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An Evaluation of Offsite Construction Recoveries after the Pandemic: The Case of the Southeast Asian Region

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Abstract: Offsite construction (OSC) in Southeast Asia is facing many challenges due to the COVID-19 pandemic. Despite its importance, there is scant research on this topic in the region. This study aims to review OSC and identify determinants of success and their correlation with success after the pandemic in the Southeast Asian region. This paper follows a sequential exploratory mixed methodology: (1) reviewing statistical data relevant to construction in four countries, (2) carrying out a configurative literature review and documentary research, (3) eliciting responses from in-depth interviews consisting of two phases, (4) collecting written consultancies, and (5) capturing experts' opinions in four countries through a questionnaire survey. The study uses three statistical techniques to determine the correlations between factors: ordinal logistic regression with factors input, a generalized linear model with ordinal logistic response and covariates, and Spearman's correlations. Based on 55 variables and 459 responses from 4 countries, the statistical calculations identify the 42 most significant pairs of relationships between determinants and success, from which the follow-up priorities involve economic differentiation, productivity in the factory setting, reducing uncertainty over the program, and minimizing disturbances in the vicinity of the site under post-COVID-19 controls. This empirical research generates three outcomes: (1) filling the gap of OSC review in the region, (2) offering topical solutions for the construction industry after COVID-19, and (3) helping four countries derive economic benefits from OSC.

Keywords: COVID-19; pandemic recovery; offsite construction; Southeast Asia

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1. Introduction

The primary purpose of offsite construction (OSC) is to offset some of the construction works to better-controlled conditions and manufacturing premises. The authors of [1–3] reported that the key advantages of OSC are shorter construction times, better quality control achieved by factory-based advantages, enhanced economies of scale in production, better health and safety control, and reduced labor costs.

Prior to the COVID-19 pandemic, the governments of four South Asian countries implemented various initiatives to stimulate the use of OSC [4,5]. A driving force for such initiatives was the significance of construction for socioeconomic growth [6], as well as its direct impact on the growth of many other major economic sectors [7,8]. The construction industry provides considerable numbers of jobs and income sources to a nation [9]. However, construction productivity was badly hit by the COVID-19 pandemic due to social distancing, lockdowns, and many other restrictions imposed by various governments [10–16].

Thus, COVID-19 has created a sense of urgency for the construction industry to accelerate the use of OSC technologies and innovations in order to restore operations, improve productivity, and maintain long-term sustainability in this ever-changing and competitive global environment. In addition, OSC techniques were predominantly used as a means to achieve efficient construction of hospitals and isolation centers during COVID-19 emergencies. The authors of [16–18] highlighted how COVID-19 acted as a catalyst and accelerator for the adoption of OSC. Despite its importance, there is a shortage of reviews of this topic within Southeast Asia under the ravages of COVID-19. The relevance and originality of this research will benefit policymakers, construction firms, practitioners, and the general public in need of construction initiatives.

This empirical study aims to review OSC and identify determinants of success and their correlation with success after the pandemic in the Southeast Asian region. Three objectives were set to achieve this aim: (a) to provide a topical configurative review of OSC in four countries; (b) to identify potential determinants of the recovery process of OSC after the pandemic; and (c) to formulate a causal relationship model between those determinants. The research was based on an initial data collection and analysis that were conducted and completed in 2018 in Vietnam, discussing major factors that drive OSC [3]. During the pandemic (in 2021), the study was extended to three additional countries, with empirical data collected from four countries. This paper also incorporates sustainability, statutory regulations, and governance into the OSC causal relationship model. In addition, the study promotes community engagement and beneficial outcomes for stakeholders of the built environment.

2. Configurative Review

Configurative reviews adopt a systematic method to organize (configure) literature findings to find solutions to a pre-identified research problem [19]. This configurative review was conducted to evaluate the performance of the construction sector of each selected country in both the pre- and post-pandemic stages.

2.1. Construction Industry Performance in Vietnam, Indonesia, the Philippines, and Malaysia

Figure 1 depicts statistical details about the construction sector performance in Vietnam, Indonesia, the Philippines, and Malaysia.

The statistical data on the Indonesian construction industry presented in Figure 1 indicate that the contribution of construction to the Indonesian economy and the value of construction completed by construction companies were increasing every year. The bar graph in Figure 1 presents data about the total numbers of workers employed by the construction industry, in conjunction with the volume of house works completed by Perumnas—a state-owned enterprise in the form of a public company where the entirety of the shares are owned by the Indonesian government.

The construction sector is one of the main economic sectors in Malaysia. Thus, it needs to be strengthened to boost the country's economy. In 2019, the construction sector accounted for 5.1% (i.e., MYR 71.85 billion) of the country's gross domestic product (GDP) [20]. In terms of the value of construction works completed, the civil engineering subsector has dominated the industry since the fourth quarter of 2015, with a contribution of 40.7%, followed by non-residential buildings (28%), residential buildings (22.6%), and special trade activities (8.6%) [10]. Malaysia had 96,000 construction companies [4] that employed a total of 1.5 million people in 2019 [9]. Based on their tendering capacity, 77% of the companies are classified as small firms, and the rest are medium (11%) and large firms (12%). However, the Malaysian construction companies are overly dependent on low-skilled foreign workers, who make up around 90% of the workforce in the industry [21]. This has led to low productivity and a lack of quality assurance in the industry [22]. Similar to Indonesia and Malaysia, statistics on Vietnam and the Philippines indicate a steady growth of construction activities (Figure 1).

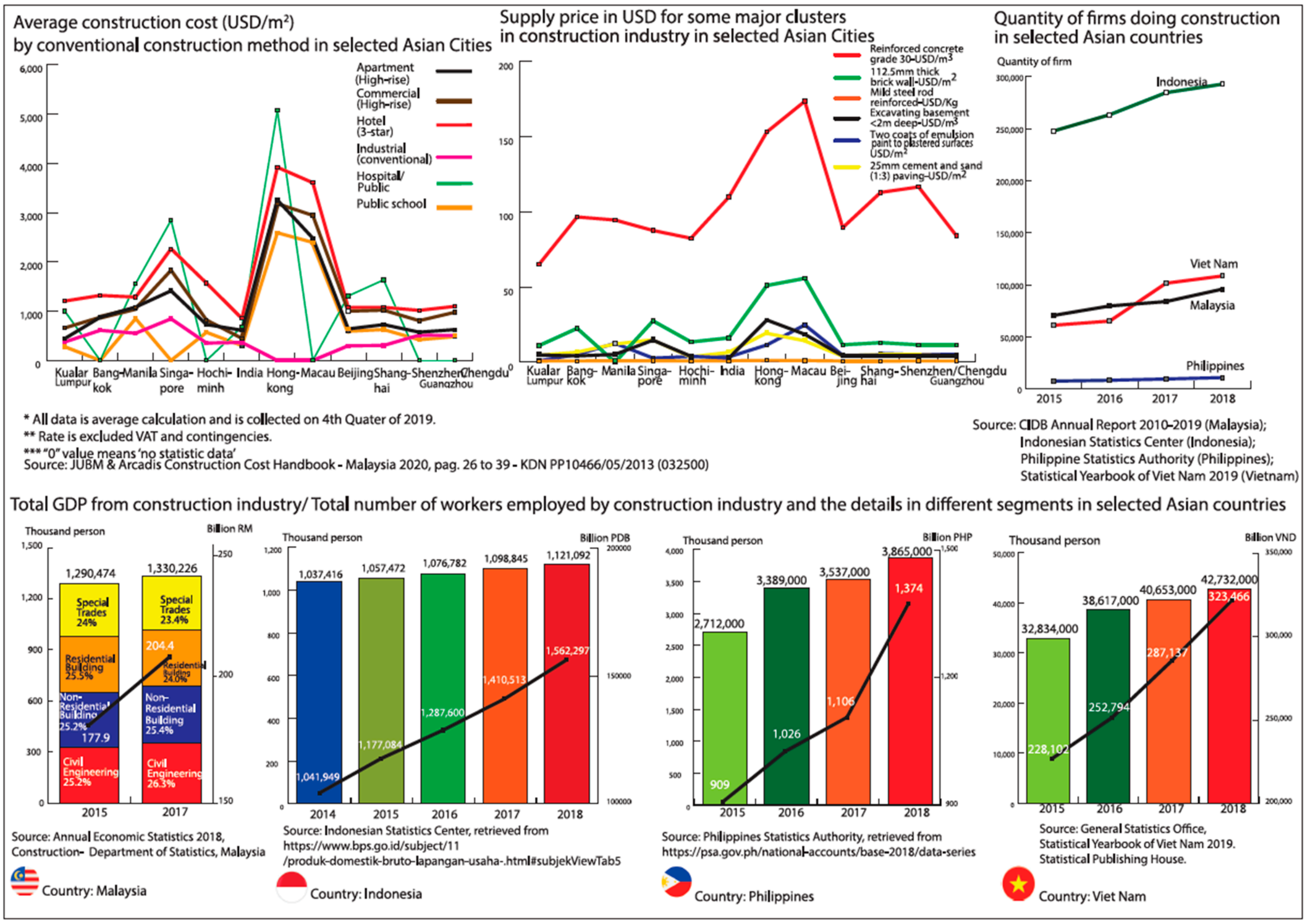

Figure 1. Statistical details relevant to construction in Vietnam, Indonesia, the Philippines, and Malaysia. Sources: [23–28].

