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Effectiveness of Lean Construction Principles on Project Efficiency in Central Jordan's Construction Projects

Hanan Al-Adwan [1,*]

Department of Business Administration, Faculty of Economics, Al-Balqa Applied University, Jordan.

hananable@outlook.com

Mohamad Al-Adwan [2,*]

Graduate Researcher in Civil Engineering, Jordan.

mohamadaladwan1@outlook.com

Abstract

Purpose – *Clarifying and measuring the effectiveness of flexible construction principles on project efficiency in construction projects in central Jordan.*

Design/methodology/approach – *This study is considered one of the quantitative studies that provide a numerical explanation to prove the effectiveness of lean construction principles in project efficiency in construction projects in central Jordan. The study sample was selected randomly from a homogeneous community of consultants and contractors who hold engineering membership from the Jordan Engineers Association.*

Results– *The results indicated that the comprehensive application of the principles of flexible construction (value definition, value stream mapping, flow creation, pull instead of push, and Pursuit of Perfection) leads to improvements in the level of efficiency in construction projects in central Jordan.*

Originality/Value - *This research highlights the research gap related to the application of flexible construction principles by the construction sector and reveals the concepts related to project efficiency. In addition, this research is considered one of the few studies that studied the extent to which the Jordanian construction sector applies flexible construction principles and its effectiveness in improving project efficiency.*

Keywords: Lean Construction Principles, Project Efficiency, Construction Projects, Project Management, Jordan.

1. Introduction:

The construction industry has undergone significant technological and managerial changes recently, as the construction industry is seen as resistant to change compared to manufacturing. Today, the construction industry is currently facing challenges related to cost and time overruns, low productivity, quality issues, delivery time, and other challenges that prevent achieving the desired level of quality (Moshood et al., 2024). These challenges have prompted the development of techniques, philosophies, and methodologies to align them with the quality standards in the construction industry. With the continuous progress, researchers in this

field have come up with the term "lean construction" derived from the principles of lean production (Singh et al., 2024; Daniel and Pasquire, 2019). As a result, the construction sector has witnessed continuous improvements and development as a result of the application of several successful approaches and principles of lean construction, which have led to reduced cost and time, as well as improved productivity (Likita et al., 2024). Numerous methods and policies have been developed to implement lean construction to achieve high levels of productivity. In addition to linking it to management theories, and sub-principles of lean construction in order to enhance the application of lean construction in construction projects of any size (Pandithawatta et al., 2019; Le and Nguyen, 2021). However, many projects still struggle with a large number of challenges such as delivery failures, cost overruns, waste, poor productivity, delays, and concerns about quality and safety, which require significant attention from researchers and decision makers (Xing et al., 2019).

The construction industry has long suffered from low productivity and high wastage of resources (Pan and Pan, 2023). This has been a major drawback in projects that practice traditional construction methods. Perhaps the most notable of these drawbacks is the poor involvement and consultation of the contractor in the construction plans and initial designs, which inevitably leads to major failures and delays in project delivery (Aslam et al., 2019; Dauda et al., 2023). In response to these errors and poor productivity, the concept of lean construction emerged in the 1990s, which stipulates understanding the client's needs to provide the best productivity and best use of resources. The principles of lean construction were formed based on three things (flow, value, and perfection), and these principles were then developed to include the project life cycle (Son and van Tien, 2024; Fernando et al., 2024; Pan and Pan, 2023; Mano et al., 2020). Lean construction then evolved to arrive at the five most important principles, including project definition, lean design, lean procurement, lean assembly, and optimal use of resources (Ullah et al., 2019).

The integration of Lean into the construction industry has led to enhanced production efficiency, significant improvement in project operations, and the achievement of the highest levels of quality (Issa and Alqurashi, 2020). Although this concept first emerged from the industrial sector, the construction industry is one of the first industries that began to consider adopting Lean methodologies, but the process of implementing it is considered a complex and lengthy process due to the nature of the construction industry, which contains major and variable complexities and challenges that prevent the application of Lean principles (León-Romero et al., 2024; Jain et al., 2023; Orlov and Kankhva, 2022; Ahmed et al., 2020; Al-Aomar, 2012). It must be acknowledged that the construction industry has an unreliable reputation due to major quality errors, delivery delays, and waste of resources (Akter et al., 2024). Therefore, it must be recognized that new theories must be adopted to support the construction industry in order to enhance project efficiency and increase productivity further (Moshood et al., 2024; Polat and Demirkesen, 2024). Hence, interest has emerged in integrating Lean practices with design and work plans in the construction sector, as a modern and flexible approach to achieving highly efficient and effective projects. This is to adopt a lean approach to create flexibility, improve productivity, and raise quality levels throughout the project life cycle (Albalkhy et al., 2024; Xing et al., 2019; Ullah et al., 2019). However, the construction industry still faces increasing challenges in project management and delivery, due to technical complexity, diversity of data to be managed, constant changes in supply chain management systems, contractual agreements, and the urgent needs of smart and green buildings (Son et al.,

2024). Therefore, many researchers consider lean construction principles an effective solution to enhance communication and collaboration among stakeholders (Moshood et al., 2024). Many companies and organizations have realized the benefits of these principles and have adopted lean construction models and methods in their operations. Despite the many benefits of lean construction principles, their integrated and flexible application with other project management systems can achieve greater improvements in project efficiency than their separate implementation in construction project management (Singh et al., 2024; Lohne et al., 2022). The benefits of lean construction include three times better quality and possibly more, faster results, and lower costs compared to traditional practices (Anupama et al., 2023). These benefits play a role in improving construction methods and providing higher quality, which leads to increased customer satisfaction. Studies show that projects that adopt lean construction have a greater chance of success and increased efficiency at every stage of the project life cycle and beyond (Akter et al., 2024; León-Romero et al., 2024; Moradi and Sormunen, 2023; Orlov and Kankhva, 2022). In addition, project efficiency can be exploited to improve the integration of lean manufacturing approaches to achieve sustainability (Polat and Demirkesen, 2024). However, there are no studies related to the construction sector to date in many countries, including Jordan, which reveals a gap in research that needs to be explored, especially regarding the potential outcomes of applying lean construction principles and assessing project efficiency in the Jordanian construction sector. Therefore, this study came to determine the effectiveness of lean construction principles on project efficiency in construction projects in central Jordan.

2. Literature review

2.1 Lean Construction Principles

The term "lean construction" was first coined in the 1990s by Koskela, who referred to it as a flexible approach and method used by construction project managers to minimize waste of materials, time, and effort in order to obtain maximum value (Dauda et al., 2023; Pheng et al., 2015). Lean construction is considered an approach that works to improve the construction process with the aim of delivering the project according to the client's needs (Aslam et al., 2024). From another point of view, lean construction is basically based on the study and practical development of how to manage construction and even manage construction projects as a whole (Braglia et al., 2023). Technically, lean construction emerged as a result of the inherent problems of the construction sector, most notably the fragmented supply chain, strong focus on individual projects, conflicting interests among stakeholders, and problems in construction industry quality and productivity (Sui Pheng and Hui Fang, 2005). Therefore, the objectives of lean construction are to enhance project efficiency and reach the required quality, reduce levels of waste in resources, and reduce the project life cycle and cost (Erik Eriksson, 2010). Fernando et al (2024) defined lean construction as the ability to manage and deal with variance to improve project performance and increase its productivity. Cardenas et al (2024) even stated that this is an improved approach to designing realistic plans to reduce waste of materials, time and effort to obtain the maximum possible productivity. Daniel and Pasquire (2019) added that the application of lean construction improves the implementation of many project aspects such as cost, timely delivery, and increased project efficiency (Bajjou and Chafi, 2021).

