Vásquez-Hernández, A., Alarcón. L.F. & Pellicer, E. (2024). Business models emerging from industrialized construction adoption. In D. B. Costa, F. Drevland & L. Florez-Perez (Eds.), *Proceedings of the 32nd Annual Conference of the International Group for Lean Construction* (IGLC32) (pp. 869–880). doi.org/10.24928/2024/0184

BUSINESS MODELS EMERGING FROM INDUSTRIALIZED CONSTRUCTION ADOPTION

Alejandro Vásquez-Hernández[1], Luis Fernando Alarcón[2] and Eugenio Pellicer[3]

ABSTRACT

Industrialized Construction (IC) has been recognized as a promising approach to improving project performance. However, its benefits are not evident in the building as an entity. The background of IC reveals approaches limited to production methods, overlooking issues related to process, collaboration, supply chain, and market. IC represents a novel strategic approach for the construction sector, introducing a business logic distinct from that of project-based companies, which is timely to understand within the context of managing IC adoption. Business models (BMs) are constructs that can be employed as tools to describe and analyze such business logic. This article aims to identify in the literature the constructs proposed for analyzing BMs associated with IC adoption, their approaches, and business-configuring elements, and to identify the business models associated with cases reported in the literature. A systematic literature review and content analysis were conducted. The results revealed fourteen proposed BMs frameworks and two approaches to IC BMs. Furthermore, following the analysis of reported cases, thirteen BMs were identified, associated with seven groupings based on the roles and value chain clustering strategies linked to IC adoption.

KEYWORDS

Industrialized construction, modular construction, off-site construction, business model.

INTRODUCTION

The construction industry can mitigate the adverse effects of its relatively unstable production environment in two ways: by minimizing its peculiarities to leverage methods developed in other industries, or by developing techniques within the sector itself to address its dynamic nature (Vrijhoef & Koskela, 2005). These two approaches are closely related in the pursuit of lean construction, as aligning construction with manufacturing logics is a conducive scenario for lean (Egan, 1998). In turn, minimizing construction peculiarities involves achieving the lean objective of controlling processes (Vrijhoef & Koskela, 2005). Industrialized construction (IC) serves as a structural means for the former approach by adopting project-independent strategies and transferring site activities to the supply chain. However, the expected benefits of this approach have not yet been fully realized in the case of buildings as entities (Richard, 2012).

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The background of IC reveals a focus that is limited to production methods, neglecting aspects of process, collaboration, supply chain, and market issues (Lessing, 2015). Many emerging problems in IC implementation experiences relate to adoption processes under a conventional context, in terms of organizational structures, project development models, working methods, and procurement methods (Ahamad et al., 2020). IC represents a new strategic approach for the construction sector (Hall et al., 2022). Its business logic differs from that of conventional construction companies, which are project-based (Lessing & Brege, 2015). Therefore, it is timely to understand how companies that have adopted IC operate. Business Models (BMs) are constructs that can be used as tools for such descriptions and analyses (Lessing & Brege, 2015). BMs are mechanisms through which a company's strategy is translated into a model of the logic for making money (Osterwalder et al., 2005) (Zott & Amit, 2008), emphasizing a systemic perspective on conducting business and aiming to explain both value creation and capture (Pan & Goodier, 2012). In this sense, it constitutes a unit of analysis in addition to product, company, industry, or network levels (Pan & Goodier, 2012).

In light of the above, this article seeks to identify in the literature the constructs proposed for the analysis of BMs associated with the adoption of IC, their approaches, and business elements. Furthermore, by understanding business models as configurations of business elements (Brege et al., 2014), this study aims to identify the business models associated with reported cases in the literature of companies adopting IC, through the analysis of patterns in how the different configuring elements of BMs are presented.

RESEARCH METHOD

A systematic literature review was conducted to identify the frameworks for analyzing BMs of IC and to identify case studies of companies adopting IC based on BM frameworks. Using database searches in electronic databases Scopus and Web of Science, a targeted search was carried out to identify related papers. The selection criteria for these databases were their extensive coverage in the research field (Chadegani et al., 2013). The search terms included "business model" combined with "industrialized construction," "industrialized building system," "modular construction," "off-site construction," "modern method of construction," or "prefabricated construction." Additionally, an exclusion criterion was applied to remove irrelevant articles, specifically those not including a BM analysis framework or descriptive reporting of BMs of IC-adopting companies identified empirically through case studies. A complementary search was performed using backward snowballing (Webster & Watson, 2002) to ensure thorough coverage of relevant literature.

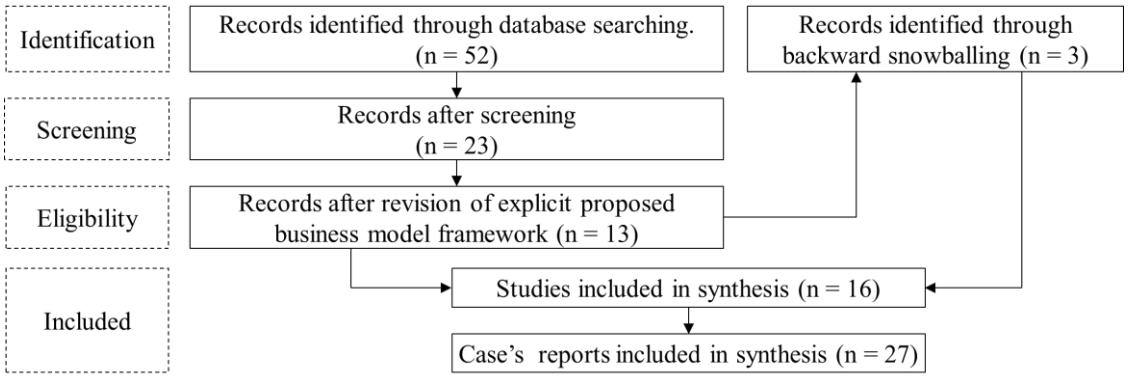


Figure 1. Information collection record. PRISMA Flowchart.

