# A Study of the Factors Influencing Labour Productivity in the Construction Industry from a Lean Perspective: A Structural Equation Modelling Approach

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Keywords: Labour Productivity, Resource Efficiency, Process Efficiency, Structural Equation Modelling.

Abstract: Labour productivity in the construction industry is an important factor in measuring the development level of the construction industry. In order to better promote the development of the construction industry and to facilitate the improvement of labour productivity in the construction industry, the study takes the influencing factors of labour productivity in the construction industry as the object, defines the two dimensions of resource efficiency and process efficiency of labour productivity influencing factors from a lean perspective, and constructs the structure of "influencing factors - resource and process efficiency - labour productivity". A structural equation model of "influencing factors - resources, process efficiency - labour productivity" was constructed. The final results confirm the importance of resource efficiency and process efficiency in improving labour productivity, and suggest countermeasures based on the findings of the study.

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# 1 INTRODUCTION

As an important industrial sector of the national economy, the construction industry plays an immeasurable role in the stable development of the economy. In recent years, the number of enterprises in the construction industry has gradually expanded in scale, but the industry as a whole has performed with low efficiency, poor profitability, low average technological content and, in particular, a seriously low level of labour productivity, which is not in line with the scale of the industry. Therefore, how to improve labour productivity in the construction industry has become the focus of research to promote sustainable growth in the construction industry. A comprehensive overview of the current state of research at home and abroad shows that there is currently more research on the factors influencing labour productivity in the construction industry, but there is a lack of research on the loss of labour productivity due to the waste that exists in the process. Therefore, from a lean perspective, the influencing factors of labour productivity are distinguished into two dimensions, namely resource efficiency and process efficiency, and the paths and degrees of influence of each influencing factor on labour productivity through resource efficiency and process efficiency are studied by constructing structural equation models, and suggestions and countermeasures are put forward in response to the analysis results, which are of great significance in promoting the improvement of labour productivity in the construction industry.

# 2 CURRENT STATE OF DEVELOPMENT OF THE CONSTRUCTION INDUSTRY UNDER DATA ANALYSIS

## 2.1 Analysis of the Current Situation of Labour Employment in the Construction Industry

The construction industry is labour-intensive and requires a large number of manual workers to complete operational tasks. At the same time, the educational level requirement is low and the relevant positions absorb a large number of migrant workers. Through big data analysis, in terms of age distribution, 38.78% of labour workers in the



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construction industry are aged over 50, 26.94% are aged 40-49, 22.98% are aged 30-39, 7.41% are aged 25-29, and 3.89% are aged under 24. According to the China Human Capital Report 2020 published by the Human Capital and Labour Economics Research Centre of the Central University of Finance and Economics, the average age of China's population is 38.8 years old (approximately 39 years old). It can be seen that nearly 66% of labour workers in the construction industry are older than the average age of China's population, and there is a lack of young, high-quality labour resources in the construction labour market.

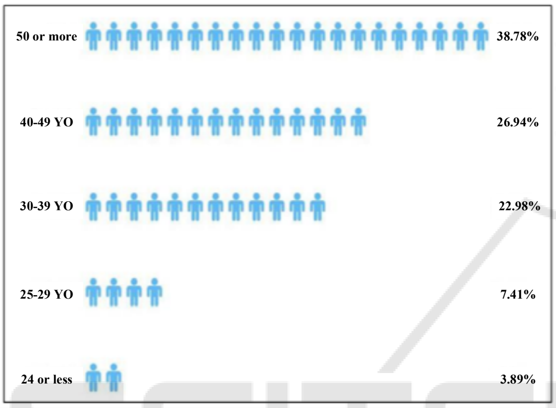


Figure 1: Construction labour age release.

