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Lean Integrated Project Delivery for Construction Procurement: The Case of Sri Lanka

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Abstract: The choice of proper procurement methods has an impact on the overall productivity and sustainability of construction projects. The current procurement methods have alerted the construction industry (CI) due to the exacerbating fragmentation among parties and the resulting low level of productivity. Therefore, introducing a new procurement system to eliminate the above challenges is imperative to the CI. Therefore, this research investigated the applicability of lean integrated project delivery (LIPD) as a construction procurement system and developed a framework for its successful implementation. A qualitative exploratory approach was adopted, informing an interpretivism stance. Accordingly, semi-structured interviews with 15 Sri Lankan (SL) CI experts were conducted to determine the applicability of the LIPD concept in a real-life CI context. Qualitative content analysis was used to analyse the collected data. This research identified the significance of LIPD compared to existing procurement methods, which may contribute to the long-term planning and management practices in the CI. However, the findings elicited several barriers that could hinder successful LIPD implementation. As a result, some of the strategies discovered include providing LIPD training and awareness, obtaining expert support, and encouraging professionals. This is the first study of its kind to reveal a LIPD framework in a developing country like SL without restricting itself to a specific construction type. Therefore, this study is expected to impact the global CI by paving the way for LIPD as a new procurement system to improve the performances of similar CIs in developing countries across the world.

Keywords: construction procurement; procurement systems; integrated project delivery (IPD); lean construction; lean integrated project delivery (LIPD); framework; Sri Lanka (SL)

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1. Introduction

The construction industry (CI) is one of the most enormous, dynamic, and complex sectors in the world [1]. In the Sri Lankan (SL) context, the CI is considered to play an essential role as an indicator of economic growth [2]. A product of the CI is considered a success when it is completed within the prescribed time and budget, and with adequate quality [3]. To deliver the products successfully, numerous procurement systems are available [4]. However, conventional construction procurement systems, such as the traditional method and design and build method, are subjected to different types of negative interactions [5]. Ref. [6] found out that to overcome the barriers of conventional procurement methods (i.e., lack of coordination, increased errors and disputes among the parties, and low levels of efficiency and productivity) and to achieve successful project completion, construction projects are required to move towards a new procurement approach. Further, [7] established that, by adopting an integrated approach to the project delivery method, problems with the current procurement systems could be minimised. Therefore, by considering these criteria, a new project delivery approach was introduced to the CI, and it is known as "integrated project delivery" (IPD) [8].

Nowadays, most countries tend to incorporate this novel IPD method into their construction sectors [9]. Thus, even within the SL context, [10] specified the potential application of the IPD system to minimise the existing problems and challenges in the SL CI. Moreover, because of much research related to IPD, [11] suggested that the inclusion of the concept of lean could provide an opportunity to achieve the optimal benefits of IPD. Therefore, to enhance the value of the IPD method, the IPD method was modified by incorporating the lean concept [11], and this concept is commonly known as "lean integrated project delivery" (LIPD). Accordingly, the significant difference between these IPD and LIPD methods is that the LIPD method's formation is achieved through incorporating the lean concept into the conventional IPD method. However, LIPD's acceptance as a construction procurement system is still in its infant stage, owing to a lack of direction for experts on how to combine the two well-established ideas of lean concept and IPD [12].

Evidently, [12,13] were the only studies found in a search of the literature that offered a framework for LIPD implementation (i.e., for road construction projects in India through case studies). Even in the SL context, there is a lack of studies to provide guidance on incorporating lean principles into IPD for the CI. In retrospect, [14] pointed out that owing to a lack of CI preparedness, the construction sectors in SL and India were not persuaded to embrace IPD in building projects. As a result, unlike IPD, there is a responsibility placed on CI professionals to explore LIPD through an empirical study to enable a potential successful implementation. As a result, the application of LIPD (i.e., related barriers and overcome strategies) within the CI context, particularly in SL, is a critical problem that has to be investigated, whilst lean principles and IPD have proven to be effective in building projects all over the world. Accordingly, this research aimed to develop a framework for the implementation of LIPD in the CI based on data collected from the SL context. To achieve that aim, this paper is structured as follows. First, it provides a comprehensive literature review on the barriers that can be affected by successful LIPD implementation and appropriate strategies to mitigate those barriers. Next, the research method, comprising of data collection and techniques, is explained. Then, the research findings are presented, and finally, we provide strategies to guide the successful implementation of LIPD in the CI.

2. Literature Review

2.1. Construction Procurement Systems

The CI plays an essential role in the economy of any country [15]. It makes a significant contribution to the national gross domestic product [16]. According to the Asian Countries Report [16], the CI provides job opportunities to millions of people. Further, as construction projects become more complex and advanced, the CI tends to become more specialised [7]. Yet, [7] stated that construction might operate under high pressure to achieve greater efficiency and productivity. Therefore, to achieve the best outcome, the CI needs a suitable and robust construction procurement method as the root of construction projects [15]. Moreover, a crucial decision needs to be made regarding the selection of procurement methods to obtain the desired outcomes for the construction projects [17].