A content analysis approach (Krippendorff, 2004) was employed to examine the data gathered from the literature. Various frameworks for analyzing BMs of IC proposed and/or used by researchers were identified and analyzed. Different approaches and specific constituent

elements of each BM analysis framework in IC were identified. Based on the identified BM elements, an analysis framework was adapted for characterizing the identified case studies. Through the identification of patterns in the presentation of different BM configuration elements in the case studies, the various business models of the analyzed cases were identified.

BUSINESS MODELS IN INDUSTRIALIZED CONSTRUCTION

From the literature review, sixteen studies were identified. These studies, along with their country of origin and the identifiers of the case studies they report, are presented in Table 1.

Table 1: Studies and cases resulting from the literature review.

Authors	Country	Reported case IDs
(Rinas & Girmscheid, 2010)	Switzerland	-
(Johnsson, 2011)	Sweden	1, 2
(Girmscheid & Rinas, 2012)	Switzerland	-
(Pan & Goodier, 2012)	UK	3, 4, 5, 6
(Kamar et al., 2012)	Malaysia	7,8, 9
(Brege et al., 2014)	Sweden	10a, 10b, 11a, 11b, 12, 13a, 13b, 14a, 14b
(Höök & Stehn, 2014)	Sweden	-
(Höök et al., 2015)	Sweden	-
(Lessing & Brege, 2015)	Sweden	16, 17
(Lessing & Brege, 2017)	Sweden- US	11a, 15, 16, 17, 18, 19, 20, 21, 22, 23
(Mohamed et al., 2019)	Malaysia	25, 26, 27
(Mueller, 2021)	Germany	-
(Mohamed et al., 2021)	Malaysia	-
(Lepinoy et al., 2022)	US	-
(Hall et al., 2022)	Sweden- US	15, 21, 27
(Saad et al., 2023)	UK	-

*Cases with subscripts ("a" and "b") in the identifier correspond to different business models within the same company. **Some case studies were reported in more than one article.

APPROACHES AND ELEMENTS OF BM

The set of elements that constitute BMs and their involved relationships allow for the articulation of a particular company's business (Osterwalder et al., 2005). There are differing viewpoints among researchers regarding the specific constituent elements of a BM (Brege et al., 2014). However, the offered value proposition and the way in which the offered value is configured and delivered are two aspects commonly held (Höök & Stehn, 2014).

Magretta describes BMs as "stories that explain how enterprises work" and suggests that a good business model answers the questions: Who is the customer? What does the customer value? How do we make money in this business? What underlying economic logic explains how we can deliver value to customers at an appropriate cost? (Magretta, 2002). Building on this, the configurative elements of BMs can be classified into four groups that respond to the question: What? Whom? How? And how much? These groups account for the company's value offering, the targeted customer, the way value is configured, and the benefits equation.

Furthermore, there are varying perspectives on whether adopting IC acts as a driving force in forming new BMs or if the IC adoption fits within established BMs. Figure 1 presents the BM configuration frameworks as a combination of elements proposed by different authors in their approaches to analyzing BMs in IC contexts, their associated elements with the mentioned questions, and the approaches identified.

In the exploration of BMs within the realm of IC, a diversity of approaches has been discerned. These approaches delineate the strategic frameworks proposed by researchers to understand the interplay between IC adoption and BM innovation. Presented herein are the varied perspectives unearthed from the analysis, each underscoring distinct facets of business model configuration in the context of IC.

