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Innovation Factors of Engineers in Thailand's Construction Industry

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Abstract:
The construction industry is important to Thailand's economy. However, due to the competition in the fast-changing world, entrepreneurs must adjust their business practices to seek opportunities to benefit from competitive advantages. Additionally, modern technology is applied to all the processes of the construction industry to increase efficiency. The objectives of this research were to 1) analyze the opinions of engineers on the construction business innovation factors, and 2) analyze how engineers with different occupations, types of construction work, training, work experience, and professional fields influenced the construction business innovation factors. This research is quantitative. The target group was engineers working in the construction industry in Bangkok and its vicinity, Chonburi and Nakhon Ratchasima, which all together are the economic center of Thailand. There were 80 samples. The questionnaire was validated by three experts before the data collection began. The sampling was not random; a purposive selection method was used. The data were analyzed using descriptive and inferential statistics with frequency, percentage, and the F test. The results of the analysis showed that the overall level of business innovation factors in the construction industry was moderate, with an average of 4.40. When considering the level of innovation factors in each aspect, it was found that paradigm innovation, product innovation, position innovation, and process innovation had an average of 4.65, 4.40, 4.38, and 4.20, respectively. It was also found that personal factors differing in occupation, types of construction work, training, work experience, and professional fields related to business in the construction industry did not have a statistically significant effect on product innovation, process innovation, position innovation, and paradigm innovation. Therefore, the research results will be useful in seeking business opportunities in the construction business for further development into building a construction industry business network that would increase sales and profits. Additionally, engineers pay attention to innovation as a factor that affects the efficiency of the construction industry. However, construction organizations must plan for employee training, experience building, and work plans to achieve better performance, and construction industry business has brought in modern technology to help in the construction process to improve the efficiency of the construction work by using Internet of Things (IoT) technology to track the use of construction resources and uses drones for on-site inspections better and more accurately.

Keywords: innovation factors, construction industry, engineers, Thailand.

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泰国建筑业工程师的创新因素

摘要：
建筑业对泰国经济很重要。然而，由于瞬息万变的世界中的竞争，企业家必须调整自己的商业行为，以寻求从竞争优势中获益的机会。此外，现代技术应用于建筑行业的所有流程以提高效率。本研究的目的是 1）分析工程师对建筑业务创新因素的看法，以及 2）分析不同职业、建筑工作类型、培训、工作经验和专业领域的工程师如何影响建筑业务创新因素. 这项研究是定量的。目标群体是在曼谷及其周边地区、春武里府和呵叻府从事建筑行业的工程师，这些地方都是泰国的经济中心。有 80 个样本。在数据收集开始之前，问卷由三位专家验证。抽样不是随机的；使用了有目的的选择方法。使用频率、百分比和 F 检验的描述性和推论性统计分析数据。分析结果显示，建筑业业务创新要素总体水平适中，平均为 4.40。当考虑各个方面的创新因素水平时，发现范式创新、产品创新、职位创新和流程创新的平均值分别为 4.65、4.40、4.38 和 4.20。研究还发现，在建筑行业的职业、建筑工种、培训、工作经验和与业务相关的专业领域等方面的个人因素对产品创新、流程创新、职位创新和范式没有显着影响。创新。因此，研究结果将有助于在建筑业务中寻找商机，进一步发展为建立建筑行业业务网络，从而增加销售额和利润。此外，工程师将创新视为影响建筑行业效率的一个因素。然而，建筑组织必须规划员工培训、经验积累和工作计划以获得更好的绩效，建筑行业业务引入了现代技术来帮助施工过程，通过使用物联网提高施工工作效率（物联网）技术跟踪施工资源使用情况，更好、更准确地使用无人机进行现场检查。

关键词：创新因素，建筑业，工程师，泰国。

1. Introduction

The construction industry in Thailand is an industry that is important to the country's economy. At present, the economy has been affected by the 2019 coronavirus epidemic since 2020. As a result, construction businesses must turn to technology to access new business opportunities. More than in the past, the approach that may be adapted is to apply innovation and technology to the construction process to create added value for the business and increase work efficiency. Engineering is another important occupation in the construction industry. Therefore, engineers in construction management need to be creative and seek new innovations to apply in their work to create business competitiveness and achieve sustainable development in the construction industry (Chae et al., 2022). New innovations in the construction business help to enhance efficiency in terms of speed, durability, economy, and safety (Mano, 2019).