This growth has been consistent for three years, from 2015 to 2018. This indicates how the construction industry contributes to the economic development of most countries and how it impacts their economic stability in a significant manner.

2.2. Global Outlook of Offsite Construction

Discussing the advantages of OSC, [29] organized a survey in the UK and revealed that the biggest advantages of OSC compared to traditional methods were decreased construction time on site, increased quality, more consistent products, reduced snagging and defects, and increased value. Researchers have found several disadvantages of OSC, such as limited synchronization between design technology and disciplines, poor production flexibility, and concurrent engineering [30]. Regarding barriers to modular construction, which is a component of OSC, [31] mentioned how the use of offsite manufacturing is not adequately understood by many stakeholders, as they tend to rely on anecdotal information rather than data-driven reasoning. Cognitive perception and bias also participate as barriers to OSC. Resistance to change and the negative image of offsite construction were identified as two emerging barriers in many recent surveys [29,32]. The authors of [29] organized surveys in the UK and identified the following perceived barriers hindering the increased use of OSC: (1) higher costs, (2) longer lead-in times, (3) client resistance, (4) lack of guidance and information, (5) increased risk, (6) few codes/standards available, and (7) negative image [3].

Compared to developed countries such as the UK, USA, Japan, Sweden, Germany, and Australia that promote the use of OSC, developing countries lag behind in the adoption of OSC [33]. However, OSC research in some developing countries is at an extensive level [34], with Malaysia promoting industrialized building systems (IBSs) [5] and China conducting research on precast concrete elements [35]. Researchers have found how developing countries face similar types of barriers to the adoption of OSC. Among these barriers, high fixed costs incurred at the beginning, inadequacy of government support, lack of skilled workers and contractors who can perform OSC, unawareness of OSC, and uncertainty of market demand were found to be the most prominent barriers in Bangladesh [36]. In addition to these barriers, the Chinese construction sector faces a high reliance on traditional construction methods as one of the key barriers to the adoption of OSC [35]. Similar issues are faced by the majority of developing nations, as the Industry-4.0-driven technological advancements that act as drivers for the adoption of OSC are yet to gain momentum in many parts of the world.

2.3. Offsite Construction in Four Countries with Respect to Pre-COVID-19 and Post-COVID-19 Responses

This section outlines how OSC occurred in four selected Asian countries (Vietnam, Indonesia, Malaysia, and the Philippines) in both the pre- and post-pandemic eras.

2.3.1. Vietnam

With the boost from the 2014 Housing Law, Vietnam's real estate market started to warm up which, in turn, supported the recovery of the residential construction sector. Construction costs in Vietnam are relatively low compared to most other Asian countries within the same categories [3]. The authors of [37] identified the most critical factors causing the failure of construction projects in Vietnam as (1) "disregard of the significance of project planning process", (2) "lack of experience in executing complicated project", (3) "poor design capacity and frequent design changes", (4) "lack of knowledge and ability in managing construction projects", and (5) "lack of financial capacity of owner."

Since 2019, the COVID-19 pandemic has had a serious impact on the construction industry in Vietnam. However, very few studies have reviewed the situation of OSC. According to the recent report of [11] on the status of the construction industry in the first nine-month period, the COVID-19 pandemic has had severe impacts on the growth of the industry in some provinces due to social distancing and lockdown policy. Consequently, construction project schedules and costs have been sabotaged by the pandemic, as many construction sites were shut down [11,13]. Recent strategies to cope with the pandemic have focused on easing the social distancing [11] and ensuring the health and safety constraints on construction sites [38]. However, the on-and-off periods of social distancing measures in response to the different levels of the COVID-19 situation require different solutions in the construction industry, and global construction company leaders and consultants agree that the application of OSC is a viable one [39]. Government encouragement of OSC can be found in long-term digitalization plans for the construction industry between 2020 and 2025, with the vision for 2030 set out by the Ministry of Construction. In this plan, the application of smart technology in the design phase and in the factory setting can benefit offsite modular construction [40].

2.3.2. Indonesia

Some of the latest types of projects in Indonesia using the prefabrication method include Light Rail Transit (LRT) Jakarta, Mass Rapid Transit (MRT) Jakarta, the Jakarta–Bandung High-Speed Railway, houses and apartments using precast concrete, toll road construction, etc. LRT Jakarta is a mass transportation system by train built in Jakarta, Indonesia. The LRT structure was planned with a floating structure using U-shaped girders [41]. The Mass Rapid Transit Jakarta project began with the construction of the $\pm$ 16-km Phase 1 MRT line from Lebak Bulus Terminal to the Hotel Indonesia Roundabout [42]. Some toll road construction includes the Krian–Legundi Bunder–Manyar highway using precast concrete [43,44] and the Jakarta–Cikampek II Elevated highway using Pierhead segmental precast concrete [45]. The construction of landed houses using precast concrete has a very short construction period (about 2 weeks), is efficient in the use of labor, and is of even better quality than using bricks [46].

The COVID-19 pandemic, which began in 2019, has had an impact on the economic, social, and construction sectors. According to [12], the impact on Ambon city project impeded such factors as project financing, regional restrictions, labor, materials and equipment, project uncertainty, and strikes. In addition to Ambon, the impact of COVID-19 on construction projects in Jakarta was also found, with the smart and sustainable built environment creating poor material quality and uncontrolled application of new technology [14]. In addition to big cities, Mojokerto Regency was also affected by the pandemic [15]. In addition, almost all works or projects funded by the State Revenue and Expenditure Budget and by the Regional Revenue and Expenditure Budgets have been cut and diverted to deal with COVID-19. The impact of COVID-19 has also affected construction workers. The government issued a regulation regarding large-scale social restrictions (PSBB), restricting construction workers from engaging in activities outside the home. This has had a significant impact on construction works, resulting in work delays. Based on the results of previous research, it is known that the impact of COVID-19 on construction work has caused 78.9% of construction projects to experience delays. The main reasons for these delays were limited funding and the implementation of large-scale social restrictions, accounting for 53.8% and 29.6% of the delays, respectively. In addition, the impact on personnel has meant that activities are limited (64.22%) and communication is not smooth (24.77%) [47].

2.3.3. Philippines

The Philippine economy considers the construction industry to be a key sector. It contributes a gross value added of about PHP 336 billion in the fourth quarter of 2020. However, the global COVID-19 pandemic has had a great impact on the lives of many Filipinos and their industries. The construction sector reported a significant contraction in 2020 due to the global COVID-19 pandemic because of nationwide disruptions. The total work stoppage from the time the enhanced community quarantine was declared has adversely affected not only workers who are mostly project-based—and, therefore, paid on a daily basis—but also contractors, the majority of whom (88%) are small and medium enterprises. The Philippine Domestic Construction Board is an implementing board of the Construction Industry Authority of the Philippines, mandated to formulate policies, plans, programs, and strategies for the development of the Philippine construction industry [48]. This implementing board drafted the "Construction Guidelines for Project Implementation during the period of Public Health Emergency" as a reference for contractors and agencies. These guidelines provide pointers for managing human resources at this critical time and give important directions to contractors for managing their business—not only for survival, but to be able to contribute to the country's economic recovery program.