Hence, researchers have indicated that Lean is a tool for reducing waste and non-added value, thus improving the amount of rework and reducing deficiencies and inconsistencies in the project. In fact, lean construction has improved safety and security levels in the project and reduced the occurrence of accidents that hinder the progress of the project. Babalola et al (2019) defined lean construction as an integrated approach to achieving true value with the greatest effectiveness and efficiency. This means that this approach includes methods and techniques for cost estimates, material stocks and project schedule; which helps overcome problems that occur in the construction industry, which are represented by delays and discrepancies between the planned and actual project design and construction cost overruns (Le and Nguyen, 2021; Bygballe et al., 2018). Orlov and Kankhva (2022) indicates the need to recognize the importance of adopting the lean construction approach; to implement the change or improvement strategy, as lean construction does not only deal with resources, productivity and cost, but also predicts accidents and matters that may arise due to changing project conditions (Bajjou and Chafi, 2018). Hence, we conclude that lean construction principles mainly focus on eliminating or reducing non-value-added activities such as waste, lead times, and low quality standards and working on enhancing value-added activities such as ensuring project quality, improving safety levels, and focusing on sustainability (Moshood et al., 2024; Ullah et al., 2019). Other important principles in lean construction include using effective planning tools and working on managing the construction project workflow using lean manufacturing (Akter et al., 2024). Considering these principles, we conclude that lean construction has a significant impact on improving the construction schedule and improving the efficiency and performance of the project. Researchers (Hei et al., 2024; Cardenas et al., 2024; Albalkhy et al., 2024; Daniel and Pasquire, 2019; Sui Pheng and Hui Fang, 2005) indicated that the best positive outcome of applying Lean principles in a construction project is ensuring timely delivery of the construction project without delay, according to understanding the client's needs. As a result, studies (Estrada Herrera and Pueblita Mares, 2023; Braglia et al., 2023; Aslam et al., 2019) confirmed that adopting lean construction principles contributed to increasing the rate of innovation in the construction project, and the lean construction approach changed the organizational culture to manage the construction life cycle by delivering the project in a more systematic and efficient manner (Erik Eriksson, 2010). From the above discussion, we conclude that the principles of lean construction are derived from the principles of lean production. However, most researchers (Fernando et al., 2024; Anupama et al., 2023; Bygballe et al., 2018; Sui Pheng and Hui Fang, 2005; Koskela, 1997) agreed that the main principles of lean construction are as follows:

A. ***Defining and maximizing value*** by identifying what represents value from the customer's point of view, understanding and meeting customer requirements is considered a basic principle of lean construction on which other principles are based.
B. ***Mapping the value flow*** by planning the materials and steps that add value and those that do not add value, and working to develop a future plan for the workflow of the project, which contributes to reducing waste by improving operations and production while maintaining the flow of materials to the project continuously.
C. ***Establishing flexible flow processes*** and enhancing the standardization of operations and organizing the workplace, as one of the basic principles of lean construction is to establish sequential processes

inside and outside the construction project that allow materials to move from one step to another easily and smoothly without any obstacles.

D. ***Pull Instead of Push***, whereby materials are produced and pulled when there is an actual demand and need for materials, not according to unrealistic forecasts and estimates, in order to reduce waste and cost resulting from storing excess project materials.
E. ***Pursuit for perfection*** by developing a culture that strives for perfection through continuous improvement and promoting a dedicated mindset to maximize productivity.

Based on the above, the principles of lean construction are to reduce non-additive activities that waste project resources and thus take up a lot of time and space (Sui Pheng and Hui Fang, 2005), which prevents the implementation of the client's desire (Aziz and Zainon, 2022). In addition to reducing the variance in processes inside and outside the construction and simplifying by reducing the number of steps, parts and connections, which results in reducing the project life cycle (Le and Nguyen, 2021; Bygballe et al., 2018; Sweis et al., 2016; Pheng et al., 2015). From another point of view, this initiative helps in enhancing production efficiency and building a strong relationship with clients as a result of meeting their requirements and understanding their needs. When the project steps are clear and enjoy a high level of transparency and flexibility, it is easy to make improvements and monitor the progress and performance of work on an ongoing basis (Fernando et al., 2024; Dauda et al., 2023).

2.2. Project Efficiency

The project environment is characterized by continuous dynamic change, and over the past two decades researchers have given great importance to the science of project management due to the significant increase in the development and growth of projects (Papke-Shields et al., 2010). The researchers conducted many researches and studies that enabled them to introduce modern methods in the activities and operations that take place at every stage of the project life cycle. Many studies have referred to the project concept as the goal or goal that the stakeholders (client, contractor, manager, etc.) seek to achieve, defined by a time frame for start and delivery (Chies and Mazieri, 2023; Zidane and Olsson, 2017; Ayodeji, 2014). This requires a number of activities, steps, and procedures necessary to complete and deliver the project (Prasad Babu and Vasumathi, 2023; Godsell et al., 2018). Undoubtedly, project management is one of the most important basic requirements to achieve the project efficiency expected by the client. It is also the basis for the feasibility study, and the time period required to complete it is determined based on the project objective (Oke et al., 2023; Sundqvist et al., 2014; Bouras, 2013). Hence, achieving project efficiency is not an easy matter; as it requires organized and systematic project management of resources in all their forms, and comparing alternatives; to choose the best way to complete a specific project, taking into account many elements, the most important of which are quality, time, cost and productivity (Ong and Bahar, 2019; Haaskjold et al., 2019). The meaning of efficiency varies depending on the project and its nature; as most projects are established for a specific purpose or goal, or to solve a problem and are linked to achieving this goal in order to achieve the goals, actual results that serve the project idea (Godsell et al., 2018; Atkinson, 1999).

Achieving project efficiency requires a great effort by an individual or a group to implement a specific idea or work, whether it is a product or a service. In addition, efficiency includes the actual and correct use of the financial, human and cognitive resources of the project (Liu et al., 2022). Hence, many researchers have agreed that the meaning and value of project efficiency differs according to the nature and type of the project, the purpose or goal, the project life cycle, and even the characteristics of the project such as uniqueness and reliability (Sposito et al., 2023; Meeampol and Ogunlan, 2006). Considering the efficiency of projects, it includes the efficiency of leadership, communication, project teams, organization, individual project member, cost, time, quality, and supply chains, all of which are considered important basic elements that project management depends on to achieve efficiency, which ensures that the project is completed and delivered in a timely manner. At the predetermined time, with the required quality, lowest cost and highest productivity (Wyke et al., 2023; Lindhard and Larsen, 2016; Jugdev and Müller, 2005).

Zidane and Olsson (2017) referred to the term "efficiency" as the ability to solve problems, while others referred to "efficiency" as the ability to reach the maximum level of productivity. We conclude from this that project efficiency is represented by the activities carried out by the project management to determine the goals and needs, prepare the budgets for the project, and follow up and evaluate the procedures that are carried out in order to achieve the project's goals and meet the needs of customers (Bouras, 2013). Khan et al (2022) added that project efficiency is the achievement of set objectives within a specific period of time, at the agreed cost, and with the agreed-upon activities. Chies and Mazieri (2023) believe that project efficiency is determined by a specific time within a specific starting and ending point. Yoo and Kang (2024) added that even if the progress of the project was as planned, it may precede or follow another activity, which constitutes an issue that hinders the achievement of the required efficiency. To achieve project efficiency, Godsell et al (2018) believes that project management must actually implement the set plans and follow the actual methods and procedures for implementation by employing knowledge, skills, and tools in the project workflow. While Mainga (2017) confirmed that achieving project efficiency requires reviewing two basic elements: the first is the project manager who directs the workers administratively, works to utilize the resources efficiently, and directs all elements to achieve the desired goal (Sundqvist et al., 2014). The second element is the project itself, which plays a pivotal role determined by the time and cost that is achieved through the efforts made by senior management, departments and branches of a specific company, and the human resources working in it (Frinsdorf et al., 2014). We conclude from this that the success of the project requires high efficiency and superior management that includes methods and procedures such as planning, organization and direction, the aim of which is to use the project’s capabilities and resources to achieve the desired goals and objectives specified within a specific time period, and is managed by a manager who plans and directs to ensure that the work proceeds as planned, and takes corrective measures when necessary (Serrador and Turner, 2015; Trindade et al., 2015). In fact, researchers (Yoo and Kang, 2024; Chies and Mazieri, 2023; Khan et al., 2022; Godsell et al., 2018; Serrador and Turner, 2015; Todorović et al., 2015; Cavaleri et al., 2012; Alam et al., 2010; Shenhar and Dvir, 2007; Whitley, 2006; Crawford and Bryce, 2003) agreed that there is a group of elements that directly affect the achievement of project efficiency, which requires focusing on the following:

A. ***Time:*** The main goal of any project is to deliver on time and avoid delays. To achieve this, work and activities must be completed the first time. Time is a critical factor that prevents the project from achieving maximum efficiency according to the desires and needs of the client and stakeholders (Meeampol and Ogunlan, 2006; Koushki and Kartam, 2004). Hence, project time management is an important matter that the project manager devotes his efforts to preparing project timetables (Le-Hoai and Dai Lee, 2009); to ensure adherence to the start and end times, and to make timetables for the steps and procedures that take place in the project, in addition to preparing a comprehensive list of activities, their sequence, and estimates of their time periods. Therefore, understanding the project mechanism will help solve the problems it faces, and the ability to monitor them continuously. When determining timetables, the project staff will be able to face the pressures of delivery and deliver the project on time (Sinesilassie et al., 2019; Aibinu et al., 2019; Famiyeh et al., 2017).

