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Guidelines for Reducing Production Costs in the Construction Industry for Sustainable Competition

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Abstract

The industrial construction contracting business is crucial across all sectors, including private, government, and the public, with cost being a crucial factor. The goal of this study was to create an equation model that could decrease the cost of production factors in the construction industry. The study conducted high-quality research, including in-depth interviews with nine experts to create quantitative research tools and feedback from 11 qualified individuals on the research model. The study gathered data from 500 industrial construction contracting businesses, using descriptive, inferential, and multivariate statistics for analysis. The research guideline for the cost reduction strategies for the production factors in the construction industry is composed of four aspects. The most important item of each aspects are as following: 1) Business Alliance ($\bar{X} = 4.03$) joint planning between contractors and subcontractors to prevent potential conflicts, 2) Work Process Improvement ($\bar{X} = 4.00$) quality control throughout the construction process and before delivery, 3) Skill Labor Development ($\bar{X} = 3.72$) establishment of training centers to continuously improve labor skills, and 4) Construction Technology ($\bar{X} = 3.64$) use of video conferencing to facilitate collaboration among teams working on multiple projects simultaneously. The hypothesis test showed that the difference in the construction industry varies significantly between large, medium and small-sized businesses at a statistically significant level of 0.05 the results of the analysis of the developed equation model structure found that it met the evaluation criteria and was consistent with empirical data. The coefficient of determination (R-squared) was 0.137, the adjusted R-squared was 1.109, the index of fit was 0.961, and the root mean square error of approximation was 0.015.

Keywords: *Construction contracting business, business alliance, work process improvement, skill labor development, construction technology.*

Introduction

Derivation and the significant of the problems

Thailand is entering the era of Industry 4.0, which is necessary to drive the country forward at a rapid pace, it is also important to have efficient structural management of the country. Moreover, there must be support from abroad because most of Thailand's income comes from

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industrial activities and exporting products to foreign countries. The government recognized the importance of the industrial sector and thus established the Eastern Economic Corridor (EEC) Development Project, which involves upgrading areas in three provinces: Chonburi, Rayong, and Chachoengsao in its first phase. The aim is to establish the region as the Eastern Special Economic Zone. Currently, a Mega Project is being developed to support the industrial sector in competing with foreign countries systematically and efficiently, by allowing the private sector to enter participate in driving the country concretely and continuously. It is considered an important turning point for Thailand that will make the country have more industrial potential. It also strengthens existing industries for better efficiency, can attract investors both within the country and abroad, creating a desire to invest in the country. According to the latest information from reports by EEC, the Japan International Trade Organization (JETRO) and the International Trade Promotion Board (China Council for the Promotion of International Trade: CCPIT), organize a seminar Japan-China Workshop on Business Cooperation in Thailand, more than 260 Japanese and Chinese businessmen, as well as Thai businessmen from the Federation of Thai Industries (F.T.I.) and the Thai Chamber of Commerce attended the event. The main objective is to organize seminars to provide information and build Businesses Networking between the Japanese and Chinese private sectors, in joint investment in the EEC area. It was found that, Japan and China have great confidence in this project and are therefore expected to invest in Thailand. From the cabinet resolution approving investment in 5 important infrastructure projects in the EEC. The total investment value for all 5 projects was 650,000 million baht. It is expected that, there will be private investors as co-investors. The EEC. development project is considered a good opportunity for contractors, both the public and private sectors will be involved in developing the construction business and will have more opportunities to work on construction projects. The investment trend in the industry analyzed from statistics appears as shown in Figure 1.

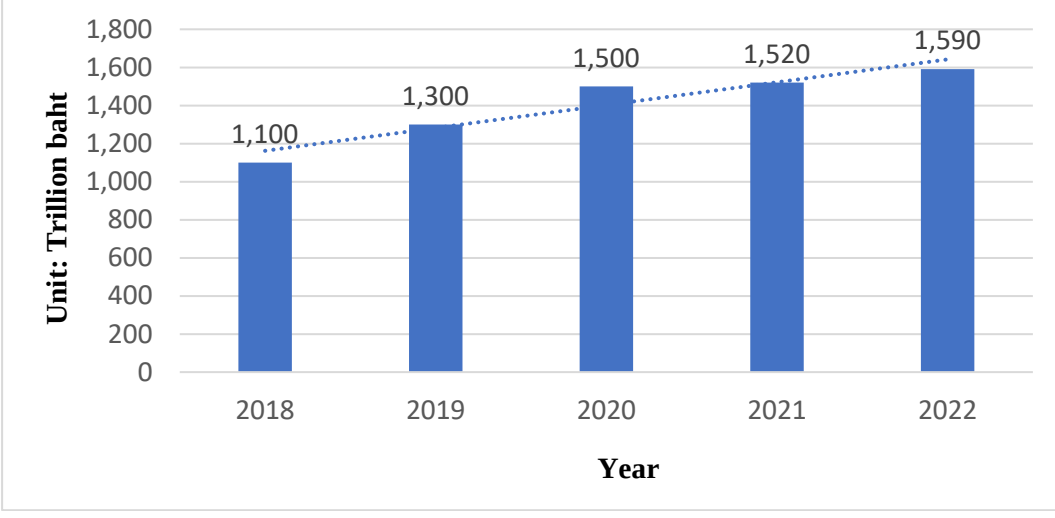

Figure 1. Investment trends in construction business (Office of the National Economic and Social Development Council, 2023)