### 2.2 Analysis of the Current State of Materials Utilization in the Construction Industry

Rough construction is widespread, leading to a serious waste of materials, energy and human resources. In addition, the various segments of the construction industry are disconnected from each other and building materials are basically supplied in the form of raw materials, resulting in a large amount of manual reprocessing of raw materials once they arrive at the construction site and a large amount of actual loss of materials. For example, raw materials of various sizes are delivered to the construction site, "dismembered" to form a large amount of construction waste and then shipped out of the city. Statistical analysis of the data shows that, compared to the construction of buildings in developed countries, the use of steel is 10% to 25% higher per square metre and the use of cement is 80 kg higher per square metre. It can be seen that although China's construction industry is developing rapidly, the transition process from rough construction to fine construction has been relatively slow.

### 2.3 Analysis of the Current State of Management in the Construction Industry

On the one hand, there are deficiencies in the management system of construction enterprises, leading to the emergence of poor execution, especially by those located at the end of management. On the other hand, basic aspects of the system of ownership, distribution, personnel and operating procedures of the enterprise are not adapted to the increasingly competitive environment. In addition, the regulations and technical specifications governing the conduct of the construction market are still imperfect, the appraisal system lacks objective criteria, and employees are not motivated to work efficiently.

## 3 FACTORS AFFECTING LABOUR PRODUCTIVITY IN THE CONSTRUCTION INDUSTRY

Analysing the current state of development of the construction industry provides a basis for studying labour productivity in the construction industry. From the level of the construction industry, domestic and foreign researchers based on a large number of analyses and studies have obtained the factors influencing labour productivity in the construction industry such as technology level, management capacity, wage level, labour force, material and equipment, external environment and capital investment.

Huo Chunting (2013) analysed the factors influencing labour productivity in construction enterprises by building a structural equation model, and the results showed that human resources and material inputs have an indirect positive impact on labour productivity in enterprises. Li Qingxiu (2017) used DEA-Malmquist index and multiple regression models to evaluate the total factor productivity, technical efficiency and technology level of China's construction industry. The factors affecting the technological progress of the construction industry in different regions were identified, and the evaluation results showed that technological investment and asset investment promote the development of total factor productivity and put forward rationalization suggestions. Liu Guiwen et al. (2011) established a labour productivity growth function model to analyse the degree of influence of technological progress and capital deepening on labour productivity growth, and concluded that the positive influence of technological progress on labour productivity is greater than that of capital investment, and the actual growth rate of average labour productivity in China's construction industry is lower. Liu and Qin (2010) used a linear regression model to analyse the impact of wages on labour productivity in the construction industry, and concluded that wages have a facilitating effect on labour productivity, and each increase of 1 yuan in wages can lead to an increase of 1.45 yuan in labour productivity.

From the perspective of construction professionals, foreign scholars DBH (2009) identified constraints that negatively affect labour productivity such as skills shortages in the sector, procurement methods for construction projects, the impact of regulations and lack of innovation in certain sectors of the industry, particularly in relation to construction materials.Jarkas (2012) et al. identified factors that affect labour productivity, which were further divided into Bekr (2016) found that poor planning and scheduling, shortage of materials on project sites, shortage of equipment and tools, lack of skilled labour, poor site management, rework due to construction errors, obsolete and inefficient equipment, lack of supervisory experience, delayed payments to suppliers, and slow response from consultants inspecting the work can lead to labour productivity losses in the construction industry. Loss of labour productivity. Shamil (2016), through literature research, came up with 46 factors that affect labour productivity. 36 engineers were interviewed face-to-face through questionnaires and interviews, and analysis of the questionnaire data revealed that project management factors such as efficiency of project planning, working environment, procurement methods, experience of managers, technical knowledge, and inefficient site layout all affect labour productivity. On the other hand, found through questionnaires that the management level of managers had a significant impact on labour productivity (Almeida and Carneiro 2009; Alinaitwe and Mwakali 2007; Abdulaziz and Bitar 2012).

Based on an in-depth study of the relevant literature, the various factors affecting labour productivity performance can usually be categorised into five areas, referred to as the 5Ms, namely management and control, labour, materials and equipment, external factors and incentives, which further provides the basis for constructing the research model for the thesis.