2.2. Problems in the Construction Industry Due to the Procurement Systems

Due to limited resources and unlimited human needs, the modern CI is more complicated than it has been in the last few decades [18]. There are numerous issues that can be identified in the CI, such as increased errors and disputes among the parties, low levels of efficiency and productivity, and other issues like these [19]. The SL CI also suffers from these problems [16]. Among those problems, the inability to achieve employer satisfaction is the most profound problem [20]. Therefore, for a construction project to be successful in satisfying the employer, it should achieve the three thresholds of sustainable project management: time, cost, and quality [15].

The foundation of these issues is laid by the current procurement methods (i.e., traditional and design and build procurement systems) of the CI [17]. Therefore, it is essential to select the most suitable and full-strength route for the construction project at an early

stage [17]. Ref. [5] found out that to overcome the barriers of conventional procurement methods and to achieve successful project completion, construction projects are required to move towards a new procurement approach. Further, [7] found that, by adopting an integrated approach to the project delivery method, problems with the current procurement system could be minimised [21]. Therefore, by considering these criteria, a new project delivery approach was introduced to the CI, which is known as the IPD [8].

2.3. Integrated Project Delivery (IPD)

As cited in [14], in 1990, a group of businesspeople created an integrated group that combined engineering, commercial interests, and subsurface considerations. This was successful, and it was named "project alliancing" [22]. As [22] mentioned, this project alliance concept was spectacularly successful and was recognised as the IPD. The American Institute of Architects California Council (AIACC) defined IPD as a project delivery approach that integrates people, systems, business structures, and practices into a specific process that collaboratively harnesses the talents and insights of all participants to optimise project results, increase value to the owner, reduce waste, and maximise efficiency through all phases of design, fabrication, and construction [23].

The goal of this new approach is to create more successful projects by solving the problems of the current CI [24]. Therefore, the IPD approach seeks to improve project outcomes in terms of time taken, cost, and quality, while minimising waste, in the CI [7]. In addition, the major stakeholders work collaboratively as a team to understand each other and get the most out of the construction project [9]. Therefore, all team members try to achieve the project goals rather than their individual goals [25].

As a project delivery approach, the IPD system is highly beneficial to all stakeholders in the CI [26]. Moreover, [11] found that adding the lean concept into the IPD method helps to further increase the value of the IPD. This concept of leanness can be defined as the systematic removal of waste by the organisation from all areas of the value stream [27]. By conforming to this, the IPD system can be modified by incorporating the lean concept.

2.4. Lean Integrated Project Delivery (LIPD)

As in IPD, the lean concept is a collaborative approach that is focused on increasing efficiency by reducing waste in construction [28]. To get optimum service from the IPD, it is necessary to integrate the lean concept [11]. Ref. [29] called this new integrated procurement method "lean integrated project delivery" (LIPD), which should achieve the ultimate goals of the CI [30].

Ref. [31] explained that LIPD is an alternative and innovative approach to collaborating with the construction project stakeholders. Furthermore, LIPD has evolved from a management approach that focuses on the lean concept in the construction phase to the project delivery phase [32]. Delivering the product with the maximum value and least waste are the fundamental goals of the LIPD system [28]. By combining these two principles, the LIPD method provides more outstanding services to the construction sector than any other method. This is because the IPD method fosters project team collaboration, and the lean concept helps to achieve that. Correspondingly, [28] further explained, "IPD provides a contractual environment through its principles, and lean provides collaborative efficiency for project objectives through lean principles and tools". As a project delivery method, two milestones can be seen in the LIPD [32]. According to [32], those milestones are the definition of a project-based production system and the definition of a LIPD agreement. As a project-based production system, LIPD is involved in creating innovative design and construction mechanisms for the project. As a definition of an agreement, LIPD is involved in adopting a relational contract [33]. The benefits of LIPD include quality products, a higher production rate [34,35], increased constructability [28], time and cost savings [32], reduced project risk [36], satisfied team members [32], and employer satisfaction [35]. Moreover, one of the primary goals of LIPD is to achieve sustainable construction through economic, social, and environmental sustainability [34]. This objective is achieved by

improving the performances of construction projects, especially by reducing construction waste, construction time, and total construction costs, and improving the quality of projects and the environment [15].

Ref. [37] stated that LIPD evaluates all aspects of a project from the beginning to the end to improve the project's overall performance. Ref. [29] recognised five steps in LIPD: project definition, lean design, lean supply, lean assembly, and lean consumption.

At the project definition stage, a better understanding of the project is essential [38]. Therefore, financial analysis and project risk analysis significantly contribute to fulfilling this requirement [29]. The project definition allows team members to understand the employer's requirements and then act on them [29]. Furthermore, the successful project definition stage comprises needs and values, design criteria, and conceptual design [37].

Then, lean design transfers the conceptual design into a lean process and product design [38]. However, this stage is associated with building output for the project definition phase, which is a deviation from other procurement methods [29]. In the traditional project delivery method, the design team creates the preliminary drawings and then engineers apply relevant design parameters to that framework [39]. Moreover, in the design and build procurement method, a single entity performs the duty of design, but the involvement of the employer is inferior [40]. Therefore, lean design is a significant departure from conventional project delivery methods [37], as the design is produced because of the involvement of all team members [41]. Therefore, the best design output can be expected from the LIPD method [33].