Lee et al. (2019), Lundberg et al. (2019), Mansell et al. (2020), and Si et al. (2020) conclude that innovation means doing something new through the ability to use knowledge, creativity, skills, and technological or managerial experience to develop and produce new products, new production processes, or new services, that meet market needs. It is divided into 4 categories (the "4 Ps" of innovation). First, product innovation is a change in the "products or services" of the organization. Second, process innovation is a change in the production process, product presentation process, or the process of bringing innovations to the market. Third, the position innovation is a change in the form of a product or service, or a change in the position of an innovative product or service that has been in the market to be perceived as new. Fourth, the paradigm innovation aims to create innovations that change the new framework (change in mental model).

An important objective is to analyze the opinions of engineers on the innovation factors of the construction business, as it creates business opportunities and competitive advantages in the construction industry, and how different engineer professions, types of construction, training, work experience, and professional fields influence construction business innovation factors for construction organizations to plan their training, enhance experience, and plan work to achieve better performance. The research results will be used in the construction industry's business. It also helps generate income for the country's economy. It also creates employment from the innovation of new products in the construction industry that have a process for sustainable performance. Moreover, the results of the research can be useful in the construction industry to seek opportunities for high competition during the COVID-19 pandemic. However, the realization of the results of research depends on the support of corporate executives and the government's promotion of innovation.

2. Literature Review

Research on innovation factors for engineers in Thailand's construction industry has reviewed the literature and related research. This covers the following topics:

2.1. Overview of Thailand's Construction Industry Business

Nopparat (2021) concluded that the overall construction industry in Thailand is important to the economy, business sector, and households. It is related to the supply chain of the business that the process consists of upstream, midstream, and downstream, such as the design, production, and distribution of construction materials, including financial institutions, etc. Although construction investment was affected by the stagnation of the real estate sector and the spread of COVID-19, it still grew by 2.2% with a value of 1.32 trillion baht in 2020 and a high proportion of GDP as high as 8.4 percent in 2021. Construction investment is likely to expand by 4.9 percent, accelerating in line with the recovery of the domestic economy. It has been assessed that the public sector construction remains the main target of contractors. This is due to a growth trend following the increase in capital expenditures in the fiscal year 2021, which encourages public construction investment to increase by 7.0 percent.

Relying on one side of a business may not be able to produce consistently good results, even with long experience because the work must be enhanced, whether it is marketing or production. Contractors should increase their potential to receive work in different areas, abroad or in the country. Additionally, the construction business is a business that impacts the environment. Therefore, it must be responsible for developing innovations in the business, especially innovations that are environmentally friendly and do not harm good health and safety, to make the organization acceptable to society (Mahattanalai, 2021).

2.2. Concept of Innovation Factor

At present, innovation and technology have become important in the construction industry. Construction tools and equipment have been invented and developed with the introduction of technology to help the construction industry grow rapidly. Tidd and Bessant (2020), Lee et al. (2019) divided innovations into 4 types (four dimensions of innovation space: 4P's):

1. *Product innovation:* Changing the products or services, an improvement to a commercial product, or a new product on the market. Product innovation can be divided into tangible and intangible products.

2. *Process innovation:* Changing the approach or method of producing goods or services in a different form, such as just-in-time production (JIT), Total Quality Management (TQM), and Lean Production, etc.

3. *Position innovation:* Changing the position of innovative products or services that have been in the market to be perceived as new. For example, corrugated roof tiles are viewed as obsolete, thus changing to a flat floor, which is repositioning to be in Lifestyle. of the new generation successfully.

4. *Paradigm innovation:* A complete new conceptual change in the original product or service. It used to be believed that the production of aerated bricks was so expensive that only the economically wealthy customers could afford it, but later, mass production allows them to have a reasonable or even lower price, resulting in customers of all income levels having access to the product, etc.

Additionally, Aujirapongpan et al. (2010) have defined innovation as something new that arises from the use of knowledge and creativity that are beneficial to the economy and society. Innovation is the process of combining knowledge and creativity with management capabilities to create innovative or new business, leading to new investments that result in enhancing the capacity of the country's competitors.

2.3. Review of Related Research

Noyraiphoom and Intrachooto (2017) studied the application of new materials in the construction of local buildings in the Nakhon Chaisri River Basin. This research focuses on the use of elastic cords from the textile industry in general building construction. The main factors that made the elastic cord accepted in the community were its flexibility and adapted by the farmers in a way that was compatible with their traditional way of life.

Ngamkamolrat et al. (2016) studied the reasons why innovations in construction in Thailand were not as successful as they should be. The construction innovation has continued to evolve in Thailand, and the cost factor for new innovations is an important factor in deciding whether to use them or not.

