MCRJ_Volume_26,_No.3_2018_-62-76.pdf

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REVIEW OF THE TECHNIQUE APPLICATION IN CONCEPTUAL COST ESTIMATION FOR BUILDING PROJECTS: A BIBLIOMETRIC ANALYSIS

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Abstract
This paper presents the latest research development in conceptual cost estimation (CCE). The period is from 1995-2014. The methodology involves compiling all the relevant paper in the construction management related journals. Fifty-six relevant articles obtained from 18 major journals associated with construction management studies were successfully assessed. The four findings are: (1)trend of paper for CCE in building project show an upward trend with some fluctuations during the period; (2)the active contributors of the study in supplying analytical thinking and critical ideas are dominated by researcher from Turkey and Korea; (3) there is a clear positive trend for the papers that have applied quantitative approach which starts from 2005, whereas the papers applied qualitative approach began to steadily decrease; (4) the areas of cost factors that have increasingly higher growth affecting CCE are d*esign and project-specific factor*. Two broad recommendations are made to the field of study that researcher must select an appropriate historical data to be used for CCE and also each method is appropriate for certain individual situations.

Keywords: *conceptual cost estimation; building project; research trend; review; bibliometric*

INTRODUCTION

Conceptual Cost Estimation (CCE) is a fundamental in initial decision-making processes for construction project. The primary function of conceptual cost estimation is to tell the owner about the anticipated cost. It is also important for feasibility studies and impact upon final project success that can be used in project evaluations, engineering designs, cost budgeting, and cost management(Cheng et al., 2009; Cheng et al., 2010; Sonmez, 2004) or even to support bid price estimation (Gunduza et al., 2011; Wang et al., 2012).

Scholars in the construction area have thus been attracted to scrutinize the phenomena, explore method, and study the problem to improve the accuracy of cost estimation at early stage. Their contributions are to develop a systematic methodology for CCE, so as to standardize and facilitate the estimating process, making the approach more objective. In this way, the quality of the estimate produced can be more accurate and consistently developed.

Although, CCE in a building construction project is a difficult and generally a subjective process with no set standard of practice, so far, it appears to have been overlooked. Therefore the aim of this paper is to systematically analyze the findings of relevant manuscripts published in some selected journals. The objectives are to map the CCE studies and to identify their active contributors, including their countries and research center origin, and the common research methods adopted in the CCE studies.

CONCEPTUAL COST ESTIMATION METHOD

One of the purposes of CCE is to persuade key decision-makers whether to initiate or continue a project. However, essential information on the project is not sufficient at its early stages. Koo et al. (2011) suggested that it is very important to quickly, economically and accurately find particular information. The process of assumptions generate the cost of work activity or output by interpreting data or knowledge which is usually done by creating a cost model (Curran et al., 2004; Langmaak et al., 2013; Sonmez, 2011). Many researchers have studied various methodologies for predicting the cost in the initial phase with the use of limitation information. Various conceptual cost estimation methods and techniques have been done to calculate the conceptual cost estimation including neural network (Adeli & Wu, 1998; Creese & Li, 1995; Hegazy & Ayed, 1998; Kim et al., 2005) regression analysis (Kwak & Watson, 2005; Lowe et al., 2006) and case base reasoning (Chou, 2009; Koo et al., 2011; Marzouk & Ahmed, 2011). Some researchers also have integrated two of the above methods or techniques altogether (Gunduza et al., 2011; Sonmez, 2004; 2011).

Kim et al. (2004) said that regression or multiple regression analysis is very simple and powerful statistical methods that can be used as analytical and predictive techniques to examine the overall cost estimate reliability. Lowe et al. (2006) concurred that multiple regression analysis arrives at the result of a statistical analysis but its results are too linear to be used in a standardized model. On the other hand, it is not appropriate when describing non-linear relationships, which are multidimensional, consisting of a multiple input and output problem (Tam & Fang, 1999). Moreover, most of the parametric method has adopted the regression analysis (Ji et al., 2010).