B. ***Cost:*** Many foundations and standards are set by project management to accomplish customer-focused work and activities, and monitor the time required for delivery. The most important of these standards is the cost of completing and delivering the project (Famiyeh et al., 2017;Koushki and Kartam, 2004). The process of managing project costs is very difficult, as Meeampol and Ogunlan (2006) mentioned that the cost is determined by the project manager's ability to estimate the financial resources needed to complete the project while working to control its budget, by monitoring the course of work in it, and the steps that the project goes through so that it is completed within the budget allocated to it (Wyke et al., 2023), and the ability to control the factors that affect the different costs of the project stages, which requires good planning for existing and potential costs, which leads to working within an appropriate plan (Haaskjold et al., 2019); To manage the project costs, and its contribution to estimating the costs of each activity and process in the project more accurately, while determining the flexible limits associated with the permissible costs(Aslam et al., 2019; Atkinson, 1999). Chong et al (2024) stated that there are several measures that the project manager resorts to in order to measure the costs of the project in different ways, and at several times, so the manager estimates the costs based on the requirements and capabilities of the stakeholders, and according to the most important foundations that the manager must take into consideration in order to complete the work in the manner specified in the project plan, by using experts, consultants and specialists in the field of cost management; to determine the general framework of the financial budget necessary to complete each stage of the project through cost forecasts to start finishing the project on time (Olatunji et al., 2024; Aibinu et al., 2019).

C. **Quality:** Many researchers have conducted several studies to understand how to achieve the highest level of quality in line with the developments taking place in the world; and the major challenges facing projects, perhaps the most severe and prominent of these challenges is the level of customer satisfaction, in addition to the increase in their requirements that may prevent the success of the project (Pheng et al., 2015; Bryde, 1997). Although the concepts of quality have emerged for a long time, it did not appear as a basic factor for management until recent times, as quality has come to be viewed in modern management thought as a function that is completely equivalent to other functions (such as

finance, production, manufacturing, marketing, etc.) (Berg and Nyhus, 2024; Meeampol and Ogunlan, 2006). Interest in the issue of quality in projects has increased recently due to the increasing requirements of customers, and the emergence of quality standards that must be available to implement the project within the financial and time requirements specified in the agreed plan, as achieving the concept of quality in the project requires meeting the needs for which the project was established, taking into account the quality standards of projects stipulated globally and locally, and ensuring that the level of quality in each stage of the project is as required (Olatunji et al., 2024). It requires making a comparison between the plan set for quality and the actual results achieved in each stage, and conducting a continuous evaluation process for each step to continuously improve the level of quality, thus achieving the efficiency of the planned project (Chong et al., 2024; Wyke et al., 2023; Haaskjold et al., 2019).

D. ***Productivity:*** This represents the project's ability to connect to its objectives, continue to achieve them, and suit the project's outputs as previously planned, and the project's ability to meet the needs of the target group, and achieve the goals of its private financiers (Mano et al., 2020). This criterion focuses on the project's ability to achieve high-quality outputs, with high efficiency, by converting inputs of materials, other resources, and competencies into economically feasible and productive outputs within the pre-prepared plans (Pheng et al., 2015). The extent to which the project achieves the purpose for which it was designed, and its ability to proceed within the established plan without deviating from it, and without wasting the available resources in it, means productivity at its highest levels. Oke et al (2023) added that the productivity criterion means the level to which the project management has achieved the required quality among the target group and its financiers, and the project's ability to achieve distinguished quality outputs that contribute to raising its competitiveness in the market (Atkinson, 1999). While Bajjou and Chafi (2021) pointed to the extent that demonstrates the project's ability to continue achieving its desired results, and to work to continue achieving successive successes even after the end of the project, and to ensure the achievement of the basic goal of using international standards stipulated globally (Nila et al., 2023).

We conclude from the above that achieving high efficiency in any project requires an evaluation process. to know where the project is going, and what are the important operations it includes, and at all administrative and operational levels in the projects, on the basis of which the actual performance is compared to the target, in addition to considering it a means to push the manager to work to the fullest extent; to monitor the performance of employees, and evaluate what is required of him on an ongoing basis. Not to mention that efficiency is represented by the ability of projects to meet customer requirements, enhance performance in line with the plan set in advance, and work on developing a plan for evaluation periodically; to improve the performance of operations and activities in it, which contributes to improving the level of its outputs, and thus completing projects successfully by applying evaluation methods and tools correctly (Chong et al., 2024; Olatunji et al., 2024; Berg and Nyhus, 2024; Wyke et al., 2023; Oke et al., 2023; Nila et al., 2023; Mano et al., 2020; Sinesilassie et al., 2019; Aslam et al., 2019; Haaskjold et al., 2019; Aibinu et al., 2019; Famiyeh et al., 2017; Pheng et al., 2015; Le-Hoai and Dai Lee, 2009; Meeampol and Ogunlan, 2006; Koushki and Kartam,

2004; Atkinson, 1999).

3. Methodology

This study is considered a quantitative study that provides a numerical interpretation of the effectiveness of lean construction principles in project efficiency in construction projects in central Jordan. This approach is appropriate for the nature of this study and the purpose of using this approach, as indicated by Grinnell (1988), is to reach solutions and extract the results of testing hypotheses and theories related to a specific phenomenon directly related to the study problem. It is known as quantitative, repetitive processes based primarily on evidence, formulating hypotheses using the statistical approach. The study sample was selected randomly from a homogeneous community of consultants and contractors who hold engineering membership from the Jordan Engineers Association. The number of companies registered in the Jordan Construction Contractors Association for the year 2024 was (226) companies, while the number of offices registered in the Jordan Engineers Association was (1,321) engineering offices, meaning that the study community totaled (1547) consulting and contracting companies. A random sample was taken and the sample size was calculated using the Sekaran equation (2003) to reach (434) companies. Table (1) shows this. While the data were collected through a paper questionnaire that was hand-delivered to the study sample and verified to be completed.

4. Results

4.1. Descriptive and Frequencies for Demographic Variables

The demographic variables properties are displayed in the following Table (1).

Table (1) Sample's Demographics

Demographic Variable	Categories	Frequency	Percentage
Gender	Males	302	69.6
	Female	132	30.4
Profession	Contractor	185	42.6
	Consultant	249	57.4
Education Level	Diploma	64	14.7
	Bachelor's degree	324	74.7
	Postgraduate	46	10.6
Years of Experience	Less than 5 years	19	4.4
	From 5 to 10 years	137	31.6
	From 11 years to 20 years	235	54.1
	From 21 years and over	43	9.9
Department/Sector	Production	92	21.2
	Maintenance	100	23
	Quality	172	39.6
	Engineering	51	11.8
	Management	19	4.4

Table (1) demonstrates the demographic variables properties of the study sample, where the male respondents were (69.6%), and the female respondents were (30.4%). The majority of respondents' profession was Consultant with a percentage of (57.4%), while (42.6%) of respondents' profession was Contractor. Most respondents' education level was a bachelor's degree with a percentage of (74.7%). **T**he majority of respondents (54.1%) have from 11 years to 20 years of experience. Finally, (21.2%) of respondents' departments or sectors were Production, (23%) of respondents' departments or sectors were Maintenance, (39.6%) of respondents' departments or sectors were Quality, (11.8%) of respondents' departments or sectors were Engineering, and (4.4%) of respondents' department or sector was Management.

4.2 Model Fit Measurements

4.2.1 Test of Confirmatory Factor Analysis

Confirmatory factor analysis (CFA) is used to verify the validity of the factor structure of the observed set of variables, known as the "factor loadings." Convergent validity, composite reliability (CR), and convergent validity are assessed. Table (2) below presents the results, and discriminant validity is shown in Table (3) below.