Othongkham et al. (2009) studied the use of cotton dust residues from the manufacturing process of textile factories as composite materials in gypsum boards, which added value and helped save the environment because gypsum mixed with cotton dust is lightweight, strong, standardized, and can reduce production costs. It is a new alternative in the construction industry and helps conserve the environment.

Noyraiphoom and Intrachooto (2017) studied the process of developing upcycled materials in the architecture and construction industries in Thailand has been recognized and commercialized. The received funds were supported by the entrepreneurs. Most of the funding from the government is for the early stages of development, and there is not much funding for the industrial production stage. The development of construction presentations with the AR and Revit program used to present and design of construction projects to show the work for customers to make decisions easier. The AR and Revit program can reduce the problem of errors in the presentation of various projects and help in reducing the budget (Khiawkaew et al., 2020). However, Utomo et al. (2021) recommended further improving the development of community-based entrepreneurship to affect the motivation of youth entrepreneurs to start up a business. This study offers

the government's strategy to increase the creation of new businesses, which may include the construction industry.

The concepts, theories, and related research that described above. Therefore, the conceptual framework for this research was formulated, as shown in Table 1.

Table 1. Research conceptual framework (Developed by the authors)

Independent Variables	Dependent Variables
Occupation	Product innovation
Types of construction work	Process innovation
Training	Position innovation
Work experience	Paradigm innovation
Professional field	

3. Methodology

This research is quantitative research using a survey. The target group included in the study was engineers working in the construction industry in Bangkok and its vicinity, Chonburi and Nakhon Ratchasima, which all together are the economic center of Thailand, emphasizing only engineers with majors related to the construction industry and having at least 1 year of work experience. Studies are used to organize the importance of research problems, formulate research objectives and hypotheses, develop research concepts, identify target populations, and sample size, create, and develop data acquisition tools, collect data from the sample group, analyze the data, summarize the research results, and discuss the findings, as shown in Figure 1.

Research process:
- Research problems
- Formulating research objectives and hypotheses
- Developing research concept
- Identifying target populations and sample size
- Creating and developing a data acquisition tool
- Collecting data from the sample group
- Analyzing the data,
- Summarizing the research results
- Discussing the findings

Figure 1. Research methodology

3.1. Research Sample

The determination of the number of samples to obtain a good representation of the target population was computed with 80 samples (Sharma, 2017). Using a questionnaire instrument that measured the factors ranging from the opinion level with the highest score of 7 to the lowest score of 1. The total duration of the study was 9 months, from August 2021 to April 2022. Nonprobability sampling using purposive sampling was used.

3.2. Research Tool

The research questionnaire was broken down into three sections:

(1) It contains demographic information on the target group, such as current work area, job title, work experience, professional engineering graduate degree, average monthly income, and number of innovation training sessions relevant to the profession.

(2) The questionnaire on the level of business innovation factors in the construction industry included product innovation, process innovation, position innovation, and paradigm innovation (Lee et al., 2019). This section had closed-ended questions with a checklist form.

(3) Additional suggestions in the form of an open-ended questionnaire that allow the sample group to express their opinions on the research subject independently.

The questionnaire was a robust tool with a validity of 0.67–1.00, which is higher than the standard 0.50 (the index of item objective congruence: IOC) (Sürücü & Maslakci, 2020) and has a reliability value by using Cronbach's alpha coefficient of 0.982, which is more than 0.70 (Büssing, 2017).

3.3. Research Data Collection

The study used 80 samples from a target group that volunteered to participate in the investigation. Additionally, this study gathered information related to the factors of innovation in the construction industry's business from secondary sources such as online articles, research reports, related academic articles, etc. Additionally, the primary data, collected with a questionnaire tool, were collected from 80 target engineers working in the construction industry.

3.4. Hypotheses

To achieve the goal, the following hypotheses were developed:

Null hypothesis (H0): Engineers with different occupation, types of construction work, training, work experience, and professional fields will not affect the factors of innovation in the construction business at the statistical significance level of 0.05.

Alternative hypothesis (Ha): Engineers with different occupations, types of construction work, training, work experience, and professional fields will affect the factors of innovation in the construction business at the statistical significance level of 0.05.

3.5. Statistical Analysis

The innovation factors for engineers in Thailand's construction industry were analyzed using descriptive statistics, including percentage, mean, and standard deviation. In the hypothesis testing, inferential statistics were analyzed using the variance from the F-value.