Construction professionals in the Philippines expect to be using OSC as a trend in the future. OSC has been proven to provide cost, time, risk, and waste reductions, which also effectively improve safety, quality, and productivity. The assembly of prefabricated units has proven to be less prone to accidents as compared to onsite construction [49]. With effective management, prefabrication can lead to less expensive projects and more profits for the construction industry. One of the huge global construction projects conducted offsite [48] can be found in this country—the New Clark International Airport. The new terminal was completed in September 2020 and became operational in January 2021. It boasts facilities for over 12 million passengers across 700+ flights and 20 airlines. The modular design was chosen in part out of a desire to rely heavily on prefabrication [50].

2.3.4. Malaysia

In Malaysia, the government has stimulated industrialized building systems (IBSs) through government projects [5] and has established IBS legislation and codes [49]. High initial capital investment and lack of technical expertise are among the obstacles to IBSs in Malaysia [51]. Considering the benefits of IBSs and the government's aim to reduce the dependence on foreign workers to 15% by 2020 [21], the Construction Industry Development Board (CIDB) planned to accelerate the adoption of IBSs. To do so, the CIDB not only set up the appropriate ecosystem but also made the utilization of IBSs mandatory by amending the prevailing Uniform Building By-Law (UBBL) of 1984 [52]. Under this plan, it had been mandatory for government projects to use IBSs since 2008. However, the outcome of the adoption of IBSs was not encouraging, as 75% of construction projects were overseen by the private sector and utilized traditional methods. Thus, the mandate was extended to private construction projects in 2018. Particularly for projects worth MYR 50 million or more, they were required to achieve a minimum IBS score of 50. Despite this requirement, some companies did not comply with the proper IBS standards (Syed Jaafar, 2018). In view of this, the CIDB has introduced the IMPACT program, which aims to verify, validate, test, and certify the quality of the products and components of IBS manufacturers in the country to meet the specified requirements and boost public confidence [53]. Currently, the private projects' adoption rate only stands at 35%, and the target is to reach 50% by 2020 [54].

In order to curb the COVID-19 outbreak, the Malaysian government implemented the first nationwide movement control order (MCO) on 18 March 2020. Depending on the number of new COVID-19 cases reported daily, the movement control order would either be enhanced or relaxed in specific districts and/or states. This has impacted many industries, including the construction industry. This order has imposed restrictions on the operations of construction projects, such as stop-work orders or stringent standard operating procedures in terms of health and safety measures to be incorporated on the construction sites. In 2020, the country's GDP contracted by 5.6%, while construction was still the most affected industry, with its performance deteriorating by 19.6% [10] and its workforce shrinking to 1.4 million [9]. Due to the effects of COVID-19 and the disruption of the Fourth Industrial Revolution, it is no longer an option but a necessity for the players in the construction industry to fully adopt IBSs and embrace technological advancements to reduce costs and remain competitive in the international arena.

3. Materials and Methods

This section explains the research methodology used in this study, which includes several research methods.

3.1. Sequential Exploratory Mixed Methodology and Triangulation

Previous researchers have mentioned how qualitative approaches can begin by exploring key issues with a high degree of richness, before testing them with more structured questionnaires [55–57]. Within the context of OSC, similar steps were undertaken by [29], from a literature review to a qualitative survey of six organizations, and then to a quantitative questionnaire survey of 75 UK organizations. A similar approach was adopted in this study, starting with a qualitative approach, and then moving to a quantitative one, following the sequential exploratory mixed methodology. The authors of [58] stated how the combination of two methods can be integrated during the interpretation phase of the study, which is an advantage of sequential exploratory studies. The term "triangulation" refers to the practice of using multiple sources of data and/or multiple approaches to enhance the research's credibility [59]. This study applied triangulation with multiple research strategies under two phases: (a) a configurative literature review and documentary research; (b) qualitative in-depth interviews and focus groups; (c) written consultancies; and (d) a structured questionnaire survey for quantitative analysis (phase II only). This paper combines multiple quantitative techniques: Spearman's correlation coefficients, generalized linear models with ordinal logistic responses and covariates, and ordinal logistic regression with factors input. Justifications for using these quantitative techniques, along with citations, are provided in Sections 3.5 and 4.

Figure 2 summarizes the research methods and techniques that were applied for data collection.

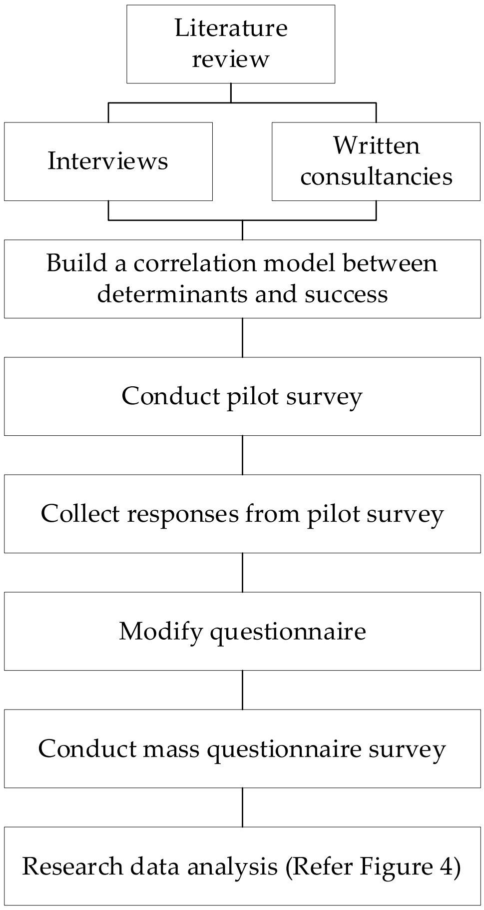

Figure 2. Methodology for data collection.

3.2. Expert Interviews and Written Consultancies

According to [60], to identify success factors, the best technique for collecting data relies on interviewing key personnel, where "interviews should be conducted one-on-one, using already developed open-ended questions" or semi-structured interviews following a laddering procedure.

Following an initial study to determine barriers to OSC in Vietnam [3], in 2021 the authors extended the study to Southeast Asia and adapted the research to the COVID-19 context. Additional literature reviews and documentary research were conducted in 2021. Moreover, in August 2021, eight expert interviews were conducted in Indonesia for this purpose. The interviews solicited the most updated viewpoints towards OSC in the context of the COVID-19 era. Interviewees included an officer from the Ministry of Public Works, contractors, and developers. Generative questions explored the types of offsite jobs, average construction costs, the balance between traditional and offsite patterns, and the general opinion of the informants. Furthermore, four written consultancies were collected in Vietnam in August 2021, which reinforced the understanding of the drivers of OSC in Southeast Asia after the pandemic. Purposive sampling was adopted, and saturation was applied to the point at which the data became repetitive; no major new insights were gained. Previous research has recognized data saturation as the recommended reason for completing qualitative data collection [16,58]. During the interviews, the interview transcripts were recorded in shorthand.

Finally, barriers and potential success factors identified by the aforementioned research between 2018 and 2021 were elaborated to form inputs, and then they were exported to two questionnaires for subsequent quantitative analyses. The ultimate goal of these analyses was to formulate a correlation model between determinants and OSC success in the post-pandemic future. Thematic and template analyses were applied before exporting the information to these questionnaires.

3.3. Questionnaires and Surveys

The two questionnaires conducted in this research are antecedents of OSC success models in the regional and post-COVID-19 context. These two questionnaires included a pilot test and a mass questionnaire. The questionnaires were developed in three steps: first questionnaire; pilot test; final questionnaire. The questions were derived from five sources: (1) a literature review of OSC [3], (2) expert interview findings in 2018 [3], (3) configurative review and documentary research in 2021, (4) in-depth interviews in 2021, and (5) written consultancies in 2021.

Before conducting the final questionnaire, the first questionnaire was sent as a pilot test. The purposes of this pilot test were as follows: (a) to validate the enriched viewpoints from cross-country experts, (b) to synchronize the comparative applicability and consistency of success factors over time, (c) to amend any exhaustive factors that might have been overlooked from the five aforementioned sources, and (d) to validate one uniform questionnaire suitable for four Southeast Asian countries. The pilot test sample included academics and professionals in Vietnam, Indonesia, Malaysia, and the Philippines. The authors implemented a pilot test and collected 18 responses along with 75 comments from the pilot test participants. In general, 80% of responses agreed that all questions in the pilot test would be very appropriate as inputs for real survey questionnaires.

