New Business Models for Industrialized Construction

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Abstract The past few years have seen new entrants into the construction sector backed with unprecedented levels of funding from venture capital funds or other large investment firms. These entrants seek to leverage industry 4.0 principles for the digitalization and industrialization of construction. In addition to new technologies, these firms also bring new business models that depart from the project-based tendering system found in traditional construction. The first new business model is *vertical integration*. These firms are structured as integrated hierarchical firms, keeping control of product architecture and processes in-house. These firms control production by developing their own off-site factories. The second new business model is *digital systems integration*. These firms leverage an integrated cloud-based product configurator to enable mass customization. Using principles of capital-light industry 4.0 supply chains, digital system integrators can manufacture parts from periphery supply chain partners suppliers, including new sectors such as automotive, aerospace, manufacturing or industrial. The third new business model is the transformation of an existing project-based business toward industrialized construction through the creation of a *spinoff factories*.

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The chapter includes examples of the three business models and concludes with a discussion of how new business models may be catalysts for potential disruption of the established construction sector.

Keywords Industrialized construction · Industry 4.0 · Business models · Factory

1 The Rise of Industrialized Construction

Industrialized construction is a broad term that can be used to describe the new conceptual orientation and strategic perspective emerging within construction sector. As construction industrializes, it also creates opportunities for new business models. A business model explains the logic of the firm, the way it operates, and how it creates value for its stakeholders [1].

In the past, the construction sector has been characterized by extreme fragmentation between stakeholders. Independent firms organize together on a temporary basis to design and construct a new construction project. By contrast, industrialized construction represents an attempt at re-organization to build continuous and industrialized production systems. The investment in such production systems also requires more specific market targets and product ranges [2].

It is a mistake to narrowly define the industrialization of construction only as a strategy to move away from on-site craft production and toward advanced manufacturing in a controlled factory environment. However, this mistake is made often and industrialized construction is considered synonymous with terms such as off-site manufacturing, prefabrication, or modular construction. In this chapter, we argue that industrialized construction should be considered as a far more holistic and encompassing approach that should not be confused with the means of production alone.

Instead, industrialized construction includes a new strategic orientation that develops long-term relationships between participants, integrates advanced supply chain management and logistics, designs new technical systems that better support manufacturing and assembly activities, captures experience and knowledge for continuous improvement, improves the planning and control of processes, and increases understanding of customer requirements and market forces [3]. In other words, industrialized construction is an entirely new strategic approach for the construction sector. This new strategic approach opens an opportunity for the development of new business models that can capture value from a new way of thinking about construction[

Investors, financiers and governments are also paying attention to how the construction sector is evolving. From the private sector, venture capital and large investment firms have committed unprecedented levels of funding to industrialized construction startup firms. For example, in 2019 Japan's Softbank increased their investment to over 1 billion USD for the unsuccessful industrialized construction startup Katerra. Overall, the amount of capital flowing into the construction sector

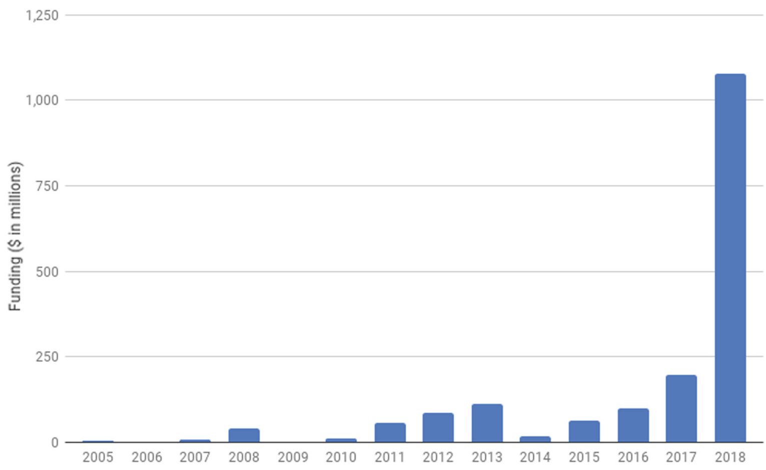


Fig. 1 Venture capital funding for industrialized construction startups by year [4]

continues to rapidly increase (see Fig. 1). As new manufacturing technologies such as 3D printing and on-site robotics emerge (see Chapter "Cyber-Physical Construction and Computational Manufacturing") and combine with the promises of industry 4.0 for industrialized construction, it is likely to bring about future digitally-enabled factories organized around smart automated systems, mobility, flexibility, integration of customers, and new business models.