# 4 A THEORETICAL MODEL OF THE FACTORS INFLUENCING LABOUR PRODUCTIVITY IN A LEAN PERSPECTIVE

## 4.1 Application of Lean Construction Theory

Lean construction is derived from lean production, which is a successful application of the principles of economic production in the field of building construction. This new construction management model can effectively help construction companies to reduce costs, improve the quality of their work, increase their real profitability and play a huge role in the process of schedule control, safety management and environmental management.

Furthermore, researchers of lean construction argue that the labour production process in the construction industry focuses only on the resource level of utilisation and lacks attention to the waste that exists in a large number of processes, resulting in low labour productivity. Resource efficiency and process efficiency is an important aspect of lean construction, where resource rationalisation and reliable processes not only improve labour productivity and project performance, but also lead to faster delivery of construction projects at lower cost and higher quality.

## 4.2 Resource Efficiency and Process Efficiency

Efficiency is the amount of work done per unit of time. In management terms, efficiency refers to the ratio between the various inputs and outputs of an organisation in a given time.

Resource efficiency refers to the efficiency of the input and output of resources, usually using human resources, capital resources and natural resources as input factors. In the concept defined in this paper, resource efficiency refers to the maximisation of the value created given the input conditions of various resources (labour, materials and equipment, etc.) and examines the value created in the process of development and utilisation of resources in an integrated manner. The input indicators for measuring resource efficiency are natural resources, human and capital resources, etc., and the output indicator is the useful value created.

Process efficiency is the amount of compliant product or service that a process can deliver in a given amount of time given a certain amount of resources invested. In Lean thinking, the variability of work processes increases the amount of waste and hinders the performance of the system, so labour productivity losses can be reduced by improving process efficiency and eliminating waste.

This study addresses the topic of workforce management, focusing on site productivity improvements. exploratory research by Kisi (2017) and others identifies system and operational inefficiencies to estimate optimal labour productivity. modig and Ahlström (2015) propose 'process efficiency' to reflect the relationship between time spent creating value and total time. while 'resource efficiency' focuses on maximising the utilisation of machines and individual workers. Therefore, this paper uses 'process efficiency' and 'resource efficiency' to distinguish between two different sources of labour productivity. Time-motion studies and PPC metrics are used to measure both 'resource efficiency' and 'process efficiency'.

### 4.3 Theoretical Model of Factors Influencing Labour Productivity

At the individual project level, there are two branches of productivity performance measurement. The Lean approach focuses more on performance measures based on project schedule, processes and procedures than the traditional approach which focuses only on the optimisation of resource utilisation, providing a useful framework for the industry to improve labour productivity. Based on this logic, 'resource efficiency' and 'process efficiency' were selected as key antecedent variables affecting labour productivity in the construction industry, based on the relationship between the influencing factors and the resource efficiency input indicators and process efficiency influencing factors, including management and control, labour, external factors and incentives. Based on the relationship between the influencing factors and resource efficiency input indicators and process efficiency influencing factors, the five key factors of management and control, labour, materials and equipment, external factors and incentives are further divided into two dimensions: resource and process, and the differences between the influencing factors of different dimensions are analysed to draw a labour productivity model mediated by resource efficiency and process efficiency. The research model of this paper is shown in Figure 1.

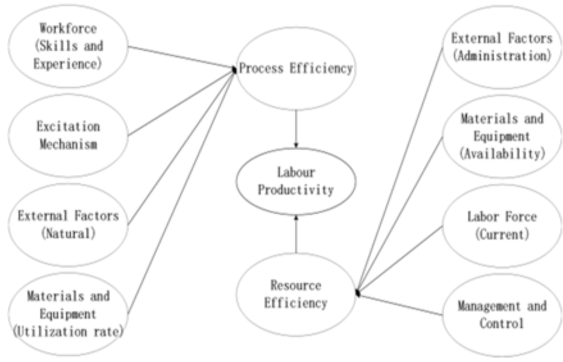


Figure 2: Research model.