The writers conducted mass surveys to gather 497 responses. Out of these, 459 responses were finalized as valid responses. These mass surveys were organized in Vietnam, Indonesia, Malaysia, and the Philippines. Among the contributors to the mass survey, there were two significant categories from the occupation information field: graduate construction students (accounting for 26%) and lecturers (accounting for 14%). As for the respondents' age, more than 80% of them belonged to the 20–49 years age category. Out of the total replies, Vietnamese, Indonesians, and Filipinos made up the majority.

Details and evidence of the pilot test and mass survey records are presented in Figure 3.

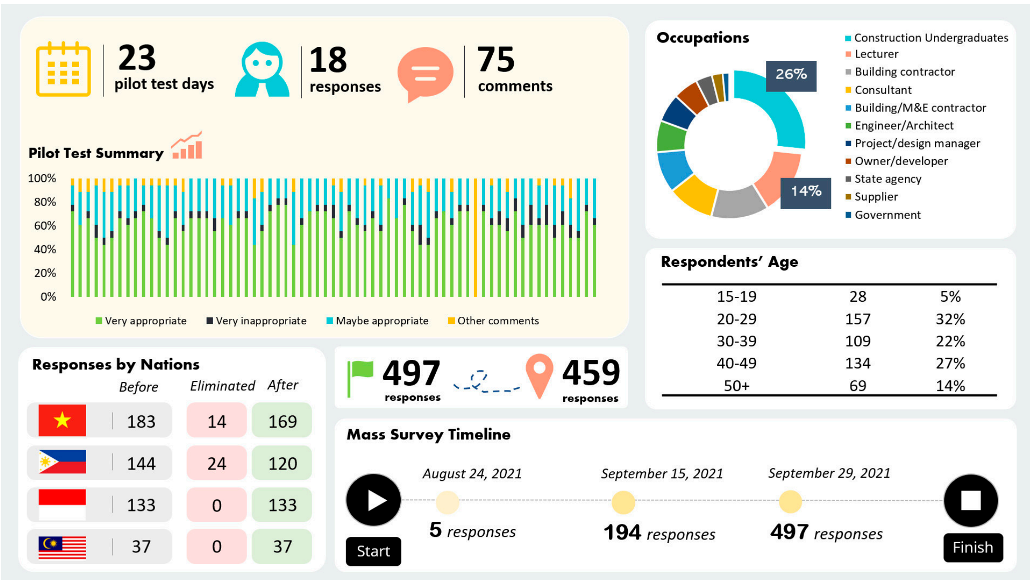

Figure 3. Pilot test and mass survey records.

The mass questionnaire survey data collection was initiated on 24 August 2021, and up to 194 responses were received within three weeks' time on 15 September 2021. Data collection was concluded on 29 September 2021 once 497 responses had been received. The final questionnaire included 55 questions in connection with 55 variables. A full description of all of the variables and codes is provided in Appendix A.

3.4. Quantitative Data Collection

3.4.1. Sample Size

The probability sample size depends on two factors: the population's standard deviation, and the level of confidence desired in the estimate [61]. Therefore, Formula (1), which includes these factors, was utilized to establish the sample size. Calculation of the sample size "*n*" followed the formula introduced by [61].

$$n = \left(Z^2_{B,CL}\right) \cdot \left(\frac{\Sigma^2}{e^2}\right) \tag{1}$$

where:

$Z_{B,CL}$ = the z-value associated with the level of confidence;

σ = the estimate of the population's standard deviation based on similar historical information;

e = the acceptable tolerance level of error (stated in percentage points).

Based on the authors' previous experience, with estimated values of σ = 1.05 (on a 5-point Likert scale), e = 0.1, and z = 1.96 (95% confidence), a round figure of "*n*" would be 450, which is smaller than the actual number of records received (497).

$$n = 1.96^2 \frac{1.05^2}{0.1^2} = 425$$

Sample sizes can also be determined by the number of questions on a questionnaire; for example, a typical rule of thumb is five respondents for each question asked [61]. For this study, using 55 questions, the minimum sample size would therefore be 55 × 5 = 275. This research exceeded the minimum number by obtaining 459 valid responses.

3.4.2. Sampling

Key variables of this study were rated on a 5-point Likert-style ordinal scale—where "1" = "completely disagree", "2" = "disagree", "3" = "neither agree nor disagree", "4" = "agree", and "5" = "completely agree"—translated into 55 multilingual rating questions. The self-completed questionnaire was designed to collect quantitative data from the target respondents. Social media channels and emails were used to distribute the survey via Google Forms. Country-specific survey links were created to gather data from the four countries. Out of the 497 responses received, 459 entries were usable after screening and cleaning for inadequacies. This was higher than the required sample size of 450.

3.5. Data Analysis Methods

The data analysis involved the use of several analytical techniques, and this process is presented in Figure 4. We combined multiple statistical techniques before drawing conclusions on the correlations between predictors and OSC success after the pandemic. As specified by [62], the findings were also subjected to validation and reliability tests. With the aim of identifying relationships rather than plunging into theoretical statistics, each of these methods is briefly summarized below, while Appendix B presents the validation results.

3.5.1. First Route: Ordinal Logistic Regression with Factors Input

We used ordinal logistic regression (OLR) as the first route to determine the associations between variables. The log-odds (or logit) of the outcome were modelled as linear in the regression parameters. The proportional odds model is the usual (or default) form of ordinal logistic regression provided by statistical software. The authors of [63] wrote that the proportional odds model is based on the assumption that the effects of the covariates $x_1,\ldots,x_{p-1}$ are the same for all categories on the logarithmic scale, presented as follows:

$$\log \frac{\pi_1 + \cdots + \pi_j}{\pi_{j+1} + \cdots + \pi_J} = \beta_{0j} + \beta_1 x_1 + \cdots + \beta_{p-1} x_{p-1} \tag{2}$$

On the log-odds scale, the probabilities for categories are represented by parallel lines. The odds ratio associated with a one-unit increase in an explanatory variable x_k is $\exp(\beta_k)$, where k = 1,..., p − 1. The coefficients for predictors in logistic regression analysis include (a) the Bl coefficient, indicating the linear increase in the logit for a one-unit increase in the predictor; and (b) the coefficients for the predictors, presented as odds ratios. The odds ratio can reveal the amount by which the odds of being in the case group are multiplied when the predictor is increased by a value of one unit [64]. Using SPSS software, we applied ordinal logistic regression with factors input and repeatedly checked the model fitting, goodness of fit, test of parallel lines, and parameter estimates against constraints.