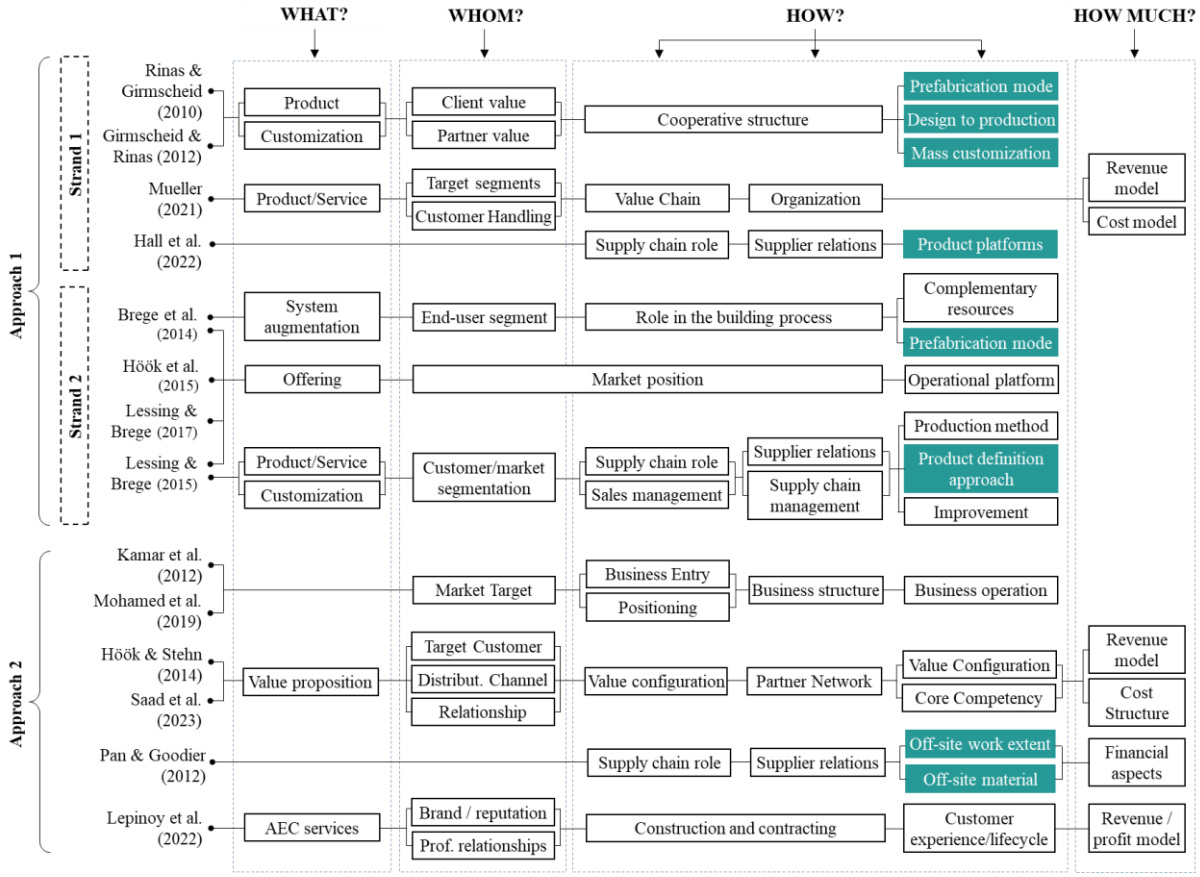


Figure 1: Approaches and elements of BM

Approach 1: IC as a driving force in the formation of BM

This perspective views IC as a driving force in the creation of new or modified business models (Brege et al., 2014). This view is echoed by Lessing et al. (2017), who highlighted that production strategies, business models, and company organization should be specifically designed and structured for IC to reap the benefits of industrialization. From this viewpoint, a clear demarcation exists between project-oriented BMs, which are traditional models for constructing unique projects using on-site methods, and product and/or process-oriented BMs, which are based on prefabrication strategies and product platforms characteristic of IC adoption (Lessing & Brege, 2015). From this approach, two strands were identified:

Strand 1: BM as a supply chain aggregation strategy. Contrasting with the extreme fragmentation characterizing the construction industry, where independent companies temporarily organize to design and build a new project, IC is seen as an effort to reorganize and build continuous production systems (Hall et al., 2022). New business models within this approach represent efforts to deliver buildings in a more integrated manner throughout their lifecycle (Hall et al., 2022), spurred by the adoption of IC methodologies. While this approach also touches upon product ranges and market goals, the BM focus is on models of actor integration; hence, the identified business models are configured based on these variations.

In this direction, the framework proposed by Rinas & Girmscheid (2010) advocates for a cooperative approach, viewed as promising for linking complementary competencies and

providing holistic solutions. This model emphasizes cooperation among various actors, such as prefabrication companies, local architects, and other partners, to bolster IC. It includes two cooperative dimensions: one oriented towards production, encompassing development and manufacturing, and another towards sales, covering assembly and sales. Furthermore, Mueller (2021) introduces a framework to categorize the spectrum of IC approaches from a business strategy perspective. This framework conceptually outlines six dimensions classified in pairs on scales: market vision (targeting segments and solution characteristics), the underlying business model (value chain position and value chain organization), and technological approach (scope of industrialization and level of pre-specification). As such, market elements and strategic focus are regarded as distinct strategic dimensions apart from the business model, which incorporates value chain elements. Additionally, Hall et al. (2022) suggest that the new BM for IC is characterized by longitudinal continuity, as opposed to a project-based orientation. It is the focus on IC that facilitates this novel form of longitudinal continuity, through the development of product platforms, providing a mechanism for continuously establishing and enhancing organizational knowledge about the construction technical system. Products not manufactured by the company are sourced through long-term partnerships within the supply chain, rather than through competitive bidding.

Strand 2: BM as a construct supported by three pillars: offer, market position, and operational platform. Beyond efforts to reorganize the value chain, this line of approaches supports the understanding of BMs from the construct proposed by Brege et al. (2014), which is predicated on three pillars: offer, market position, and operational platform. This framework articulates a clear distinction between strategic effectiveness and operational effectiveness, with market platforms indicative of the former and operational platforms denoting the latter.

This analytical framework is further explored in the works of Höök et al. (2015), Lessing & Brege (2015), and Lessing & Brege (2017). Within this framework, Brege et al. (2014) and Lessing & Brege (2015) delineate the foundational element for model construction from an IC perspective, alongside the necessary complementary elements. Brege et al. (2014) posit the level of prefabrication as the model's central element and identify four essential complementary elements: system enhancement (offer), end-user segments (market position), roles in the construction process (market position), and complementary resources for design and on-site construction (operational platform). Conversely, Lessing & Brege (2015) posit the product platform as the inception point for BM design and as the principal resource of the operational platform. This product-oriented approach is considered complementary, extending the scope of investigation to encompass construction companies not necessarily tethered to specific productive resources at the outset of BM design.