2 The Role of Business Models for New Technologies

When Steve Jobs initially released the iPhone in 2007, few understood the implications that this new technology would have on Apple's business model. Jobs himself infamously shot down the notion that Apple should introduce a developer platform. Instead of creating an environment where third-party software developers could develop their own applications on the iPhone, Jobs believed these developers should write applications using the native Safari web-browser engine found within the iPhone operating system.

However, Apple received tremendous backlash from the developer community. Jobs reversed his decision in 2007, stating:

> Let me just say it: We want native third-party applications on the iPhone, and we plan to have a software development kit in developers' hands in February… We are excited about creating a vibrant third party developer community around the iPhone and enabling hundreds of new applications for our users [5].

In 2008, Apple announced the release of the App Store platform with the first 500 Apps available. The combination of the new iPhone with the App Store platform was one of the key factors that led to the disruption of the mobile phone industry, paving the way Apple to become a dominant player on the smartphone market for decades to come. The App Store represented a new platform-based business model that enabled tremendous value capture from the new technology of the iPhone.

Business model scholars have understood this for some time. The development of innovative technology alone will not transform or disrupt an industry. Instead, disruption occurs when an innovative technology is paired with the development of a new and transformative business model [6].

Furthermore, new business models and operational structures can better align the organization of the firm with the technical dependencies required by the product [7]. These business models might capture greater value than existing business models.

3 The Traditional Business Model for Construction

The traditional business model in construction is based on the delivery of unique projects organized through temporary project teams. Each individual project is delivered using a specific project delivery model. Project delivery models and business models are different, yet related, constructs [8]. A project delivery model defines how the multiple parties involved in a project are organized and managed in order to create and capture value on a one-time basis. Project delivery models are temporary by nature; they conclude when the end task is completed [8].

However, such intense focus on singular projects has led to extreme fragmentation in the business model logic of construction. Therefore, it has been suggested that emphasis on projects has led to extreme fragmentation across horizontal, vertical, and longitudinal dimensions (see Fig. 2) [9].

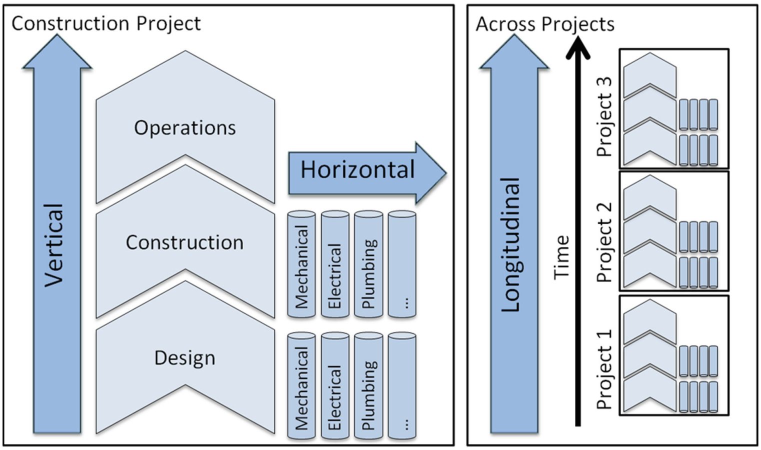


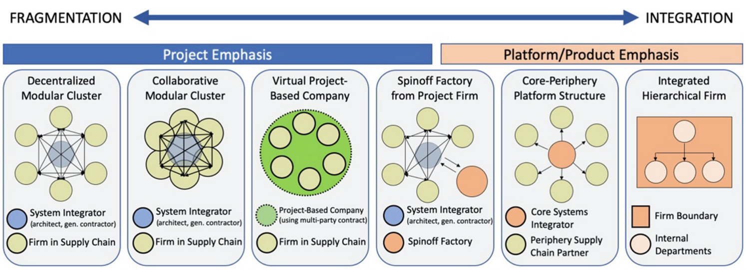
Fig. 2 Three dimensions of fragmentation found in the construction sector [14]

Horizontal fragmentation occurs in the trade-by-trade, competitive bidding environment of traditional project deliveries. It is difficult to cross-subsidize changes in work scope across trades. New innovations—even if they provide holistic benefits to the project—cannot compete with traditional solutions that are more cost-effective from the perspective of a particular scope-of-work.