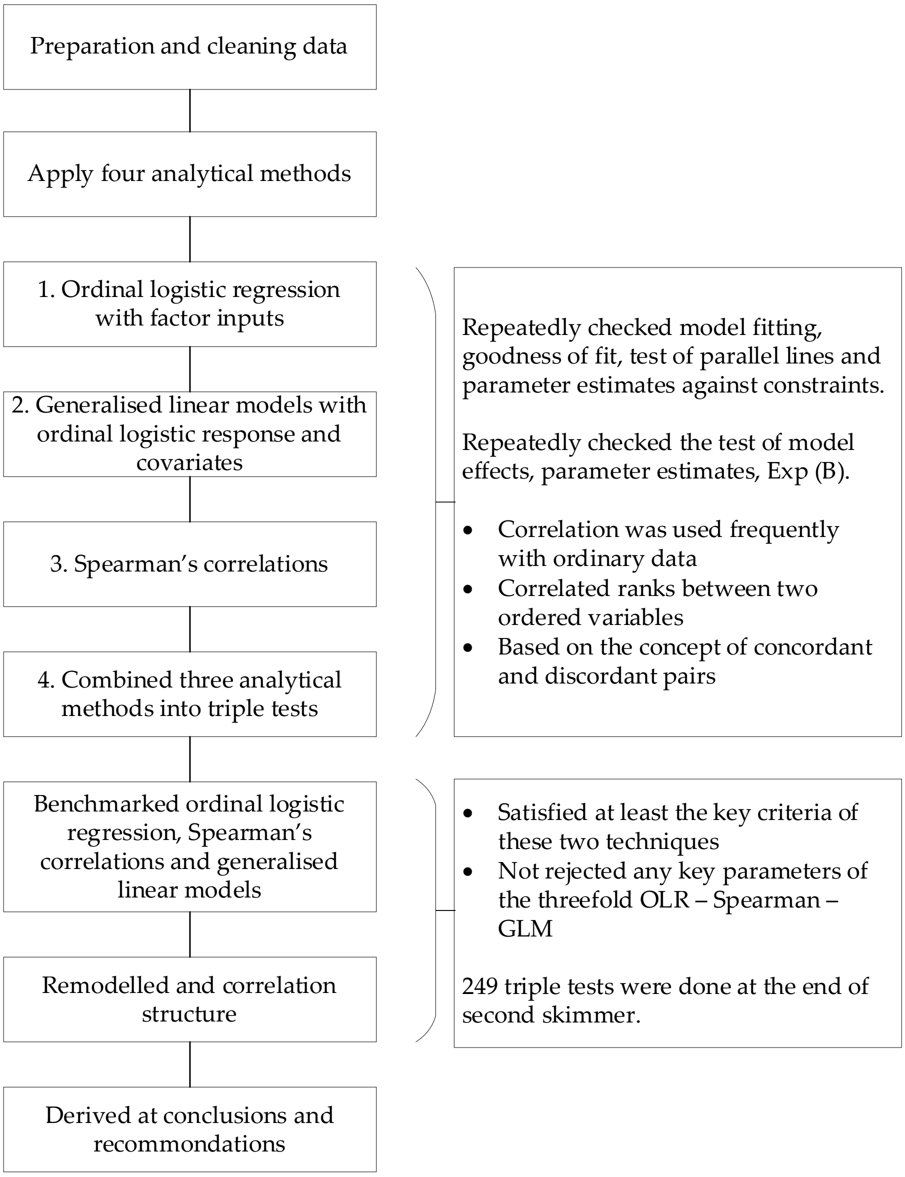

Figure 4. Methodology for data analysis.

3.5.2. Second Route: Generalized Linear Models with Ordinal Logistic Response and Covariates

Generalized linear models (GLMs) are a natural generalization of the classical linear model, using maximum likelihood methods to estimate the model parameters [65]. This allows the use of data for which the mean of the dependent variable is a nonlinear function of the regression parameters and the response variable is not normally distributed [66]. Given the mean response E(Y) and g(μ) as a function of the mean response, a GLM with "p" independent variables can be expressed as g(μ) equals β_0 plus the sum of the "p" independent variables times their beta coefficients [65].

$$g(\mu) = \beta_0 + \sum_{h=1}^{p} \beta_h X_h \quad (3)$$

3.5.3. Third Route: Spearman's Correlations

Spearman's rho ® correlation is frequently used with ordinal data, correlating ranks between two ordered variables based on the concept of concordant and discordant pairs. It does not require the assumption of a bivariate normal distribution, yet by incorporating order, most variables produce a range from −1.0 (a perfect negative relationship) to +1.0 (a perfect positive one). As a special form of Pearson's product-moment correlation, the strengths of which outweigh its weaknesses [57], for this study, Spearman's correlations between all 55 ordinal variables were calculated.

4. Results and Discussion

This section explains the results that were generated from this research, including statistical model outputs and the correlation model between determinants and OSC success.

4.1. Benchmarking Ordinal Logistic Regression, Spearman's Correlations, and Generalized Linear Models

This study used multiple statistical techniques to identify the relationships between predictors and latent success factors of OSC after the pandemic. Spearman's correlation was the first gate filter. A total of 1540 Spearman's correlation tests were calculated. Satisfactory outputs from the first gate filter were then moved to the second "skimmer" using the OLR and GLM techniques. To conclude the correlations, successful pairs of variables must have additionally (a) satisfied at least the key criteria of OLR and GLM, and (b) not rejected any of the key parameters of the threefold OLR–Spearman–GLM. A total of 249 triple tests were conducted at the second "skimmer".

4.2. Correlation Model between Determinants and OSC Success

From the 249 triple tests, 42 pairs (determinants and targets) were identified as satisfying all three tests (OLR, GLM, and Spearman's). These 42 pairs were also the final results of the study. Figure 5 interprets these 42 correlations between determinants and targets for OSC success in the four countries after the pandemic. This model is a new theory generated by the authors of this paper, developed from their own empirical study, without any reference to any other models.

Figure 5 depicts a network of nodes and arrows. Each node represents a variable, and each arrow delineates dependency/correlation between two nodes. There are two types of nodes: target, and determinant (DETERM). Targets are dependent variables that represent the success of OSC after the pandemic. Determinants are independent variables/predictors that will lead to OSC success. Depending on common attributes of certain determinants and their statistical significance, these determinants are grouped into three batches: DETERM 1, 2, or 3. Both the target and determinant groups come from the final questionnaire. Each arrow (in Figure 5) starts from an independent variable (determinant) and points to a dependent variable (target) with which it has a significant relationship. To avoid too many arrows in the figure, dots are plotted at the intersection of two itineraries. Every time a dot is placed, it means that two itineraries/arrows share the same path and will converge to the same destination (i.e., target/dependent variable).

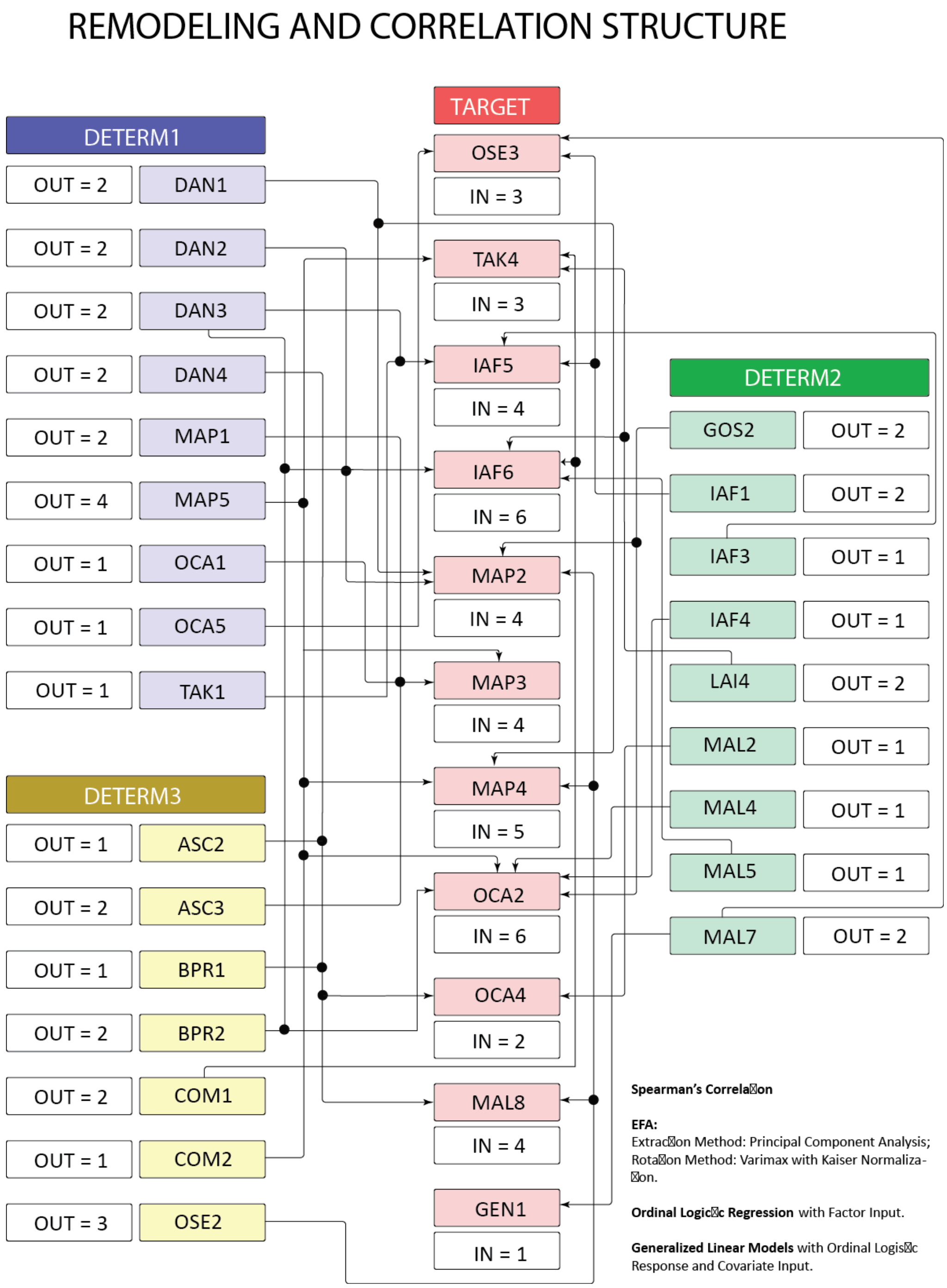

Figure 5. Correlation model between determinants and OSC success in Southeast Asia after the pandemic.