Furthermore, Lessing & Brege (2015) distinguish between IC business models: production-oriented and product-oriented BMs. Product-oriented BMs are characterized by their reliance on a product-based offer, anchored in a product platform, serving as the foundational or initial point. Conversely, production-oriented BMs prioritize off-site production methods as the starting point, concentrating on the production facet of novel construction concepts.

Approach 2: IC fits into established BMs

The proposals within this approach are predicated on the notion that IC does not inherently introduce distinguishing attributes between BMs. The proponents of this viewpoint concentrate on how IC adoption aligns with, or necessitates adaptations to, pre-existing BMs.

Some researchers investigating BMs in IC leverage the Business Strategy concept, drawing on the foundational ideas of Porter, who articulates strategy as the crafting of a unique and valuable position through a distinct set of activities (Porter, 1996), and Thompson et al., who envisage strategy as management's action plan to grow the business, secure a competitive market position, attract and satisfy customers, compete successfully, conduct operations, and achieve targeted objectives (Thompson et al., 2006). The analytical framework employed is

delineated by Kamar et al. (2012), encompassing five key elements: business entry, business positioning, market target, business structure, and business operation. This framework was utilized by Kamar et al. (2012) in examining IC adoption among large contractors and by Mohamed et al. (2019) among small and medium-sized construction enterprises.

Höök & Stehn (2014) and Saad et al. (2023) ground their models in the framework developed by Osterwalder et al. (Osterwalder et al., 2005), known as the Business Model Canvas. This model is structured around four foundational pillars—product, customer interface, infrastructure management, and financial aspects—and articulates nine interconnected elements: Value Proposition, Target Customer, Distribution Channel, Relationship, Value Configuration, Core Competency, Partner Network, Cost Structure, and Revenue Model.

Similarly, Pan and Goodier (2012) base their approach on the BM categorizations proposed by Ball (Ball, 2010), specifically tailored to the UK housing construction sector. These categorizations are developed with a focus on the construction process and its associated activities, highlighting the role of the company within this framework. Through an analysis of the practices of leading private home builders in the UK, who are progressively embracing IC, the authors pinpoint innovative procurement and supply chain strategies that emerge or are catalyzed by the adoption of off-site construction methodologies. Likewise, Lepinoy et al. (2022) introduce an analytical framework supported by four pillars: value proposition, generating demand, fulfilling promises, and sustaining growth. These pillars are paired with six elements: architecture, engineering, and construction services; revenue and profit model; brand and reputation; professional or other influencer relationships; construction and contracting; and customer experience and lifecycle. This framework aims to provide a comprehensive understanding of how IC can be integrated into existing business models, emphasizing the strategic and operational adjustments necessitated by this integration.

IDENTIFICATION OF BMS

Some of the studies included in the analysis (50%) feature case reports associated with companies that have adopted IC (see Table 1). To analyze these case studies, a common analytical framework was established to integrate the information reported and to identify the types of BMs associated with the different cases. The defined framework is an adaptation of the proposal by Bregue et al. (2014), which is the base framework associated with Strand 2. The choice of this framework is based on two premises: *(i)* the number of case studies reported using this analytical framework; 37.5% of the articles that reported case studies used this framework as a basis and the case studies reported in these articles account for 51.8% of the total. *(ii)* It explicitly includes IC as a driving force in the formation of new or modified BMs.

The framework by Bregue et al. (2014) was adapted in terms of elements in two ways: the inclusion of the element 'supplier relations', as adapted by Lessing et al. (2015), to explicitly outline the value chain reorganization strategies, which are the focus of the frameworks associated with Strand 1. Furthermore, the inclusion of 'predefinition level,' as adapted by Lessing et al. (2017), as a complementary element to 'prefabrication level' in the IC approach.

Accordingly, the analytical framework employed for examining the case study data is anchored in three core pillars: Offering, Market Position, and Operational Platform. It further is delineated by six elements: Scope of Offering (pertaining to Offering), Marketplace Role and Value Chain Role (relating to Market Position), as well as Value Chain Relations, Predefinition Level, and Prefabrication Level (associated with Operational Platform). Each of these components is elaborated upon as follows:

Offering: It embodies the company's value proposition (Lessing & Brege, 2015). It encompasses the amalgamation of physical products and services provided to customers and is often conceptualized as a blend of hardware, software, and services, sometimes coupled with a revenue generation model (Brege et al., 2014).

- Scope of Offering: It represents the breadth of the offering in terms of added value, manifested in the combination of the level of prefabrication and the company's role in the value chain (Brege et al., 2014).

Market Position: It delineates the company's role within the market and value chain.

- Marketplace Role: It describes the customer segments to which a company aims to deliver value (Osterwalder et al., 2005). The spectrum of segments ranges from variable concepts of offering with broad market coverage to niche market orientations with highly standardized and specific solutions.
- Value Chain Role: The company's position in the building process, which is associated with the level of control it exercises over the value chain (Lessing & Brege, 2015).

Operational Platform: Company's internal resources and competencies, alongside complementary external resources from suppliers and partners, and how these elements are organized and utilized.