A neural network is a computer system that simulates the learning process of human brain offering an alternative approach for cost estimation. Ahn et al. (2014) said that neural network can be more beneficial when involving intuitive judgment or when patterns of data become too irregular to be identified with traditional techniques. Moreover, the user does not need to exert too much effort to decide on the class of relations or the probability distribution of the variables (Sonmez, 2004). However, another study found the neural network is a black box technique and its process is time-consuming to determine the network factors that best fit the application (Adeli & Wu, 1998; Creese & Li, 1995; Hegazy & Ayed, 1998).

Another method or technique in conceptual cost estimation is Case Based Reasoning (CBR). In CBR systems, expertise is embodied in a library of past cases which contains a description of the problem, plus a solution and/or the outcome (Marzouk & Ahmed, 2011) or expert prototype system that compares historical data at the work item-level across the case library (Chou, 2009). According to Ahn et al. (2014); Marzouk and Ahmed (2011), a general CBR is able to modify, or adapt, a retrieved solution when applied in a different problem solving context. However, Watson (1997) in Ahn et al. (2014) stated the usefulness of CBR with complicated, structured symbolic data rather than purely numeric data.

To conclude regardless of which method or technique used, Riquelme and Serpell (2013) said that there is a need to select an appropriate historical construction data to be used for cost estimation. Therefore, this paper also aims to verify the correlation between the used of method or technique applied, with cost factors and historical data from similar project.

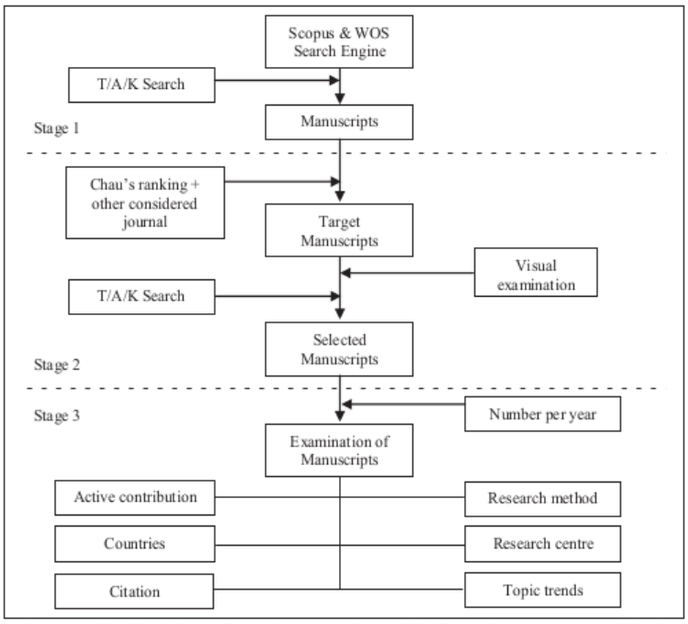
DATA AND METHODOLOGY

The data set concerns all publication as far as published in 15 main academic literature collections, Web of Science (WOS) and Scopus databases. Focusing only on the peer-reviewed contributions, this paper eliminated non- reviewed content (e.g., reports and books or book chapters). These databases are the most widespread databases on different scientific fields which are frequently used for searching the literature or specialized used for bibliometric data.

One of the problems related to select the scientific quality of journals is based on central assumption by the experience of author (Raan, 2005; Utama et al., 2015). However, according to Chau (1997), ranking of the top compressive live of journals highly recommended by most communities in the field that were selected. Therefore, the choice is based on the author's knowledge with a complete search encryption for databases on WOS and Scopus are given as follow:

> TITLE-ABS-KEY (*conceptual cost estimation OR cost estimation at early stage OR cost modeling for construction project OR estimating model for building project OR predicting project cost estimation) AND PUBYEAR AFT 1996 AND PUBLICATION TITLE (expert system with application OR international journal of project management OR automation on construction) TOPIC (model OR project OR cost OR project management) AND CONTENT TYPE (journal)*

Three filters were set (e.g. keyword, year and type of source) to ensure that it met the demand. All papers that had applied the qualitative and quantitative analysis techniques on CCE were selected from the related journals. Figure 1 presents the search process and Table 1 provides a breakdown of the total number of papers included in the study.