Table (2): Results of the CFA Test

a	***Items***	***Factor Loading***	***Factor Loading Square***	**Average Variance Extracted (> 0.50)**	**Composite Reliability (> 0.70)**	**Cronbach's Alpha (> 0.70)**
Value Definition	VD1	0.854	0.729	0.638	0.875	0.884
	VD2	0.74	0.548			
	VD3	0.849	0.721			
	VD4	0.744	0.554			
Value Stream Mapping	VSM1	0.781	0.610	0.603	0.859	0.891
	VSM2	0.744	0.554			
	VSM3	0.788	0.621			
	VSM4	0.793	0.629			
Flow Creation	FLC1	0.689	0.475	0.53	0.818	0.919
	FLC2	0.748	0.560			
	FLC3	0.785	0.616			
	FLC4	0.684	0.468			
Pull Instead of Push	PIP1	0.759	0.576	0.524	0.814	0.868
	PIP2	0.655	0.429			
	PIP3	0.73	0.533			
	PIP4	0.747	0.558			
Pursuit of Perfection	POP1	0.829	0.687	0.536	0.821	0.858
	POP2	0.689	0.475			

	POP3	0.714	0.510			
	POP4	0.688	0.473			
Time	T1	0.628	0.394	0.535	0.773	0.802
	T2	0.754	0.569			
	T3	0.801	0.642			
Cost	CO1	0.691	0.477	0.623	0.831	0.788
	CO2	0.836	0.699			
	CO3	0.832	0.692			
Quality	QU1	0.834	0.696	0.804	0.925	0.889
	QU2	0.929	0.863			
	QU3	0.924	0.854			
Productivity	TI1	0.892	0.796	0.794	0.92	0.881
	TI2	0.911	0.830			
	TI3	0.87	0.757			

Table (2) showed that the factor loadings of the above items ranged from 0.628 to 0.929. This is considered acceptable according to what Bollen (2014) indicated that a valid factor loading should be 0.50 or higher, and preferably 0.70 or higher. Looking at the table, the composite reliability and the average variance extracted can be used to assess the convergent validity of the factor loadings. This indicates the presence of strong internal consistency, as the composite reliability scores ranged from 0.773 to 0.925, which is greater than 0.7. The average values of the extracted variance are also greater than 0.50, ranging from 0.524 to 0.804. Accordingly, all variables are considered suitable for proving convergent validity (Hair et al., 2011).

4.2.2 Discriminant Validity

Table (3) shows the results of discriminant validity, which is a measure of the extent to which a factor differs and is unrelated. The results of the AVE analysis are shown in Table (3). It is clear that the AVE values exceed all correlation coefficients between constructs and are greater than 0.5.

Table (3): Discriminant Validity.

	1	2	3	4	5	6	7	8	9
Value Definition	**0.638**								
Value Stream Mapping	.468	**0.603**							
Flow Creation	.486	.561	**0.53**						
Pull Instead of Push	.562	.603	.463	**0.524**					
Pursuit of Perfection	.464	.540	.406	.449	**0.536**				
Time	.499	.481	.370	.399	.441	**0.535**			
Cost	.165	.309	.338	.371	.392	.357	**0.623**		
Quality	-.007	.081	-.008	.036	.030	-.013	.227	**0.804**	
Productivity	-.084	-.118	-.053	-.168	-.141	-.126	-.041	.068	**0.794**

**Correlation at 0.01 level (1 tailed), *Correlation at 0.05 level (1 tailed).

4.2.3 Model of Measurement

The model of measurement with its 9 dimensions measured by 32 measurement items was assessed using CFA available on AMOS. According to Chen, (2007), the model showed a dissatisfactory model fit concerning major model fit indices, where some measures were not within the limits of recommended cut-off values of model fit (Chi-square χ 2(P > 0.05); (RAMSE< 0.10, NFI ≥ 0.90; CFI ≥ 0.90; IFI ≥ 0.90; TLI ≥ 0.90. Model fit statistics for the primary measurement model are shown in Table (4):

Table (4): Model Goodness-of-fit Test Results

χ2	**χ2/df**	**SRMR**	**CFI**	**TLI**	**NFI**	**IFI**	**RMSEA**
30.233	5.039	0.045	0.988	0.928	0.985	0.988	0.097

The basic measurement model was used to examine the factor loadings and adjustment indices of this study, where the ratio of χ^2 to degrees of freedom (df), which is an indicator of model fit, gave a value of 5.039, indicating an acceptable fit. Items with high adjustment indices were addressed by introducing correlations between their error terms. Table 3 shows a strong fit of the model with SRMR < 0.08, CFI > 0.90, TLI > 0.90, NFI > 0.90, IFI > 0.90, and RMSEA < 0.1, confirming an excellent fit of the hypothesized model to the current data. Considering the table, the improved measurement model showed a favorable fit. Figure (1) below presents the final best-fitting model based on the data from tables (3) and (4) above.

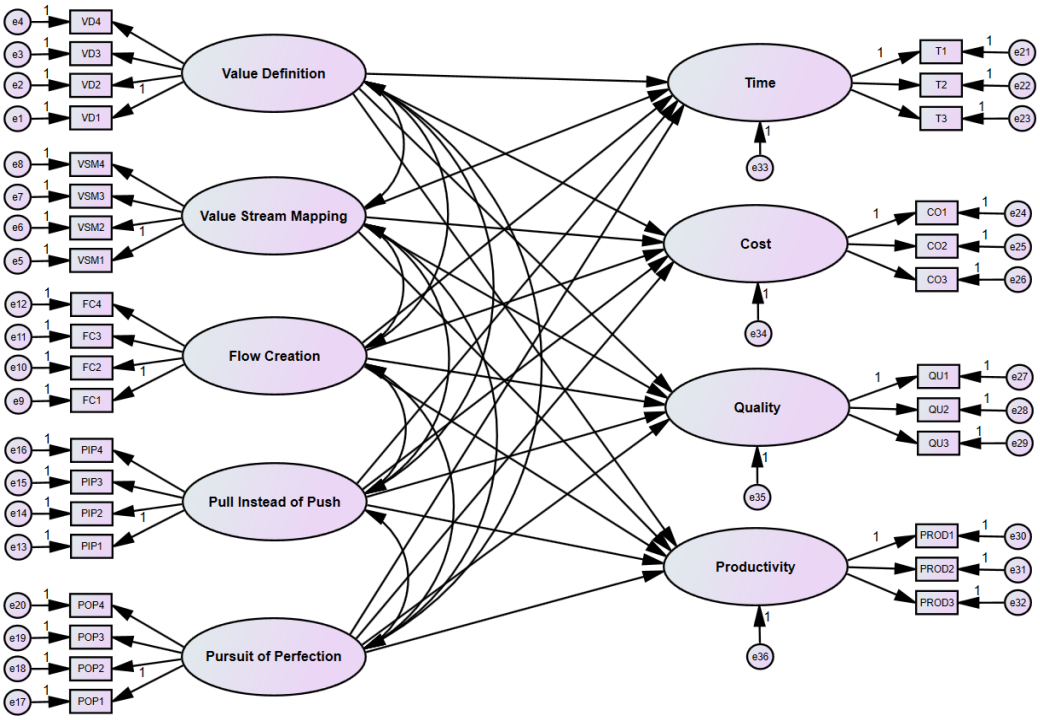

Figure (1): Best Model Fit

4.3 Hypotheses Testing

The variance-based Partial Least Squares (PLS) and Structural Equation Model (SEM) are used to assess the research hypotheses because of its ability to model interactions between several dependent and independent variables, which is needed for this study.

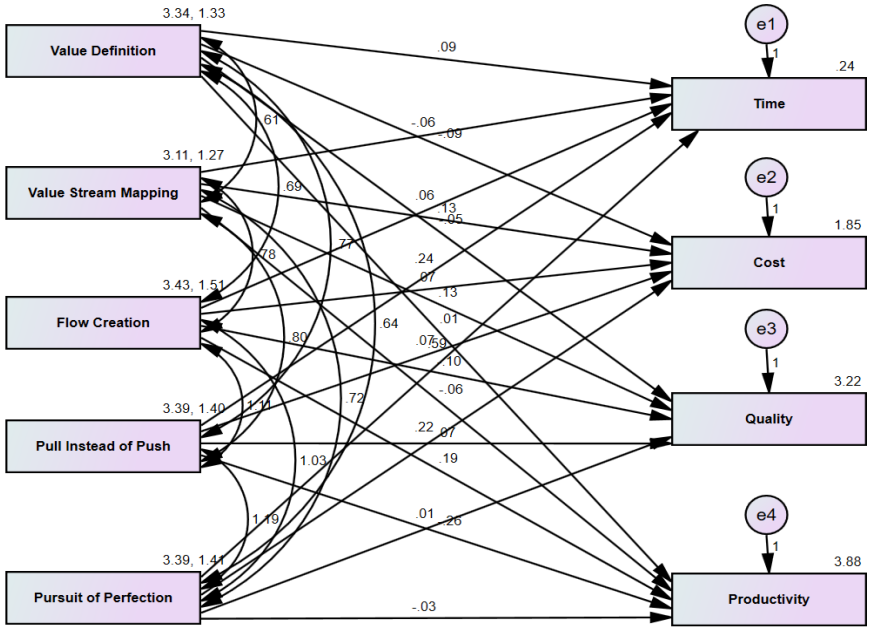

Figure (2) Structural Equation Model (SEM)

To analyze the effectiveness of lean construction principles on project efficiency in Central Jordan's construction projects, the following hypotheses can be established:

Hypothesis 1 (H1): Applying the "Value Definition" principle in lean construction improves project efficiency in terms of time.

Hypothesis 2 (H2): Utilizing "Value Stream Mapping" in lean construction reduces project costs.

Hypothesis 3 (H3): Implementing "Flow Creation" in lean construction enhances project quality.