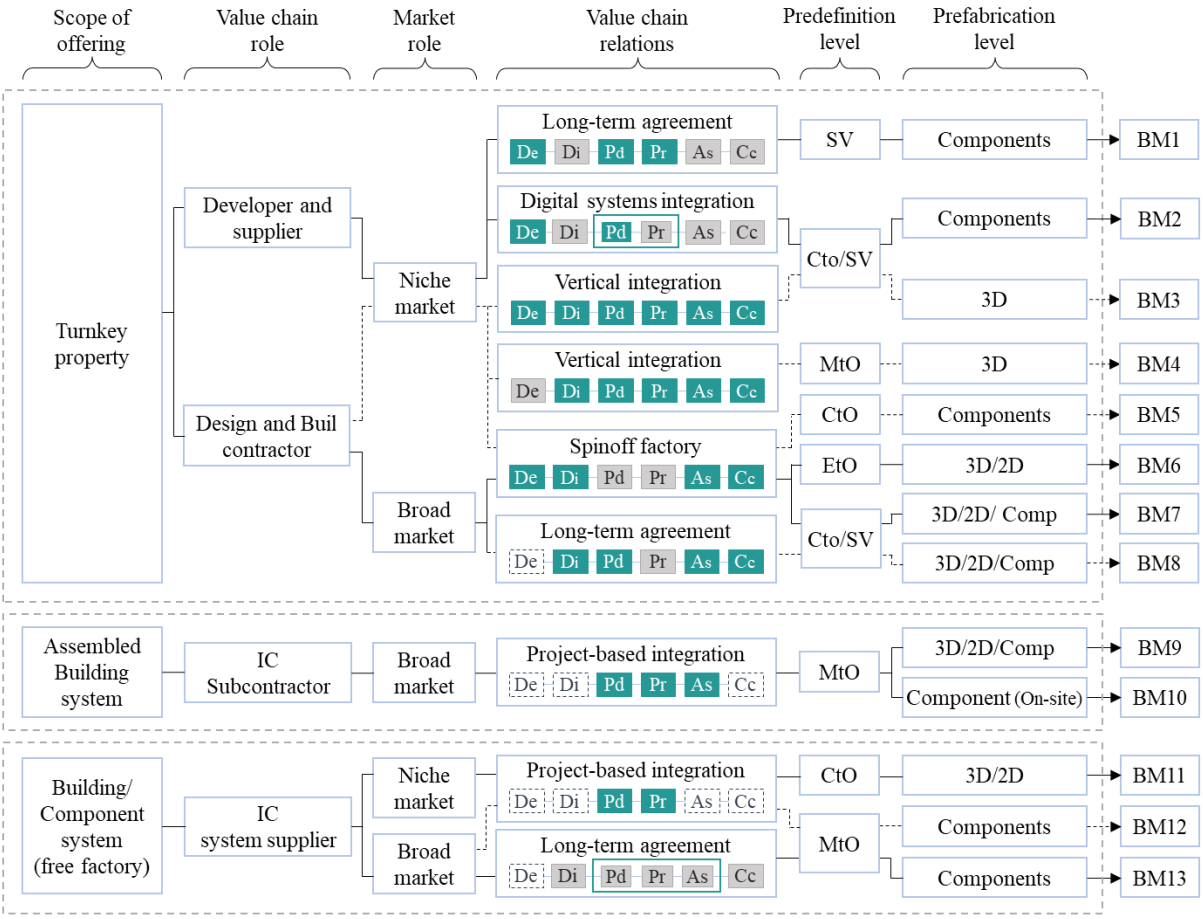
- Value Chain Relations: Access to external resources from suppliers and partners involves five strategies: *Vertical Integration*, referring to companies that maintain control over product architecture and processes internally (Hall et al., 2022); *Digital System Integration*, where long-term relationships with partners in design, procurement, manufacturing, and assembly stages are built through digital platforms (Hall et al., 2022); *Spinoff Factory*, related to the creation of a new factory or business line originating from an existing project-based company (Hall et al., 2022); *Long-term Agreement*, linked to long-term commercial and collaborative agreements with external companies, not limited solely to the project scale; *Project-based Integration*, associated with formal and informal integration strategies confined to the project scale.
- Predefinition level: Indicates the standardization level and defines the entry point for design customization (Mueller, 2021). Following Hvam et al. (2008), Lessing and Brege (2015) outline four levels: *Engineer to Order (EtO)*, employing industry norms as starting points in client-controlled project design; *Modify to Order (MtO)*, using established technical solutions and predefined geometries for essential components within project-specific designs; *Configure to Order (CtO)*, employing set parts and modules in a uniform configuration approach; and *Select Product Variant (SV)*, achieving near-final construction with predetermined variations, significantly reducing the need for project-specific designs by pre-setting most details (Hvam et al., 2008).
- Prefabrication level: Three levels of prefabrication in construction systems are identified: 3D elements, 2D elements, and component systems, all associated with off-site production. Additionally, within the component systems level, a distinction is made between off-site prefabricated elements and those associated with mobile factories, where the process occurs on-site. This distinction is highlighted in two of the case studies reported by Mohamed et al. (2019).

