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Predicting productivity in construction industry utilizing multiple linear regression technique and artificial neural network technique: A review for research and applications

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Abstract
Construction productivity can be very importance for development the engineering project management and reduce the time achievement. Approximation the time and cost are very important for complete any project. The objective of current study introduces the productivity in construction project, measuring construction productivity, and exploring all variable's affecting on productivity, also, display the construction productivity literature reviews and relates this review with the traditional and intelligent approaches like Multiple Linear Regression Technique (MLRT) and Artificial Neural Network Technique (ANNT) respectively.

Keywords: construction productivity, review, artificial neural network technique, construction project, multiple linear regression technique

1. Introduction
Construction productivity is one of the generality commonly researched topics due to its significance to the ability of the industries. It is regarded as a faithful reflecting of the economical and efficiency prosperity of the operations (Jarkas, 2005). Labor productivity in construction project has become such a ring word and one of the generality repetitively researched issues. In generality countries, labor cost includes 25 to 60% of the overall for cost in construction project (Guhathakurta and Yates, 1993).
Because construction is a labor-intensive industry, the significance of this effect not only justifies the concern over its labor productivity, but it can also be argued that labor power is the only productive resource, hence construction productivity is mainly dependent upon human effort and performance (Jarkas 2012) [26].
Jordan is a little nation with a developing and stable economy among its neighboring nations in the locale. Much appreciated Allah the benevolent of security in correlation with other unsteady economies in the locale, because of the political disturbance. Jordan common assets are rare, Jordan generally depend on business administrations areas, for example, training, protection, account and banking, the travel industry, and obviously a blasting land and development divisions (Saho and Shukair 2017) [6].
The sector of construction had been one of the Jordan is a little nation with a developing and stable economy among its neighboring nations in the locale. Much appreciated Allah the benevolent of security in correlation with other unsteady economies in the locale, because of the political disturbance. Jordan common assets are rare, Jordan generally depend on business administrations areas, for example, training, protection, account and banking, the travel industry, and obviously a blasting land and development divisions power sectors of the Jordanian economy lately. Construction Sector was accounted for 4.45 % of Gross Domestic Product (GDP) on average over the period 2008-2010 (Jordan Real Estate Sector – Thriving on growth, Global Investment House, 2012). The sector has grown at a Compound Annual Growth Rate (CAGR) of 14.0% during the same period. Credit to the construction sector has also expanded by Compound Annual Growth Rate of 21.0 %, and with highest a growth rates of 35.0 % and 25.0 % was registered for 2009 and 2010 respectively (Department of Statistics, Gross domestic products by kind of economic activities in Jordan (2008-2010), Jordan, 2012).

2. Construction Productivity Concept
Productivity in generally can be defined as the ratio between the output and the input. The productivity of workers could thus be measured as an output (Magee 1997) [15]. Production is a function of providing more and more of everything to more people with less and less consumption of resources (Telsang 2000). Profitability is the connection between yield made by a creation or administration framework and the information gave to make this yield. Hence, profitability is characterized as the effective utilization of assets work, capital, land, materials, vitality, data in the creation of different products and ventures. Higher profitability implies achieving more with a similar measure of assets or accomplishing higher yield as far as volume and quality for a similar info (Prokopenko 1987). This is usually stated as equation (1):

$$\text{Productivity} = \text{output} / \text{input} \ldots\ldots\ldots \quad (1)$$

Higher production levels permit contractors to concurrently increase profitability, pay higher wages to workers and increase competiveness while finishing activities sooner. Higher productivity levels generally turn into greater profitability. A sustainable progress in labor productivity is

also related to economic growth, as it causes noninflationary upsurges in salaries and wages (Rojas 2008) [8].