## 5 RESEARCH DESIGN AND DATA COLLECTION

### 5.1 Questionnaire Design

By consolidating several literature descriptions of the same variable differentiation and distinguishing between factors that fall under resource efficiency and process efficiency, specific measures of each variable and literature sources were derived as shown in Table 1. The study was conducted on the basis of a questionnaire with questionnaire measure items using a 5-point Likert scale to assess the likelihood of influencing factors (1=very unlikely, 5=very likely) that determine productivity. The completed questionnaire was reviewed, progressively revised and refined and finally validated. The final questionnaire consisted of 11 factors and 41 measures.

Table 1: Construction of variables and sources of factors influencing labour productivity.

| Potential variables | Measurement problem items | Source |
|---|---|---|
| Management factors (MC) | MC1 Construction Management Capability<br>MC2 Site Management<br>MC3 Communication<br>MC4 construction method<br>MC5 rework<br>MC6 Lack of supervision | Doloi et al. (2012), Dai et al. (2009), Huang et al. (2008), Ibbs and McEniry (2008), Bernold and AbouRizk (2010), and Ghoddousi and Hosseini (2012) |

| | | |
|---|---|---|
| | MC7 overtime | |
| | MC8 on-site storage | |
| | W1 Workforce Training | Kazaz and Ulubeyli (2004), Hanafi et al. (2010), Durdyev et al. (2013) |
| Workforce (skills) (W) | W2 Worker experience and skills | |
| | W3 Education level of the workforce | Bernold and AbouRizk (2010), and Mojahed and Aghazadeh (2008) |
| Labour force (mobility) (W) | W4 Production technology and process changes | |
| | W5 Change in labour capacity | |
| | W6 Workers' personal wishes | |
| | Availability of ME1 equipment tools | Alonso et al. (2007), Pratibha and Gaikwad (2015), Kazaz et al. (2008), and Page (2010) |
| Materials and equipment (availability) (ME) | Availability of ME2 materials | |
| | Suitability or adequacy of the plant and equipment used for ME3 | |
| Materials and equipment (utilisation) (ME) | ME4 Delayed supply of construction materials | |
| | Shortage of materials on site for ME5 project | |
| | Lack of tools and equipment on the ME6 market | |
| | E1 Economic situation | Ghoddousi and Hosseini (2012), Moselhi and Khan (2010), Durdyev et al. (2017), and Ratcliffe and Stubbs (2003) |
| External factors (administrative) (E) | E2 Excessive influence of the owner on the construction process | |
| | E3 regulations and laws | |
| External factors (natural) (E) | E4 Health and safety conditions | |
| | E5 Meteorological conditions | |
| | E6 accident | |
| | Amount of M1 compensation | Van Tam et al. (2018). Hiyassat et al. (2016), Mahamid (2013a) Hiyassat et al. (2016) Mahamid et al. (2013), Jarkas (2015) |
| | M2 creates competition | |
| | M3 job satisfaction | |
| Incentives (M) | Motivation of M4 workers | |
| | M5 facilitation opportunities | |
| | M6 Awards and Punishments | |
| | RE1 Programme Completion Rate (PPC) | Buchan et al. (2006), Kazaz et al. (2008), Smith (2013), Gouett et al. (2011),Hwang et al. (2018),Neve et al. (2020a) |
| Resource efficiency (RE) | RE2 Direct working time (DW) | |
| | RE3 Non-value added working time (NVAW) | |
| | PE1 Programme Completion Rate (PPC) | |
| Process efficiency (PE) | PE2 direct working time (DW) | |
| | PE3 Non-value added working time (NVAW) | |
| | P1 project duration | Soekiman et al. (2011) and Kazaz et al. (2016) |
| Labour productivity (P) | P2 Quality objectives achieved | |
| | P3 Projected cost of quality | |

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## 5.2 Results of Data Collection

The data collection process took the form of a professional questionnaire published on a website and the information required from those working in the construction industry (skilled workers, architects, builders, engineers, quantity surveyors and project managers). A total of 300 questionnaires were distributed (50 face-to-face and 250 via an online questionnaire). At the end of the survey, a total of 201 valid questionnaires were identified and the sample size met the basic requirements. Based on the 201 collected data, a questionnaire reliability analysis was carried out through SPSS software, and the results showed that the Cronbach's alpha value for the whole questionnaire reached 0.937, indicating that the questionnaire had good reliability.