Source: Modified from Osei-Key and Chan (2015) and Utama et al. (2016)

Figure 1. The search processes

Table 1. Breakdown of the total number of selected papers by source and techniques applied

Journal Name	Number of papers	%
Journal of Construction Engineering and Management (JCEM)	11	19.64
Construction Management and Economics (CME)	8	14.29
International Journal of Project Management (IJPM)	7	12.50
Expert Systems with Applications (ESA)	6	10.71
Automation in Construction (AC)	4	7.14
Canadian Journal Civil Engineering (CJCE)	3	5.36
Building and Environment (BE)	3	5.36
Social and Behavioral Sciences (SBC)	3	5.36
Journal of Financial Management of Property and Construction (JFMPC)	1	1.79
Concurrent Engineering (CE)	1	1.79
Information and Software Technology (IST)	1	1.79
Facilities (F)	1	1.79
Technovation (T)	1	1.79
Journal of Manufacturing Science and Engineering (JMSE)	1	1.79
International Journal of Strategic Property Management (IJSPM)	1	1.79
Journal of Engineering, Design and Technology (JEDT)	1	1.79
Advances in Civil Engineering (ACE)	1	1.79
Journal of Computing in Civil Engineering (JCCE)	1	1.79
Total:	56	100
	Number of paper	%
Number (and percentage) of papers used qualitative approach	21	41.17
Number (and percentage) of papers used quantitative approach	30	58.83

DATA ANALYSIS AND RESULTS

Trend of Research Output on CCE

Preliminary retrieval of data from journal databases on CCE produced 196 articles. These appear in numerous journals publish from 1996-2015. In-depth review of the articles in selected journal, only 56 articles were truly relevant to CCE studies (refer to Table1). The statistical trend of annual number of relevant publication from 1996-2015 of selected journals is shown in Figure 2.

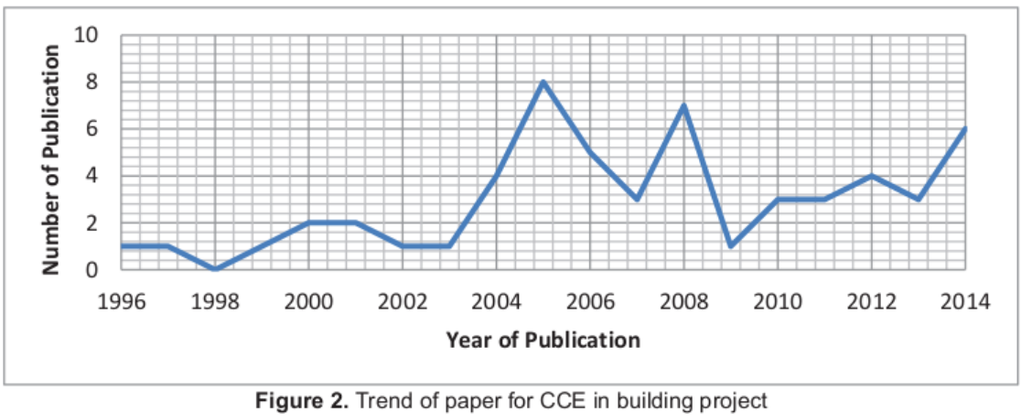


Figure 2. Trend of paper for CCE in building project

It is clear from the line graft shown in Figure 2 that the paper output trends in CCE studies fluctuated over the years from 1996 to 2014. During this period, the number of publications increased substantially over eight periods (i.e. 1998-2000; 2003-2005; 2007-2008; 2009-

2010; 2011-2012 and 2013-2014). Indeed, during 2003-2005, the number of academic papers increased dramatically from 1 paper to 7 papers. Forty-four academic papers were published over eleven year period, with average of four papers per year. Unfortunately, at the end of the trend, the number of papers jumped down from six papers to zero papers including during 1998, 2004, 2009-2011.

Active contributors to the publication

The method used to measure an individual author's contribution in multi-authored paper, and broadly adopted, is a formula initiated by Howard, Cole and Maxwell, (1987). The formula is given below:

$$Score = \frac{1.5^{n-i}}{\sum_{i=1}^{n} 1.5^{n-i}} (1)$$

Where n is the number of authors in publication; and i is the ordinal number of the specific author.