Overall construction work during 2018-2022 will benefit from the acceleration of large-scale government infrastructure investment with more than 50 projects by 2024, which is considered an important driving factor for the expansion of the construction business. Meanwhile, private sector projects are expected to gradually recover from 2018, government construction jobs will

grow significantly from Mega Projects. In the first half of 2018, there will be more large government projects open for bidding than in the past few years. This allows government investment in mega projects, both ongoing projects and new projects, to enter the construction phase simultaneously in the second half of the year. There are important projects such as the double track railway project, route from Lopburi - Pak Nam Pho and between Map Ka Bao and Chira Road Junction. Motorway project from Bang Pa In-Nakhon Ratchasima Province, and Bang Yai - Kanchanaburi Province, etc.

In addition, the government has plans to invest in small-scale infrastructure throughout the country, such as small water resource development projects, repair work on transportation routes including roads, bridges, and railway tracks, damaged from the flooding in the southern region in early 2017, etc. Due to the increase in the amount of construction work, it is estimated that this will be a positive factor for the entire construction contracting business. Especially large contractors who have quite an advantage in accepting government work. Meanwhile, SMEs contractors will have the opportunity to hire Sub-Contract following the major, make work all year round, including the trend of government construction work during 2018-2019, it will expand according to the progress of mega projects. It is expected that the value of goverment construction will grow approximately 13-16% per year, with a total construction value for two years of approximately 1.9 trillion baht, allowing large contractors to continue to accumulate work on hand (Backlog) and SMEs contractors to gain benefits from Sub-Contracting following the major. It also benefits from the government sector dividing many mega project contracts into smaller contracts, such as motorways, etc. However, it was still found the construction business important problems and obstacles that still require developing the capabilities of the construction contracting business, Krungsri Research Center (2022) analyzed data from industrial business trends 2018-2022 in the construction contracting business and found that, the value of Thai construction in 2018-2022 will expand by an average of 8-12% per year, especially the construction contracting business, which has an average share of 8.5% of the gross domestic product (GDP), but it has been found that the overall price of construction materials has increased. Since the second half of 2018 until the present, there has been an acceleration in government construction projects, including both new projects and ongoing ones. Additionally, there has been a gradual recovery in the private sector's construction activities. In particular, real estate projects are expected to generate increased demand for construction materials. The Thai construction contracting industry between 2018-2022 was influenced by both public and private construction, which had an impact on the demand for construction materials and the anticipated price increase. This is evident from the construction materials price index, as depicted in Figure 2, which shows a tendency for prices to rise.

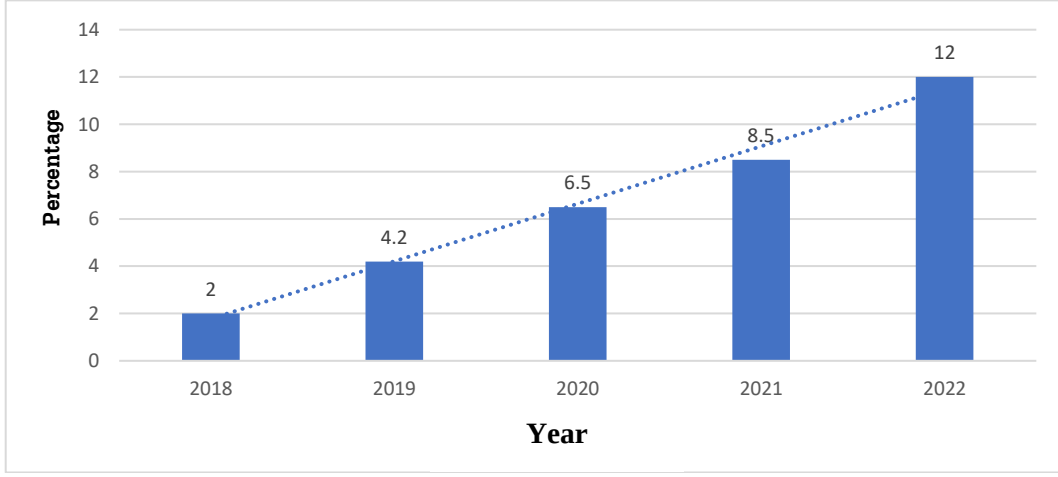

Figure 2. Construction material prices (Ministry of Commerce, 2023)

