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Analyzing the Impact of Construction Productivity over Infra Projects: Indian Scenario

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Abstract

The objective of the study is to analyse the impact of productivity in Indian transport infra projects. The methodology adopted for the study is to identify and analyze the productivity attributes from the literature review and expert focus group interviews. The identified attributes were analyzed and priorities using relative weight given by the respondents. The data has been collected using a structured questionnaire on pan India basis, using both online and offline modes. The collected data has been analyzed using SPSS 21 software. Quantitative research methodology is adopted to analyse the collected data and the following tools and techniques were used on the data: reliability analysis to check the consistency of data collected for the study, Relative importance index (RII) to prioritise and rank the attributes on the basis of weighted average score given by the respondents, and two step cluster analysis. The findings of the study provides a ranking of attributes highlights the impact of productivity in Indian infra projects are: India is planning and scheduling, followed by construction methodology, storage area, poor construction method, and direction and coordination having a relative importance index (RII) of 0.79, 0.78, 0.77, 0.76, and 0.74 respectively. This research added value to the existing knowledge bank by identifying and analyzing the impact of productivity in Indian infra projects. The study provides a solution to the construction managers and project managers to apply the findings of the study to their projects to control the issues of low productivity, and delays in completion of the projects.

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Keywords: Transport; Infra Projects; Productivity; India.

1. Introduction

Indian economy is one of the fastest growing economies in the world with an average growth rate of 6-7 %. The Construction Industry in India is the second largest employer after the agriculture industry and contributes about 10% on an average to the economy. It is going to grow further as the rate of urbanization followed by green and brownfield developments will increase. The Indian government has also come up with various policies to bridge the gap such as – Smart Cities Mission, Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Swachh Bharat Mission, Heritage City Development and Augmentation Yojana (HRIDAY). These missions are further going to boost the growth of productivity in Indian transport infra projects.

Indian Construction Industry is very diverse, fragmented and apparently unorganized. The skilled and quality workforce has always been one of the most critical issues for the industry. Due to the unique nature of work; coordination, timely delivery and quality have always been a subject to ponder. The Construction Industry in India is unorganized and the majority of the workforce employed is uneducated and ignorant to sustainable practices and are only driven by the motive of commercial viability taking every other factor ignored such as quality, sustainability, health & safety and operability. Majority of the construction projects in India is suffering from delay in construction, over budget, quality, and low productivity. Low construction productivity is one of the major issues that impact the performance of construction projects to complete on time and within budget.

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The productivity could be measured at various levels, but there are three main measures of productivity are metronomic, case and pricing studies (Edkins & Winch, 1999). On the other hand, site-based productivity comparisons (case studies) were preferred because they help construction entities to find out the area of improvement and they can easily link them to their activities (Abdel-Wahab & Vogl, 2011). The financial wealth of nations is determined by their productivity growths (Smith, 1776). The nations experienced higher productivity growth translated into increases in the average wages of the workers, which contributes to the profits and tax revenue collection of the agencies (Abdel-Wahab & Vogl, 2011). Although a few researchers try to understand the relationship between skill development and productivity in the construction industry. The trend is not consistent over time due to a number of reasons such as unplanned training sessions, consistency of skill development courses and the decrease in the number of participants (Abdel-Wahab, Dainty, Ison, Bowen, & Hazlehurst, 2008)

Construction productivity has been the area of interest for the research since the last 4-5 decades. A number of studies have been conducted in the field which includes: analysis of productivity, measurement techniques, causes of low productivity, factors affecting construction productivity and other studies.

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2. Literature review

Productivity has been one of the most researched topics in the Indian construction industry in the last few decades. Factors affecting productivity may have a short-term or long-term effect on the project, some affect the productivity for a short duration but have a ripple effect on it. Productivity consists of various attributes like labour, finance, infrastructure, plant & machinery, facilities etc. Various studies in different countries have been carried out to identify the factor affecting labour productivity. Various methodologies and approaches have been adopted by researchers who have come with different schemes in the categorization of factors affecting productivity (Rivas et al., 2011). (Li & Liu, 2011) Proposed an analysis technique to measure capital productivity changes by the evaluation of factors influencing productivity levels in the construction industry. And applied it in the Australian construction industry. The research discoveries are relied upon to be useful for settling on strategy and key choices to enhance capital productivity execution.