Vertical fragmentation occurs over the duration of the project. Each project phase has a unique set of stakeholders, decision-makers, and values. Ivolved parties can engage in self-interested behavior and pass costs off to stakeholders in a later phase of the project [10].

Longitudinal fragmentation also occurs due to the temporal nature of project organizing. Project teams disband at the end of projects and are selected on future projects by competitive bidding. They are thus unlikely to work with the same set of partner firms on future projects. Consequently, team members lose tacit knowledge about how to work together effectively. Organizations are unable to build upon ideas that cross firm boundaries if they cannot work with these same firms again [11]. This knowledge breakdown has been described as an industry "learning disability" that slows innovation diffusion [12]. In addition, the high demand fluctuations within the sector creates a reluctance by firms to invest significant capital in innovation development [13]. High liability risks holds firms responsible for design and construction mistakes and further encourages technological risk aversion.

The fragmented construction sector structure leads to the organization of large construction projects as "decentralized modular clusters" (see Fig. 3) [14]. The vertical fragmentation of the sector splits the role of the systems integrator between two very different actors—the principal contractor and the principal architect [15]. As Winch describes, "mediating and championing roles essential to successful innovation are less likely to be carried out effectively" [15]. The majority of project



Longitudinal Integration				partial	✓	✓
Horizontal Integration		informal	✓	partial	✓	✓
Vertical Integration		informal	✓	partial		✓
Project Delivery Model or **Business Model**	Traditional Design Bid Build	IPD-ish; Progressive Design Build	Integrated Project Delivery; Alliancing	**Spinoff Factory**	**Digital Systems Integration**	**Vertical Integration**
Example Firm	-	-	-	DPR Construction & Digital Building Components	Project Frog	BoKlok
Benefits	Maximize scarce cognitive resources	Explore new interdependencies for use in next project	Co-develop technical interdependencies in mutual relationship	Co-develop technical interdependencies in mutual relationship	High product integration; low capital investment	Total control of product; pushes limit (and market) of technological change
Drawbacks	Mirroring 'trap'	Uses more cognitive and financial resources	'Wastes' cognitive and financial resources	Continuous re-education of supply chain	High effort required for co-creation of new product	High capital expenses

Fig. 3 Spectrum of project delivery and business models in construction

work is governed through standardization [16] and craft administration [17]. The institutionalized product architecture and design rules act as the coordination standards to ensure that modules produced by separate firms fit together [14, 16].

In the traditional project delivery model, systems integration is provided by a general contractor or lead architect, but this integration is very weak. Instead, the typical work can be designed, coordinated, and constructed as independent pieces with relatively little system integration required (See Fig. 3). The general contractor is in large part a broker of subcontractor services and less of a system integrator than an equivalent automobile or aircraft prime contractor. General building contractors in a decentralized modular cluster lack the necessary overhead cost structure and capacity required to coordinate radical or systemic changes to the design and fabrication approaches in the project.

Therefore, the dominant business strategy of the industry over the past 50 years has been cost minimization. Firms seek attempts to reduce costs within the existing structures. However, it is very difficult to initiate new product development within this project-based business model paradigm. Overall, construction firms tend to focus innovation adoption efforts that reduce costs but do not engage in new system-wide product development or supply chain coordination that might create new value for customers. The result is incumbent firms tend to resist or ignore opportunities to engage in new industry 4.0 technologies that do not align with their dominant business model logic.

4 New Forms of Project Delivery Models

By using new forms of business models, construction firms can better align the organization of the company with the technical dependencies required [7]. They can create design-to-production chains and develop new product architectures. They can leverage industry 4.0 principles for the digitalization and industrialization of construction. This becomes essential for investment in new technologies such as robotics and factories that can never payback their investment within the boundary of a single project.

Within the existing project-based structure of the sector, there are examples of new project delivery models that emphasize integration. This can occur informally, through the use of supply chain integration practices that organize information, processes, people and/or firms for the purpose of collaboration and integration within the supply chain. Examples of supply chain integration practices include building information modeling (BIM) coordination (see Chapter "Building Information Modelling and Information Management"), the last planner system (see Chapter "At The Role of Lean in Digital Construction"), early involvement of key participants, and team co-location [18]. The informal use of supply chain integration practices represents a more interconnected project orientation.