In brief, there are 42 determinants of success (most significant) in Figure 5. The detailed forms of these determinants are onsite construction/assembly (OCA), manpower and labor (MAL), investment and finance (IAF), manufacturing and productivity factors (MAP), logistics and infrastructure (LAI), competitiveness (COM), technology and knowledge (TAK), design and norms (DAN), bias and psychological retrofit (BPR), government strategies (GOS), other socioeconomic factors (OSE), and association (ASC). Appendix A presents a full list of variables and codes, including determinants and targets.

For better understanding, these 42 most significant correlations are also presented hereafter in a tabular format. Table 1 denotes the full descriptions of all 42 correlations, together with relevant statistical parameters.

Table 1. Significant correlations between predictors and OSC success after the pandemic.

Target	Original Variance	Determinant	Generalized Linear Model B	EXP(B)	Conclusion
TAR1	OSE3	OCA5	0.468	1.597	Prefabrication can be successfully applied at rural sites in the post-pandemic future in support of offsite inspection, control, and rectification.
		MAL7	0.457	1.580	Healthier and safer conditions in the workplace will promote prefabrication at rural sites after COVID-19.
		IAF1	0.269	1.309	More incentives should be offered to modular construction investors in relation to prefabrication at rural sites in the post-pandemic era.
TAR2	TAK4	MAP5	0.377	1.457	Embedded energy reduction brought about by using simpler processes is a sustainable pathway of OSC after the pandemic.
		LAI4	0.395	1.484	The factory needs to be in a strategic location with proximity to the site to provide a sustainable prefabrication advantage after COVID-19.
		COM1	0.344	1.411	Low operational costs are a pathway to the success of smart and sustainable construction in the post-pandemic era.
TAR3	IAF5	TAK1	0.534	1.706	The application of technology (IT, prefabrication, offsite assembly, etc.) is a catalyst for earlier income generation from OSC after the pandemic.
		DAN3	0.412	1.509	Time-saving in the design phase is a factor for earlier income generation from OSC in the post-pandemic future.
		IAF1	0.689	1.992	There is a correlation between additional incentives to investors in OSC and earlier income generation from prefabrication after the disaster.
		IAF3	0.373	1.452	Earlier income generation from prefabrication after the pandemic can be obtained from non-direct costs and non-cost items (e.g., health and safety, project/product consistency, etc.)
TAR4	IAF6	DAN2	0.468	1.597	Design competition reduces monotony in designs and supports higher return on investments in OSC in the post-pandemic future.
		DAN3	0.687	1.987	Design time-saving is a success factor of OSC in the context of higher return on investment after COVID-19.
		MAL5	0.427	1.532	There is a correlation between OSC content in high school education and higher return on investment in the post-pandemic era.
		LAI4	0.300	1.350	Strategic location of factories with proximity to sites would drive higher return on investments in prefabrication after the pandemic.
		COM1	0.359	1.431	Low operational costs are a pathway to higher return on investments in OSC in the post-pandemic future.
		BPR2	0.389	1.475	Advertising/awareness and demonstrations to change conservative mindsets against modular construction are pathways to higher return on investments in OSC after the pandemic.
TAR5	MAP2	DAN2	0.581	1.788	Design competition reduces monotony in designs, increases the economies of scale, and increases the manufacturing capacity of OSC after the pandemic.
		DAN1	−0.485	0.616	Enrichment of architectural designs will support OSC economies of scale and manufacturing capacity after COVID-19.
		GOS2	0.436	1.546	Indirect incentives should be offered to OSC communities in order to build economies of scale and manufacturing capacities in response to disasters.
		OSE2	0.562	1.495	Minimizing disturbances in the vicinity of the site is a pathway to improving economies of scale and manufacturing capacities after the pandemic.
TAR6	MAP3	MAP1	0.824	2.279	Controlling the factory environment promotes OSC productivity, accelerates the speed of product delivery, reduces the time spent on commissioning, reduces uncertainty over the program, and reduces management time in the post-pandemic context.
		MAP5	1.027	2.791	Embedded energy reduction brought about by using simpler processes is a success factor of modular construction thanks to speed/time advantages and the avoidance of uncertainty.
		OCA1	0.379	1.461	Overlapping off- and onsite activities is a positive aspect of prefabrication due to speed/time advantages and the avoidance of uncertainty in the post-COVID-19 era.
		ASC3	0.813	2.255	Stakeholders' engagement should be clarified at an early stage and from the high level of the structure for the sake of OSC speed/time advantages and the avoidance of uncertainty after the pandemic.
TAR7	MAP4	MAP5	0.684	1.981	Embedded energy reduction, reductions in actual labor hours, and productivity in the factory setting would promote the success of prefabrication in the post-pandemic period.
		DAN1	−0.414	0.661	Enrichment of architectural designs together with reductions in actual labor hours and increased productivity in the factory setting would contribute to the success of OSC after the pandemic.
		OSE2	0.572	1.771	Minimizing disturbances in the vicinity of the site, together with reductions in actual labor hours and increased productivity in the factory setting, would be contributors to the success of modular construction after the pandemic.
		COM2	0.549	1.731	The smart functionality of OSC (compared to traditional approach) is a catalyst for reducing actual labor hours and increasing productivity in the factory setting after COVID-19.
		ASC3	0.385	1.469	Stakeholders' engagement should be clarified at an early stage and from the high level of the structure in order to reduce labor hours and increase productivity in the offsite factory setting

Table 1. *Cont.*

Target	Original Variance	Determinant	Generalized Linear Model B	EXP(B)	Conclusion
TAR8	OCA2	MAP1	0.390	1.477	Offsetting difficult works to better-controlled factory environments and achieving less site disruption would enhance the productivity of OSC after COVID-19.
		MAP5	0.334	1.397	Removing difficult operations from the site and reducing the embedded energy use by using simpler processes would be advantages of OSC after the pandemic.
		GOS2	0.419	1.520	Achieving less site disruption and providing indirect incentives to OSC communities would be advantages of prefabrication in the post-COVID-19 era.
		MAL4	0.592	1.807	Training for assembly and operation/maintenance of machines and removing difficult operations from the site would be determinants of the success of modular construction in the post-pandemic future.
		IAF4	0.610	1.841	Achieving less site disruption in conjunction with reducing the project time would improve the overall cost efficiency to OSC clients
		BPR2	0.555	1.742	Purposive advertising/awareness and demonstrations to change conservative mindsets in support of achieving less site disruption would be contribute to the success of prefabrication after COVID-19.
TAR9	OCA4	DAN4	0.442	1.556	Amendment of design standards, regulations, evaluation criteria, calibration, and rates in conjunction with health, safety, and working protection would be drivers of the success of OSC after the pandemic.
		MAL2	0.506	1.658	Planning for the availability of skilled manpower after the COVID-19 pandemic should be emphasized in parallel with health and safety protection.
TAR10	MAL8	DAN4	0.417	1.517	Amendment of design standards, regulations, and evaluation criteria, with special consideration of labor dynamics, would be drivers of the success of modular construction after the pandemic.
		ASC2	0.551	1.736	To succeed after COVID-19, OSC communities should focus on labor dynamics to promote trust among tenants and developers.
		BPR1	0.434	1.543	OSC stakeholders should eliminate inappropriate prevailing customs and traditions and adjust to the labor market.
		OSE2	0.510	1.666	There is a correlation between minimizing disturbance in the vicinity of the site and OSC skilled labor movement in the post-COVID-19 era.
TAR11	GEN1	MAL7	−0.437	0.646	Healthier and safer conditions in the workplace will be a success factor of OSC after COVID-19.