(U.S. Department of Labor, 2014)Suggests that measuring productivity improvement in construction has been a difficult task, generally in light of the fact that dependable output deflators are rare. This paper highlights the report of a Bureau of Labor Statistics explores gather assembled to gauge construction productivity improvement. (Kannan, 2011) This paper relates a portion of the current academic research to industry rehearses. In doing as such, it approves a few sections of the exploration and mentions new objective facts in three ranges: repair costs, residual value, and total cost of ownership (TCO). The authors suggest a few pointers for future research. (Abdel-Wahab & Vogl, 2011) Studied the growth of productivity of the construction industry between Europe, US, Japan. The study was conducted using the EU LLEMS database. The author's concluded that productivity is one of the key drivers of financial development in the country's GDP. The trend analysis concluded that the total factor productivity of the nations is in decline for the period 1990-2005 except for the UK. (Best, 2012) In a report distributed in June 2012, the Business Council of Australia (BCA) detailed that it costs extensively more to fabricate a variety of types of infrastructure in Australia than it does in the US. Air terminals (90 % extra cost) and doctor's facilities (62 % extra cost) were cited as the most pessimistic scenarios with different undertakings running from 26 to 43 % extra cost. They utilized these figures to infer that Australia is a high cost, low-productivity condition for building infrastructure project. These cases depended on cost/m2 figures distributed by a noteworthy worldwide construction consultancy.

Table 1previously identified attributes for productivity

References	Attributes of productivity
(Mojahed & Aghazadeh, 2008), [48], (Jarkas, Kadri, & Younes, 2012), (Hughes & Thorpe, 2014), (Borg & Song, 2015), (Chalker & Loosemore, 2016), (Shan, Goodrum, Zhai, Haas, & Caldas, 2011), (L. Ma & Liu, 2014), (G. Ma, Gu, & Li, 2015), (Karimi, Taylor, & Goodrum, 2017), (Jarkas & Horner, 2015) and (Jarkas, 2015)	Planning and scheduling, Rework, Poor supervisor competency and Incomplete drawings
(Dai, Goodrum, Maloney, & Srinivasan, 2009) and (Thomas & Sudhakumar, 2013)	Tools and consumables, Coordination, Materials, Labour skills
(Rivas, Borcherding, González, & Alarcón, 2011), (Jarkas & Horner, 2015) and (Hiyassat, Hiyari, & Sweis, 2016)	Coordination, rework, supervision errors, drawing management, and construction equipment
(Jarkas, 2015), (Moselhi & Khan, 2010), (Mahamid, 2013),(Saurav Dixit, Mandal, Thanikal, & Saurabh, 2019)	Drawings, delay in response to information, truck availability, and material availability
(Abdel-Wahab & Vogl, 2011) and (Abdel-Wahab, Dainty, Ison, Bowen, & Hazlehurst, 2008), (Ruddock & Ruddock, 2009), (Ruddock & Ruddock, 2011), (Dyer, Goodrum, & Viele, 2012), (Chancellor & Lu, 2016), (Chancellor & Abbott, 2015)	Shop drawings, equipment's, motivation and support, and scheduling

(Abdel-Wahab & Vogl, 2011) and ("No Title," 2012), (Yung & Agyekum-Mensah, 2012), (Yuventi, Levitt, & Robertson, 2013), (Pheng, Shang, & Foong, 2016), (Saurav Dixit et al., 2019)	Coordination and communication, timely feedback, owner's competence, favourable climatic condition, coordination among all team members, leadership, top management support, budget update, and the flow of funds

3. Research Methodology

For this research paper, quantitative research approach has been adopted to identify the attributes affecting the productivity of transport infra projects in India. Question survey has been used to collect the data. A total of 115 valid responses were received with a response rate of 35%. A questionnaire survey has been used for the collection of data from all the respondents. All the respondents who were surveyed had good prior experience of working in transport infra projects.

3.1. data collection

To achieve the desired objective the data for the study were collected through a structured questionnaire survey of 115 construction professionals and academicians from all over India. The questionnaire consists of 16 questions attempting to cover the major factors affecting productivity. The factors have been identified with the help of various studies on construction labour productivity. People with required qualification and experience answered the questionnaire, so it can safely be assumed that the data obtained has credibility and can be used for the study as the respondents are conversant with the problems related to labour productivity and factors affecting the construction labour productivity.