Table 2. Active contributor with at least 1 score point

Authors	Number of articles	Research Centre	Country	Score
Sonmez, Rifat	3	Middle East Technical University	Turkey	3.00
Kim, G.H.	4	Korea University	Korea	1.73
Akintoye, Akintola	2	Glasgow Caledonian University	UK	1.40
Dogan, S. Zeynep	3	Izmir Institute of Technology	Turkey	1.34
Ji, Sae-Hyun	2	ul National University	Korea	1.15
An, Sung Hoon	3	Korea University	Korea	1.11
Cheung, Franco K.T	2	City University of Hong Kong	Hong Kong	1.07
Stoy, Christian	2	University of Stuttgart	Germany	1.07
Gunaydin, H.M	3	Izmir Institute of Technology	Turkey	1.02
Trost, Steven M.	2	Oklahoma state university	US	1.00
Oberlender, Garold	2	Oklahoma state university	US	1.00

Of 56 papers published from 1996 to 2015, eleven researchers actively contributed to CCE study for building projects. Each researcher contributed at least two articles with one score point and more (Table 2). Although some researchers had two articles or more, they are not included in Table 2, since score point results cannot be reached a score of one. The score point was measured by using formula (1). For instance, one researcher has 4 articles. In the first paper he was 3rd author of a group of five, in the second paper, he was 3rd author of a group of three, while in the third paper, he was 3rd author of group four and the 3rd author of three in the last paper. These figures give the total contribution score as 0.17+0.21+0.18+0.21= 0.77. Thus, the author will not be included in Table 2.

Of the eleven researchers, the major research centers were Turkey and Korea with the total score of author contributor 36% and 26.8% respectively. Surprisingly, Turkey as a developing country has great interest in CCE study compared to other developed countries. The most active contributor is Sonmez, Rifaz from Middle East Technical University, Turkey with a total score of 3.00 point. Subsequently Korean author from Korea University, Kim G.H has a score of 1.73 point. Furthermore, other authors have slightly different of score value.

Table 3. Most frequently cited papers at least 50 times

Authors	Year	Journal	Cited
Akintoye, Akintola	2000	CME	363
Niazi, Adnan and Dai, Jian S.	2006	JMSE	312
, G.H., An, Sung-Hoon, and Kang, Kyung, In	2004	BE	296
Iyer, K.C. and Jha, K.N.	2005	IJPM	265
Trost, Steven M. and Oberlender, Garold	2003	JCEM	241
Akintoye, Akintola and Fitzgerald, Eamon	2000	CME	213
Hughes, Robert	1996	IST	188
Gunaydin, H.M. and Dogan, S. Zeynep	2004	IJPM	155
Oberlender, Garold D. and Trost, Steven M.	2001	JCEM	145
An, Sung-Ho, Kimb, Gwang-Hee and Kang, Kyung-In	2007	BE	130
e, David J., Emsley, Margaret W. and Harding, Anthony	2006	JCEM	115
Chua, D.K.H., Kog,Y.C., Loh, P.K., and Jaselskis, E.J	1997	JCEM	108
Rush ,Christopher and Roy ,Rajkumar	2001	CE	95
mez, Rifat	2004	CJCE	90
ag, T.M.S., Boussabaine, A.H and Ballal, T.M.A	2005	IJPM	81
Kim, G.H., Seo, D.S. and Kang, K.I.	2005	JCCE	73
, Li and Zhu, Kai	2007	JCEM	69
Cheng, Min-Yuan, Tsai, Hsing-Chih and Hsieh, Wen-Shan	2009	AC	67
Aibinu, Ajibade A. and Pasco, Thomas	2008	CME	63
Chan, Swee Lean and Park, Moonseo	2005	CME	60
ng, I-T	2005	IJPM	55
Cheng, Min-Yuan, Tsai, Hsing-Chih and Sudjono, Erick	2010	ESA	55

(Source: Google Schoolar (https://scholar.google.co.id/) accessed on July 3th, 2017)

Other important information related to the analysis of research trends is the number of citations. Generally, all journal data bases, including one such as SCOPUS and WOS, provide such information. However, according to Utama et al. (2015), these data bases gave different information about the citation count. Thus, another popular academic search engine was used to deal with this problem. The results show only 11 out of 18 journals with 22 articles contributes the list. Those journals contribute to a citation count 3,239 times, equal to a count of 147.23 cited times on average. Moreover, CME with 4 papers on the list reported 699 citations equal to 21.58% of total citation and becoming the most influential journal this study. The second influential journal is JCEM with 5 papers reported 679 citations equal to 20.96 % of total citation. Interestingly, the both journal, CME and JCEM are included in the top five of Chau's rangking.