When considering the index in 2018-2022, it was found that the trend of construction material prices is increasing. In particular, many government projects have had an impact on increasing demand for steel products, causing steel prices to start adjusting significantly in June 2018. Moreover, it is likely that steel prices will continue to rise in the second half of the year. As for the price of cement, it is expected that the growing demand from both the public and private sectors will continue to support price increases. However, the ample supply of cement in the country has resulted in a narrow price range. The entry of large business groups into the competition has been facilitated by advancements in construction technology, such as the use of precast materials, robots, and continuously developed 3D printers. As a result, large contractors may increase their proportion of self-construction, reducing the role of SMEs who work as subcontractors. Consequently, accepting work with a small proportion may not be worthwhile. This imbalance poses a challenge in terms of workers' skills and the sophistication required for the installation of high-tech construction materials, such as prefabricated walls, etc. As a result, the delivered work may suffer from quality problems for which the SME contractor must take responsibility. This can have a negative impact on their reputation and credibility. Moreover, this problem may not be limited to the labor force but may also extend to entrepreneurs who are not yet adequately prepared to effectively handle these materials. In each project that SME contractors undertake, whether it is a government or private project, there are various factors that need to be taken into account from different perspectives. For government projects, one important consideration is the project's timeline, which may end up being delayed compared to initial estimates due to several stages involved. These stages include preparing a project study report and seeking approval from the Cabinet for contract conditions. Such processes can often contribute to delays in project commencement. There may also be cases where land needs to be returned or adjusted before construction can begin, and in some instances, ownership issues may necessitate expropriation of the land, further hindering construction within the set timeframe. However, when it comes to the price of construction materials in government projects, operators have the ability to control risks and manage costs better compared to accepting private work. On the other hand, there are certain issues that need to be considered regarding private construction projects. One key concern is that the growth rate of private construction may not meet expectations in the second half of 2018-2022. In addition to the aforementioned construction material issues, other factors may contribute to this slower growth. There are also issues regarding construction labor. From the National Economic and Social Development Board (NESDB) report on the Thai labor situation, specifies conditions and impacts on the Thai labor market. Especially in terms of population structure, it is expected that during the 12th Economic Development Plan (2017-2021), the Thai population will increase from 65.5 million to 66.1 million, with the proportion of elderly people increasing from 100, from 17.1 to 19.8 percent, while the proportion of the labor population will decrease from 65.3 percent to 64.1 percent. By the time of the 13-15 Economic Development Plan (2022-2036), the proportion of elderly people will increase to hundreds from 20.6 percent, while the working age population will decrease from 63.1 percent to 56.3 percent. However, the Thai labor market situation is facing limitations in many areas. If we consider the significance in depth, it will be found that the current working age population is 38.08 million people, a decrease from 38.64 million people in 2010, which reflects the problem of the labor force entering the labor market not being consistent with the demand for employment with the current labor market, there is a trend that the demand for labor will increase from 36.4 percent in 2018 to 45.9 percent in 2022. The Siam Commercial Bank

Economic and Business Research Center (SCBEIC) has assessed labor shortage trends from 2018-2040. Thai construction contractors or contractors are likely to face a labor shortage of approximately 50,000–200,000 people per year due to the labor demand increased from government construction projects.

Research objectives

1. To study the structure and operating characteristics of the construction industry business.
2. To study the elements of methods for reducing production costs in the construction industry.
3. To develop a structural equation model for reducing production factor costs in the construction industry.

Research hypotheses

H1: *Business Alliance elements have a direct influence on technology elements in construction (Construction Technology).*

H2: *Business Alliance elements have a direct influence on Work Process Improvement elements.*

H3: *The Business Alliance component has a direct influence on the Skill Labor Development elements.*

H4: *Technological elements in construction (Construction Technology) have a direct influence on the elements of Skill Labor Development.*

H5: *Technology elements in construction (Construction Technology) have a direct influence on the elements of Work Process Improvement.*

H6: *Work Process Improvement elements have a direct influence on Skill Labor Development elements.*

H7: *The level of importance of guidelines for reducing production costs in the construction industry overall that classified according to the size of the industrial business is different.*

Literature Review

Information about the construction industry

The construction business is an industry that encompasses characteristics of medium, small, and large, causing more conflicts in operations than in other industries. Additionally, construction management is a job that requires both scientific and artistic application of academics. Engineers, architects, and others involved in construction need to understand the nature of the industry, as well as management principles and methods for overseeing construction work in order to achieve established objectives. The success of any construction operation hinges on solving various problems effectively, requiring the use of experienced individuals with substantial knowledge and ability (Ministry of Industry, 2022).

As a result, it has been concluded that the general characteristics of construction work continually change in various aspects, tending to become more complex as technology advances. Furthermore, with ongoing additions and improvements to various government regulations, architects, engineers, and project administrators must adhere to these changes to efficiently carry out construction work and conserve resources. It can be said that the general nature of construction work is presently considered a type of industrial production. According to the Civil and Commercial Code, construction work is deemed to be contracted work. However, construction work possesses specific characteristics that differ from other industries

in numerous ways.

Summarize documents and research into the issues and elements of the research.

Can be summarized into 4 components: 1) Business Alliance component, 2) Technology component in construction (Construction Technology), 3) Components of Skill Labor Development, and 4) Components of Work Process Improvement. Figure 3.