3.2. Relative importance index

The received responses by the respondents were summarised in an Excel data sheet and the data analysed using SPSS software. Relative importance indices (RII) is performed to determine the priority of the significant factors and then followed by Reliability analysis performed to check the consistency of the data received.

$$\text{Rii} = \frac{\sum_{r=1}^{5} r*n_r}{5N} \qquad (1)$$

r is the rating on a Likert scale (1-5) as for the impact on construction efficiency for a specific element influencing construction profitability, nr is the number of respondents providing a specific Likert scale rating r, N is the aggregate number of respondents to a specific question (Subhav Singh, Dixit, & Varshney, 2018). The respondents were asked to rate the questions using a five-point scale '5' being the very high, '4' high, '3' moderate, '2' low, '1' very low impact on on-site productivity.

4. Results and discussion

4.1. RII

The findings of the study conclude that the most significant attributes affecting the productivity of transport infra projects in India are planning and scheduling, followed by construction methodology, storage area, poor construction method, and direction and coordination having a relative importance index (RII) of 0.79, 0.78, 0.77, 0.76, and 0.74 respectively. The top five most significant attributes having close RII values. This finding needs to be validated and for the validation purpose, two-step cluster analysis has been performed on the top five most significant attributes to identify the main predictor out of the five attributes.

Table 2 Relative Importance Index (RII)

Rank	Total Responses	Total Score	RII	Attributes affecting the productivity of Indian transport Infra projects
1	115	455	0.79	Planning and scheduling
2	115	448	0.78	Type of Construction Methodology
3	115	441	0.77	Storage areas for materials
4	115	435	0.76	Poor construction method

5	115	428	0.74	Direction and coordination/communication
6	115	413	0.72	Adequate Crew and composition
7	115	409	0.71	Change in scope
8	115	406	0.71	Pep talk
9	115	403	0.70	Frequent change in drawings
10	115	392	0.68	Proper training provided prior to the execution of work

4.2. Reliability analysis/Cronbach's alpha

To determine the internal consistency of the survey instrument the Cronbach's alpha test was carried out (S. Dixit, Pandey, Mandal, & Bansal, 2017; Saurav Dixit, Mandal, Thanikal, & Saurabh, 2018). The test checks the reliability and consistency of the sample collection. As a rule of thumb, a minimum value of 0.5 is considered to validate the consistency and reliability of the data collected (Kenley, 2014; S. Dixit et al., 2018; Nguyen & Chileshe, 2015). For the current study, the test gave a value of $\alpha = 0.867$, therefore the data was found to be good for the study.

Table 3Reliability Cronbach's alpha

Reliability Cronbach's alpha for the attributes	
Attributes	Cronbach's alpha
All attributes selected for the study	0.867

4.3. Cluster Analysis

Cluster analysis is an exploratory technique that has been used in different domains of management because of its partitioning ability (Auyero, 2000; Johnson & LeBreton, 2004; Okazaki, 2006; Sen et al., 2010; Wilks, 2011). It identifies the structures within the data using exploratory analysis of the data. It used to group the data on the basis of inherent homogeneity in the groups (Botstein, 1999; Nijman, 2010; Okazaki, 2006; Routray et al., 1996; Wu, Benjamin Zhan, Zhang, & Deng, 2016). Two-step cluster analysis was used for the analysis of data and the test performed using SPSS 20. Two-step cluster analysis enables captured both, the categorical, and continuous variables. The attributes having a significant RII value (i.e. above 0.8) have been considered for the cluster analysis within groups. The attributes selected for the study are mentioned in table 2.

Cluster analysis has been performed on the selected top five significant attributes using SPSS 21, and the findings of the two-step cluster analysis validates the finding of RII i.e. planning and scheduling is the most significant predictor and shows an impact value of 100% on all the remaining four attributes, followed by construction type, and coordination between the teams working on the infra projects. Two-step cluster analysis formed two major clusters sharing of 41.7%, and 58.3% respectively (fig. 1, 2, 3, and 4).