# 6 RESEARCH FINDINGS AND ANALYSIS

## 6.1 Reliability and Validity Tests of the Measurement Model

Firstly, the suitability test of the model. Suitability tests were carried out by SPSS 22.0 to reduce the data set dimensional data according to principal components, where the KMO test value was 0.901 and the statistical value of Bartlett's sphere test had a probability of significance of 0.000, indicating that the questionnaire data met the prerequisite requirements for factor analysis.

Secondly, the reliability of the model was tested using the widely used criterion of Cronbach's alpha coefficient greater than 0.7, and then the reliability of the model was tested according to the criterion that the overall correlation coefficient (CITC) of the items should not be less than 0.5 as proposed by the scholar Churchill. The analysis showed that the Cronbach's alpha coefficient for each construct was greater than 0.8 and the CITC values were all above 0.5, indicating that the questionnaire had high reliability.

Finally, the model convergent validity was tested. The convergent validity of the measurement model was subjected to a validation-type factor analysis. Further assessment of the structural model could only be performed if the fit of the measurement model met acceptable criteria. As can be seen from Table 2 below, the standardised factor loadings for each question were greater than 0.5 or more, and the residuals were positive and significant. The composite reliability (C.R.) values were greater than 0.7 and the average variance extracted (AVE) values were greater than 0.5, all of which met the criteria for convergent validity and the fit was within acceptable limits. The model was retained for subsequent analysis.

Table 2: Results of the validation factor analysis.

| Structure | Title item | Non-standardised factor loadings | Standard Error S.E. | C.R. (t-value) | P | Standardised factor loadings | CR | AVE |
|---|---|---|---|---|---|---|---|---|
| Workforce (Skills) | W1 | 1 | | | | 0.788 | 0.801 | 0.573 |
| | W2 | 1.091 | 0.098 | 11.127 | *** | 0.753 | | |
| | W3 | 0.988 | 0.091 | 10.901 | *** | 0.729 | | |
| Incentives | M1 | 1 | | | | 0.759 | 0.88 | 0.551 |
| | M2 | 1.056 | 0.083 | 12.716 | *** | 0.768 | | |
| | M3 | 1.034 | 0.084 | 12.26 | *** | 0.742 | | |
| | M4 | 1 | 0.083 | 12.051 | *** | 0.73 | | |
| | M5 | 0.957 | 0.083 | 11.562 | *** | 0.703 | | |
| | M6 | 1.044 | 0.084 | 12.404 | *** | 0.75 | | |
| External factors (Nature) | E4 | 1 | | | | 0.742 | 0.84 | 0.637 |
| | E5 | 1.089 | 0.089 | 12.296 | *** | 0.784 | | |
| | E6 | 1.232 | 0.094 | 13.068 | *** | 0.864 | | |
| Materials and equipment (Utilisation) | ME4 | 1 | | | | 0.855 | 0.866 | 0.684 |
| | ME5 | 0.999 | 0.065 | 15.303 | *** | 0.826 | | |
| | ME6 | 0.931 | 0.063 | 14.78 | *** | 0.799 | | |
| External factors (Administrative) | E1 | 1 | | | | 0.782 | 0.792 | 0.56 |
| | E2 | 1.026 | 0.097 | 10.549 | *** | 0.715 | | |
| | E3 | 1.055 | 0.097 | 10.845 | *** | 0.747 | | |
| Materials and equipment (Availability) | ME1 | 1 | | | | 0.816 | 0.867 | 0.685 |
| | ME2 | 1.211 | 0.079 | 15.378 | *** | 0.873 | | |
| | ME3 | 1.145 | 0.081 | 14.123 | *** | 0.791 | | |
| Workforce (Mobility) | W4 | 1 | | | | 0.846 | 0.896 | 0.741 |
| | W5 | 1.168 | 0.066 | 17.651 | *** | 0.876 | | |
| | W6 | 1.119 | 0.065 | 17.296 | *** | 0.861 | | |