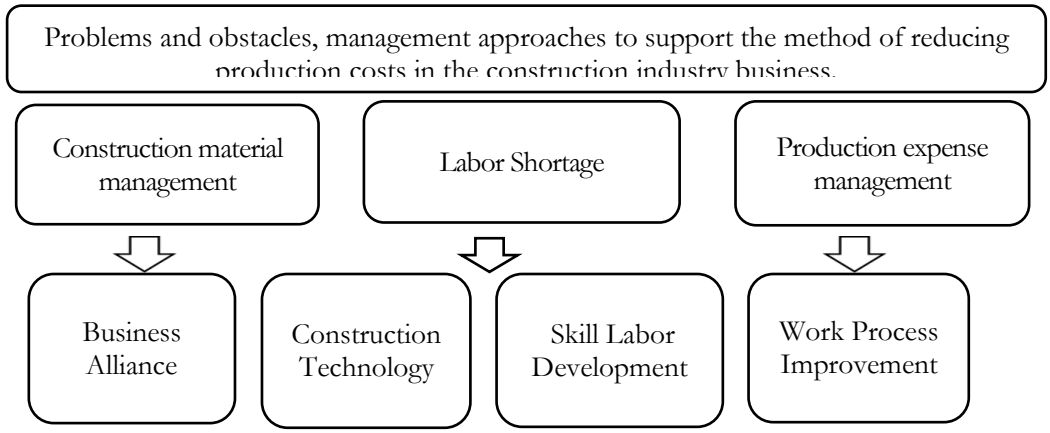

Figure 3. Model of Guidelines for reducing production costs in the construction industry for Sustainable competition

Statistics used in data analysis

1. Qualitative research Using the In-depth Interview technique, content analysis was used and the results were summarized as guidelines for reducing production costs in the construction industry business, it is classified into four components.
2. Quantitative research, this research analyzed general basic data including descriptive statistics, reference statistics, and multiple statistics with the ready-made programs SPSS (Statistical Packages for the Social Science) and AMOS (Analysis of Moment Structure).

Developing a model that is consistent with empirical data, must take into account the criteria that will be used in the evaluation. Arbuckle has recommended four criteria for evaluating the model that should be considered, as shown in **Table 1**. (Thanin, 2020)

Table 1. Criteria for evaluating the harmony of the model.

Evaluating the Data-Model Fit	Criteria	Reference
1. CMIN-ρ	Higher than 0.05	Arbuckle (2016)IBM SPSS AMOS v.20
2. CMIN/DF	Less than 2	Arbuckle (2016)IBM SPSS AMOS v.20
3. GFI	Higher than 0.90	Arbuckle (2016)IBM SPSS AMOS v.20
4. RMSEA	Less than 0.08	Arbuckle (2016)IBM SPSS AMOS v.20

3. Qualitative research with group discussion techniques Use the method of content analysis

(Content

Analysis) and summarize comments and suggestions obtained from group discussions.

Result

The statistical analysis results of the Guidelines for reducing production costs in small to medium-sized industrial construction contracting businesses as in Table 2.

small to medium-sized industrial construction contracting businesses.

Table 2. The mean and standard deviation of Guidelines for reducing production costs in

Guidelines for reducing the cost of production factors in the construction industry.	**Small to medium size**			**large size**		
	$\overline{X}$	SD.	Sig. level	$\overline{X}$	SD.	Sig. level
Overall	3.52	0.68	High	4.10	0.35	High
1. Construction Technology	3.26	0.91	Medium	4.03	0.48	High
2. Work Process Improvement	3.82	0.63	High	4.18	0.34	High
3. Skill Labor Development	3.36	0.89	Medium	4.07	0.44	High
4. Business Alliance	3.63	1.02	High	4.24	0.71	High

Results

Results of structural equation model analysis of approaches to reducing input costs in the construction industry in the Unstandardized Estimate mode and the Standardized Estimate mode before improving the model, shown in Figure 4-5.