Hypothesis 4 (H4): Applying the principle of "Pull Instead of Push" in lean construction increases project productivity.

Hypothesis 5 (H5): The pursuit of "Perfection" in lean construction leads to improvements in all aspects of project efficiency (time, cost, quality, and productivity).

Hypothesis 6 (H6): Comprehensive application of lean construction principles (Value Definition, Value Stream Mapping, Flow Creation, Pull Instead of Push, and the Pursuit of Perfection) leads to significant improvements in the efficiency of construction projects in Central Jordan.

4.3.1 First Hypothesis Test

Ha_1: There is a statistically significant relationship between Value Definition and Project Efficiency in terms of time, cost, quality, and productivity in construction projects in Central Jordan.

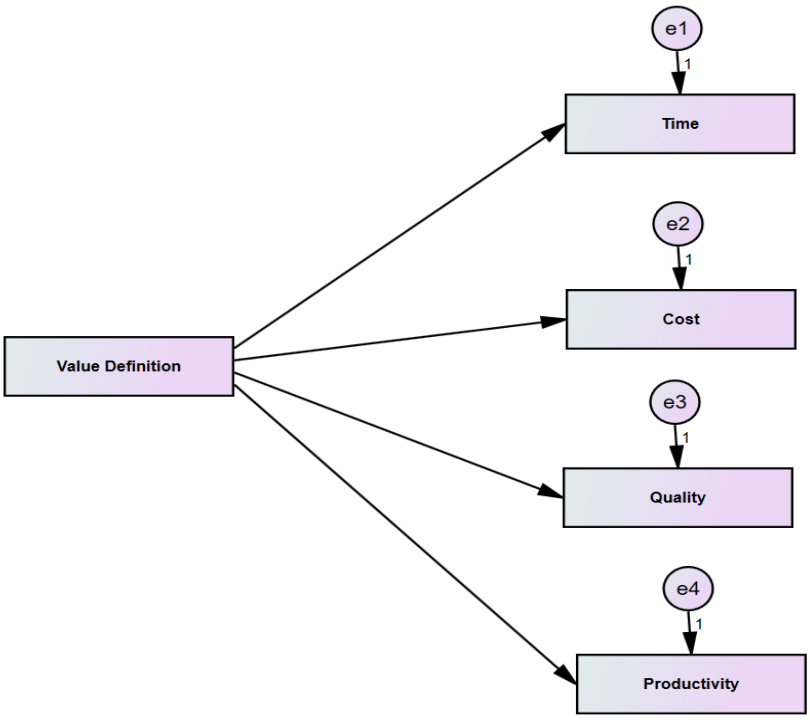

Figure (3) Structural Equation Model for the first hypothesis

The results of analysis are presented in table (5) below.

Table (5) Analysis results for the first hypothesis

			Estimate Weight	Standard Error	Critical Ratio	P-value	Effect Size	R Square
Value Definition	→	**Time**	0.52	0.043	11.983	***	0.499	0.249
Value Definition	→	**Cost**	0.158	0.045	3.479	***	0.165	0.027
Value Definition	→	**Quality**	-0.007	0.05	-0.145	0.885	-0.007	0.000
Value Definition	→	**Productivity**	-0.086	0.049	-1.755	0.079	-0.084	0.007

p-value (<0.05, **<0.01, ***<0.001)*

Table (5) presents the following results of the analysis:

- Regression weights indicate that Value Definition significantly affects project Time, according to (Byrne, 2013) the path is significant since the p-value (***) is less than 0.001 and the critical ratio value is more than 2. Thus, "There is a statistically significant relationship between Value Definition and Project Efficiency in terms of time in construction projects in Central Jordan". With an R square value of 0.249, the Value Definition explains 24.9% of the variation in project efficiency in terms of time. R square indicates the percentage of changes in the dependent variable that the independent variable can explain. The Value Definition effect size on Time is 0.499.
- Regression weights also indicate that Value Definition significantly affects project Cost, according to (Byrne, 2013) the path is significant since the p-value (***) is less than 0.001 and the critical ratio value is more than 2. Thus, "There is a statistically significant relationship between Value Definition and Project Efficiency in terms of cost in construction projects in Central Jordan". R square value of 0.027, the Value Definition explains 2.7% of the variation in project efficiency in terms of cost, which is a small value. The Value Definition effect size on cost is 0.165.
- According to (Byrne, 2013) the p-value (0.885) is greater than 0.05 and the critical ratio value is less than 2, the path is insignificant. Thus, "There is an insignificant relationship between Value Definition and Project Efficiency in terms of quality in construction projects in Central Jordan". R square value of 0.000, the Value Definition cannot explain any of the variation in project efficiency in terms of quality.
- According to (Byrne, 2013) the p-value (0.079) is greater than 0.05 and the critical ratio value is less than 2, the path is insignificant. Thus, "There is an insignificant relationship between Value Definition and Project Efficiency in terms of productivity in construction projects in Central Jordan". R square value of 0.007, the Value Definition can explain just 0.7% of the variation in project efficiency in terms of productivity, which is a very small value.

4.3.2 Second Hypothesis Test

Ha_2: There is a statistically significant relationship between Value Stream Mapping and Project Efficiency in terms of time, cost, quality, and productivity in construction projects in Central Jordan.

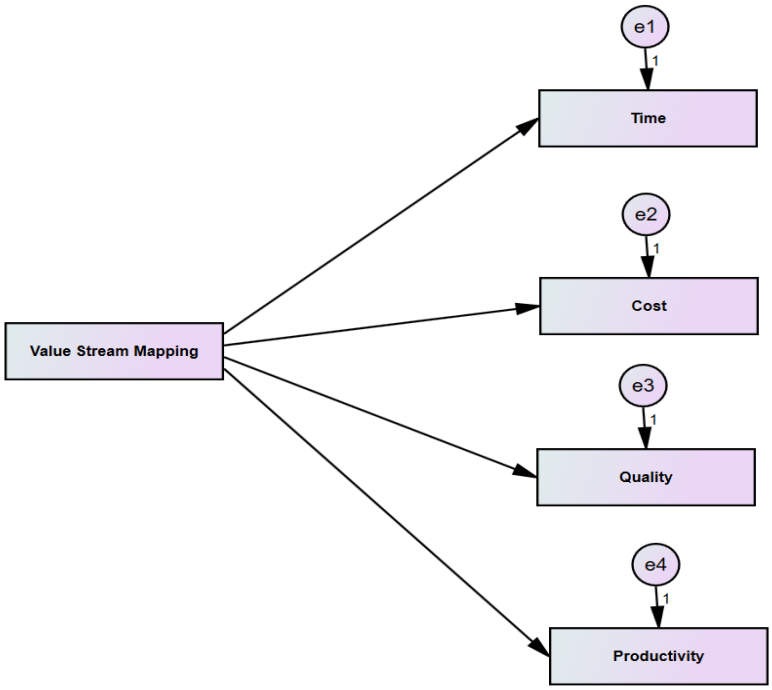

Figure (4) Structural Equation Model for the second hypothesis

The results of analysis are presented in table (6) below.

Table (6) Analysis results for the first hypothesis

			Estimate Weight	Standard Error	Critical Ratio	P-value	Effect Size	R Square
Value Stream Mapping	→	**Time**	0.514	0.045	11.415	***	0.481	0.231
Value Stream Mapping	→	**Cost**	0.304	0.045	6.767	***	0.309	0.096
Value Stream Mapping	→	**Quality**	0.085	0.051	1.688	0.091	0.081	0.007
Value Stream Mapping	→	**Productivity**	-0.124	0.05	-2.477	0.013	-0.118	0.014

p-value (<0.05, **<0.01, ***<0.001)*

Table (6) presents the following results of the analysis:

- Regression weights indicate that Value Stream Mapping significantly affects project Time, according to (Byrne, 2013) the path is significant since the p-value (***) is less than 0.001 and the

critical ratio value is more than 2. Thus, "There is a statistically significant relationship between Value Stream Mapping and Project Efficiency in terms of time in construction projects in Central Jordan". With an R square value of 0.231, the Value Stream Mapping explains 23.1% of the variation in project efficiency in terms of time. The Value Stream Mapping effect size on Time is 0.481.