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| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Management and control | MC1 | 1 | | | | 0.818 | 0.899 | 0.529 |
| | MC2 | 1.033 | 0.07 | 14.661 | *** | 0.786 | | |
| | MC3 | 0.884 | 0.069 | 12.747 | *** | 0.707 | | |
| | MC4 | 0.774 | 0.065 | 11.856 | *** | 0.667 | | |
| | MC5 | 0.908 | 0.072 | 12.596 | *** | 0.7 | | |
| | MC6 | 0.833 | 0.07 | 11.877 | *** | 0.668 | | |
| | MC7 | 0.916 | 0.073 | 12.503 | *** | 0.696 | | |
| | MC8 | 0.915 | 0.065 | 14.017 | *** | 0.76 | | |
| Resource efficiency | RE1 | 1 | | | | 0.802 | 0.789 | 0.557 |
| | RE2 | 0.956 | 0.088 | 10.872 | *** | 0.757 | | |
| | RE3 | 0.919 | 0.091 | 10.086 | *** | 0.674 | | |
| Process efficiency | PE1 | 1 | | | | 0.867 | 0.792 | 0.563 |
| | PE2 | 0.723 | 0.072 | 10.015 | *** | 0.648 | | |
| | PE3 | 0.804 | 0.074 | 10.867 | *** | 0.719 | | |
| Labour productivity | P1 | 1 | | | | 0.698 | 0.822 | 0.608 |
| | P2 | 1.312 | 0.121 | 10.844 | *** | 0.861 | | |
| | P3 | 1.218 | 0.112 | 10.884 | *** | 0.772 | | |

## 6.2 Studies Based on Structural Equation Modelling

### 6.2.1 Evaluation of the Overall Fit of the Model

Table 4 details the key fit indicators from the structural model tests. When compared to the recommended values given for the fitness indicators, the fitted values for the fitness indicators fall within the recommended values. It can be seen that the setting of the theoretical model is acceptable.

Table 3: Model fit.

| Fitted indicators | Acceptable range | Measured values |
|---|---|---|
| CMIN | - | 941.357 |
| DF | - | 741 |
| CMIN/DF | <3 | 1.270 |
| GFI | >0.8 | 0.868 |
| AGFI | >0.8 | 0.847 |
| RMSEA | <0.08 | 0.031 |
| IFI | >0.9 | 0.966 |
| TLI(NNFI) | >0.9 | 0.962 |
| CFI | >0.9 | 0.966 |

### 6.2.2 Results of Testing the Research Hypothesis

The structural relationships between the latent variables and the estimates of their standardised path coefficients, t-values and hypothesis testing results are shown in 5. As can be seen, all hypotheses passed the t-test and the path coefficients were significant at the confidence level of α = 0.001. The final model of the factors influencing labour productivity in the construction industry (path relationship) and the standardised path coefficients between each of its internal variables are obtained, as shown in Figure 2.

Table 4: Structural equation model path coefficients.

| Path relationships | | | Standard i-sation factor | Non-standardized coefficients | Standard error | T-value | P | Assuming establishment of support |
|---|---|---|---|---|---|---|---|---|
| Resource efficiency | <-- | Workforce (skills) | 0.313 | 0.358 | 0.084 | 4.275 | *** | Support |
| Resource efficiency | <-- | Incentives | 0.203 | 0.214 | 0.071 | 3.032 | 0.002 | Support |
| Resource efficiency | <-- | External factors (natural) | 0.26 | 0.308 | 0.088 | 3.502 | *** | Support |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Resource efficiency | <-- | Materials and equipment (utilisation) | 0.235 | 0.213 | 0.061 | 3.499 | *** | Support |
| Process efficiency | <-- | External factors (administrative ) | 0.266 | 0.321 | 0.091 | 3.529 | *** | Support |
| Process efficiency | <-- | Materials and equipment (availability) | 0.171 | 0.221 | 0.087 | 2.526 | 0.012 | Support |
| Process efficiency | <-- | Labour force (mobility) | 0.213 | 0.226 | 0.074 | 3.054 | 0.002 | Support |
| Process efficiency | <-- | Management and control | 0.271 | 0.3 | 0.076 | 3.954 | *** | Support |
| Labour productivity | <-- | Process efficiency | 0.411 | 0.338 | 0.061 | 5.57 | *** | Support |
| Labour productivity | <-- | Resource efficiency | 0.441 | 0.326 | 0.055 | 5.97 | *** | Support |