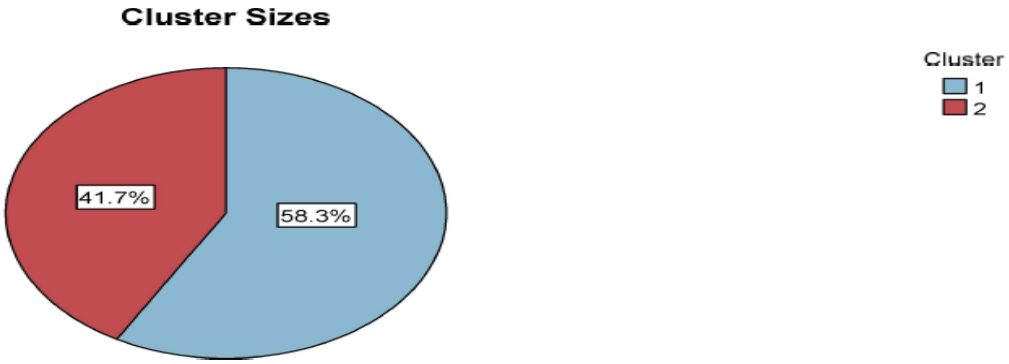

Figure 1cluster size

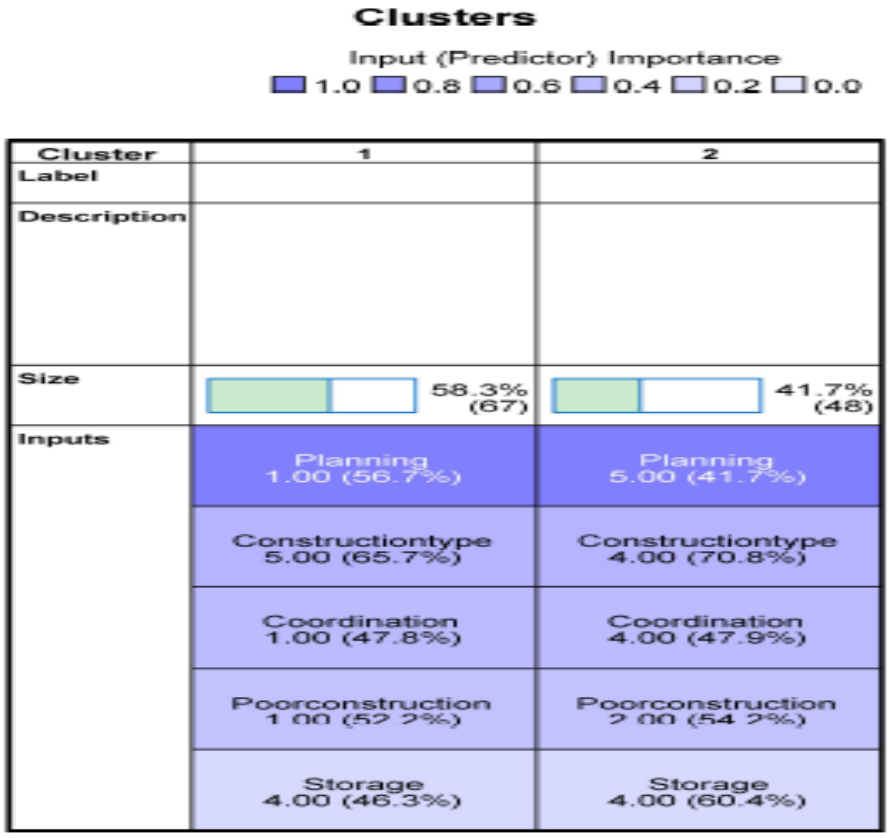

Figure 2 clusters

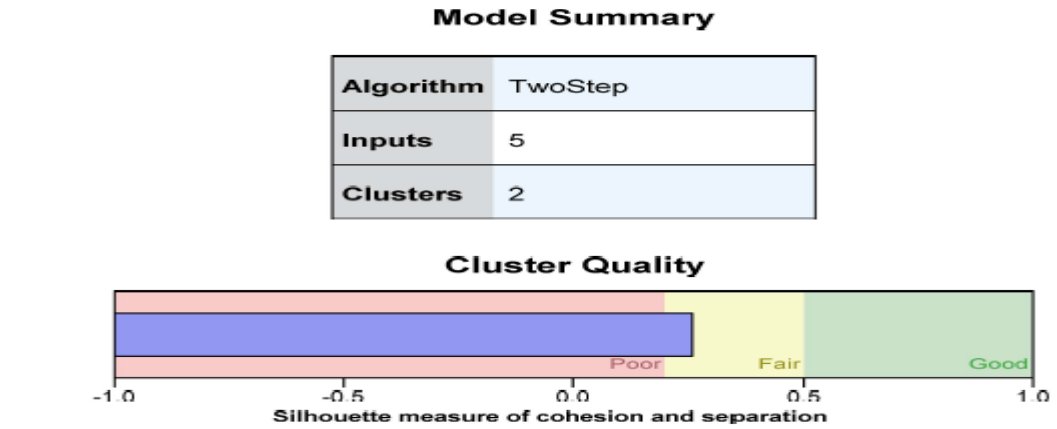

Figure 3model summary

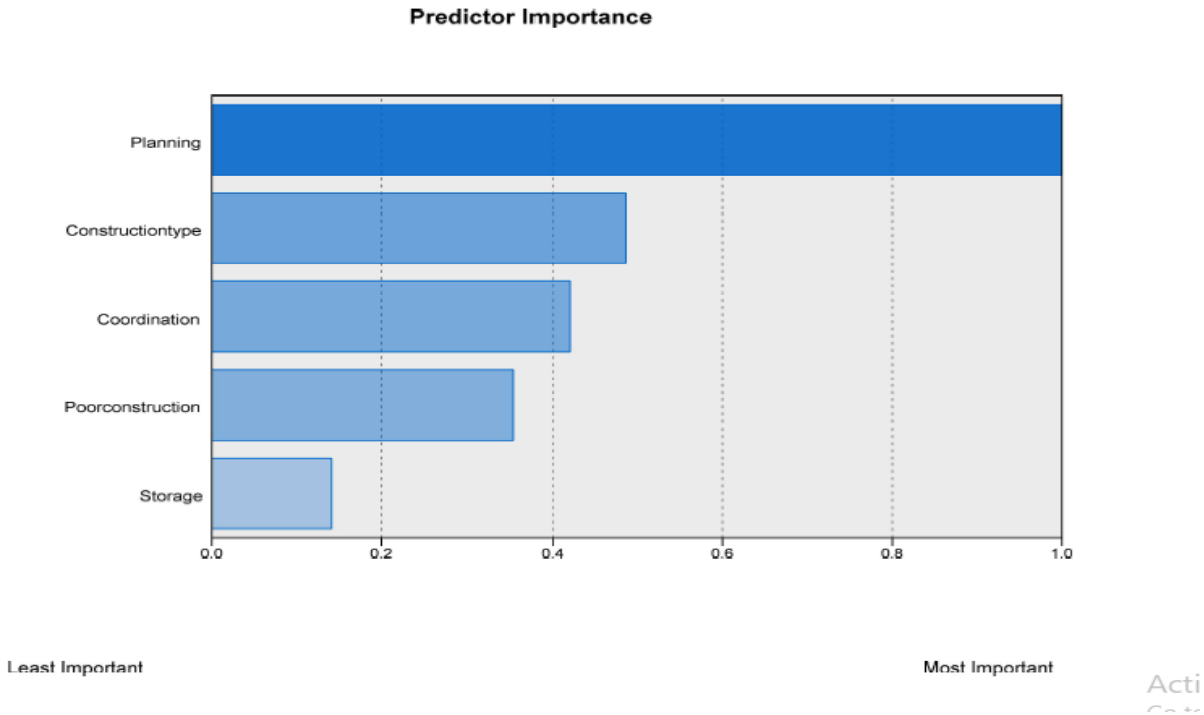

Figure 4 predictor importance for the top five attributes

5. Conclusion and recommendations

The productivity in the construction industry has been studied and documented all around the world and has the advantage of over 40 years of research that have developed models, identified the factors affecting productivity, studies at the industry level, the study of equipment and technology to enhance productivity, and techniques to measure and improve construction productivity. Which results in enhancing construction productivity and labour productivity. Various researches have been done to find out several factors which influence the construction productivity and the findings include the business culture, education level, tools and technologies used, values and ethics of the people and workers involved, politics, local laws and regulations governing the project, HR policies of the organization, importance given to the employee, religion of the people, their cultures, languages etc. The current paper highlights the importance of productivity in transport infra projects and provides a ranking of the most significant attributes impacting the productivity of transport infra projects in India.