After the lean design, the design is transferred to the lean supply phase [38]. Refs. [38,42] explained the detailed engineering, fabrication, and delivery aspects of lean supply. Moreover, this phase provides a logistical method to reduce inventory and lead time [33,37]. As the fourth stage, lean assembly begins with the delivery of materials and information for their installation [37]. During this stage, project activities are performed at the last responsible moments to minimise change orders for the construction [33]. The final stage, lean usage, refers to the operational and maintenance stage of this LIPD method [29,33].

2.4.1. Level of LIPD Implementation in the Construction Industry

Even though many studies have enacted a wide range of initiatives to investigate IPD in the US [7,43], Peru [44,45] and Norway [24,44,45], among others, research on LIPD is limited to a few initiatives in the global CI. [29,33,37,39,40] conducted research on LIPD implementation in the US. Ref. [29] said that further study is needed for a better understanding of LIPD practices in various circumstances. [33] distinguished between LIPD and traditional project delivery in the CI. Ref. [33] emphasised the importance of further research on the applicability of LIPD outside of the US. As a result, [40] proposed that design–build contracts can be an effective tool for adopting LIPD in the US, and that LIPD can infiltrate the industry more thoroughly if more owners are able to employ it. Refs. [12,13] created lean integrated project delivery models for road building and highway projects in India, respectively. Furthermore, [46] conducted a LIPD conformance review for Indian CI and found crucial success criteria for effective implementation. Ref. [32] recently conducted a comparative analysis in Chile on integrated project delivery and lean project delivery, emphasising the need to implement LIPD for the CI. Nonetheless, the focus of the above research has given minimum attention towards establishing a technically feasible framework for LIPD implementation.

2.4.2. Barriers to Implementing LIPD in the Construction Industry

When implementing LIPD in the CI as a new method, it is inevitable to face various barriers [47]. Those barriers (or challenges) are categorised in Table 1.

Table 1. Barriers to implementing LIPD in the construction industry.

Barriers/Challenges			References
Organisational Barriers	Financial barriers	High initial investment Inventory cost Compensation structure	[9,48]
	Managerial barriers	Resistance to change Poor awareness Inefficiency in resource planning	[7,49]
	Contractual barriers	Lack of mutual trust among stakeholders Lack of existence of similar IPD contracts Inappropriate contractual strategies	[50,51]
	Educational barriers	Lack of knowledge of IPD and lean Lack of existing training material	[49,51]
	Communication barriers	Poor transmission through all phases of the project Lack of transparency Lack of organisational communication	[48,49]
	Technology barriers	Unwillingness to use new technologies The high financial cost of new software and equipment	[47]
External Barriers	Cultural barriers	Resistance to change Continuation of individual interests	[7,34]
	Legal barriers	Unclear responsibilities of the parties A requirement of the new legal framework	[34,51,52]
	Political barriers	Change in the culture of teamwork Lack of government support	[9,49]

According to Table 1, various researchers have identified different barriers (or challenges) that can affect the implementation of LIPD in the CI. However, no such research has been done so far to identify the barriers affecting the implementation of LIPD in SL.

2.4.3. Strategies to Implement LIPD in the Construction Industry

For a successful LIPD implementation, minimisation of the barriers (in Table 1) is essential. Refs. [53,54] stated that enhancing the awareness of LIPD, organising training and workshops, public sector organisation encouragement, and professional motivation can have positive impacts on successful LIPD implementation. Similarly, [8] added that having more employer focus, getting support from IT experts, and arranging proper teamwork are some of the profound strategies that can be applied to the successful LIPD implementation. In addition, the use of good construction management practices also helps to minimise the barriers to LIPD implementation [55]. Ref. [55] further noted that determining the best management team and structure and encouraging team members to solve problems and share knowledge can also be used as critical opportunities for successful LIPD implementation. Accordingly, these are the most appropriate strategies to assist construction professionals in the successful implementation of LIPD. However, these strategies need to be further investigated in the SL CI.

Although attempts have been made by SL research to develop lean frameworks, which include Lean in Large Contractors [56,57] and Lean in SMEs [58,59], the focus on LIPD in such frameworks is insufficient. Therefore, research on LIPD in the SL CI is long overdue. Hence, there is a critical need to investigate the applicability of LIPD to the SL context, and thus to develop a guiding framework for the SL CI.