The production was one of generality importance aspects for the construction sector that helps for revivals and growths (Garza et.al, 2017) [16]. Among man, material and machinery, labour were the generality precious resources and if labour were consider as an input in production then the production was known as labor productivity (Dey et.al, 2017) [36]. Be that as it may, the procedure (sets of various tasks) can be institutionalized by playing out an accumulation of information in relations to the time engaged with all the contained methodology in the create of a decent and administration (manufactures of a hardware) can be separated into exercises (hold the bases, introduce the cases, embed electronic units) and in components (arranges right pivots, left, collect entryways in primary rooms, and so forth.) (Garza et.al, 2017) [16] Productivity of labor had a profounder impact on the project management. Accurate predicting of construction productivity was essential to effectively plan activities that depended on the duration and cost and is critical for the success of an engineering project for both the planners, contractors and the owners. However, predicting productivity of operations is challenging since the multiple characteristics of workers, the interrelation-ships between labour, and the site condition that impacts the performance of crews and affect project goals (Florez, 2016) [22]. Engineering productivity rates are the origin for predicting costs and duration accurately that is necessary to completed construction project. Construction productivity can be defined as the ratio between the output of quality that was needed and respects to the inputs of the certainty production condition. From the engineering sector, it was normally acknowledged as worked output per man - hours worked (Faiq et.al, 2016). "The enhanced production contributes in helping contractors and a project owner in terms of it is considered more profitable and efficient. Also, it was aids them to accurately predicting bidding for construction projects (Al-Zwainy *et al*., 2013)" [12]. Can be used construction productivity as a input when to need calculated productivity as shown in equation (2), When resource used expressed by: (Labor, Machine, Equipment).

$$\text{Productivity} = (\text{Construction output})/(\text{Resource used}) \ldots\ldots\ldots \quad (2)$$

Researchers can be defined the construction productivity as an amount from achieved engineering work per labour in construction project for any measures unit such as (Meter Square, Cubic Meter, ….. etc) at each period of time (Day, week, Month).

3. Measuring of Construction Productivity

In overall industries, labour production was considered to be one of the best of the indicators of the productivity efficiency. Nonetheless, because of the extraordinary attributes of building ventures, heuristic cost projection and booking are favored over efficiency - based estimations. In spite of the fact that significance, it very well may be hard to quantify work profitability hands on location because of the intricacy of assignment depictions and the length expending procedure of the following the efficiency of work. Additionally, it was trying to distinguish the deliberate creation for an assigned action at an especially amount so as to deliver the unit all out expense of the activity (Lee et.al, 2017) [23].

One challenge was the unit of measurement depended on the engineering activity since differences between productivity rate levels among tasks types (Chang 2017). Productivity was measures be categorized as a single factor productivity measures or partial productivity (relation a measure of the output into a single measure of the input) or multifactor productivity measures (relating a measure of the output to a groups of the inputs). (OECD, 2001) [30]. Uniqueness and non - repetitive activities of engineering projects make it difficult to develop a standards productivity definitions and measures (Sweeis 2000).

Total Factor pf the productivity can be expressed as productivity calculations which including all the operations on the engineering site were as called total variables productivity. (Rasool 2016) [35].

4. Variables Affecting on Productivity in Construction Project

In general, the variable's affecting on construction productivity classified into two groups; internal variables (Controllable variables) and External variables (Non-controllable variables). Figure (2.1) illustrate the factors affecting productivity (Prokopenko, 1987).