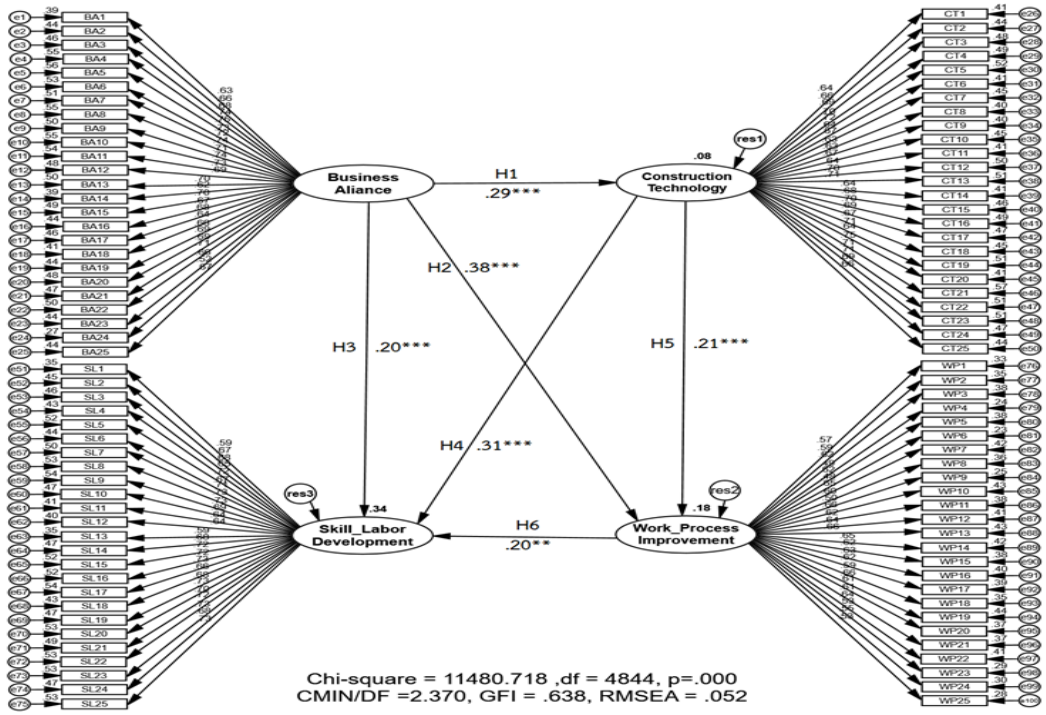

Figure 4. Structural equation model for reducing input costs in the construction industry in the Unstandardized Estimate mode, before improving the model.

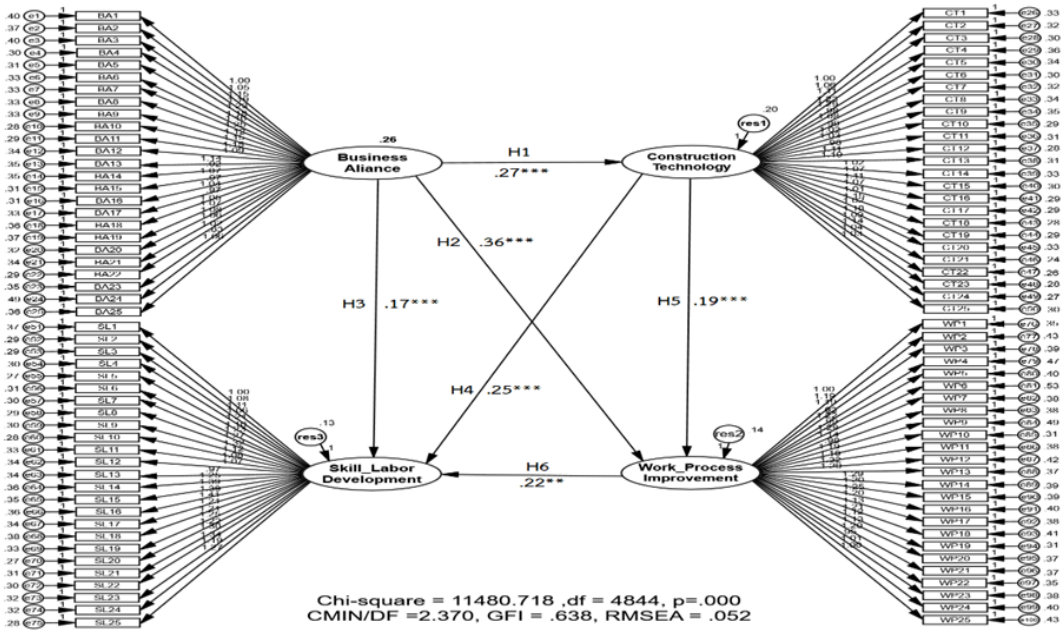

Figure 5. Structural equation model for reducing costs of production factors in the construction industry in Standardized Estimate mode before improving the model.

Results of structural equation model analysis of approaches to reducing production costs in the construction industry in the Unstandardized Estimate mode and the Standardized Estimate mode after improving the model. The results appear as shown in Figure **6-7.**

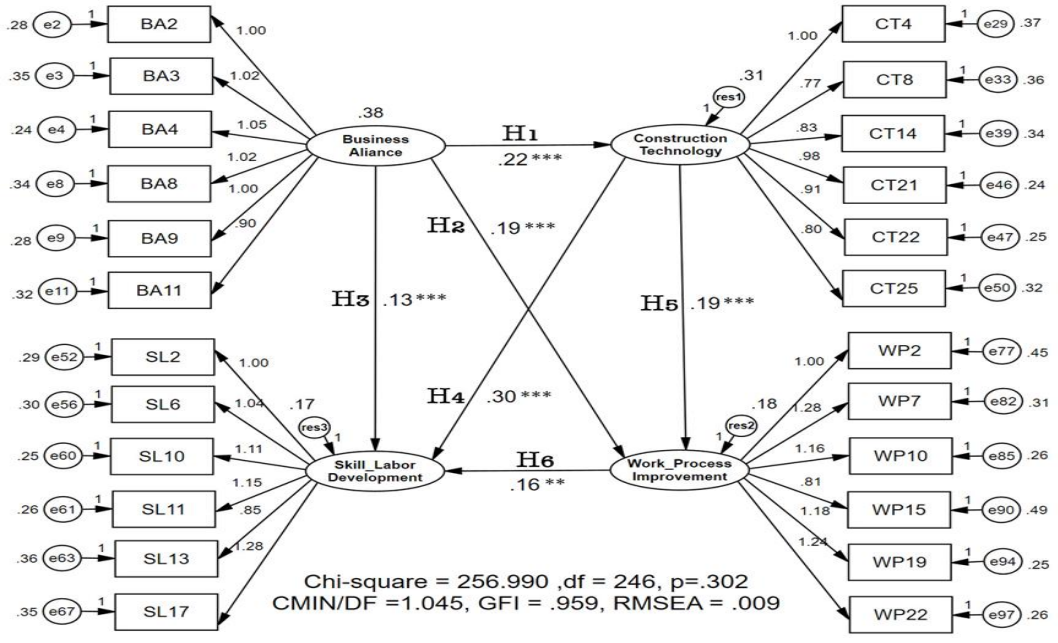

Figure 6. Structural Equation Modeling: Guidelines for reducing production costs in the

construction industry for sustainable competition: Unstandardized Estimate mode After improving the model.