3. Research Methodology

This research aimed to develop a framework for LIPD implementation in the CI. A literature review was carried out to explore the theoretical background of LIPD. In the absence of prior research, there is a need to ascertain the different views of the experts. Appreciating and fostering the free flow of ideas, views, impressions, and experiences

of people within the studied environment, and human relationships, were regarded as the study's key motivations. Hence, the study adopted the ontological assumption that "reality is not pre-determined, but socially constructed" and the epistemological assumption that "knowledge is gathered by examining the views of the people," as suggested by [60]. Similarly, in terms of axiology, we took the value-laden stance, as we recognise the possibility of researchers adding value in a manner that influences the study. Thus, the overall research approach is in line with the interpretivism stance. According to [61], it will enable researchers to obtain an in-depth understanding of new and emerging topics for which the sample of respondents is limited. As both the lean and IPD concepts are new to the SL CI, it was difficult to find professionals who had adequate knowledge of leanness and IPD. This limited the ability to form a large sample of respondents to carry out data collection within the local context and to adopt questionnaire/Delphi survey to determine the intensity of significance of various factors affecting LIPD (i.e., barriers, challenges, and strategies). In such a situation, where existing knowledge regarding a particular subject area is limited and the potential to draw a large sample of interviewees is constrained, the literature suggests the use of a qualitative research approach. These facts led to the ultimate selection of the qualitative approach for this research. According to [60], the use of interviews is widely acknowledged for qualitative data collection. The study adopted semi-structured interviews through online forms (i.e., Skype and MS Teams) due to the COVID-19 restrictions in the country, which also provided room for further questioning than mentioned in the interview guidelines during data collection. The theoretical sampling method was used to select the interviewees by considering their expertise in IPD and leanness, respectively. Even though LIPD is not widely known in the SL context, the interviewees were given a brief outline of the literature review findings on LIPD prior to the semi-structured interviews, allowing them to express their insights on how those theoretical findings may be validated in a real-world construction project setting. As shown in Table 2, interviews were conducted with professionals in the SL CI to determine the applicability of the literature review findings in the real-life construction project context.

Table 2. Profile of the semi-structured interview respondents.

Respondent	Current Designation	Current Working Sector	Past Experiences	Experience (Years)	Awareness of the Concepts	
					Lean	IPD
R1	Manager (Estimation and Contracts)	Contractor	Assistant General Manager, Project QS	20	Well aware	Well aware
R2	Project QS	Consultant	Project QS, Contract Administrator	21	Well aware	Well aware
R3	Senior Lecturer	University	Contract Administration	25	Well aware	Well aware
R4	Director	Consultant	Charted QS, Planning Engineer	23	Well aware	Well aware
R5	Senior Lecturer	University	Lecturer, Lean Researcher	25	Well aware	Well aware
R6	Chief QS	Consultant	Senior Contract Administrator, Contracts Manager, Senior QS	40	Well aware	Aware
R7	Contracts Manager	Contractor	Contract Administrator, Estimator, QS	20	Well aware	Aware
R8	Project Manager	Contractor	Contracts and Cost Manager	23	Well aware	Aware
R9	Senior Lecturer	University	Director, Consulting Engineer, Civil Engineer	25	Well aware	Aware

Table 2. *Cont.*

Respondent	Current Designation	Current Working Sector	Past Experiences	Experience (Years)	Awareness of the Concepts	
					Lean	IPD
R10	Director	Consultant	Structural Engineer, Civil Engineer	22	Well aware	Aware
R11	Project Manager	Consultant	Senior Contracts Manager	25	Well aware	Aware
R12	Contracts Manager	Contractor	Contract Administrator	20	Well aware	Aware
R13	Project Manager	Contractor	Contracts and Cost Manager	23	Well aware	Aware
R14	Director	Consultant	Mechanical Engineer	25	Well aware	Aware
R15	Director	Consultant	Planning Engineer, Civil Engineer	21	Well aware	Aware

This study used [62]'s three-phase coding content analysis method, in which the research results were explored as themes (selective codes) after the creation of open and axial codes. Primarily, the information obtained from expert interviews was transcribed. Following that, the transcripts were closely scrutinised to recognise distinct concepts and patterns for categorisation; this practise is known as "open coding". These themes were further sifted, refined, and categorised. They were assigned axial codes derived through deductive and inductive coding. As an example, when any of the respondents' opinions were comparable to literature (aligned with a pre-determined code from literature), a code derived from literature was assigned using deductive coding principles. On the other hand, inductive coding was used to assign new codes to the themes that emerged from the results. This was replicated in several cycles until no new codes were found from the collected data, at which point the final codes were known as selective codes. Accordingly, this approach ensured the development of a detailed list of themes for a qualitative study's content analysis [63,64] and was thus used for this research study.

4. Research Findings and Discussion

The key research findings and their discussions are elaborated on in this section. Furthermore, the blue rows in Tables 3–7 show unrecognised factors from the literature review, and the green rows show unrecognised factors from the expert interviews. Consequently, the white rows show the factors identified from both the literature review and expert interviews.

Table 3. Problems with the conventional procurement methods.

Problems of Conventional Methods	Literature Reference	Identified by Respondents
Conflicts and disputes	[65]	✓
Constructability issues	[20]	✓
Over budgeting	[15]	✓
Time-consuming	[15]	✓
Many change orders	[41]	✓
Lack of transparency	[9]	✓
Low level of efficiency	[19]	✓
Low level of productivity	[19]	✓
Price fluctuation issues	Not referred	✓
Absence of the proper information model	Not referred	✓

Table 4. Benefits of LIPD implementation.