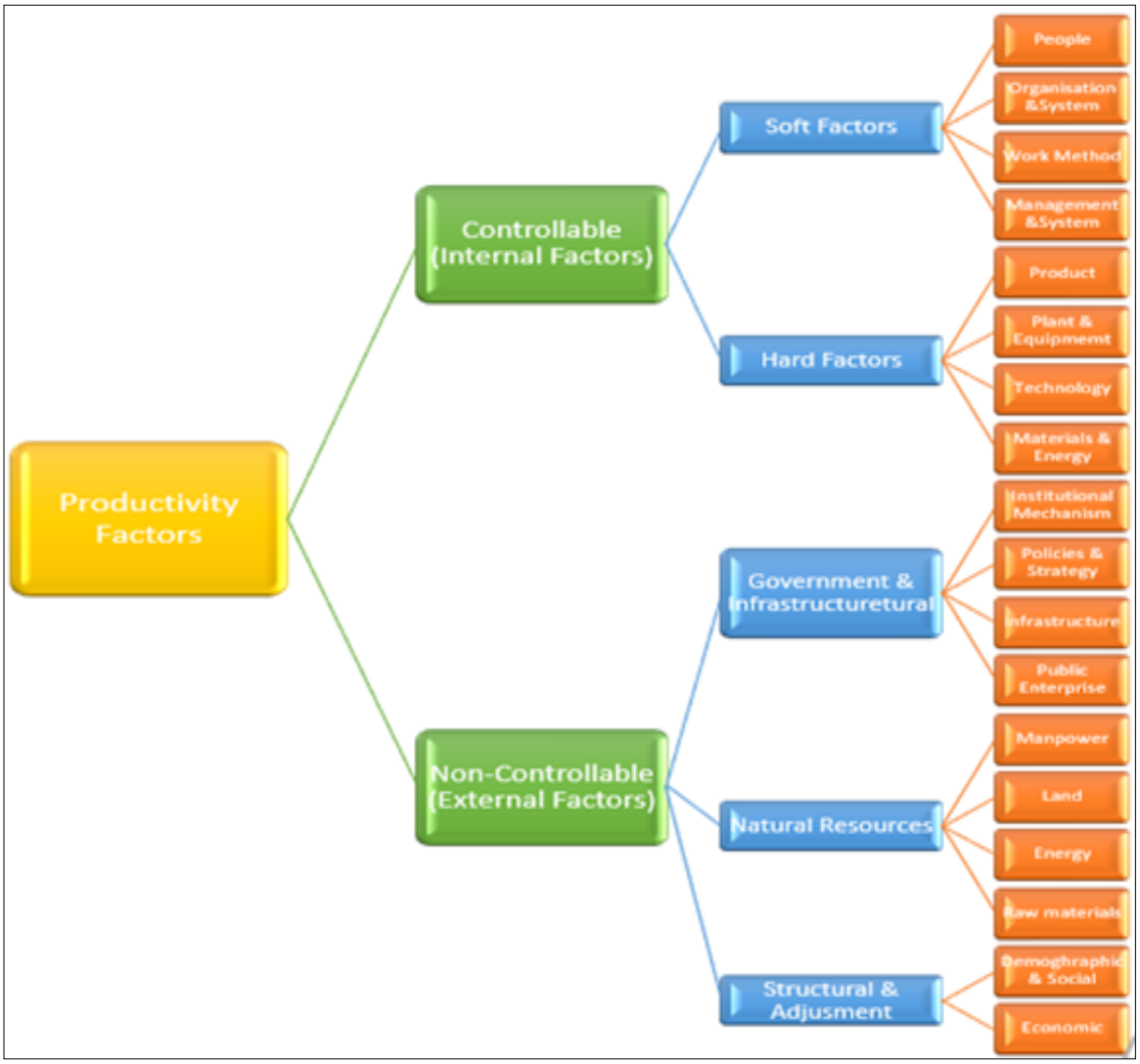

Fig 1: Factors affecting productivity

In order to enhance production, studies variables that affecting on it, whether the negatively or the positively, was essential. Make using those variables that positively affecting in the productivity and neglecting or controlling variables that have negatively affect (Lema, 1995) [29].

Based on past researches (Soekiman, 2011) [3], one hundred thirteen variables that affecting construction labour had been identified and were grouped into fifteen (15) groups according to their characteristics, namely:

1. design five (5) variables;
2. Executing plan five (5) variables;
3. Materials eight (8) variables;
4. Equipment six (6) variables;
5. Labour eighteen (18) variables;
6. Health and safety four (4) variables;
7. Supervision six (6) variables;
8. Working duration six (6) variables;
9. Project factor fifteen (15) variables;
10. Quality three (3) variables;
11. Financial six (6) variables;
12. Leadership and coordination five (5) variables;
13. Organization twelve (12) variables;
14. Owner/consultant four (4) variables;
15. External factor ten (10) variables.