BMs of IC identified

Through the analysis of patterns in the various combinations or configurations of elements presented in the reported cases of companies adopting IC, thirteen BMs were identified, as depicted in Figure 2. These identified BMs can be categorized based on similarities in roles and value chain aggregation strategies adopted. The categorizations are outlined as follows:

(i) Contractor-developer and owner of the construction system and manufacturing facilities (BM3 and BM4). The value chain is integrated vertically, whereby contractors maintain complete control, allowing them to directly reap the benefits associated with repetition and systematic improvement. This strategy fosters horizontal, vertical, and longitudinal integration

but requires taking on the risks associated with the development and deployment of fixed capital assets, as well as the costs of operating and maintaining manufacturing facilities. In the studied cases, the companies adopting this strategy are contractors that have embraced IC from their inception, offering turnkey property solutions and prefabrication at the 3D element level. However, this approach is observed in companies targeting specific market niches with high levels of predefinition (CtO/SV) (BM3), as well as in companies aiming for broad market coverage with low levels of predefinition (MtO) (BM4).



De = Project development; Di = Project design; Pd = Product design; Pr = Off-site production; As = Assembly; Cc = Construction and coordination.
= In-house; = Partner/Long-term relation; = Outsourced.

BM1: case 16; **BM2:** cases 17, 21; **BM3:** cases 1, 6, 8, 9, 10a, 10b*, 11a, 12, 15; **BM4:** case 23; **BM5:** case 20; **BM6:** cases 19, 27; **BM7:** cases 3, 4, 22, 25; **BM8:** cases 2, 7**; **BM9:** cases 13b; **BM10:** cases 24, 26; **BM11:** cases 5, 11B; **BM12:** cases 13a, 14a***, 14b; **BM13:** case 18.
*In addition to turnkey property, the company's offer includes the operation (build-to-own).
**The company established a joint venture agreement for off-site production.
***The company offers technical support in the design and on-site production/coordination phases, which implies having complementary resources.

Figure 2: Identified BM´s

(ii) Contractor-developer of construction systems and manufacturing facilities via spinoff (BM5, BM6, and BM7). This strategy is employed by 100% of the studied cases where the company is a conventional contractor adopting IC. These project-based contractor companies integrate system development and off-site production phases through a new product/process-oriented business line. This approach allows project-based companies to balance project demands with the need for longitudinal continuity centered around the factory. However, the integration achieved is partial and depends on an internal integrator agent continuously updating and educating the existing supply chain about the new factory's capabilities (Hall et al., 2022). This strategy is linked to turnkey property solutions. It is adopted by companies targeting specific market niches with a high level of predefinition (CtO) and component-level prefabrication, as

well as by companies offering low levels of predefinition (EtO/MtO), covering various prefabrication levels, aimed at broad market coverage.

(iii) Contractor-developer and owner of externally manufactured construction systems (BM8). This model is utilized by contractor companies that establish long-term agreements to integrate the off-site production phase. The prefabrication of construction systems is conducted off-site and outsourced to external industrial suppliers, yet the contractor remains the developer and owner of the construction system. The primary rationale behind this approach is that contractors seek to control the design of the construction system while avoiding the risk of fixed capital investments in manufacturing facilities. Although off-site production is outsourced, it necessitates commercial relationships that extend beyond individual construction projects and framework agreements that ensure a steady supply of construction systems at the required rate. Such agreements are also vital for industrial suppliers, providing them with a guarantee of consistent demand, thereby reducing the investment risk in capital goods. This arrangement also facilitates early-stage involvement of the industrial supplier (Andersson & Lessing, 2017). In the cases studied, companies adopting this strategy are contractors that have incorporated IC from their inception, offering turnkey property solutions, low levels of predefinition (MtO), covering various prefabrication levels, and aimed at broad market coverage.

(iv) Contractor as purchaser of IC goods and services (BM9, BM10, BM11, and BM12). This strategy aligns with IC implementations in value chains characterized by minimal integration, stemming from a fragmented process dominated by short-term relationships (Cox & Ireland, 2002). Contractors procure construction systems developed and manufactured by external entities, subcontractors in the case of BM8 and BM9, which include on-site assembly, and free factory system providers in the case of BM11 and BM12. Relationships with these subcontractors and suppliers are limited to the project scale, hindering effective cooperation, efficient information exchange, and innovation drives, leading to suboptimization and productivity losses (Winch, 2010). To mitigate the impacts of this fragmentation, the company associated with case 14a, implementing BM12, provides technical support in design phases, construction, and on-site coordination, requiring additional resources. However, the achieved integration remains informal (Hall et al., 2022). The studied cases include adoption of this strategy with offerings both aimed at specific market niches, with construction systems of high predefinition level (CtO) and prefabrication at the 3D and 2D element levels (BM12), and broad market coverage offerings, with construction systems of low predefinition level (MtO) covering various prefabrication levels (BM9, BM10, and BM12). BM10 features a unique aspect regarding the mode of prefabrication, observed in cases where industrial suppliers do not have a permanent manufacturing facility but rather a mobile factory that is commissioned per project to save on logistics costs.

(v) Project developer and supplier of own construction system manufactured in-house (BM1). These are project-configuring companies that own a construction system developed and manufactured in-house, within their own facilities. Assembly, construction, and on-site coordination tasks are performed by long-term collaborative partners. The associated offering is turnkey property solutions, with component-level prefabrication, high predefinition (SV), and targeted at a specific market niche.