Benefits of LIPD Implementation	Literature Reference	Identified by Respondents
Increase constructability	[28]	✓
Time and cost-saving	[32]	✓
Reduce waste	[66]	✓
Increase quality	[35]	✓
Reduce project risk	[36]	✓
Increase efficiency	[34]	✓
Employer satisfaction	[35]	×
Team member satisfaction	[32]	×
A good path to motivate foreign investors	Not referred	✓
Stability of cash flow	Not referred	✓
Announces the innovative ideas	Not referred	✓

Table 5. Organisational barriers for LIPD implementation.

Organisational Barriers	Literature Reference	Identified by Respondents
Managerial barriers		
Resistance to change	[7]	✓
Poor awareness	[7]	✓
Inefficiency in resource planning	[50]	✓
Issues of the negotiation process	Not referred	✓
Financial barriers		
High initial investment	[9]	✓
Compensation structure	[9]	×
Currency fluctuation	Not referred	✓
Contractual barriers		
Lack of mutual trust	[51]	✓
Lack of existence of similar IPD contracts	[50]	✓
Inappropriate contractual strategies	[51]	×
Issues of drafting contracts	Not referred	✓
Educational barriers		
Lack of knowledge about IPD and Lean	[7]	✓
Lack of existing training material	[7]	✓
Lack of knowledge about the construction process	Not referred	✓
Lack of negotiation skills	Not referred	✓
Communication barriers		
Lack of transparency	[67]	✓
Stakeholders' issues in communication	[49]	✓
High cost to have an informational model	Not referred	✓

Table 5. *Cont.*

Organisational Barriers	Literature Reference	Identified by Respondents
Technology barriers		
Unwillingness to use new technologies	[50]	✓
High financial cost for new software	[9]	✓
Lack of technical knowledge	Not referred	✓

Table 6. External barriers for LIPD implementation.

External Barriers	Literature Reference	Identified by Respondents
Political barriers		
Change in the culture of teamwork	[9]	×
Lack of government support	[9]	×
Political impact to project delay	Not referred	✓
Highly changing economy	Not referred	✓
Legal barriers		
The requirement of the new legal framework	[51]	✓
Unclear responsibilities of the parties	[51]	×
Public sector NPA guideline	Not referred	✓
Limitations of the organisationa's rule book	Not referred	✓
Cultural barriers		
Resistance to change	[9]	✓
Continuation of individual interest	[9]	✓
Poor awareness	Not referred	✓

Table 7. Strategies for successful LIPD implementation.

Strategies to LIPD Implementation	Literature Reference	Identified by Respondents
By enhancing the awareness of LIPD	[54]	✓
Organise training and workshops	[54]	✓
Organise awareness programs	[8]	✓
Be more employer focus	[8]	✓
Getting support from IT professionals	[8]	✓
Encouragement of professional skills	[53]	✓
Encourage public sector	[54]	✓
Use a good construction management practice	[55]	✓
Use job counseling practice	[54]	✓
Encourage team members to solve problems and share knowledge	[55]	✓
Arrange proper teamwork	[8]	✓

Table 7. *Cont.*

Strategies to LIPD Implementation	Literature Reference	Identified by Respondents
Determination of the best management team and structure	[55]	✓
Good professional motivation	[54]	✓
Create communication channels	Not referred	✓
Encourage investors	Not referred	✓
Train stakeholders to work in temporary multiple organisations	Not referred	✓
By emphasizing the waste of existing conventional practice	Not referred	✓
Improve the client-initiated process	Not referred	✓
Encourage public sector to provide demand-side guarantee	Not referred	✓
Try to reduce the depth to GDP ratio	Not referred	✓
Organise process to remove psychological barriers in the organisation	Not referred	✓
Get marketing support to motivate clients to invest in LIPD	Not referred	✓
Motivate precast, prefabrication, and construction automation among project parties	Not referred	✓

4.1. Problems of Conventional Procurement Methods

The findings related to the conventional procurement methods are briefly presented in Table 3.

Most of the respondents recognised that all the findings in the literature related to the problems with conventional procurement methods were applicable in a real-life project environment according to their experience in the CI. As expressed by R1, R5, and R8, price fluctuation issues and the absence of the proper information model were identified as the most highly affected problems due to the conventional procurement methods in the CI. R5 further elaborated that the absence of a proper information model that integrates the project team can have a variety of negative effects. Similarly, this is a major issue highlighted in the traditional procurement method. Respondents mentioned that, in most cases, clients' requirements are always changing, even challenging the initially anticipated contract sum. Moreover, problems with price fluctuations could lead to several issues, such as loss of profit for the contractor, cash flow problems for the project, project delays, and inferior quality of the final project. Accordingly, all the problems included in Table 3 are those related to the conventional procurement methods in the CI.