The findings of this paper also include follow-up priorities to help OSC to recover from the pandemic. The follow-up priorities are a subset of the 42 abovementioned correlations. These priorities were identified from highest accumulated IN/OUT indices and coincidences of correlations shown in Figure 5. The authors recommend priorities involving the following actions: (a) building economies of scale and adapting manufacturing capacity to safety conditions; (b) generating economic differentiation from higher returns on investment compared to conventional construction approaches; (c) offering differentiation by earlier income generation; (d) promoting uniqueness by reducing the embedded energy use by using simpler processes; (e) targeting labor reductions after the pandemic and increased productivity in the factory setting; (f) accelerating the speed of product delivery and reducing uncertainty over the program; and (g) minimizing disturbances in the vicinity of the site under post-COVID-19 control.

In a scientometric review, [67] mentioned that prefabricated construction can reduce energy consumption, construction waste, material waste, and carbon emissions. Similar conclusions can be drawn from this study of offsite construction in Southeast Asian countries, where sustainability, statutory regulations, and governance were incorporated into the offsite construction relationship model. In addition, the authors compared their findings with those of [68]. Both papers had similar topical findings in 2022, including the following:

(a) Reductions in man-hours when work is performed offsite.
(b) Increased productivity due to the more controlled environment (the factory)—described by the correlations between MAP5/DAN1 and TAR7 in this study in the Southeast Asian context.
(c) Increased workforce health and safety—described by the correlations between DAN4 and TAR9 or between GEN1 and TAR11.

The COVID-19 pandemic has forced most industrial sectors into one of the most challenging times they have ever experienced. As the governments of the four Southeast Asian countries considered in this study have introduced lockdowns and other restrictions at varying degrees and levels of intensity to curb the outbreak of COVID-19, the GDP of their construction industries has plummeted. However, the costs and benefits to national construction industries may differ from those for the national economy. Issues such as intra-industry diffusion of technologies and knowledge require further investigation through future research. Despite the hurdles faced by the construction industry in Southeast Asian countries, attempts are visible that help to recover resilience and continuity from the economic impacts of COVID-19. Therefore, for more efficient and responsive strategies, it is critical for construction organizations to adapt to the crisis and accelerate the adoption of OSC in completing their projects in the new normal, so as to remain vital in future.

5. Conclusions

To fill the current literature gap and to recommend solutions for OSC in Southeast Asia after the COVID-19 pandemic—a matter of high urgency and topicality—this paper follows a sequential exploratory mixed methodology focusing on four Southeast Asian countries: Vietnam, Indonesia, the Philippines, and Malaysia. This study adopts triangulation consisting of multiple sources of data and multiple approaches to analyzing data. The sources of data include (1) a literature review of OSC conducted in 2018, (2) eight expert interviews conducted in 2018, (3) configurative review and documentary research conducted in 2021, (4) in-depth interviews conducted in 2021, (5) written consultancies completed in 2021, and (6) 459 responses to a questionnaire survey conducted in four Southeast Asian countries in 2021. "Triangulated" multiple analytical approaches were used to filter and skim the ordinal-scale results before drawing conclusions.

The rigorous screening processes used in this research identified 42 correlations between "targets" and "determinants" (Figure 5 and Table 1). Targets are latent variables representing the ultimate success of OSC after the pandemic. Targets were selected from the writers' experiences and experts' opinions in four countries. Determinants are antecedent success factors. Both target and determinant groups were derived from the final questionnaire.

Apart from these 42 correlations, this study also recommends follow-up priorities as a subset of those 42 significant correlations. Recommendations for policymakers include the following potential regulatory actions: (i) additional design standards, regulations and codes, evaluation criteria, calibration, and rates should be amended with consideration of health and safety; (ii) more incentives should be offered to rural sites and to domestic/foreign firms investing in OSC; (iii) governments should provide indirect incentives for OSC communities to develop modular construction; (iv) a labor skills shortage may arise after the pandemic, so policies should foster labor dynamics and availability with consideration of onsite/offsite protection.

The main strength of this study is the incorporation of sustainability, statutory regulations, and governance into the OSC relationship model. It also promotes community engagement and beneficial outcomes for stakeholders of the construction environment and the built business. This study provides an evaluation of Southeast Asia through four countries. The fact that we did not conduct a cross-country evaluation using pre- and post-COVID-19 longitudinal data can be identified as a potential limitation of this research. Since this study covers only four Southeast Asian countries, there is a need for further studies to represent other parts of the continent or developing countries as a whole.

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Appendix A

Full list of variables and codes.

Variables	Codes	Questions/Issues
General (GEN)	GEN1	Advantages of offsite construction outweigh their drawbacks.
	GEN2	Modular construction is facing serious challenges (both objective and subjective).
	GEN3	What are the most serious difficulties that offsite construction is dealing with? ☐ Regulations and Codes ☐ Technology and Knowledge ☐ Investment and Finance ☐ Manpower and Labor ☐ Stakeholders ☐ Infrastructure and Logistics ☐ Other
	GEN4	What types of prefabricated assemblies would fit best to the national construction sector? Select and rank the followings. (1: most suitable—7: least suitable) ☐ Precast concrete structure ☐ Steel assemblies ☐ HVAC plumbing and electrical fittings ☐ Curtain walls/exterior walls ☐ Permanent volume modules (volumetric construction) ☐ Solid timber structures ☐ Shoring and beams
	GEN5	Should reduce disruption and synchronise the OSC system life cycle, i.e., land acquisition, equipment/machinery import, design and prefabrication, dis-assembling/re-assembling components, mobilization
	GEN6	What market sectors (building types) are most suitable for modular construction? Please rank the following items: (1: most suitable—9: least suitable) ☐ Infrastructure ☐ Housing ☐ Public Non-residential ☐ Private Industrial ☐ Private Commercial ☐ Repair and Maintenance Building ☐ Warehouse and Logistics ☐ Military ☐ Education and Healthcare
Technology and Knowledge (TAK)	TAK1	Technology (in the sense of IT, prefabrication, and off-site assembly) should be used widely enough across the construction sector in order to promote OSC at post-pandemic.
	TAK2	Stakeholders should gain enough technical knowledge in order to understand the “realistic” advantages of offsite construction, e.g., affordability, reusability, easy-to-design, feasibility.
	TAK3	Simplicity and usability are important factors for OSC technology to succeed.
	TAK4	Offsite construction promotes more sustainability compared to traditional construction.
	TAK5	OSC technology should consider the entire project life cycle in the long run.
Investment and Finance (IAF)	IAF1	Modular construction market is currently not large enough to become effective. For OSC to succeed after the COVID-19 pandemic, more incentives should be offered to domestic/foreign firms to encourage investments in offsite construction.
	IAF2	Appropriate cost-value-benefit analysis/demonstration is useful to promote offsite construction.