Research Methodology Employed in CCE

In the next phase analysis, the papers were classified by type of techniques applied in CCE for building project. A total of 51 papers were compiled. From the table 1, the results indicated that there was more paper having applied quantitative approach than qualitative approach. They were 30 (about 58.83%) and 21 papers (about 41.17%), respectively. Likewise, the respective trends depicted in Figure 3 confirmed this finding.

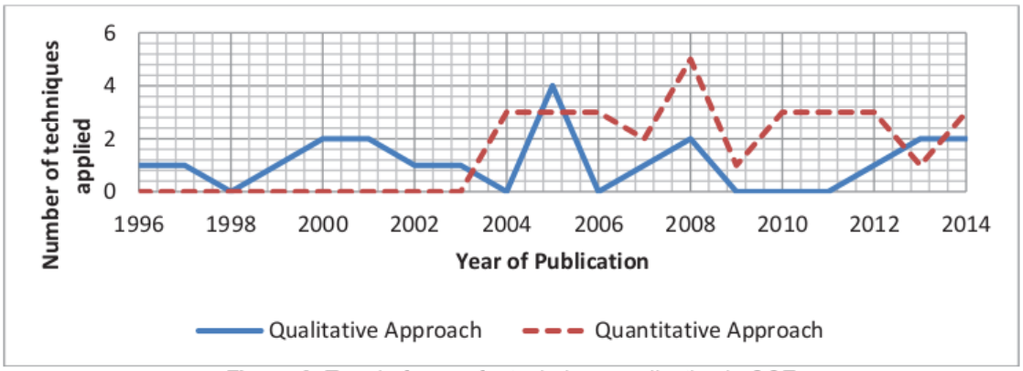


Figure 3. Trend of paper for technique application in CCE

In cost modeling, quantitative approach is defined as cost element and known structures of elements which form the basis of a cost estimate and that are measurable (Rush & Roy, 2001b). On the contrary, qualitative approach can be defined as the assumption and judgment that related to how the estimator refers the past project as a basis for the generation of a new estimate (Datta & Roy, 2010; Niazi & Dai, 2006; Rush & Roy 2001a). Based on the year of publication in Figure 2, there were not papers having applied quantitative techniques during 1996 – 2004. However, in 2005, researchers started to study CCE papers in applied quantitative approach. Furthermore, in the ten years after 2005 spent tracing the trends, production of CCE papers had more papers having in quantitative approach than qualitative approach. There was a total of 24 and 8 papers, respectively. Otherwise, in the first eight years, there were only papers in applied qualitative approach with a total of nine papers.

Through comprehensive review on research methodology, the papers were also classified by analysis method and model applied. Figure 4 shows the distribution of papers into three of categories in term of research analysis employed. In this study, the model dominantly was used in analysis for about 54%. In contrast, the descriptive and statistic were used just over 14% and 32% respectively.

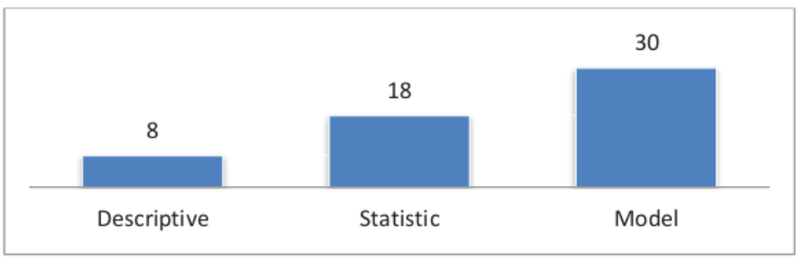


Figure 4. Trend of research analysis employed in CCE studies

As mention before, various conceptual cost estimation methods and techniques have been done to calculate the conceptual cost estimation including regression, neural network, case base reasoning (CBR), and simulation. Instead, some researchers also have integrated the two above methods or techniques altogether. Through the process, a total of 30 papers was classified into technique of models were used. From Figure 5, the result indicated that, there were not a large different between technique of models used including CBR, neural network, regression and simulation. There were 8, 7, 5 and 5 papers respectively, for integrated technique altogether.