- Regression weights indicate that Value Stream Mapping significantly affects project Cost, according to (Byrne, 2013) the path is significant since the p-value (***) is less than 0.001 and the critical ratio value is more than 2. Thus, "There is a statistically significant relationship between Value Stream Mapping and Project Efficiency in terms of cost in construction projects in Central Jordan". With an R square value of 0.096, the Value Stream Mapping explains 9.6% of the variation in project efficiency in terms of cost. The Value Stream Mapping effect size on Cost is 0.309.
- According to (Byrne, 2013) the p-value (0.091) is greater than 0.05 and the critical ratio value is less than 2, the path is insignificant. Thus, "There is an insignificant relationship between Value Stream Mapping and Project Efficiency in terms of quality in construction projects in Central Jordan". R square value of 0.007, the Value Stream Mapping explain just 0.7% of the variation in project efficiency in terms of quality, which is a very small value.
- Regression weights indicate that Value Stream Mapping significantly affects project Productivity, according to (Byrne, 2013) the path is significant since the p-value (0.013) is less than 0.05 and the critical ratio value is more than 2. Thus, "There is a statistically significant relationship between Value Stream Mapping and Project Efficiency in terms of productivity in construction projects in Central Jordan". With an R square value of 0.014, the Value Stream Mapping explains 1.4% of the variation in project efficiency in terms of productivity, which is a small value. The Value Stream Mapping effect size on Productivity is -0.118, and the relationship between Value Stream Mapping and Project Efficiency in terms of productivity in construction projects in Central Jordan is negative.

4.3.3 Third Hypothesis Test

Ha_3: There is a statistically significant relationship between Flow Creation and Project Efficiency in terms of time, cost, quality, and productivity in construction projects in Central Jordan.

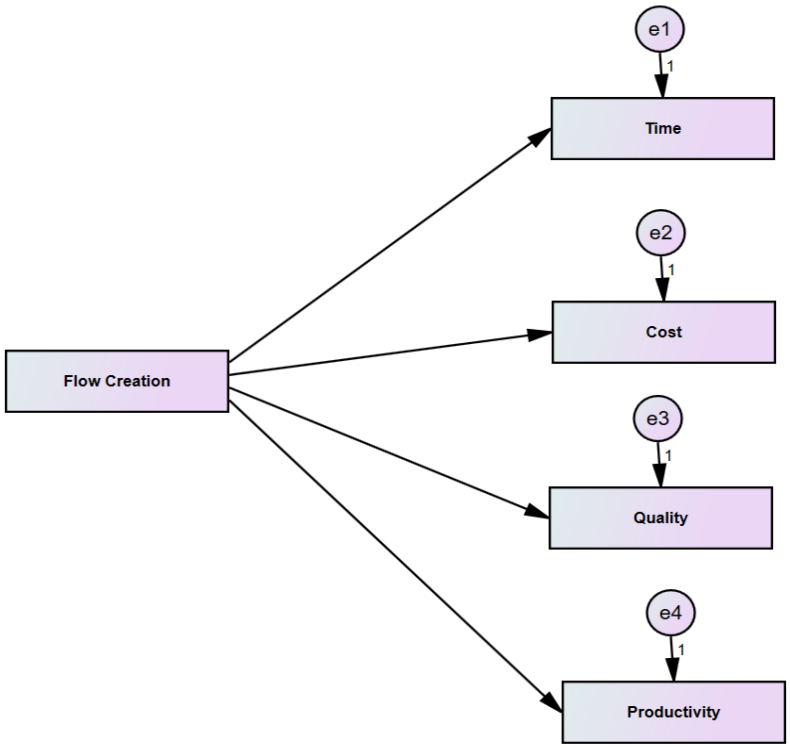

Figure (5) Structural Equation Model for the third hypothesis

The result of the SEM is presented in table (7) below.

Table (7) Analysis results for the third hypothesis

		Estimate Weight	Standard Error	Critical Ratio	P-value	Effect Size	R Square
Flow Creation →	**Time**	0.655	0.035	18.768	***	0.67	0.449
Flow Creation →	**Cost**	0.304	0.041	7.479	***	0.338	0.114
Flow Creation →	**Quality**	-0.007	0.046	-0.157	0.875	-0.008	0.000
Flow Creation →	**Productivity**	-0.051	0.046	-1.111	0.266	-0.053	0.003

p-value (<0.05, **<0.01, ***<0.001)*

Table (7) presents the following results of the analysis:

- Regression weights indicate that Flow Creation significantly affects project Time, according to (Byrne, 2013) the path is significant since the p-value (***) is less than 0.001 and the critical ratio value is more than 2. Thus, "There is a statistically significant relationship between Flow Creation and Project Efficiency in terms of time in construction projects in Central Jordan". With an R square value of 0.449, the Flow Creation explains 44.9% of the variation in project efficiency in terms of time. The Flow Creation effect size on Time is 0.670.
- Regression weights also indicate that Flow Creation significantly affects project Cost, according to (Byrne, 2013) the path is significant since the p-value (***) is less than 0.001 and the critical

ratio value is more than 2. Thus, "There is a statistically significant relationship between Flow Creation and Project Efficiency in terms of cost in construction projects in Central Jordan". R square value of 0.114, the Flow Creation explains 11.4% of the variation in project efficiency in terms of cost, which is a small value. The Flow Creation effect size on cost is 0.338.

- According to (Byrne, 2013) the p-value (0.875) is greater than 0.05 and the critical ratio value is less than 2, the path is insignificant. Thus, "There is an insignificant relationship between Flow Creation and Project Efficiency in terms of quality in construction projects in Central Jordan". R square value of 0.000, the Flow Creation cannot explain any of the variation in project efficiency in terms of quality.
- According to (Byrne, 2013) the p-value (0.266) is greater than 0.05 and the critical ratio value is less than 2, the path is insignificant. Thus, "There is an insignificant relationship between Flow Creation and Project Efficiency in terms of productivity in construction projects in Central Jordan". R square value of 0.003, the Flow Creation can explain just 0.3% of the variation in project efficiency in terms of productivity, which is a very small value.

4.3.4 Fourth Hypothesis Test

Ha_4: There is a statistically significant relationship between Pull Instead of Push and Project Efficiency in terms of time, cost, quality, and productivity in construction projects in Central Jordan.

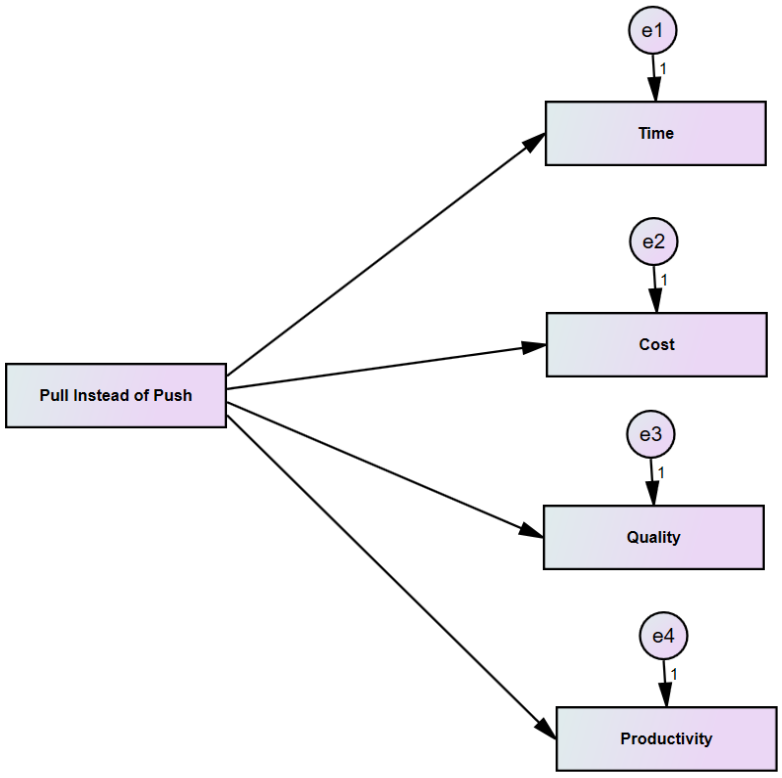

Figure (6) Structural Equation Model for the fourth hypothesis

The result of the analysis is presented in table (8) below.