4. Results

The target groups were younger than 29 (48.8%), 30-44 (30%), and 45-59 (21.2%), male and female in the proportion of 88.8% and 11.2% respectively. Most of them graduated in civil engineering, 83.8%, followed by electrical engineering (3.8%), mechanical engineering (1.3%), and environmental engineering (1.3%). The occupation of private business 47.5%,

followed by government or state enterprises and business owners are 28.7% and 17.5%, respectively. Additionally, it was found that the target engineers were working in civil works (49%), followed by residential, public buildings, and industrial works at 26%, 14%, and 11%, respectively. Innovative training related to professional practice, it was found that most of them passed 1-2 training sessions, accounting for 65.0%. In terms of work experience, most of them had experience less than or equal to 5 years, representing 46.3%, followed by 6-10 years, and 16-20 years, representing 16.3% and 15%, respectively. The results of the analysis can be summarized as follows according to the research objectives:

4.1. The Results of the Analysis of the Construction Business Innovation Factor

Overall, it was found that the level of business innovation factors in the construction industry was moderate, with an average of 4.40. When considering the level of innovation factors in each aspect, it was found that the innovation paradigm had a rather high average of 4.65, whereas innovation on the product side, the average was 4.40. Additionally, repositioning innovation had a moderate average of 4.38. Moreover, the process innovation had a moderate average of 4.20.

The results of each innovation factor-level analysis revealed that the highest average product innovation was the organization has products that improve the strength of the construction industry with an average of 4.50. The process innovation with the highest average was that the organization has adopted modern technology to help the construction work, improving the efficiency of the construction work with an average of 4.59. In terms of innovation factors, the highest average repositioning was when an organization had a new product or service that was reasonably priced above its competitors, with an average of 4.44. Moreover, the innovation paradigm with the highest average was that organizations believed that building a business network in the construction industry would increase sales and profits, for example, by building a network between construction companies, building materials stores, and subcontractors, with an average of 4.75 (Table 2).

Table 2. Average level of innovation factors in the construction industry (Developed by the authors)

Product innovation	**Mean**	**Level of meaning**
- The organization offers products that enhance the strength of the construction industry.	4.50	Quite high
- The organization has a new product or service that is higher in technology compared to its competitors.	4.31	Moderate
- The organization always develops new products or services that are superior to competitors.	4.35	Moderate
- The organizations have new products or services that can be used in a wide variety of applications in the construction industry.	4.38	Moderate
- The organization invests in new technologies and innovations in construction.	4.43	Moderate
Total	4.40	Moderate
Process innovation	**Mean**	**Level of meaning**
- The organization has brought in modern technology to help in the construction process to improve the efficiency of the construction work.	4.59	Quite high
- The organization is adopting virtual reality simulation technology to reduce costs in the construction industry.	3.90	Moderate
- The organization has adopted Internet of Things (IoT) technology to track the use of construction resources better and more accurately.	4.43	Moderate
- The organization has applied Internet of Things (IoT) technology to sensors for machine maintenance work to reduce damage, such as using drones for on-site inspections.	4.05	Moderate
- The organization is using Internet of Things (IoT) technology to manage energy in the transmission of fuel data to keep machines running efficiently.	3.95	Moderate
- The organization uses Big Data to store numbers and complex data through the cloud and is a system that reports immediately.	4.30	Moderate
Total	4.20	Moderate
Position Innovation	**Mean**	**Level of meaning**
- The organization has new products or services in the existing customer market that can be used in conjunction with other products or machines supportively.	4.29	Moderate
- The organization has new products or services in the new target customer market.	4.31	Moderate
- The organization has various channels to reach target customers to sell new products or services.	4.33	Moderate
- The organization has new products or services that are reasonably priced above competitors.	4.43	Moderate
- The organization is constantly using new knowledge bases on products and services to create competitive opportunities.	4.38	Moderate
Total	4.34	Moderate
Paradigm Innovation	**Mean**	**Level of meaning**
- The organization has leaders at all levels, having a vision to analyze the changes occurring in the construction industry all the time.	4.66	Quite high
- The organization believes that building a business network in the construction industry will increase sales and profits, for example, building a network between construction companies, building materials stores, and subcontractors, etc.	4.75	Quite high
- The organization has a business plan to	4.53	Quite high

Product innovation	Mean	Level of meaning
- The organization offers products that enhance the strength of the construction industry. use in its operations to increase sales and profits.	4.50	Quite high
- The organization continually reviews its concepts and beliefs in managing business changes to seek competitive opportunities.	4.61	Quite high
Total	4.65	Quite high

4.2. The Results of the Analysis of the Engineers with Different Occupations, Types of Construction Work, Training, Work Experience, and Professional Fields Influenced the Construction Business Innovation Factor

The results of hypothesis testing of personal factors differing in occupation, types of construction work, training, work experience, and professional fields related to business in the construction industry did not have a statistically significant effect on product innovation, process innovation, position innovation, and paradigm innovation (Table 3). Therefore, the hypothesis was rejected as all individual factors were greater than the 0.05 level of significance.