A more formal approach to the integration of projects occurs through the signing of multi-party contracts. This is known as project alliancing or integrated project delivery (IPD). For example, in IPD projects, as many as 24 firms have signed a single, multi-party contract and therefore share the associated financial risks and rewards of the project [19]. In essence, the firms are bound together to create a "virtual, project-based company" [20]. As described by Thomsen et al. [20], this company is not so much a "legal entity but more like a temporary social organization. People remain employed by their respective companies, but assume one or more roles based on individual skills and project needs, rather than the nature of the employer's business." The structure of these virtual project-based companies creates vertical integration (including the project sponsor/owner, designers, general contractor, and trade contractors) and horizontal integration (between traditionally separate trade contractors and system designers).

However, the use of more integrated project delivery models still does not change the dominant business logic of project-based organizing. While both of the above approaches have been successful at solving challenges of horizontal and vertical fragmentation, they still represent a project-based business model orientation. In particular, they do not solve challenges that come from longitudinal fragmentation, where project teams disband at the conclusion of each project and all associated process improvements and tacit knowledge are lost.

5 New Business Models for Industrialized Construction

The new business model for industrialized construction is characterized by longitudinal continuity instead of the project-based orientation [21]. One new form of longitudinal continuity can be achieved through the development of a product platform. Product platforms enable continuity through the development of a proprietary technical building system. Projects are then delivered using a "kit of parts" derived from this platform. The platform provides a mechanism for organizational knowledge about the technical building system to be established and continuously improved. Versions of the building system are released in a similar way to versions of mobile phones or software are released (e.g., version 1.0, version 2.0, etc.). The knowledge embedded in the development and maintenance of this technical building system platform can be considered a strategic asset [22]. Products that are not built by the firm are procured using long-term partnerships with others in the supply chain instead of through competitive bidding.

Product platforms only enable customization within defined limits. These limits are specified and tailored with a level of predefinition of design and technical solutions that are aligned with the company's market strategy. This means that the company specializes on a certain niche on the market, creating a product platform that is optimized to deliver buildings to that niche and structures a production system that produces these products (buildings) in an efficient and reliable way. Therefore, industrialized construction companies using product platforms must ensure a tight fit between market segment requirements and the offerings of their platform [31]. The structure and utilization of operational platforms are characterized by high control of both product configuration and production processes [23]. From observation, new industrialized construction entrants tend to use one of two new business models.

The first business model is *vertical integration*. These firms often redefine the business model of construction through horizontal, vertical and longitudinal integration. They are structured as integrated hierarchical firms, keeping the control of product architecture and processes in-house. These firms do not outsource production but typically elect to conduct construction activities within a central off-site factory. Design, manufacturing, transport, and assembly are all coordinated within the same integrated firm. However, a drawback to this approach is high-capital costs. These new firms often focus on the delivery of housing as it offers repeatable modules and the ability to scale across the market. An example of successful vertical integration is presented below for the Swedish company BoKlok.

The second business model is *digital systems integration*. These firms design and integrate a new system or product architecture but do not own the manufacturing technology themselves. They tend to focus on integrative software approaches such as a cloud-based product configurator [24] to enable mass customization. Using principles of capital-light industry 4.0 supply chains, digital system integrators can manufacture parts from periphery supply chain partners suppliers such as the timber, automotive, aerospace, manufacturing or industrial sectors. They are longitudinally integrated through their digital platforms and build long-term relationships with partners in the design, procurement, fabrication, and assembly stages. The benefit is a capital-light digital firm that can create a new ecosystem around its digital platform integration. One challenge for these firms is that it takes more time to build consensus for new product development across the ecosystem when compared to vertical integration. An example of digital systems integration is presented below for the company Project Frog.

The third business model is the creation of a new "spinoff" factory or new business line that originates from an existing project-based firm. Such attempts allow project-based companies to evolve toward a more industrialized construction orientation. Such a relationship enables the creation of a learning relationship between the demands of the project with the need to set up longitudinal continuity in a factory environment. However, a drawback to this approach is the need to continuously update and educate the existing supply chain about the capabilities of the new factory. An example of the "spinoff" factory comes from the general contractor DPR Construction and their spinoff factory Digital Building Components.

These new business models are summarized in Fig. 3, with comparison to the existing project delivery models. Each of the three new business models represent re-organization efforts to deliver buildings in a more integrated manner across their lifecycle through vertically, horizontal, or longitudinal continuity [25].