Table (8) Analysis results for the fourth hypothesis

			Estimate Weight	Standard Error	Critical Ratio	P-value	Effect Size	R Square
Pull Instead of Push	→	**Time**	0.811	0.029	27.639	***	0.799	0.638
Pull Instead of Push	→	**Cost**	0.346	0.042	8.311	***	0.371	0.138
Pull Instead of Push	→	**Quality**	0.036	0.048	0.744	0.457	0.036	0.001
Pull Instead of Push	→	**Productivity**	-0.169	0.047	-3.554	***	-0.168	0.028

p-value (<0.05, **<0.01, ***<0.001)*

Table (8) presents the following results of the analysis:

- Regression weights indicate that Pull Instead of Push significantly affect project Time, according to (Byrne, 2013) the path is significant since the p-value (***) is less than 0.001 and the critical ratio value is more than 2. Thus, "There is a statistically significant relationship between Pull Instead of Push and Project Efficiency in terms of time in construction projects in Central Jordan". With an R square value of 0.638, the Pull Instead of Push explains 63.8% of the variation in project efficiency in terms of time. The Pull Instead of Push effect size on Time is 0.799.
- Regression weights indicate that Pull Instead of Push significantly affect project Cost, according to (Byrne, 2013) the path is significant since the p-value (***) is less than 0.001 and the critical ratio value is more than 2. Thus, "There is a statistically significant relationship between Pull Instead of Push and Project Efficiency in terms of cost in construction projects in Central Jordan". With an R square value of 0.138, the Pull Instead of Push explains 13.8% of the variation in project efficiency in terms of cost. The Pull Instead of Push effect size on Cost is 0.371.
- According to (Byrne, 2013) the p-value (0.457) is greater than 0.05 and the critical ratio value is less than 2, the path is insignificant. Thus, "There is an insignificant relationship between Pull Instead of Push and Project Efficiency in terms of quality in construction projects in Central Jordan". R square value of 0.001, the Pull Instead of Push explain just 0.1% of the variation in project efficiency in terms of quality, which is a very small value.
- Regression weights indicate that Pull Instead of Push significantly affect project Productivity, according to (Byrne, 2013) the path is significant since the p-value (***) is less than 0.001 and the critical ratio value is more than 2. Thus, "There is a statistically significant relationship between Pull Instead of Push and Project Efficiency in terms of productivity in construction projects in Central Jordan". With an R square value of 0.028, the Pull Instead of Push explains 2.8% of the

variation in project efficiency in terms of productivity, which is a small value. The Pull Instead of Push effect size on Productivity is -0.168, and the relationship between Pull Instead of Push and Project Efficiency in terms of productivity in construction projects in Central Jordan is negative.

4.3.5 Fifth Hypothesis Test

Ha_5: There is a statistically significant relationship between the Pursuit of Perfection and Project Efficiency in terms of time, cost, quality, and productivity in construction projects in Central Jordan.

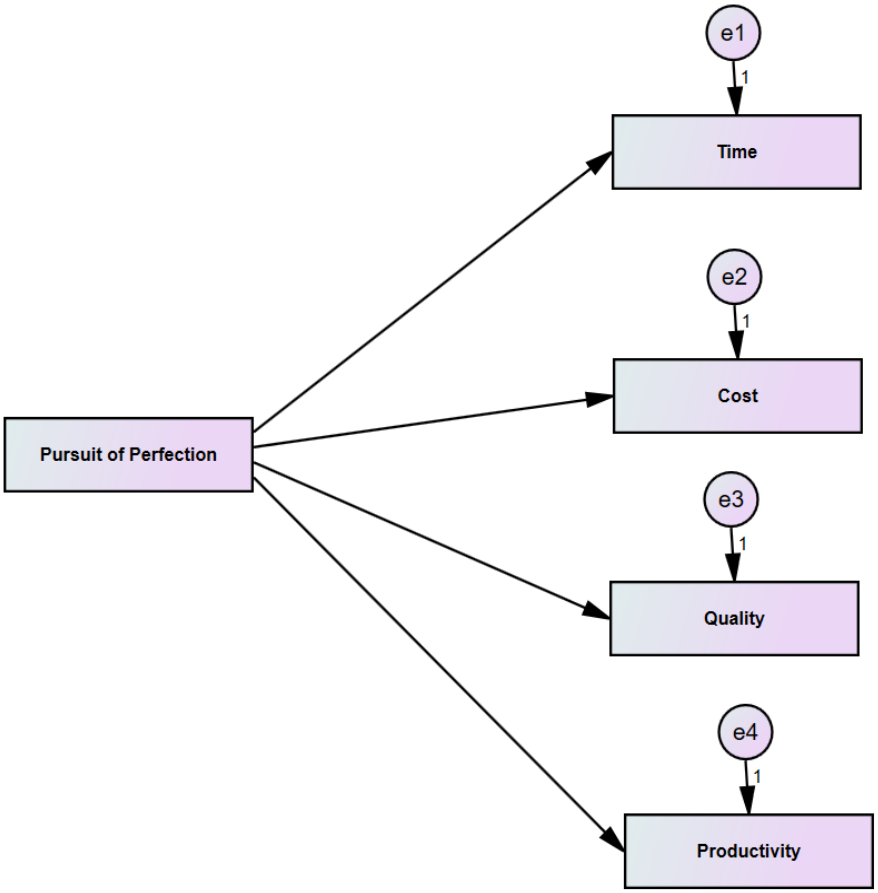

Figure (7) Structural Equation Model for the Fifth Hypothesis

The result of the analysis is shown in table (9) below.

Table (9) Analysis results for the fifth hypothesis

			Estimate Weight	Standard Error	Critical Ratio	P-value	Effect Size	R Square
Pursuit of "Perfection"	→	**Time**	0.851	0.026	32.367	***	0.841	0.708
Pursuit of "Perfection"	→	**Cost**	0.364	0.041	8.854	***	0.392	0.153
Pursuit of "Perfection"	→	**Quality**	0.03	0.048	0.633	0.526	0.03	0.001
Pursuit of "Perfection"	→	**Productivity**	-0.141	0.047	-2.971	0.003	-0.141	0.02

p-value (<0.05, **<0.01, ***<0.001)*

Table (9) shows the following results:

- Regression weights indicate that the pursuit of "Perfection" significantly affects project time, according to (Byrne, 2013) the path is significant since the p-value (***) is less than 0.001 and the critical ratio value is more than 2. Thus, there is a statistically significant relationship between the Pursuit of Perfection and Project Efficiency in terms of time in construction projects in Central Jordan. The pursuit of "Perfection" can explain 70.8% of the changes in project time, the R^2 value equals 0.708. The effect size of the pursuit of "Perfection" on project time is 0.841.
- Regression weights indicate that the pursuit of "Perfection" significantly affects project cost, according to (Byrne, 2013) the path is significant since the p-value (***) is less than 0.001 and the critical ratio value is more than 2. Thus, there is a statistically significant relationship between the Pursuit of Perfection and Project Efficiency in terms of cost in construction projects in Central Jordan.
  The pursuit of "Perfection" can explain 15.3% of the changes in project cost, the R^2 value equals 0.153. The effect size of the pursuit of "Perfection" on project cost is 0.392.
- Regression weights indicate that the pursuit of "Perfection" has an insignificant effect on project quality, according to (Byrne, 2013) the path is insignificant since the p-value (0.526) is greater than 0.05 and the critical ratio value is less than 2. Thus, there is an insignificant relationship between the Pursuit of Perfection and Project Efficiency in terms of quality productivity in construction projects in Central Jordan.
  The pursuit of "Perfection" can explain a very small percentage (0.1%) of the changes in project quality, the R^2 value equals 0.01.
- Regression weights indicate that the pursuit of "Perfection" significantly affects project productivity, according to (Byrne, 2013) the path is significant since the p-value (0.003) is less than 0.01 and the critical ratio value is more than 2. Thus, there is a statistically significant relationship between the

Pursuit of Perfection and Project Efficiency in terms of productivity in construction projects in Central Jordan. The pursuit of "Perfection" can explain only 2% of the changes in project productivity, the R^2 value equals 0.02. The effect size of the pursuit of "Perfection" on project productivity is -0.141 but from the results above we can see the effect size is negative, which means that the relationship between the pursuit of "Perfection" in lean construction and project productivity is negative, so, when the pursuit of "Perfection" in lean construction increases project productivity decreases.

4.3.5 Main Hypothesis Test

Ha_{man}: There is a statistically significant relationship between the application of Lean Construction Principles and the improvement of project efficiency in Central Jordan's construction projects. The result of the analysis is presented in table (10) below.

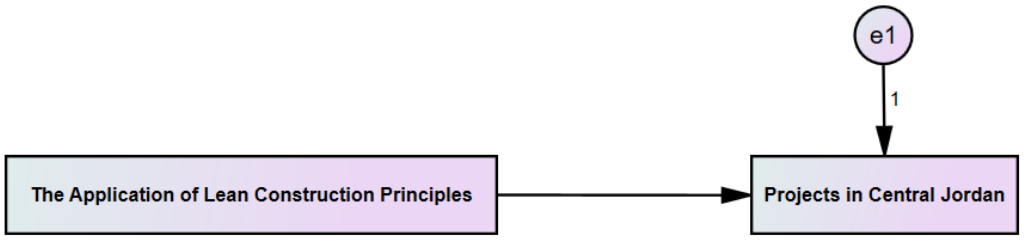

Figure (8) Structural Equation Model for the sixth hypothesis

Table (10) Analysis results for the sixth hypothesis

		Estimate Weight	Standard Error	Critical Ratio	P-value	Effect Size	R Square
The Application of Lean Construction Principles →	**Construction project efficiency**	0.324	0.028	11.575	***	0.486	0.236

p-value (<0.05, **<0.01, ***<0.001)*

Table (10) shows the following results:

The Application of Lean Construction Principles can interpret 23.6% of the changes in Construction project efficiency, the R^2 value equals 0.236.