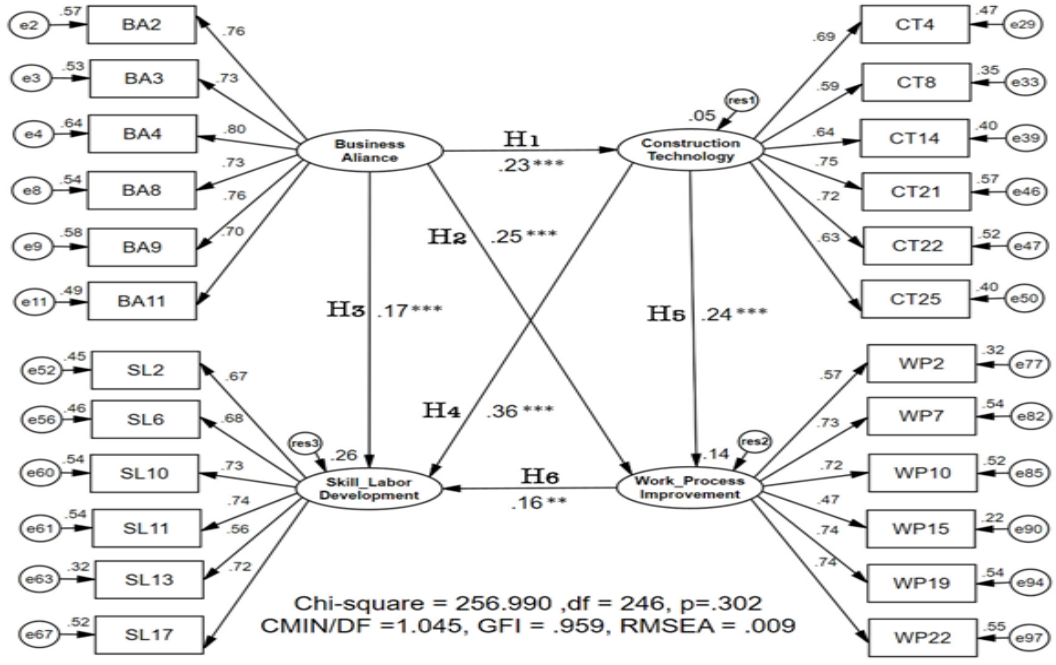

Figure 7. Structural Equation Modeling: Guidelines for reducing production costs in the construction industry for sustainable competition: Standardized Estimate mode.

Conclusion

Presentation of summary of research results, an overview of methods are as follows:

1. The results of the analysis of methods for reducing production costs in the construction industry business through qualitative research using in-depth interview techniques from experts revealed that four elements can be classified as: 1) Business Alliance Components, 2) Technology Components in construction (Construction Technology), 3) Work Process Improvement components, and 4) Skill Labor Development components, totaling 100 items divided into 25 variables per component, respectively.

2. In the general status of industrial business organizations, it was found that the respondents were small and medium-sized industrial businesses as well as large industrial businesses, accounting for 50 percent, with the form of business registration mostly being a limited company, accounting for 50.20 percent. The period of operation is less than 10 years, accounting for 39.60 percent. There is no foreign joint venture, representing 78.80 percent, and the quality management standards that are most important to the organization account for 42.60 percent.

3. The general structure and operating characteristics of the construction contracting industry found that:

1) The majority of operations involve other public utility system work, accounting for 37.60 percent. **2)** Construction operations include both recipients and contractors, with direct contractors and subcontractors accounting for 64.80 percent. **3)** Subcontractors are utilized, accounting for 82.80 percent. **4)** Construction personnel in the organization have educational

qualifications lower than a bachelor's degree, representing 61.20 percent. **5)** Internal factors affecting the reduction of production factor costs include machinery, representing 25.80 percent. **6)** External factors affecting the reduction of production factor costs include economy, accounting for 32.40 percent. **7)** The proportion of construction personnel in the organization is mostly Thai workers, accounting for 58.00 percent. **8)** Estimated annual income is more than 25-million-baht, accounting for 36.40 percent.