Note: ***=P<0.001

### 6.2.3 Analysis of Resource and Process Mediation Effects

This paper applies the Bootstrap technique to re-estimate the standard errors and confidence intervals for the indirect effect and the results of the validation data are shown in Table 6. Following the determination criteria that the upper and lower intervals of Bias-corrected and Percentile do not contain 0 and Z > 1.96 or Z= 1.96, which proves that the indirect effect holds, the data show that both resource efficiency and process efficiency have significant indirect effects.

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Table 5: Resource, process efficiency intermediary validation.

| Paths | Indirect effects | Bias-Corrected 95% CI | | Percentile 95% CI | |
|---|---|---|---|---|---|
| | Valuation | Lower | Upper | Lower | Upper |
| 1 Labour force (skills) → resource efficiency → labour productivity | 0.129 | 0.05 | 0.25 | 0.034 | 0.225 |
| 2 Incentives → Resource efficiency → Labour productivity | 0.083 | 0.017 | 0.203 | 0.009 | 0.187 |
| 3 External factors (nature) → resource efficiency → labour productivity | 0.107 | 0.016 | 0.263 | 0.011 | 0.249 |
| 4 Materials and equipment (utilisation) → resource efficiency → labour productivity | 0.097 | 0.035 | 0.194 | 0.02 | 0.171 |
| 5 External factors (administrative) → process efficiency → | 0.117 | 0.026 | 0.262 | 0.024 | 0.258 |

| | | | | | |
|---|---|---|---|---|---|
| 6 Materials and equipment (availability) → process efficiency → labour productivity | 0.075 | 0.007 | 0.18 | 0.003 | 0.174 |
| 7 Labour (mobility) → process efficiency → labour productivity | 0.094 | 0.03 | 0.191 | 0.019 | 0.171 |
| 8 Management and control → Process efficiency → Labour productivity | 0.119 | 0.043 | 0.244 | 0.032 | 0.227 |