4.2. Lean Integrated Project Delivery

Due to the above-mentioned problems, most of the authors and all of the respondents agreed to move on to the new procurement methods, such as IPD. R3 explicates IPD as a "project delivery model which gathers key project stakeholders entering into a single contract while encouraging collaboration, optimising results, reducing waste, maximising efficiency and expertise". Furthermore, researchers identified that, by incorporating leanness into the IPD, the value of the IPD method could be increased. As an example, [28] cited that with the combination of these two concepts, the LIPD method provides more exceptional services to the CI. This is because the IPD method encourages the project team to collaborate, and the lean concept helps to achieve it. Correspondingly, [28] further explained that IPD provides a contractual environment through its principles, and leanness

provides collaborative efficiency for project objectives through lean principles and tools. Furthermore, both the researchers and the experts explained being lean as reducing waste and improving value. Accordingly, respondents also agreed to incorporate leanness into the IPD method, and R5 explicates LIPD as the *"form of a construction point of view, it is about trying to bring a fragmented industry together"*.

4.2.1. Benefits of LIPD implementation for the construction industry

The benefits of LIPD implementation for the CI are briefly presented in Table 4.

In line with the literature, most of the experts recognised the benefits of LIPD for the CI in terms of the productivity and sustainability enhancement of construction processes. Apart from that, literature findings noted satisfaction with the employer and team members as the benefits of the LIPD. In the respondents' view, achieving employer satisfaction and satisfying other team members are some of the most difficult tasks in the CI, even in the SL context, as human beings are more interested in achieving their personal goals than in achieving a common goal. For this reason, team members' satisfaction could not be successfully achieved in the CI. Yet, the experts added that LIPD implementation could be a good way to motivate foreign investors and announce innovative ideas. According to R1, R7, and R13, the CI of Sri Lanka is currently showing a negative market economy. Therefore, LIPD implementation will improve the confidence of foreign investors to invest in the SL CI, which will minimise this negative impact. Moreover, R12 stated that LIPD helps contractors get more chances to maintain the stability of their cash flow. By sharing knowledge and experience among team members and applying new technologies, LIPD helps to create innovative ideas among team members. Therefore, several general benefits can be achieved for the CI through LIPD implementation, and some specific benefits for a developing nation like SL can be achieved as well.

4.2.2. Barriers to Implementing LIPD in the Construction Industry

Barriers to successful LIPD implementation can be divided into organisational and external barriers. Tables 5 and 6 summarise the findings of the LIPD implementation barriers from both the literature and the expert interviews.

(1) Organisational Barriers

Organisational barriers are the issues that directly affect the implementation of LIPD in the CI. Managerial, financial, contractual, educational, communication, and technology limitations are the major organisational barriers, and Table 5 summarises the findings of the research.

The study's findings identified poor awareness, inefficiency in resource planning, and resistance to change as managerial barriers to LIPD implementation. In addition to that, R7 and R11 identified issues in the negotiation process as a managerial barrier. R7 and R13 further stated that the negotiation process is very rigorous. The reason is that all parties come to the negotiating table intending to get the least amount of risk and maximum benefits. Therefore, negotiators need to have enough skills for that. Otherwise, the relationship among the parties might be damaged in the preliminary stages, which would eventually affect the success of the project.

According to the findings in the literature, the high initial investments and compensation structure are considered the financial barriers to LIPD implementation. However, respondents only agreed with the barrier of the high initial investment. According to the views of R1 and R3, in the CI, there is a proper compensation procedure. Therefore, it would not affect the LIPD implementation. In addition, R1, R5, and R14 noted that price fluctuation is a financial barrier, though it was not found in the literature.

As for the contractual barriers, a lack of mutual trust, the existence of similar IPD contracts, and inappropriate contractual strategies were identified. However, respondents agreed with the first two, but they did not agree with inappropriate contractual strategies as a contractual barrier. Conversely, R7 mentioned that drafting contracts not to match the

needs of the LIPD method would act as a contractual barrier for LIPD implementation in Sri Lanka.

Considering the educational barriers, the main challenges identified through the research findings were the lack of knowledge about leanness and IPD areas and the lack of existing training material. Similarly, respondents agreed with these, and therefore, these barriers would also apply to local contexts. In addition, all the respondents noted the lack of negotiation skills and lack of knowledge of the construction process as educational barriers to LIPD implementation in the SL context.

Regarding the communication barrier, lack of transparency and stakeholders' issues in communication were identified. Accordingly, R1, R6, R7, and R15 noted that these issues would affect the implementation of LIPD, especially in the SL CI. This is because of the lack of proper information models in the local context, and to achieve the advanced level of information, additional cost and knowledge are required.

The final set in the organisational barriers category is the technology barriers set. Unwillingness to use new technologies and the high costs of new software and equipment are the prominent technology barriers identified by both the respondents and the literature. In addition, lack of technical knowledge was also recognised as a technical barrier by the respondents. This was backed by the respondents, who also mentioned the well-known resistance to innovative technologies within the CI (irrespective of geographical locations). Such technologies are normally comprised of various software and equipment which require construction professionals to have sufficient technological knowledge.

(2) External Barriers

In this category, the three barriers have been identified as political, legal, and cultural barriers. Table 6 shows the research findings on external barriers.