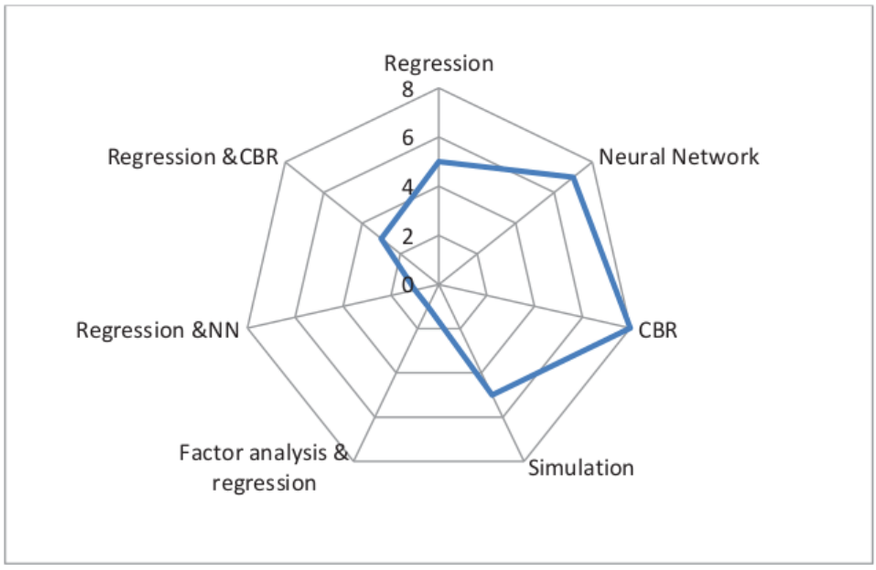


Figure 5. breakdown of the total number for model applied

Trends of research topic

To figure out the evolution of CCE research topics on factors influencing the cost estimation, researchers attempted to classify the large number of cost factors into categories or factors with similar attributes (Akintoye & Fitzgerald, 2000; Cheng, 2014; Elhag et al., 2005; Enshassi et al., 2005; Liu & Zhu, 2007; Toh et al., 2012; Trost & Oberlender, 2003). The cost factors are identified into five categories: 1) information of consultant and design parameter, 2) project's characteristics, 3) client's characteristics, 4) contract requirements and procurement methods, and 5) external factors and market conditions. In order way, the above factors can be categorized into two distinct group: 1) estimator-specific factors and 2) design and project-specific factors (Akinci & Finchers, 1998; Elfaki et al., 2014). However, through comprehensive reading of articles, the above cost factors can be combined into four categories as presented in figure 5.A four and five-year interval had been chosen for a distribution of 19 years over four consecutive periods. The main reason for using a longer interval period instead of annual period was to ensure that the depicted trend would be less erratic or smoother.