(vi) Project developer and supplier of proprietary construction system manufactured externally (BM2). These companies are project configurators owning a construction system developed in-house. However, instead of establishing their own production facilities, they partner with specialized manufacturers and suppliers. Local contractors carry out the assembly. The company retains ownership of the concept, managing and orchestrating the delivery of component kits to project sites. Value chain integration is achieved through a digital systems integration approach, allowing for the manufacture of parts through peripheral supply chain partners (Hall et al., 2022). Digital platforms enable the building of long-term relationships with

partners in design, procurement, manufacturing, and assembly stages. This strategy enables growth by establishing new partner networks without the need to invest in creating their own production facilities. The associated offering is the supply of a component system (free factory) with a high level of predefinition (CtO, SV), targeted at a specific market niche.

(vii) Supplier of own construction system manufactured externally (BM13). The company supplies a construction system with a low level of predefinition (MtO), targeting broad market coverage. The prefabrication level is component-based, and the company-owned structural system can be adapted for various building configurations. The company also partners with subsystem suppliers to integrate them into the complete building system. Product design, production, and assembly are all outsourced, aligning with the company's strategy to avoid high-capital investments and specific manufacturing commitments. This BM is defined by subcontracting as a fundamental principle, suitable for companies with limited internal resources. Close relationships with partners ensure access to external product development, production capabilities, and market presence, all while maintaining minimal financial risk (Lessing & Brege, 2017).

CONCLUSIONS

A systematic review of the literature on BM analytical frameworks within IC was undertaken, and a content analysis oriented to identify the distinct constitutive elements of a BM, the approaches, and the BMs associated with documented instances of IC adoption by companies. This inquiry uncovered fourteen proposed BM frameworks and delineated two approaches to BMs in the context of IC. Furthermore, 27 case reports detailing the operational practices of companies that have implemented IC, framed within a BM analysis, were found. Analysis of these cases led to identifying thirteen distinct BMs, which were categorized based on their roles and the strategies they employ for value chain integration within the realm of IC adoption.

The identified frameworks present two main perspectives: considering IC as a driving force in creating new business models and viewing IC as not defining attributes that necessitate new models but rather fitting into conventional BMs or deriving adaptations from them.

An adaptation of the model proposed by Brege et al. (2014) was presented, enabling the integration of information from reported cases. This adaptation faced limitations related to the integrated elements. The customization element is crucial for categorizing both a company's offering and the market standard it targets. However, only three of the discovered frameworks included explicit descriptions of this aspect, thus not constituting a common element that would allow for a joint characterization of the identified cases.

Seven BM groupings were identified based on the roles performed and the value chain aggregation strategies: *(i)* Contractor-developer and owner of the construction system and manufacturing facilities; *(ii)* Contractor-developer of construction systems and manufacturing facilities via spinoff; *(iii)* Contractor-developer and owner of externally manufactured construction systems; *(iv)* Contractor as purchaser of IC goods and services; *(v)* Project developer and supplier of own construction system manufactured in-house; *(vi)* Project developer and supplier of proprietary construction system manufactured externally; and *(vii)* Supplier of own construction system manufactured externally.

LIMITATIONS AND FUTURE RESEARCH

The cases analyzed originate from six countries, with a notable concentration of 55% coming from Sweden. This uneven distribution may introduce inherent bias, particularly considering that most Swedish literature on BMs of IC focuses on residential construction. This bias limits the generalizability of the findings to other geographical contexts and market sectors. It is recommended that future research explores BMs of IC from a broader perspective, including other market sectors and business practices from different regions.

ACKNOWLEDGMENTS

The authors wish to acknowledge financial support from ANID through the FONDECYT Regular project No. 1210769 and extend their gratitude to ANID for funding the first author's postgraduate studies through the National Doctorate Scholarship 2022-21220895.

REFERENCES

Ahamad, N. B., Binti Mazlan, A. N., Zin, R. M., & Tukirin, S. A. (2020). Construction Procurement in Industrialised Building System. *IOP Conference Series: Materials Science and Engineering*, *849*(1), 0–7. https://doi.org/10.1088/1757-899X/849/1/012072

Andersson, N., & Lessing, J. (2017). The Interface between Industrialized and Project Based Construction. *Procedia Engineering*, *196*(June), 220–227. https://doi.org/10.1016/j.proeng.2017.07.193

Ball, M. (2010). *The housebuilding industry: Promoting recovery in housing supply.*

Brege, S., Stehn, L., & Nord, T. (2014). Business models in industrialized building of multi-storey houses. *Construction Management and Economics*, *32*(1–2), 208–226. https://doi.org/10.1080/01446193.2013.840734

Chadegani, A. A., Salehi, H., Yunus, M. M., Farhadi, H., Fooladi, M., Farhadi, M., & Ebrahim, N. A. (2013). A Comparison between Two Main Academic Literature Collections: Web of Science and Scopus Databases. *Asian Social Science*, *9*(5). https://doi.org/10.5539/ass.v9n5p18

Cox, A., & Ireland, P. (2002). Managing construction supply chains: the common sense approach. *Engineering Construction and Architectural Management*, *9*, 409–418.

Egan, J. (1998). *Re-thinking construction*. DETR.

Girmscheid, G., & Rinas, T. (2012). Business Design Modeling for Industrialization in Construction: Cooperative Approach. *Journal of Architectural Engineering*, *18*(2), 164–175. https://doi.org/10.1061/(ASCE)AE.1943-5568.0000089

Hall, D. M., Lessing, J., & Whyte, J. (2022). New Business Models for Industrialized Construction. In *Structural Integrity* (Vol. 20, pp. 297–314). https://doi.org/10.1007/978-3-030-82430-3_13

Höök, M., & Stehn, L. (2014). Exploring the management of multiple business models in one company. *Proceedings 30th Annual Association of Researchers in Construction Management Conference, ARCOM 2014*, *September*, 1315–1324.