Respondents identified project delays and the political impact on a highly unstable economy as noteworthy political barriers. Since then, with a lifetime of experience in the SL CI, sudden changes in governments and their political motives have caused many construction projects to be delayed. Therefore, this factor is mainly applicable to SL culture, and this also affects the economy. In addition, a change in the culture of teamwork and a lack of government support can be considered the political barriers to LIPD implementation in the global context. However, these two barriers were not identified by the respondents. R9 mentioned that, in the SL context, the government provides sufficient support to develop the CI. R9 further stated that the SL government provides encouragement for researchers, and therefore, assists the local CI in successfully implementing LIPD.

Regarding the legal barriers, the findings of the research have identified that a new legal framework is needed to implement LIPD. Moreover, the literature found that the unclear responsibilities of the parties' act in a project life cycle as a legal barrier to LIPD implementation. However, during the interviews, respondents did not agree with this factor. R13 mentioned that, in the local context, team members were aware of their roles and responsibilities. Moreover, in the local context, most of the respondents identified that the NPA guidelines would be a challenge to implement in LIPD in public sector projects. This is because public-sector projects must abide by NPA guidelines. Therefore, it would be difficult to apply the LIPD method to government projects. Similarly, R9 and R10 added that the limitations in the organisation's rule books also affect the SL CI as a challenge to LIPD implementation.

The cultural barrier is the final barrier under the external barriers. Research findings elicited that resistance to change and the continuation of individual interests are the cultural barriers that highly affect LIPD implementation. In addition, R4 noted that poor awareness can also affect successful LIPD implementation. Respondents commonly mentioned that people resist change due to their poor awareness. Therefore, in the local context, this also acts as one of the external barriers to LIPD implementation.

4.2.3. Strategies to Implement LIPD for the Construction Industry

It is important to identify the appropriate strategies for successful LIPD implementation in the CI. CI professionals can increase the value of an LIPD system by eliminating barriers to LIPD implementation by following the relevant strategies outlined in Table 7.

The mentioned strategies can be used to successfully implement LIPD for the CI. Organizing awareness programs, getting support from IT professionals, determining the best management team and structure, and providing courteous professional motivation are some of the profound strategies to overcome barriers to LIPD implementation. In addition, creating a communication channel and encouraging investors were identified by the R4 and R6 as the LIPD implementation strategies. According to their view, a communication channel to enhance open communications and the interest of foreign and local investors in adopting LIPD are more critical for the SL CI.

Furthermore, R5 proposed training stakeholders to work in multiple temporary organisations. Stakeholders must work with different organisations and individuals. Therefore, they need to improve their collaborative ideas. The R5 also suggested emphasising the ongoing waste in conventional practices to the construction community. Other than those, improving the client-initiated process, encouraging the public sector to provide the demand-side guarantee, implementing a process to remove psychological barriers in organisations, improving the clients' interest in LIPD, and encouraging precasting, prefabrication, and construction automation among project parties were proposed as the strategies to overcome the challenges for LIPD implementation in the CI by most of the respondents.

4.3. Framework for LIPD Implementation in the Construction Industry

Based on the research findings, a framework, as illustrated in Figure 1, was developed to present the flow of the LIPD method. According to the research findings, LIPD is particularly important to any country trying to overcome the prolonged challenges of traditional construction projects. As a result of the findings, several barriers to LIPD implementation have been identified, including resistance to change, a lack of awareness of lean and IPD areas, and a high initial cost, among others. Therefore, to achieve a successful and targeted outcome, those negative interactions should be managed. Accordingly, this study sought to explore appropriate strategies to minimise or eliminate those barriers. Some of the profound strategies presented in this study include providing training and awareness on lean and IPD areas, obtaining expert support, and encouraging professional skills. Consequently, a framework was formed to present the findings in a structured way while eliciting correlations between empirical evidence and theoretical perspectives through the same colour coding method adopted in the analysis. Accordingly, the blue factors indicate unrecognised factors from the literature review, while the green factors indicate unrecognised factors from the expert interviews. Consequently, the uncoloured factors indicate the factors identified from both the literature review and expert interviews. Additionally, strategies found through this study have been linked to the LIPD stages identified by [29] to indicate the suitability of each strategy under each stage. The existing LIPD implementation frameworks of [12,13] are limited to the road construction context, where only the viability of LIPD stages has been assessed. In comparison, the proposed framework in this study would benefit the CI as a whole and its experts by accelerating LIPD adoption, which would be a substantial advance in the LIPD research stream. Furthermore, by studying this framework, stakeholders (the client, contractor, and consultant team) can identify any potential barriers before embarking on physical work and can identify the appropriate strategies to overcome those challenges. This framework clearly shows how the stakeholders should act at various stages of the LIPD, which was not evident in previous studies.