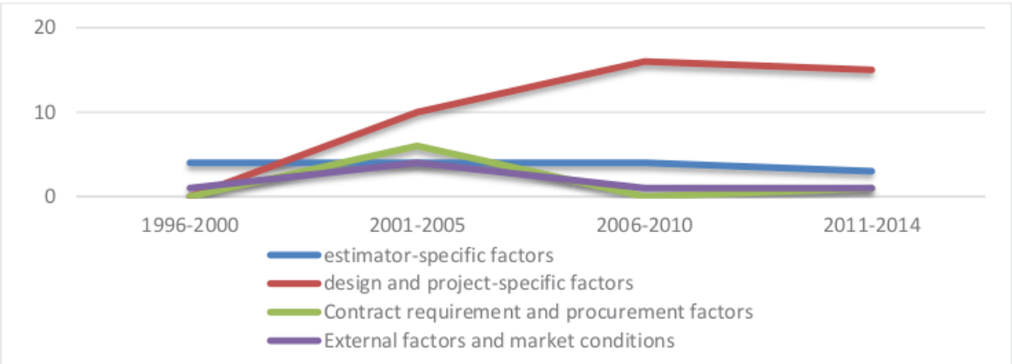


Figure 6. The development of cost factors on CCE

Figure 6 depicts how research topics in CCE changed during the period 1994-2014. The first point to note is that there is one topic which attract researcher's in particular. In the three last terms, the cost factor related to *Design and project-specific* (e.g. gross floor area, number of stories, total unit, location, roof types, foundation types, usage of basement, finishing grades, etc) piqued researcher's interest. There is a growing trend of *design and project-specific factors* being applied to research in the field of CCE with total of 41 papers in all period. On the contrary, the trend changes to *Estimator-specific factors* (e.g. experience of estimator, frequency of estimating, estimation process, estimation conditions, client characteristics, consultant and contractor attributes, etc.). In the early three terms (i.e. 1996-2000; 2001-2005; 2006-2010), the papers remained relatively steady in 4 papers and decreased one paper in the following term.

Interestingly, *Contract requirement and procurement factors* and *External factors and market conditions* have the same total of papers during all the period (1996 to 2014) with 7 papers. Compared to the two mention topics, *Contract requirement and procurement factors* (e.g. building tender price index, poor tender document, insufficient tender document analysis, etc) and *External factors and market conditions* (e.g. construction demand, bank landing, hostile socio economic, etc) tend to be overlooked in all terms. There were not many researchers incorporating these factors as a significant cost factor in CCE.

In addition, from Table 4, the results revealed one active area of cost factors, in term of having the highest numbers of papers among the seven categories of model applied. The area identified were *design and project-specific factors* (with 27 papers). This area also had the highest number of papers to which neural network and CBR techniques had been applied (in 7 papers). Regression and simulation techniques also had the same number of papers (in 5 papers). The patterns of the papers were plotted in Figure 5 depicting the trends of all papers including descriptive and statistical analysis that were applied.

Table 4. Classification of papers by model applied for area of cost factors

Area of cost factors in CCE	Estimator-specific factors	Design and project-specific factors	Contract requirement and procurement factors	External factors and market conditions
Regression (RS)		Hua, Goh (1999) Li, Heng and Shen (2005) Lowe et al. (2006) Sonmez, Rifat (2008) Ji, Sae-Hyun et al. (2010)		Hua, Goh (1999)
Neural Network	Chua, D.K.H et al. (1997) Cheng, MY et al. (2009)	Gunaydin and Dogan (2004) Kim, G.H et al. (2005) Wen-Der (2006) Cheng, MY et al. (2009) Cheng, MY et al. (2010) Sonmez, Rifat (2011) Bala, Kabir et al. (2014)		
CBR	Lai, Yu-Ting (2008) Rush and Roy (2001)	Kim, G.H et al. (2004) An, S. H et al. (2007) Doğan, S. Z et al. (2008)		Lai, Yu-Ting (2008)

Area of cost factors in CCE	Estimator-specific factors	Design and project-specific factors	Contract requirement and procurement factors	External factors and market conditions
		Lai, Yu-Ting (2008)		
		Koo, C.W et al. (2010)		
		Ji, Sae-Hyun et al. (2011)		
		Koo, C.W et al. (2011)		
Simulation	Khodakarami et al. (2014)	Yang, I-T (2005)		
		Kim, H.J et al. (2012)		
		Wang, W.C et al. (2012)		
		Khodakarami et al. (2014)		
Factor analysis & RR	Trost and Oberlender (2003)	Trost and Oberlender (2003)	Trost and Oberlender (2003)	
Regression & NN		Sonmez, Rifat (2004)		
Regression & CBR		Jin, RunZhi et al. (2012)		
		Jin, R.Z et al. (2014)		
		Ahn, Joseph et al. (2014)		

CONCLUSION AND RECOMENDATIONS

The three main finding are as follows:

