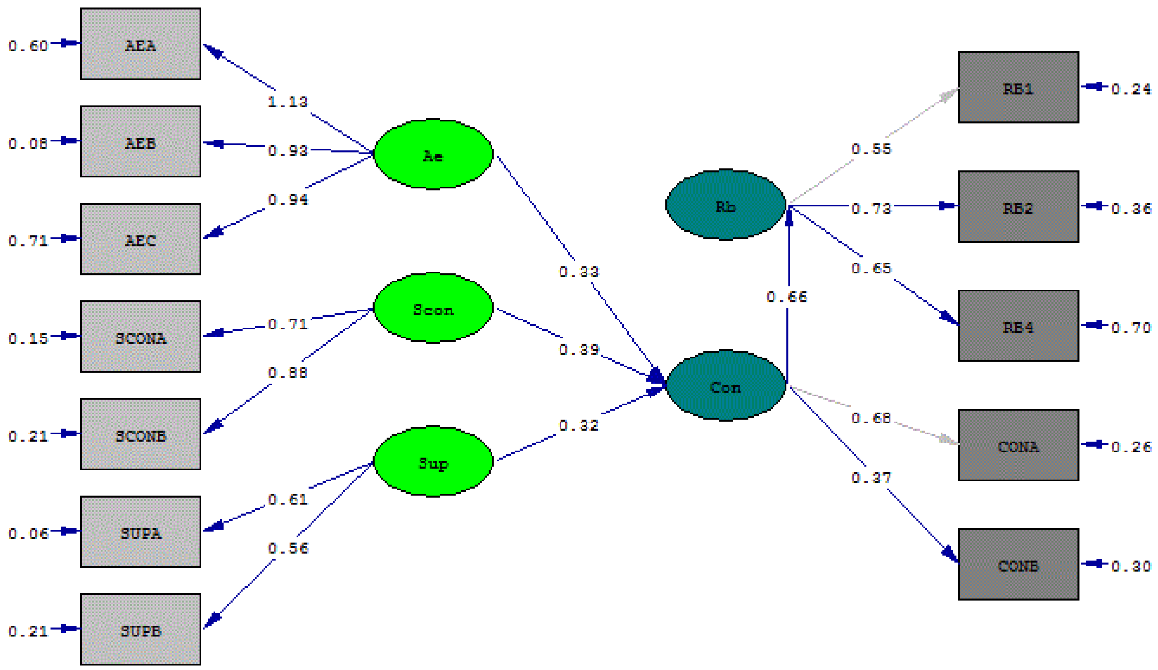
The hypotheses defined before, were tested statistically by using the LISREL program. Path coefficients of the structural model and t-values of the variables were used to check the statistical results and observe the relations between the construct components having p value greater than 0.05.

As mentioned earlier in the proposed rbSC performance model, there were 48 p erformance indicators and determinants. In the construct assessment phase, all latent variables were validated and variables that have insignificant values removed from the analysis.

As shown in Figure 2 contractor related factors positevely influenced the rbSC performance (path coefficient = 0.66, t-value = 5.14, significant at $p<0.01$ level), by the way H1 was accepted. CONA was not validated in the construct and removed. The new construct with the remaining variables has higher path coefficients meaning, the higher influence on the rbSC performance. AE related factors, subcontractor related factors and supplier related factors positively influenced the rbSC performance indirectly. This means H2, H3 and H4 hypotheses were accepted. AE related factors influenced the contractor related factors with path coefficient of 0.33 and t-value of 3.02 that is significant at $p<0.01$ level. None of the variables was removed from the AE related factors construct for validity and reliability of the model. Three variables related to AE companies had significant path coefficients and t-values (for AEA path coefficient = 0.83 t-value = 10.44, for AEB path coefficient = 0.96 t-value = 13.12 and for AEC path coefficient = 0.74 t-value = 9.04).

Sub-contractors related factors have a direct affect on contract related factors with path coefficient of 0.39 and t-value of 3.59 that is significant at $p<0.01$ level. SCONA and SCONB have direct affects with path coefficients 0.88 and 0.89 and t-values of 10.46 and 10.60 that are significant at $p<0.01$ level respectively. Similarly supplier related factors with two items provide significant value at $p<0.01$ level about the direct influence to the contractor related factors (SUP path coefficient = 0.32 t-value = 2.99). Two items under the subscale SUP naming SUPA has path coefficient of 0.93 and t-value of 10.41 and SUPB has path coefficient of 0.77 and t-value of 8.47 that are significant at $p<0.01$ level.

The χ^2 to dof ratio was 1.93 and smaller than 3 as suggested by Kline (1998). While NNFI (0.907) was above the recommended level, and the GFI (0.83) did not demonstrate perfect fit indices due to the small sample size as Byrne (1998) pointed out (Table 8).



Chi-Square=90.71, df=47, P-value=0.00013, RMSEA=0.090

Goodness-of-fit measure	Allowable range of GOF measure	Final model
χ^2/dof	< 3	1.93
RMSEA	< .01	0.90
GFI	0 (No fit) – 1(Perfect fit)	0.883
CFI	0 (No fit) – 1(Perfect fit)	0.933
NNFI	0 (No fit) – 1(Perfect fit)	0.907

Table 8: Model fit indices for final model

5 CONCLUSION

As the construction materials account a high percentage in the total building cost, it was worthwile to study on material related topics. The general view in Turkey shows that reinforced concrete is the first choice of the customer for most types of buildings. One of the components of reinforced concrete called re-bar, and relationally re-bar supply chain (rbSC) became an important subject. It will be more critical if the number of the participants and factors affecting the performance increase. Moving with the participants in the chain, worked with the specialized groups is imminent for all industries, and also the construction industry. With this point of view, the impacts of participants on rbSC performance were analysed.

The questionnaire survey among the rbSC participants according to the rbSC performance framework revealed that the rbSC performance was influenced by the factors related to the SC participants. According to the results contractor related factors constituted the main construct of the framework,as were in the proposed framework. Contractor related factors took the mediator role in the construct.

There were AE company related factors influenced contractor related factors. Whereas AE companies affect rbSC performance indirectly. All sub items related to AE companies were found to be prominent with high path coefficients at a high significance level.

Sub-contractor related factors had a direct impact on contractor related factors and an indirect impact on rbSC performance. Items related to work planning and scheduling (labor utilization), logistics and wrokflow on construction site, repetitive construction works and standardization in design and workforce characteristics (education level, abilities, team relationships) were considered to be significant in this subject of matter.

According to the results of this study supplier related factors like sub-contractor related factors influenced the contractor related factors directly and rbSC performance indirectly. On time, just in time delivery, price and quality of the material and suppliers financial conditions were found to be more important items for supplier related factors.

The items ,‘‘responsiveness to customers‘‘ and ,‘‘rbSC integration‘‘ were distinguished above the other factors related to rbSC performance with higher path coefficients. Eliminating missing / wrong/damaged/defective product item from the construct can be commented as the customers satisfaction is more important than the profit of the project for rbSC participants. As construction industry struggle with fragmentation for many decades, an opposite issue of integration found to be important to increase the performance.

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