Variables	Codes	Questions/Issues
	IAF3	Benefits of OSC also come from the effects of non-direct costs and non-cost items, e.g., health and safety, project/product certainty and consistency, etc. These effects are useful for offsite construction after the pandemic.
	IAF4	Overall cost efficiency for OSC clients can be obtained by reducing the project time.
	IAF5	Earlier income generation (early return compared to the conventional construction approach) is a strong point to boost prefabrication in the post-pandemic future
	IAF6	Modular construction can drive to a higher return in investment (compared to conventional construction method).
Design and Norms (DAN)	DAN1	Modularization may lead to repetitive architectural styles. Solutions should be taken to enrich the architectural designs.
	DAN2	Design competition may be a solution to monotony in OSC designs.
	DAN3	Offsite construction saves time to the design phase.
	DAN4	For modular construction to succeed after the pandemic: additional design standards, regulations and codes, evaluation criteria, calibration and rates should be amended accordingly.
	DAN5	Standards and codes should refer to OSC systems and norms from advanced countries.
	DAN6	Design disciplines should be better synchronised; i.e., between architecture, structure, building services, HVAC, fittings, etc.
	DAN7	Should encourage touchless and offsite technologies in OSC design after the pandemic.
Manufacturing and Productivity Factors (MAP)	MAP1	Factory controlled environment can reflect good OSC productivity to stakeholders.
	MAP2	Significant economies of scale and manufacturing capacity can promote offsite construction after the pandemic.
	MAP3	Modular construction accelerates speed of product delivery, spends less time on commissioning, reduces uncertainty over the programme, and reduces management time.
	MAP4	Actual labor hours can be reduced by the increased productivity in the factory setting, creating good promotion for OSC after COVID-19.
	MAP5	Offsite construction can reduce the embedded energy brought about by using simpler processes.
Onsite Construction/Assembling (OCA)	OCA1	OSC time advantage can be obtained by overlapping off- and on-site activities rather than in sequence.
	OCA2	Prefabrication achieves less site disruption by removing difficult operations off the site.
	OCA3	Offsite construction reduces congestion work areas and multi-trade interfaces onsite.
	OCA4	OSC improves health, safety and security onsite and balances with offsite working protection.
	OCA5	Modular construction enables inspection, control and rectification in offsite zones.
Manpower and Labor (MAL)	MAL1	After the pandemic, OSC supply chain and subcontractors will become unstable in the short run. Arrangement should be conducted to maintain the continuity of manpower.
	MAL2	After the pandemic, labor skills shortage may happen. Should plan ahead for skilled manpower availability.
	MAL3	Education and training are substantial factors influencing the productivity of modular construction after the pandemic.
	MAL4	Needs to promote training for assembly and operation/maintenance of the machine.
	MAL5	After the pandemic, offsite construction should become a content at high school education.
	MAL6	After the pandemic, economically active laborers remaining with the OSC industry should be maintained and controlled.
	MAL7	Healthier and safer conditions in the workplace will be the promoting point of OSC at post-pandemic.
	MAL8	Labor dynamics play an important role in determining the success of modular construction after the pandemic.
Government Strategies (GOS)	GOS1	Government should provide more direct support to modular construction, e.g., approval, regulations, import tax and quota, etc.
	GOS2	Government should provide indirect incentives for OSC communities to develop modular construction, e.g., fee and fine waivers, health facilities
Association (ASC)	ASC1	Should establish official bodies to enhance OSC applicability and initiatives at post-pandemic.
	ASC2	OSC communities should promote trust to tenants and developers.
	ASC3	Stakeholders' engagement should be clarified at an early stage and from the high level of the structure
Logistics and Infrastructure (LAI)	LAI1	Needs adequate land capital, supply chain and equipment for moving/assembling prefabricated modules.
	LAI2	Suppliers/sellers should provide "closed-end package" including manufacturing, transport, and assembling to site.
	LAI3	Needs appropriate infrastructure for large capacity vehicles and cranes after the pandemic
	LAI4	Factory needs to be in strategic location with proximity to site.
Competitiveness (COM)	COM1	In order to succeed after the pandemic, modular construction must maintain its operational cost lower than conventional construction.
	COM2	Functionality of offsite construction should stand better than traditional construction.
Bias and Psychological Retrofit (BPR)	BPR1	Stakeholders' inappropriate prevailing customs and traditions should be eliminated.
	BPR2	Needs more advertising/awareness campaign and demonstration to change conservative mindset against modular construction.
Other Socio-Economical Factors (OSE)	OSE1	Continuing employment for well-trained operatives working close to their homes and reducing travel/subsistence costs and recruitment will help offsite construction succeed after the pandemic.
	OSE2	Minimising disturbance to the vicinity of the site will promote modular construction for post-COVID-19.
	OSE3	Prefabrication can also apply successfully to rural sites in the post-pandemic future.

Appendix B

Triple tests between OLR–Spearman–GLM *: table of typical inferences.

Ordinal Logistic Regression with Factors Input *							**Spearman's Correlation Result**		**Generalized Linear Model with Covariates Input ****				
Parameter Estimates (All IVs)			Sig. (MFI) < 0.05	Sig. (GoF) > 0.05	Pseudo R-Square (N)	Sig. (ToPL) (>0.05)	Factors	Corr.	*Test of Model Effects*	*Parameter Estimates (All IVs)*		*Max in PE*	*Exp(B)*
Factors	Est.	Sig (<0.05)							Sig (<0.05)	Sig (<0.05)	B		
						TAR2 vs. A1							
[TAK2=3]	−1.494	0.000	0.000	0.000	0.257	0.000	TAK2	0.448	0.000	0.000	0.677	TAK2	1.969
[DAN2=1]	−5.743	0.001	0.000	0.000	0.135	0.000	DAN2	0.354	0.012	0.012	0.393	DAN2	1.481
[TAK5=2]	−3.938	0.002	0.000	0.000	0.295	0.000	TAK5	0.531	0.000	0.000	0.752	TAK5	2.120
[DAN4=2]	−4.356	0.006	0.000	0.000	0.105	0.000	DAN4	0.328	0.841	0.841	−0.035		
[TAK1=1]	−3.751	0.008	0.000	0.000	0.206	0.000	TAK1	0.405	0.493	0.493	−0.125		
[MAP5=1]	−7.049	0.009	0.000	0.000	0.178	0.346	MAP5	0.392	0.016	0.016	0.377	MAP5	1.457
[MAP1=2]	2.876	0.012	0.000	0.004	0.111	0.006	MAP1	0.326	0.185	0.186	−0.212		
[DAN6=1]	9.846	0.013	0.000	0.000	0.085	0.000	DAN6	0.284	0.011	0.011	−0.448	DAN6	0.639
[DAN5=1]	5.152	0.024	0.000	0.002	0.093	0.002	DAN5	0.290	0.333	0.334	−0.166		
[OCA1=1]	−4.855	0.033	0.000	0.045	0.112	0.150	OCA1	0.301	0.401	0.402	−0.124		
[OCA5=1]	−3.869	0.065	0.000	0.000	0.178	0.062	OCA5	0.384	0.004	0.004	0.490	OCA5	1.633
[DAN3=1]	2.659	0.304	0.000	0.002	0.168	0.022	DAN3	0.381	0.042	0.042	0.312	DAN3	1.366
						TAR7 vs. A1							
[GEN2=1]	39.014	0.000	0.000	0.000	0.057	0.720	GEN2	0.258	0.464	0.465	−0.103		
[MAP5=2]	−4.468	0.000	0.000	0.000	0.379	0.146	MAP5	0.586	0.000	0.000	0.684	MAP5	1.981
[DAN1=2]	3.208	0.001	0.000	0.000	0.198	0.110	DAN1	0.435	0.011	0.012	−0.414	DAN1	0.661
[TAK5=1]	−11.697	0.007	0.000	0.000	0.276	0.116	TAK5	0.460	0.840	0.840	−0.036		
[GEN5=2]	−2.709	0.009	0.000	0.000	0.145	0.425	GEN5	0.384	0.104	0.102	0.228		
[DAN5=1]	−7.240	0.016	0.000	0.000	0.282	0.036	DAN5	0.495	0.478	0.479	−0.126		
[DAN7=1]	−6.431	0.017	0.000	0.000	0.328	0.425	DAN7	0.526	0.456	0.456	0.135		
[OCA3=2]	−2.548	0.031	0.000	0.000	0.384	0.006	OCA3	0.567	0.026	0.026	0.430	OCA3	1.538
[MAP1=1]	6.746	0.167	0.000	0.000	0.393	0.026	MAP1	0.602	0.003	0.003	0.499	MAP1	1.647
[TAK2=1]	−1.721	0.521	0.000	0.000	0.306	0.397	TAK2	0.498	0.010	0.010	0.466	TAK2	1.593
[DAN4=1]	−2.244	0.341	0.000	0.025	0.347	0.348	DAN4	0.551	0.010	0.010	0.477	DAN4	1.612
[DAN6=2]	−1.166	0.232	0.000	0.000	0.370	0.435	DAN6	0.550	0.033	0.033	0.397	DAN6	1.487
[DAN3=1]	−3.612	0.327	0.000	0.000	0.316	0.245	DAN3	0.533	0.035	0.035	0.336	DAN3	1.400
[OCA1=1]	−1.028	0.698	0.000	0.000	0.319	0.059	OCA1	0.538	0.040	0.040	0.334	OCA1	1.397

* Ordinal logistic regression with factors input. ** Generalized linear models with ordinal logistic response and covariates input.

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