Table 3. The results of hypothesis testing of personal factors differing in occupation, types of construction work, training, work experience, and professional fields related to business in the construction industry

Personal factors	F test	Sig.	Hypothesis results
Occupation	1.007	0.395	Reject
Types of construction work	1.653	0.184	Reject
Training	2.434	0.071	Reject
Work experience	0.918	0.458	Reject
Professional fields	0.365	0.833	Reject

5. Discussion

The results of each innovation factor-level analysis revealed that the highest average product innovation was the organization has products that improve the strength of the construction industry. This is consistent with the research by Othongkham et al. (2009), who studied the use of cotton dust as a composite material in gypsum board to be used as a product or as a building material that adds value and helps the environment. This gypsum mixed with cotton dust is lightweight, strong, and standardized, and reduces the production costs. It is also consistent with the research by Noyraiphoom and Intrachooto (2017) that applied a new material in construction products from the use of elastic cords from the textile industry in building construction and focused on solving problems by creating new technology to replace the old technology by using specialized expertise to be effective and meet the needs of the target customers.

Regarding the process innovation factors, it was found that Thai engineers believed the organization has adopted modern technology to assist in the construction process to improve the efficiency of the construction work. This is in line with research by Khiawkaew et al. (2020) that studies the development of presentations' process with virtual reality (AR) technology and Revit to make use of real construction presentations for customers to make informed decisions. Two groups of factors have made this new concept in marketing communication possible: market and technological (Bižić et al., 2021).

Regarding position innovation factors, it was found that Thai construction engineers saw that the organization has new products or services that are reasonably priced above competitors. The study results are consistent with research by Ngamkamolrat et al. (2016), who found that the price factor of innovations most influenced the decision to use or not to use that innovation to reach new market segments.

Paradigm innovation factors are averaged at a relatively high level, with the organization believing that building a construction industry business network will increase sales and profits, for example, by fostering networking between construction companies, material shops, construction, and subcontractors. Findings from Paradigm Innovation were consistent with research by Donkwa et al. (2021), which found that the company should have business partners to increase the number of customers, its revenue, and profit.

6. Conclusion

To increase business opportunities, it is necessary to develop new product innovations that enhance the strength of the construction industry. For example, the organization offers products that enhance the strength of the construction industry and invests in new technologies and innovations in construction. The construction industry business has brought in modern technology to help in the construction process to improve the efficiency of the construction work, such as the organization has adopted Internet of Things (IoT) technology to track the use of construction resources and uses drones for on-site inspections better and more accurately. The organization has new products or services that are reasonably priced above those of competitors, various channels to reach target customers to sell new products or services, and new products or services in the new target customer market. Therefore, the research results will be useful in seeking business opportunities in the construction business for further development into building a construction industry business network that would increase sales and profits and where the organization has leaders at all levels, having a vision to analyze the changes in the construction industry.

The findings also found that personal factors differing in occupation, types of construction work, training, work experience, and professional fields related to business in the construction industry did not have a statistically significant effect on product

innovation, process innovation, position innovation, and paradigm innovation. This study concludes that engineers prioritized the innovation as factors affecting construction industry performance. However, construction organizations must plan for employee training, experience building, and work plans to achieve better performance.

7. Further Study

To obtain a full analysis, the research will be undertaken qualitatively, using focus groups and in-depth interviews. Additionally, there should be an analysis of innovation factors that influence the sustainable performance of the construction industry business in terms of society, economy, and environment to apply the results of the analysis to be more comprehensively useful in the industrial business.

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Authors' Contributions

Professor, Dr. Suksun Horpibulsuk, an expert in civil engineering research and a consultant for educating private and governmental organizations, has published research papers in national and international journals. Assoc. Prof. Kwunkamol Donkwa has worked at Suranaree University of Technology for more than 20 years, cooperated in this study. The public's interest in the business innovation and aging societies is growing both domestically and internationally. Research papers have been published in both national and international publications. Ms. Nichakan Lunkhunthod has obtained a Master's degree in civil engineering and works as an officer of the civil engineering and construction management program at Suranaree University of Technology. This collaboration has a common interest in the issue of the opinions of engineers on the construction business innovation.

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