9) Estimated annual profit is 1,000,001-5,000,000-baht, accounting for 55.60 percent. **10)** The source of funds for operations is obtained by borrowing from a bank or financial institution in the country, accounting for 69.80 percent. **11)** Most of the organization's operations involve accepting construction work from the private sector, accounting for 73.60 percent. **12)** The organization has never had cooperation with a foreign contractor in the form of a joint venture or otherwise, accounting for 62.20 percent. **13)** The competitive strategy is to provide services that offer maximum benefit to customers, accounting for 32.80 percent. **14)** Most of the procurement of raw materials comes from domestic sources, accounting for 58.00 percent. **15)** Most of the construction period is completed according to the schedule specified in the construction contract, accounting for 79.00 percent. **16)** The plan for dealing with situations that have an impact on higher costs, such as the conflict between Russia and Ukraine and the spread of COVID-19, involves accelerating the closure of construction work to avoid rising costs, accounting for 34.20 percent. **17)** The greatest strength of the organization in its operations is its high adaptability, labor, and financial resources, accounting for 38.20 percent. **18)** The greatest weakness of the organization in its operations is the skills of its workers and the lack of skilled labor, accounting for 41.40 percent. **19**) The most common problem in construction operations is labor problems, accounting for 49.60 percent.**20)** No corporate social responsibility activities (Corporate Social Responsibility- CSR) are undertaken, accounting for 43.00 percent.**21)** The 3R principles (Reduce, Reuse, and Recycle) are used, accounting for 83.00 percent.

4. The level of importance of the components of the approach to reducing production costs in the construction industry business has been found to be high, with an average value of 3.81 for guidelines for reducing production costs in the construction industry, with the following order of components: **1)** Business Alliance components have an average of 4.03, **2)** Work Process Improvement components have an average of 4.00. **3)** Skill Labor Development has an average of 3.72. **4)** Technological elements in construction (Construction Technology) have an average of 3.64.

When classified by item in each aspect. with the first 3 highest levels of importance, it was found that:

Technological elements in construction (Construction Technology) include the use of VDO conference to meet with work teams in cases where multiple projects are running simultaneously, with an average of 3.92, followed by the use of an accurate virtual modeling system (Building Information Modeling: BIM) to calculate structures, estimate prices, and plan building systems to increase efficiency in construction work, with an average of 3.87. The use of Top-Down Construction technology in construction has an average of 3.83, respectively.

Components of work process improvement (Work Process Improvement) includes checking the quality of work both during construction and before delivering construction work, with an average of 4.16, followed by the installation of warning signs in construction areas, especially in areas that are clearly very dangerous, with an average of 4.15. The choice to use high-quality but low-priced construction materials to reduce construction costs has an average of 4.11,

respectively.

Components of skill labor development includes establishing a skill development center to provide continuous training services to workers, with an average of 3.89, followed by providing all workers with training courses related to accident prevention and working with safety, with an average of 3.88 (S.D. = 1.00). Providing practical training in various courses such as pouring concrete floors, plastering bricks, making reinforced concrete, concrete work techniques, and cost estimation, had an average of 3.88 (S.D. = 1.07), respectively.

Components of Business Alliance include planning collaboration between direct contractors and subcontractors to prevent conflicts that may occur, with an average of 4.16, followed by delivering quality work to the owner (Owner) with an average of 4.14, and paying subcontractors on time, with an average of 4.13, respectively.

5. Comparison of the importance of elements in the approach to reducing production costs in the construction industry business: Classified by industry business size and testing the difference between the means of two independent population groups using a t-test, it was found that the level of importance of the components of the guidelines for reducing production costs in the construction industry business is illustrated. When classified by organization size, there is a statistically significant difference at the 0.05 level. It was found that large industrial businesses place more importance on methods of reducing production costs in the construction contracting industry than medium and small industrial businesses. Regarding the analysis of the differences in the level of importance of the components of the approach to reducing production costs in the construction industry business by area, including the technology component in construction (Construction Technology), Work Process Improvement, Skill Labor Development, and Business Alliance elements, it was found that every aspect is significantly different in terms of statistics at the 0.05 level. When comparing each item, it was found that there were differences that were statistically significant at the 0.05 level for 97 items, divided into technological elements in construction (Construction Technology) with 25 questions, Work Process Improvement with 23 questions, Skill Labor Development with 25 questions, and Business Alliance with 25 questions and 24 items. Of these 97 items, large industrial businesses give more importance to guidelines for reducing production costs in the construction industry business than small and medium-sized industrial businesses.

6. The results of the analysis of the structural equation model for reducing input costs in the construction industry before improving the model found that the root mean square error approximation index (RMSEA) was equal to 0.052. Evaluation criteria for consistency with empirical data but for other values, including Chi-Square Probability Level: CMIN-ρ) equal to 0.000, chi-square correlation value (CMIN/DF) equal to 2.370 and consistency level index (GFI)) equal to 0.638 did not pass the criteria for evaluating consistency with empirical data. Therefore, the researcher proceeded to improve the model. By considering the Modification Indices values obtained from ready-made programs with theoretical principles. To eliminate some inappropriate observational variables one by one. Then proceed with the new processing. Do this until you get a model with all 4 statistical values that pass the criteria. After the model improvement has been completed, it is found that the chi-square probability value (CMIN-ρ) is equal to 0.302. is greater than 0.05, the relative chi-square value (CMIN/DF) is 1.045, is less than 2.00, the concordance index (GFI) is 0.959, is greater than 0.90, and the root mean square

index of error approximation is greater than 0.05. (RMSEA) equal to 0.009 is less than 0.08. Therefore, it can be concluded that all 4 statistics pass the evaluation criteria. It is consistent with empirical data.