References

Abdel-Wahab, M., & Vogl, B. (2011). Trends of productivity growth in the construction industry across Europe, US and Japan. *Construction Management and Economics*, *29*(6), 635–644. https://doi.org/10.1080/01446193.2011.573568

Abdel-Wahab, M. S., Dainty, A. R. J., Ison, S. G., Bowen, P., & Hazlehurst, G. (2008). Trends of skills and productivity in the UK construction industry. *Engineering, Construction and Architectural Management*, *15*(4), 372–382. https://doi.org/10.1108/09699980810886865

Borg, L., & Song, H.-S. (2015). Quality Change and Implications for Productivity Development: Housing Construction in Sweden 1990–2010. *Journal of Construction Engineering and Management*, *141*(1), 05014014. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000928

Chalker, M., & Loosemore, M. (2016). Trust and productivity in Australian construction projects: a subcontractor perspective. *Engineering, Construction and Architectural Management*, *23*(2), 192–210. https://doi.org/10.1108/ECAM-06-2015-0090

Chancellor, W., & Abbott, M. (2015). The Australian construction industry: is the shadow economy distorting productivity? *Construction Management and Economics*, *33*(3), 176–186. https://doi.org/10.1080/01446193.2015.1028954

Chancellor, W., & Lu, W. (2016). A Regional and Provincial Productivity Analysis of the Chinese Construction Industry: 1995 to 2012. *Journal of Construction Engineering and Management*, *142*(11), 05016013. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001177

Chia, F. C., Skitmore, M., Runeson, G., & Bridge, A. (2012). An analysis of construction productivity in Malaysia. *Construction Management and Economics*, *30*(12), 1055–1069. https://doi.org/10.1080/01446193.2012.711910

Dai, J., Goodrum, P. M., Maloney, W. F., & Srinivasan, C. (2009). Latent Structures of the Factors Affecting Construction Labor Productivity. *Journal of Construction Engineering and Management*, *135*(5), 397–406. https://doi.org/10.1061/(ASCE)0733-9364(2009)135:5(397)

Dixit, S., Mandal, S. N., Thanikal, J. V., & Saurabh, K. (2019). Evolution of studies in construction productivity: A systematic literature review (2006–2017). *Ain Shams Engineering Journal*, (xxxx). https://doi.org/10.1016/j.asej.2018.10.010

Dixit, S., Mandal, S. N., Thanikal, J. V, & Saurabh, K. (2018). Critical Analysis of Factors Affecting the on-site Productivity in Indian Construction Industry, (July), 38–45. https://doi.org/10.3311/CCC2018-006

Dixit, S., Pandey, A. K., Mandal, S. N., & Bansal, S. (2017). A study of enabling factors affecting construction productivity: Indian scnerio. *International Journal of Civil Engineering and Technology*, *8*(6).

Dixit, S., Singh, S., Singh, S., Varghese, R. G., Pandey, A. K., & Varshney, D. (2018). Role of Solar energy and issues in its implementation in the Indian context. In *MATEC Web of Conferences* (Vol. 172). https://doi.org/10.1051/matecconf/201817206001

Dyer, B., Goodrum, P. M., & Viele, K. (2012). Effects of Omitted Variable Bias on Construction Real Output and Its Implications on Productivity Trends in the United States. *Journal of Construction Engineering and Management*, *138*(4), 558–566. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000460

Hiyassat, M. A., Hiyari, M. A., & Sweis, G. J. (2016). Factors affecting construction labour productivity: a case study of Jordan. *International Journal of Construction Management*, *16*(2), 138–149. https://doi.org/10.1080/15623599.2016.1142266

Hughes, R., & Thorpe, D. (2014). A review of enabling factors in construction industry productivity in an Australian environment. *Construction Innovation*, *14*(2), 210–228. https://doi.org/10.1108/CI-03-2013-0016

Jarkas, A. M. (2015). Factors influencing labour productivity in Bahrain's construction industry. *International Journal of Construction Management*, *15*(1), 94–108. https://doi.org/10.1080/15623599.2015.1012143