(Zakeri et.al, 1997) [27] explored ten factors which have effect on the construction productivity: total quality; amount and balance of labor forces; motivation of labor forces; continuity of work;

Complexity of work; degree of mechanization required; method of construction; quality of finished work; type of contracts; total quality and the number of construction managers; and weather. State that productivity in construction projects is determined by many aspects other than labor including: construction material; construction equipment; tools and techniques; construction methodology; and management skills.

However, these resources were inactive, and without use if not converted into productivity techniques by the human component and the total quality of the human performance that hinge mainly upon motivation.

Some researchers in the Arabic world worked studies and researches to determine that factors affecting on the labor construction productivity, as shown in Table (1).

Table 1: Variables affecting on the labor construction productivity in Arabic world countries

Author Name	Year	Number of variables	Number of groups	Location
Jarkas and Radosavljevic	2013	23	_	Kuwait
Mahamid	2013	31	5	Palestine
Alzwainy et,al	2013	10	1	Iraq
Elgohary and Aziz	2014	30	3	Egypt
Jarkas et,al	2014	38	1	Qatar
Bekr	2016	37	5	The Hashemite Kingdom of Jordan

5. Overview of Applications of the Construction Productivity in Project Management

Table (2.2) clarified the summary of previous work on construction productivity through kind of research, Publishing date, data collection, technique were used, Software, research population, Place of research and results.

Table 2: Summary of previous studies on construction productivity

	Research Name	Research Kind	Publishing Date	Data Collection	Technique	Software	Research population	Research Place
1	Nasirzadeh and Nojadhi	Review article	2013	Project report documentation and data from the site	MLR and Dynamic system (SD)	MATLAB	Construction project	Iran
Result	Got flexibility and robust methods for the simulations of labour productivity with the possibility of find the root causes of a decreasing in construction productivity. Therefore, the labour productivity can be improved by construction of propers solves							
2	Shah *et al*,	Review article	2014	Explorative Questionnaire	Relative Importance Index (RII)	SPSS	Owner, Engineer, Architect, Project Manager, Consultant, Supervisor	India
Result	"Low Payment" factor get the most affecting factor construction productivity by RII = 0.8729, "Poor Construction Method" get the second factor affecting construction productivity but the last rank was "Unclear Or Incorrect Communication" by RII= 0.7648.							
3	Ghanim A.Bekr	Review article	2016	Structured Questionnaire	Relative Importance Index (RII)	SPSS	Clients, Consultants and Contractors	Jordan
Result	"Poor Planning and Scheduling" factor get the most affecting factor labor productivity in construction projects followed technical group by RII = 86.26, "Material Shortage Of Project Site" get the second factor affecting labor productivity in construction projects followed Material and Equipment group but the last rank was "Project Size" followed Project group by RII= 45.68							
4	Opperman	Thesis	2016	Questionnaire and Interviews	Content data analysis	SPSS	Construction workers	South Africa
Result	The findings were the workers agreed that lack of supervisory motivational techniques negatively impact their productivity. Specifically the findings supervisory must be used motivational communication, extrinsic rewards, intrinsic rewards and positive reinforcement techniques rather than punishment techniques were the most strategies can help workers to accomplish higher level of productivity.							
5	Gurmu	Thesis	2017	Questionnaire and Interviews	Matrix, Correlation, Linear Regression and Logistic regression	Excel and SPSS	Experts, Principal Contractors	Australia
Result	The practices "Well-defines scope of works", "Safety and health policy" and "Safety's and health's plans" were found the most three important project management practices that had the potential to improve construction productivity in multi-story buildings.							
6	Al-Zwainy et.al,	Review article	2013	Observation and Recompiled	MLR	SPSS	Residential, Educational and Commercial project	Iraq
Result	Developing the construction productivity predicting models for marble finishing work, The (MLR) was strong technique of estimating construction productivity model for marble finishing work because a Coefficient Correlation equal to 91.6% and the Average Accuracy Percentage (AA%) equal to 96 %.							
7	Thomas and Sudhakumar	Review article	2014	Work Study	MLR	SPSS	Construction project	India
Result	Development a mathematical model for quantified the impact of the influential variables on the masonry labor productivity, regression model was identified excessive overtime and materials delay as the major factors impacting on the construction productivity							
8	Rasool and Alzwainy	Review article	2016	Historical data	MLR and Logistic Regression	SPSS	Residential, Educational and Commercial project	Iraq
Result	Estimating labor productivity rates for brickwork item, (MLR) Average Accuracy Percentage (AA %) is 92.5% and Mean Absolute Percentage Error (MAPE) is 7.5%. While the results from Logistic Regression were Average Accuracy Percentage (AA%)=92.5% and Mean Absolute Percentage Error (MAPE) is 7.5%							
9	Karimi et.al,	Review article	2016	Two different database	MLR	SPSS	Construction Project	US and Canada
Result	Shown that there were factually noteworthy relationship between increment makes utilizing trouble and lower ventures efficiency and furthermore increment plan overwhelms. The amazing this investigation lies in the realities that the analyzes on two unique databases, with contrast proportions of art work accessibility and profitability, shows comparable outcomes. This backings the reliabilities and							