7. The results of the hypothesis testing to analyze the causal influence between the latent variables in the structural equation model of guidelines for reducing input costs in the construction industry, 6 assumptions, found that the 6 assumptions were following the set assumptions, namely:

H1: *It was found that Business Alliance elements have a direct influence on technology elements in construction. (Construction Technology) with statistical significance at the 0.001 level, with Standardized Regression Weight = 0.23.*

H2: *Business Alliance elements have a direct influence on Work Process Improvement elements with statistical significance at the 0.001 level, with Standardized Regression Weight = 0.25.*

H3: *The Business Alliance component has a direct influence on the Skill Labor Development component with statistical significance at the 0.001 level, with Standardized Regression Weight = 0.17.*

H4: *Technology components in construction (Construction Technology) have a direct influence on the skill labor development component with statistical significance at the 0.001 level, with Standardized Regression Weight = 0.36.*

H5: *Technology components in construction (Construction Technology) have a direct influence on the components of work process improvement (Work Process Improvement) with statistical significance at the 0.001 level with the Standardized Regression Weight = 0.24, and*

H6: *Work Process Improvement components have a direct influence on Skill Labor Development components with statistical significance at the 0.01 level, with Standardized Regression Weight = 0.16.*

8. The results of the analysis of the overall influence of latent variables within the structural equation model for reducing input costs in the construction industry, after improving the model, found that the greatest overall influence will be on the technological component of construction (Construction Technology), which holds an overall influence on the component of skill labor development (Skill Labor Development) equal to 0.40. This influence stems from two factors: 1) The direct influence between technological elements in construction (Construction Technology) influencing the component of skill labor development (Standardized Regression Weight) equals 0.36, and 2) The indirect influence between technological elements in construction (Construction Technology) influencing the components of work process improvement (Work Process Improvement) with a weight (Standardized Regression Weight) equal to 0.24, which is then forwarded to the Skill Labor Development component with a weight (Standardized Regression Weight) equal to 0.16, resulting in a combined weight equal to 0.04 (0.24 x 0.16 = 0.04).

9. Results of the analysis of the relationship between the variables of the structural equation model for reducing production costs in the construction industry revealed that there were 276 pairs, divided into 161 pairs of variables with statistical significance at the 0.001 level, 73 pairs of variables with statistical significance at the 0.01 level, 24 pairs of variables with statistical significance at the 0.05 level, and 24 pairs of variables with statistical significance at the 0.01

level. There were 18 pairs that were not statistically significant at the 0.05 level.

10. The qualitative research involved using Focus Group Discussion techniques and inviting 11 experts to evaluate a model guideline for reducing production costs in the construction industry. The experts unanimously approved the model guideline, and their suggestions consistently emphasized the importance of the construction technology industry. Specifically, they focused on enhancing the efficiency, quality, and sustainability of construction projects, including environmentally friendly construction technology and advanced construction safety technology to ensure the well-being of everyone involved. Furthermore, they highlighted the use of innovative construction methods to improve structural integrity, aesthetics, and durability, as well as the application of digital technology, such as management software, to enhance team collaboration and database management and ultimately reduce production costs.

Discussion

From the results of this research, the researcher brought the discussion to a conclusion by bringing relevant research documents to support or contradict the following 5 points:

1. From the results of the research, when comparing the methods for reducing production costs in the construction contracting industry between small and medium-sized industrial businesses and large industrial businesses, a statistically significant difference was found at the 0.05 level, consistent with the research of Ke You and Cheng Zhou (2023) and M. Durai Aravindh and N. S. Sriram (2023).

2. From the results of the hypothesis testing, it was found that technological elements in construction (Construction Technology) have an overall influence on the skill labor development component, which is the highest overall influence with a weight value (Standardized Regression Weight) of 0.40 and also has the highest direct influence. Research by Ritva Toivonen and Heini Vihemäki (2021) suggests that the development of construction workers in each field is very important, as workers with more knowledge and ability can work with higher quality and safety. Using technology in construction can also help increase labor efficiency, ensuring high-quality work and adherence to plans.

3. In the guidelines for reducing production costs in the construction industry, the area of business alliances (Business Alliance) had an average of 4.03, the highest average in the area. This reflects that the construction business must focus on business partners to minimize construction costs. This is consistent with research by Ard-Pieter de Man and Dave Lewison (2019).

4. In the guidelines for reducing production costs in the construction industry, items with the highest average values were found to include collaborative planning between direct contractors and subcontractors to prevent potential conflicts, with an average of 4.16, which was the highest among the items. This finding aligns with the research of Dalia and Mohamed (2022).

5. From the results of the analysis of the relationship between variables in the guidelines for reducing production costs in the construction industry business, after improving the structural equation model, it was found that recruiting multiple suppliers as partners saves time and provides the opportunity to compare product prices with various suppliers, with the highest correlation value of 0.608. This finding corresponds with the research of Amin Mahmoudi and Saad Ahmed Javed (2022) on large public construction projects, which often require the services of several subcontractors to carry out the project. Performance

evaluation after selecting subcontractors using the Ordinal Priority Approach (OPA) was also highlighted.

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