Jarkas, A. M., & Horner, R. M. W. (2015). Creating a baseline for labour productivity of reinforced concrete building construction in Kuwait. *Construction Management and Economics*, *33*(8), 625–639. https://doi.org/10.1080/01446193.2015.1085651

Jarkas, A. M., Kadri, C. Y., & Younes, J. H. (2012). A survey of factors influencing the productivity of construction operatives in the state of Qatar. *International Journal of Construction Management*, *12*(3), 1–23. https://doi.org/10.1080/15623599.2012.10773192

Karimi, H., Taylor, T. R. B., & Goodrum, P. M. (2017). Analysis of the impact of craft labour availability on North American construction project productivity and schedule performance. *Construction Management and Economics*, *35*(6), 368–380. https://doi.org/10.1080/01446193.2017.1294257

Ma, G., Gu, L., & Li, N. (2015). Scenario Based Proactive Robust Optimization for Critical Chain Project Scheduling. *Journal of Construction Engineering and Management*, *141*(10), 1–12. https://doi.org/10.1061/(ASCE)CO.1943-7862

Ma, L., & Liu, C. (2014). Did the late-2000s financial crisis influence construction labour productivity? *Construction Management and Economics*, *32*(10), 1030–1047. https://doi.org/10.1080/01446193.2014.944927

Mahamid, I. (2013). Contractors perspective toward factors affecting labor productivity in building construction. *Engineering, Construction and Architectural Management*, *20*(5), 446–460. https://doi.org/10.1108/ECAM-08-2011-0074

Mojahed, S., & Aghazadeh, F. (2008). Major factors influencing productivity of water and wastewater treatment plant construction: Evidence from the deep south USA. *International Journal of Project Management*, *26*(2), 195–202. https://doi.org/10.1016/j.ijproman.2007.06.003

Moselhi, O., & Khan, Z. (2010). Analysis of labour productivity of formwork operations in building construction. *Construction Innovation*, *10*(3), 286–303. https://doi.org/10.1108/14714171011060088

Pheng, L. S., Shang, G., & Foong, W. K. (2016). Enhancing Construction Productivity Through Organizational Learning in the Singapore Construction Industry. *International Journal of Construction Project Management*, *8*(1), 71–89.

Rivas, R. a., Borcherding, J. D., González, V., & Alarcón, L. F. (2011). Analysis of Factors Influencing Productivity Using Craftsmen Questionnaires: Case Study in a Chilean Construction Company. *Journal of Construction Engineering and Management*, *137*(4), 312–320. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000274

Ruddock, L., & Ruddock, S. (2009). Reassessing productivity in the construction sector to reflect hidden innovation and the knowledge economy. *Construction Management and Economics*, *27*(9), 871–879. https://doi.org/10.1080/01446190903131166

Ruddock, L., & Ruddock, S. (2011). Evaluation of trends in the UK construction industry using growth and productivity accounts. *Construction Management and Economics*, *29*(12), 1229–1239. https://doi.org/10.1080/01446193.2011.645494

Shan, Y., Goodrum, P. M., Zhai, D., Haas, C., & Caldas, C. H. (2011). The impact of management practices on mechanical construction productivity. *Construction Management and Economics*, *29*(3), 305–316. https://doi.org/10.1080/01446193.2010.538070

Singh, S., Bala, A., Dixit, S., & Varshney, D. (2018). Critical analysis of causes of delay in residential construction projects in India. *International Journal of Civil Engineering and Technology*, *9*(1).

Thomas, A. V., & Sudhakumar, J. (2013). Critical analysis of the key factors affecting construction labour productivity -an Indian perspective. *International Journal of Construction Management*, *13*(4), 103–125. https://doi.org/10.1080/15623599.2013.10878231

Yung, P., & Agyekum-Mensah, G. (2012). Productivity losses in smoking breaks on construction sites: a case study. *Engineering, Construction and Architectural Management*, *19*(6), 636–646. https://doi.org/10.1108/09699981211277540

Yuventi, J., Levitt, R., & Robertson, H. (2013). Organizational Barriers to Productivity and Innovation in Large-Scale, US-Based Photovoltaic System Construction Projects. *Journal of Construction Engineering and Management*, *139*(10), 5. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000767.