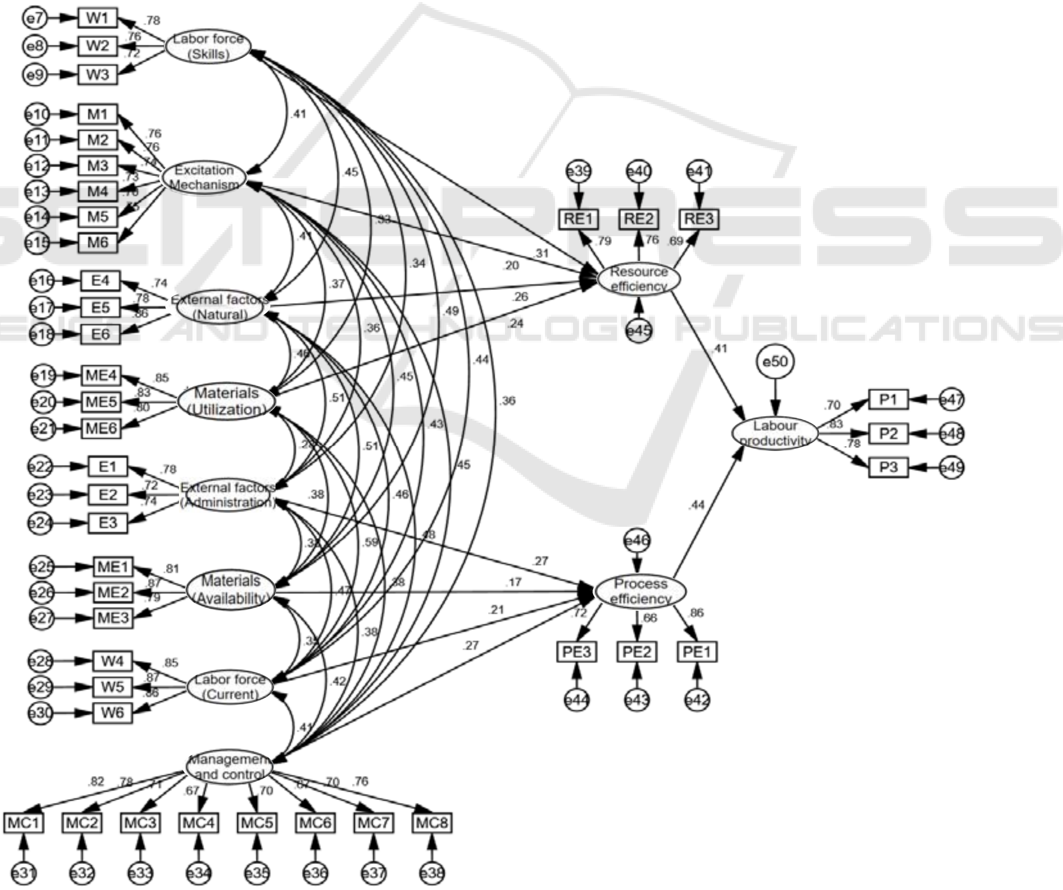


Figure 3: Final model of factors influencing labour productivity in the construction industry.

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# 7 STRATEGIES FOR SUSTAINABLE LABOUR PRODUCTIVITY GROWTH IN THE CONSTRUCTION INDUSTRY

The final model shows that the impact of resource efficiency and process efficiency on labour productivity in the construction industry is verified to exist, with the process aspect having a more significant impact on labour productivity than the traditional resource utilisation dimension. Factors such as labour (skills), incentives, external factors (nature) and material and equipment (utilisation) affect labour productivity by influencing resource efficiency and hence labour productivity. Of these, labour force skills are the most important factor with a path coefficient of 0.313 and material and equipment utilisation with a path coefficient of 0.235. It is therefore necessary to provide regular training for workers and to enhance the maintenance and renewal of materials and equipment for construction projects. In addition, management and control, external factors (administrative), labour (mobility) and material and equipment availability factors have an impact on process efficiency, with management and control being the most important factor with a path coefficient of 0.271. Clearly, the construction project management team plays an important role in conveying tasks and instructions to workers. The results are therefore reasonable, as inadequate management and control can lead to a reduction in construction labour productivity.

The findings suggest that improving labour productivity in the construction industry can be considered from both resource and process perspectives, with more focus on performance measurement based on project objectives (schedule, cost and quality), and improving resource utilisation and optimising process efficiency based on lean theory, thereby achieving the goal of improving labour productivity.

# 8 CONCLUSION

Firstly, we systematically review and analyse the influencing factors of labour productivity in the construction industry, identify the potential influencing factors of labour productivity in the construction industry from five levels: management and control, labour, external factors, materials and equipment and incentives, and introduce resource efficiency and process efficiency, transforming the influencing factors of labour productivity from the traditional resource utilisation perspective to the resource-process optimisation objective The model of labour productivity is constructed. The model provides a reliable model basis and practical guidance for decision-making on labour productivity in the construction industry.

Secondly, the relationship between labour productivity factors was analysed using structural equation modelling and the final structural model was derived based on acceptable GOF measures. The analysis of the model's parameter estimation showed that the effects of resource efficiency and process efficiency on labour productivity were significantly present. In addition, among the influencing factors, labour force skills, management and control are the most important factors affecting resources and processes respectively.

Finally, through quantitative research, the relationship between labour productivity influencing factors and resource efficiency and process efficiency is verified, and it is proposed that the practice of focusing on both resources and processes in the labour production process in the construction industry achieves improved labour productivity and project performance to deliver construction projects faster with lower costs and higher quality. It also provides a theoretical basis for subsequent in-depth research on labour productivity in the construction industry.

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