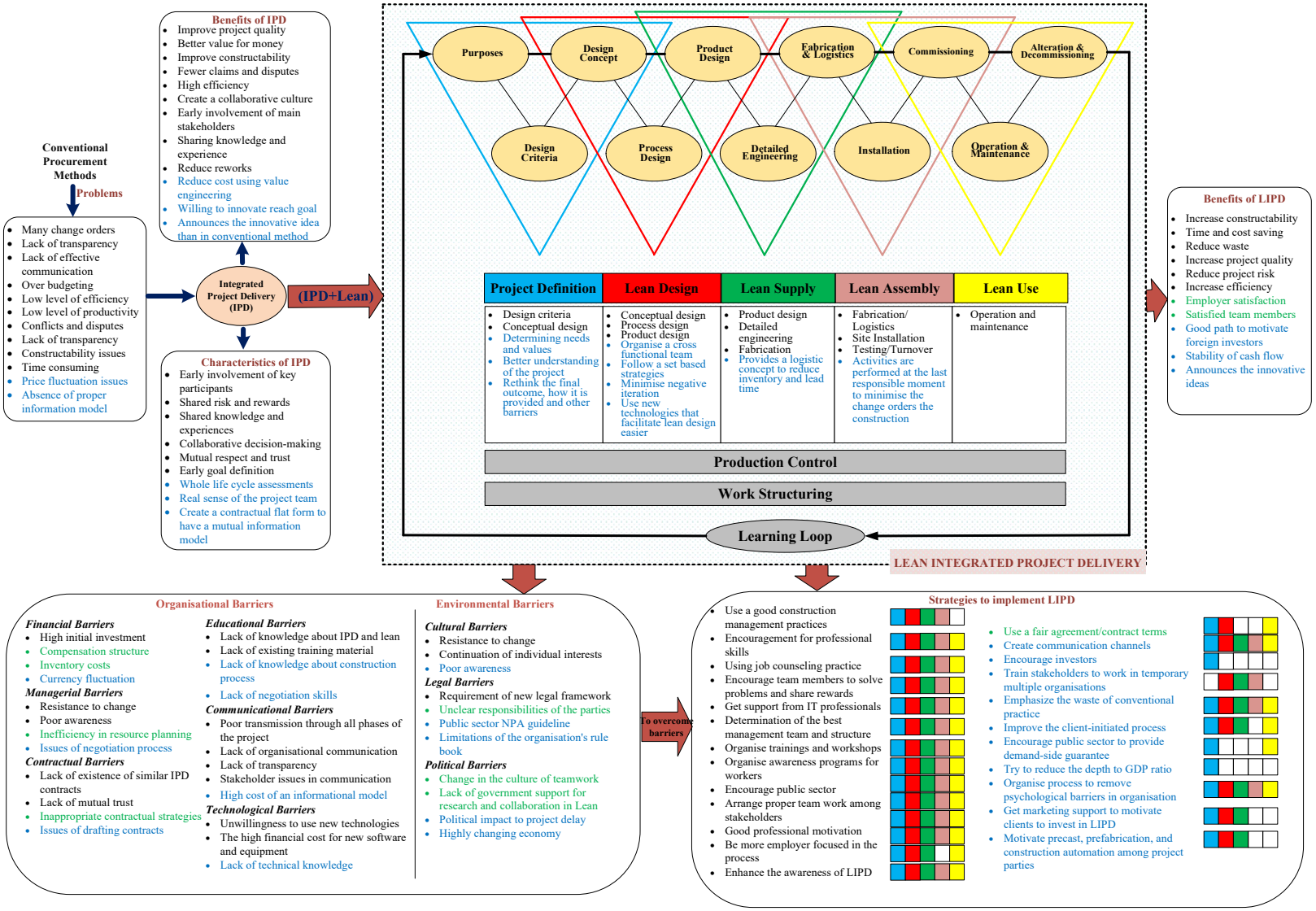

Figure 1. Framework for LIPD implementation in the construction industry.

5. Conclusions

Procurement methods affect the overall success of construction projects. Distinct types of procurement methods are available in the CI, and traditional and design-and-build procurement methods are the methods of priority, while being heavily criticised for various drawbacks concerning lack of coordination and fragmentation/disputes in the project environment. Therefore, the introduction of a new procurement system to address the challenges of conventional procurement methods will increase the productivity and sustainability of construction. Based on the data collected from fifteen (15) SL CI experts, this research elicited several barriers that can negatively affect LIDP implementation in the CI. Providing training and awareness on lean and IPD, getting support from experts, and encouraging professional skills are some of the profound strategies identified in this study to overcome barriers to LIPD implementation. Finally, based on the research findings, this study developed a novel framework that enables industry practitioners to explore strategies to accelerate successful LIPD implementations in the CI. This study adds to the body of knowledge by revealing the viability of LIPD implementation for the first time in the SL context and then by providing a LIPD implementation framework for the general CI, its practitioners, and policymakers, rather than limiting it to a specific sector of CI, as previous studies have done. Considering the SL context, this research found the necessity of involving policymakers, particularly the CI Development Authority and relevant ministries, in developing strategies to encourage LIPD implementation. This additional knowledge about LIPD can be further incorporated into the tertiary and vocational education syllabuses to increase the awareness of LIPD among students who are soon to become CI stakeholders. Future research can be directed towards applying this novel LIPD implementation framework in any similar socio-economic, demographic, or culturally trailed CI context (i.e., CI that has established opinions about IPD and lean concepts, but sufficient initiatives have not been made by its professionals to integrate those concepts) by fine tuning the factors that are being recognised only by the SL CI experts.

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