Höök, M., Stehn, L., & Brege, S. (2015). The development of a portfolio of business models: a longitudinal case study of a building material company. *Construction Management and Economics*, *33*(5–6), 334–348. https://doi.org/10.1080/01446193.2015.1075052

Hvam, L., Mortensen, N. H., & Riis, J. (2008). *Product Customisation*. Springer Verlag Science and Business Media.

Johnsson, H. (2011). The building system as a strategic asset in industrialised construction. *6th Nordic Conference on Construction Economics and Organisation, Barney 1991*, 541–552. http://urn.kb.se/resolve?urn=urn:nbn:se:ltu:diva-27480

Kamar, K. A. M., Hamid, Z. A., Ghani, M. K., Rahim, A. H. A., Zain, M. Z. M., & Ambon, F. (2012). Business strategy of large contractors in adopting industrialised building system (IBS): The Malaysian case. *Journal of Engineering Science and Technology*, *7*(6), 774–784.

Krippendorff, K. (2004). *Content Analysis: an Introduction to its Methodology* (2nd ed.). SAGE Publications.

Lepinoy, O., Heide, G. van der, & Moore, C. (2022). Innovation in Construction. In S. H. Ghaffar, P. Mullett, E. Pei, & J. Roberts (Eds.), *Innovation in Construction. A Practical Guide to Transforming the Construction Industry* (pp. 355–408). Springer International Publishing. https://doi.org/10.1007/978-3-030-95798-8

Lessing, J. (2015). *Industrialised House-Building, Conceptual Orientation and strategic perspectives*. Faculty of Engineering, Lund University.

Lessing, J., & Brege, S. (2015). Business models for product-oriented house-building companies - experience from two Swedish case studies. *Construction Innovation*, *15*(4), 449–472. https://doi.org/10.1108/CI-02-2015-0009

Lessing, J., & Brege, S. (2017). Industrialized Building Companies' Business Models: Multiple Case Study of Swedish and North American Companies. *Journal of Construction Engineering and Management*, *144*(2), 05017019. https://doi.org/10.1061/(ASCE)CO.1943-7862.0001368

Magretta, J. (2002). Why business models matter. *Harvard Business Review*, *May*, 3–8.

Mohamed, M. R., Mohammad, M. F., & Mahbub, R. (2021). Business Model Elements for Industrialised Building System. *International Journal of Academic Research in Business and Social Sciences*, *11*(4). https://doi.org/10.6007/IJARBSS/v11-i4/9687

Mohamed, M. R., Mohammad, M. F., Mahbub, R., Ramli, M. A., Gunasagaran, S., & Halim, S. M. A. (2019). Business Strategy of Small and Medium-Sized Enterprise Construction Companies in Adopting Industrialised Building System in Malaysia. *International Journal of Academic Research in Business and Social Sciences*, *9*(9). https://doi.org/10.6007/IJARBSS/v9-i9/6407

Mueller, B. (2021). *Business Innovation Framework for Industrialized Construction*. Technical University of Munich.

Osterwalder, A., Pigneur, Y., & Tucci, C. L. (2005). Clarifying Business Models: Origins, Present, and Future of the Concept. *Communications of the Association for Information Systems*, *16*(July). https://doi.org/10.17705/1CAIS.01601

Pan, W., & Goodier, C. (2012). House-Building Business Models and Off-Site Construction Take-Up. *Journal of Architectural Engineering*, *18*(2), 84–93. https://doi.org/10.1061/(ASCE)AE.1943-5568.0000058

Porter, M. E. (1996). What is strategy? *Harvard Business Review*, *november–d*, 33–55.

Richard, R. B. (2012). Industrialised Building Systems: the "Palette" of Options. *2012 ACSA Fall Conference*, 315–321.

Rinas, T., & Girmscheid, G. (2010). Business model of the prefab concrete industry – a two-dimensional cooperation network. In Ghafoori (ed.) (Ed.), *Challenges, Opportunities and Solutions in Structural Engineering and Construction* (pp. 677–682). Taylor & Francis Group.

Saad, A. M., Dulaimi, M., & Zulu, S. L. (2023). Broader use of the Modern Methods of Construction (MMC) in the UK public sector: A Business Model Canvas (BMC) perspective. *Journal of Open Innovation: Technology, Market, and Complexity*, *9*(2), 100035. https://doi.org/10.1016/j.joitmc.2023.100035

Thompson, A. A., Gamble, J. E., & Strickland, A. J. (2006). *Strategy, winning in the marketplace: core concepts, analytical tools, cases*. McGraw-Hill/Irwin.

Vrijhoef, R., & Koskela, L. (2005). Revisiting the three peculiarities of production in construction. *13th International Group for Lean Construction Conference*, 19–27.

Webster, J., & Watson, R. T. (2002). Analyzing the Past to Prepare for the Future: Writing a Literature Review. *MIS Quarterly*, *26*(2), xiii–xxiii.

Winch, G. M. (2010). *Managing Construction Projects*. Wiley-Blackwell.

Zott, C., & Amit, R. (2008). The fit between product market strategy and business model: implications for firm performance. *Strategic Management Journal*, *29*(1), 1–26. https://doi.org/10.1002/smj.642