(1) Trend of paper for CCE in building project show an upward trend with some fluctuations during the period of 1997 to 2014 (refer to Figure 1)
(2) The active contributors of the study in supplying analytical thinking and critical ideas are dominated by researcher from Turkey and Korea (refer to Table 2)
(3) There is a clear positive trend for the papers that have applied quantitative approach which starts from 2005, whereas the papers applied qualitative approach began to steadily decrease (refer to Figure 2)
(4) The areas of cost factors that have increasingly higher growth affecting CCE are *Design and project-specific factor*, e.g. gross floor area, number of storeys, total unit, location, roof types, foundation types, usage of basement, finishing grades, etc (refer to Figure 6)

Over the years, research in cost estimation at early stage (CCE) has been done. Empirical evidence from this bibliometric paper indicates that previous calls for paradigm in area of significant cost factor have changed in practice toward the adoption of more on *design and project-specific factor*. This paper also verifies there is no correlation between cost factors with model applied in CCE (refer to Table 4). The paper can apply all defined technique or method in using data analysis.

The study using one cost factors in factor *design and project-specific factor* could expound not only the significant cost variable but also the prediction interval to show the range estimating possible of accuracy. Trost and Oberlender (2003), in data analysis for their study had three cost factors as shown in Table 3. They have analyzed five significant cost factors from three above defined cost factors (11 variables with 45 elements) and there was not a conclusion on estimating possible of accuracy. This study has been also shown by Chua et al. (1997). Moreover, most papers used historical project data to develop causal models where relationships of the variables can be established in a predictable interval of accuracy.

In conclusion, it seem to agree with Riquelme and Serpell (2013) that there is a need to select an appropriate historical data to be used for cost estimation and also each method is appropriate for certain individual situations. And the analysis result could help estimators and researchers to make plans for the applications and supporting future research.

ACKNOWLEDGMENT

The study was financially supported by The Ministry of Research, Technology and Higher Education of the Republic of Indonesia. Acknowledgments are given to Universitas Bung Hatta, Indonesia and University of Malaya, for their support.

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A CONCEPTUAL MODEL OF LEAN CONSTRUCTION: A THEORETICAL FRAMEWORK

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Abstract
Lean Construction has become a global reference of a production system with the minimum of waste. However, previous research shows that there are several implementation scenarios, which differ from one company to another according to their own understanding of the Lean Construction principles. This work aims to fill this gap by proposing a generic framework leading to a better understanding of the basics of Lean Construction. In this paper, an original conceptual model has been developed based on a rigorous analysis of the most relevant Lean construction models that have been applied and tested in several countries. The outcome of this model shows that there are nine main Lean Construction principles, and which are: customer focus, supply, continuous improvement, waste elimination, people involvement, planning and scheduling, quality, standardization and transparency. In addition to that, the most used Lean Construction sub-principles have been identified based on an extensive literature review.

Keywords: *Lean Construction; Conceptual model; Framework; Principles; Sub-principles*

INTRODUCTION

The construction industry is highly characterized by the generation of waste, uncertain safety conditions and a high variability of its construction process (Koskela, 1999; Tezel and Nielsen, 2013). In addition, building construction sector is often classified at the bottom of the ranking of reports regarding the efficiency of the production management techniques (Antunes and Gonzalez, 2015). Indeed, several solutions had been implemented to overcome the costs and deadlines overruns of construction projects, such as the introduction of industrialization techniques through prefabrication, the use of new computer technologies as Building Information Modelling (BIM), as well as automated and robotic construction techniques. Despite the introduction of new advanced tools and materials in order to improve the performance of construction processes, this industry has not been able to achieve a significant change in its production system compared to other sectors such as the manufacturing industry. This is mainly due to the lack of a renovation strategy of the traditional management techniques (Johansen and Walter, 2007). A lot of researchers (Aziz and Hafez, 2013; Dupin, 2014; Harris and McCaffer, 2013) have demonstrated that these solutions alone cannot create a major revolution for the construction sector, especially in the absence of a solid basis of management.

The international competitiveness and the economic crisis permanently increase the pressure on the actors of construction projects to seek better and more innovative approach. Recently, the construction companies have begun to experience the lean manufacturing philosophy that has been applied for many years in the automotive industry and which has become the benchmark for industrial excellence in the manufacturing sector, but which is still recent in the construction industry. The term "Lean" means the optimal use of the available resources within the company. This approach uses only half of the human resources, half of the production space, and half of the investment costs in tools and new

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