- Regression weights indicate that the Application of Lean Construction Principles has a significant effect on the efficiency of construction projects in Central Jordan, according to (Byrne, 2013) the path is significant since the p-value (***) is less than 0.001 and the critical ratio value is greater than 2. Thus, there is a statistically significant relationship between the application of Lean Construction Principles and the improvement of project efficiency in Central Jordan's construction projects.
- The effect size of the application of Lean Construction Principles on project efficiency in Central Jordan's construction projects is 0.486.

5. Discussion

Discussion of results of first sub-hypothesis: Value Definition

The results of the statistical analysis indicate that Value Definition significantly affects project time, as the probability value (***) was less than 0.001 and the critical ratio value was greater than 2. Therefore, the first alternative hypothesis is accepted, "Using the Value Definition principle in lean construction increases project efficiency in terms of time only", while the results showed that Value Definition does not significantly affect cost, quality and productivity, and therefore the comprehensive application of the Value Definition principle leads to slight improvements in the efficiency of construction projects in central Jordan. This result is consistent with the study (Aziz and Zainon, 2022; Aziz and Hafez, 2013) that value definition does not contribute to significant improvements in the project, but rather it should also focus, as indicated by (Womack and Jones 2015), on reducing waste, maximizing productivity and ensuring that the project meets the client's expectations, and that the focus on value should be at all stages of the project

Discussion of results of second sub-hypothesis: Value Stream Mapping

The results of the study indicate that Value Stream Mapping significantly affects project cost only, where the probability value (***) was less than 0.001 and the critical ratio value was greater than 2. Therefore, the second alternative hypothesis "Value Stream Mapping in lean construction significantly affects project costs" is accepted. Value Stream Mapping can explain 9.6% of the changes in project cost; the R^2 value is equal to 0.096. The effect size of Value Stream Mapping on cost is 0.309, but from the above results we can see that the effect size is positive, which means that the relationship between the use of "Value Stream Mapping" in lean construction and project cost is positive, therefore, when the use of "Value Stream Mapping" in lean construction increases, the project cost increases. While the results were weak for Value Stream Mapping, time, quality and productivity. This result is consistent with the study (Womack and Jones 2015) which confirmed that identify and map all activities that contribute to removing waste from the value stream or unnecessary materials for the project, which reduces the cost definitely. This is confirmed by Olsson (2006) Efficiency in the construction process in terms of cost and time used

Discussion of results of third sub-hypothesis: Flow Creation

The results of the study indicate that Flow Creation has an insignificant effect on project quality, as the probability value (0.875) appeared greater than 0.05 and the critical ratio value is less than 2. Therefore, the third null hypothesis is accepted "Implementing flow creation in flexible construction does not enhance project quality compared to time, cost and productivity. The results showed that the comprehensive application of the flexible construction principle (Flow Creation) has a significant impact on the efficiency of construction projects in central Jordan, as the p value (0.01) is less than 0.05 and the critical ratio value is greater than 2. Therefore, the comprehensive application of the flexible construction principle (Flow Creation) leads to significant improvements in the efficiency of construction projects in central Jordan. The effect size of (Flow Creation) on construction projects in central Jordan is 0.112. This was confirmed by the results of the study (Aziz and Zainon, 2022) that there is a positive return to creating flow to reach the efficiency and

improvements of the entire project, and this is not limited to quality only, but rather it is an integrated process based on five principles of flexible construction, which are value, value flow, Flow, and perfection. This is what (Hong et al., 2018; Eldeep et al., 2022) confirmed that it can help in planning and designing the flow to create added value.

Discussion of results of fourth sub-hypothesis: Pull Instead of Push

The results of the study indicated that the Pull Instead of Push principle significantly affects project productivity, with the probability value (***) less than 0.001 and the critical ratio value greater than 2. Therefore, the fourth alternative hypothesis "The application of the Pull Instead of Push principle in lean construction significantly affects project productivity" is accepted compared to time, cost and quality. The "Pull Instead of Push" principle can only explain 2.8% of the changes in project productivity, and the R^2 value is equal to 0.028. The effect size of the "Pull Instead of Push" principle on project productivity is -0.168, but from the above results we can see that the effect size is negative, which means that the relationship between the "Pull Instead of Push" principle in lean construction and project productivity is negative, therefore, when the "Pull Instead of Push" principle in lean construction increases, project productivity decreases directly. This is what the study (Moshood et al., 2024; Koskela et al., 2019; Jørgensen and Emmitt, 2008) agreed upon, that project management should focus on the principle of pull rather than push in all stages and life cycle of the project.

Discussion of results of fifth sub-hypothesis: Pursuit of "Perfection

The results of the study indicated that the comprehensive application of the principle of flexible construction (Pursuit of "Perfection") has a significant impact on the efficiency of construction projects in central Jordan, as the probability value (***) is less than 0.001 and the value of the critical ratio is greater than 2. Therefore, the comprehensive application of the principle of flexible construction (Pursuit of "Perfection") leads to significant improvements in the efficiency of construction projects in central Jordan. This result is consistent with the study of (Moshood et al., 2024; Marhani et al., 2021; Womack and Jones, 2015), where they indicated that the Pursuit of "Perfection" is a continuous process to reach high project efficiency by eliminating waste, improving productivity, and designing and planning the required value of this project, which inevitably leads us to the Pursuit of "Perfection" in project construction.

Discussion of the results of the sixth sub-hypothesis: Lean construction and project efficiency

The results indicated that the comprehensive application of lean construction principles (Value Definition, Value Stream Mapping, Flow Creation, Pull Instead of Push, and the Pursuit of Perfection) leads to significant improvements in the efficiency of construction projects in central Jordan. This is what was confirmed by (Fernando et al., 2024; Anupama et al., 2023; Eldeep et al., 2022; Aziz and Zainon, 2022; Bygballe et al., 2018; Womack and Jones 2015; Aziz and Hafez, 2013; Olsson, 2006; Sui Pheng and Hui Fang, 2005) that achieving the ideal efficiency for any project requires focusing on the principles of lean construction from Value Definition, Value Stream Mapping, Flow Creation, Pull Instead of Push, and the Pursuit of

Perfection with the aim of reducing waste, removing non-additive activities, and focusing on meeting the customer's needs in terms of time, cost, quality, productivity, and requirements.

6. Conclusion

All of the Applications of Lean Construction Principles (Value Definition, Value Stream Mapping, Flow Creation, Pull Instead of Push, and Pursuit of Perfection) have a statistically significant relationship with Project Efficiency in terms of time in construction projects in Central Jordan. The biggest effect of the above-mentioned factors on Project Efficiency in terms of time in construction projects in Central Jordan was for the pursuit of Perfection with a beta value of 0.841, then comes the factors (Pull Instead of Push, Flow Creation, Value Definition, and Value Stream Mapping) with beta values (0.799, 0.670, 0.499, and 0.481) respectively. All of the Applications of Lean Construction Principles (Value Definition, Value Stream Mapping, Flow Creation, Pull Instead of Push, and Pursuit of Perfection) have a statistically significant relationship with Project Efficiency in terms of cost in construction projects in Central Jordan. The biggest effect of the above-mentioned factors on Project Efficiency in terms of cost in construction projects in Central Jordan was for the pursuit of Perfection with a beta value of 0.392, then comes the factors (Pull Instead of Push, Flow Creation, Value Stream Mapping, and Value Definition) with beta values (0.371, 0.338, 0.309, and 0.165) respectively. All of the Applications of Lean Construction Principles (Value Definition, Value Stream Mapping, Flow Creation, Pull Instead of Push, and Pursuit of Perfection) have an insignificant relationship with Project Efficiency in terms of quality in construction projects in Central Jordan. The Applications of Lean Construction Principles (Value Stream Mapping, Pull Instead of Push, and Pursuit of Perfection) have a statistically significant negative relationship with Project Efficiency in terms of productivity in construction projects in Central Jordan. The biggest effect of the above-mentioned factors on Project Efficiency in terms of productivity in construction projects in Central Jordan was for Pull Instead of Push with a beta value of -0.168, then comes the factors (the Pursuit of Perfection, Flow Creation, Value Definition, and Value Stream Mapping) with beta values (0.141, and 0.118) respectively. In general, there is a statistically significant relationship between the application of Lean Construction Principles and improving of project efficiency in Central Jordan's construction projects.

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