	consistency of the outcomes as they remotely approve each other's.							
10	Greek et.al,	Review article	2012	Historical data	ANN	MATLAB	Construction Project	Turkey
Result	Modeling the relationships between productivity and influencing factors by using two ANN techniques, the (RBNN) technique is better than (FFNN) technique. This judgment done by correlation of coefficient and mean absolute percentage error.							
11	Al-Zwainy	Review article	2013		ANN	NEUFRAM		Iraq
Result	Develop a new model for construction productivity estimation of finishing stone works for buildings projects. The model gets acceptable degree of accuracy; Average Accuracy Percentage is 96.4% and Coefficient of Correlation (R) is 93.2%.							
12	Heravy and Eslamdoost	Review article	2015	Related research and expert judgment	ANN	MATLAB	Statistical publications of the Iran Power Generation	Iran
Result	Build up a work profitability model, early halting and Bayesian regularization are executed and analyzed. Results demonstrated a superior expectation execution for Bayesian regularization than early halting.							
13	ElGhohary et.al,	Review article	2017	proposed data-acquisition system	ANN	Neurosolution	Residential and commercial buildings	Egypt
Result	Presents development ideas to records, controlling, foreseeing, and improving the contractual worker's work profitability. arranges enough merged with have observable and sensible summing up abilities							
14	Mahamid	Review article	2013	Questionnaire	Frequency Index, Severity Index and Importance index		Contractors in public construction	Palestine
Result	Distinguished that factors show that best ten significance factors adversely influencing work profitability of open building ventures in the Palestine are: political circumstances, types of gear deficiencies, old and wasteful supplies, absence of work encounters, poor destinations the board, poor correspondences and coordination between development parties, installments delay by the proprietors, low wages, revamp, and abuse of time booking.							
15	Chaturvedi et.al,	Review article	2018	Questionnaire and historical data	Dematl		Professional experts in construction company	India
Result	Result acquire for a run of the mill instances of Indian designing industry demonstrated that the security at building destinations have a profounder impact on work profitability and execution.							
16	Usukhbayar and Choi	Review article	2018	Questionnaire,Historical data, Previous concreting work	MLR	SPSS	Mongolian Association of Civil Engineers (MACE), commercial, industrial, institutional and residential.	Mongolia
Result	Analysis results indicated that low temperatures, highest winds and precipitation were the critical variables affecting on the productivity losses in terms of outdoor concrete works.							

6. Conclusion

In this research, Clarified the productivity in construction sector in Hashemite Kingdome of Jordan and what its obtained from Gross Domestic Product (GDP), Reviewed the Productivity definition, Measures and factors affecting construction productivity; Classified in two group the first is Controllable factors and the second is Non controllable factors. Demonstrated the productivity previous study in construction sector the most studies in this topics were identifying the factors influencing Construction productivity whether negatively or positively impact, previous study in Multiple Linear Regression approach, most studies in these topics were developed a model to estimating the construction productivity, previous study in Artificial Neural Network approach, most studies in these topics were developed a models to estimating the construction Productivity. In addition to compare between previous study and current study to illustrate the current study carry a new idea and no repetitive to another study.

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