5.1 *BoKlok—Two Decades of Successful Vertical Integration*

BoKlok housing is a company based on the BoKlok concept. It was jointly established in 1996 as a collaboration between the furniture giant IKEA and the construction company Skanska. BoKlok has built 13,000 homes over the past two decades with great customer satisfaction: customer surveys done by an independent market investigation institute state that BoKlok have had the highest proportion of satisfied customers among Sweden's housing companies during several years (1st place 2017, 2018, 2020; 2nd place 2019).

BoKlok was founded based on the vision of "creating better homes for the many people" and is operated by BoKlok housing, a subsidiary of Skanska. The company is specialized in building sustainable, quality homes with a low price, aimed at the large customer segment with a median income. This specialization affects the whole company, from marketing and sales, through product development, manufacture, sourcing, land acquisition, etc., in terms of systematically keeping the costs low, in order to successfully deliver on the customer promise.

The initial development of the product concept was based on three main steps. First, an investigation was done to determine what the targeted customer segment could afford to spend on housing and what this group considered important in an enjoyable home. This led to an identified target cost and important customer priorities such as natural daylight, the use of natural materials and a safe outdoor environment were identified as aspects of high priority. This defined the starting point for the concept's development. Second, these aspects were used as input to the product development and the first BoKlok product was designed. The product included both the homes, the buildings and the surrounding gardens and shared areas and spaces, to create a complete concept for quality living spaces (Fig. 4).

The third step in the development was to establish a production system optimized for producing the BoKlok products in the most efficient way. This meant designing a supply chain, an optimized factory production and site work that could produce BoKlok products at scale and with a predictable outcome in terms of costs and quality. It resulted in a factory production of volumetric elements with a very high prefabrication level and only complementing work and installations remained to be executed on-site.

The concept soon became a success, and BoKlok as a company has grown rapidly. The company has 420 employees, of whom around 150 work in business, project and product development, while the remainder work in manufacture and site production. The concept has been developed continuously and now encompasses a portfolio of multiple product platforms, for single family terraced houses and multi-family buildings. BoKlok is operating in Sweden, Norway, Finland and the United Kingdom.

A key component of BoKlok's competitive advantage is their vertically integrated business model. BoKlok keeps much of the home-building process within

Fig. 4 Automated wall-panel nailing at the BoKlok factory

their own firm boundaries, including real estate acquisition, customer sales, design, engineering, factory production, on-site assembly, and final commissioning of the building. As CEO of BoKlok Jonas Spangenberg explains (Fig. 5):

> We have put together our value chain to be able to deliver on our customer promise. We are using the product approach and our industrialized construction processes as means to build sustainable, quality homes for the many people with average incomes.

5.2 *Project Frog—Embracing Construction 4.0 Without the Factory*

Project Frog was founded in 2006 as a venture capital-backed startup in San Francisco, California. They emphasize design to enable digital production. In its first years, the firm positioned itself as an alternative solution to the traditional construction fragmentation by providing pre-engineered and prefabricated kits of parts for the efficient assembly of permanent buildings. Project Frog describes one core element of its strategy to not own or operate their own factory. They view themselves as a "product supplier" that utilizes an industry 4.0 approach. Project Frog then partners with manufacturers and suppliers around the world. Project Frog develops the product, develops and details the overall system design, and manages the supply chain and delivery process. Local partner contractors assemble the products at the building site.

Fig. 5 **a** Module production at BoKlok factory, **b** on-site module assembly, **c** finished BoKlok housing

Project Frog views their role as developing core solutions to allow integration of product designs provided by digital-manufacturing suppliers. Mike Eggers, Vice President of Product and Innovation, believes Project Frog can integrate a product-ready supply chain and enable a new kind of ecosystem for construction. He further describes (Fig. 6):

> There needs to be a common, integrated and scalable cloud based platform for AEC not just fragmented co-opting of products off the shelf today. Every company rolls out their own software and nothing talks to each other. Only a Cloud platform built for AEC will allow interoperable solutions to start to address the fragmentation in our sector in a scalable way. Our solutions rely on this broader platform's existence and are focused on bringing manufacturing best practices to design information as early as possible in the process.

Compared to BoKlok, Project Frog has never owned their own manufacturing facility. They intentionally avoid committing to high-capital investments or specific forms of manufacturing. With purely horizontal integration, they are not burdened by the costs of factory ownership but have freedom to think about technology integration and building systems. This approach enables agility in product design and low capital costs, which allows them to turn "software development cycles with buildings" (Fig. 7).

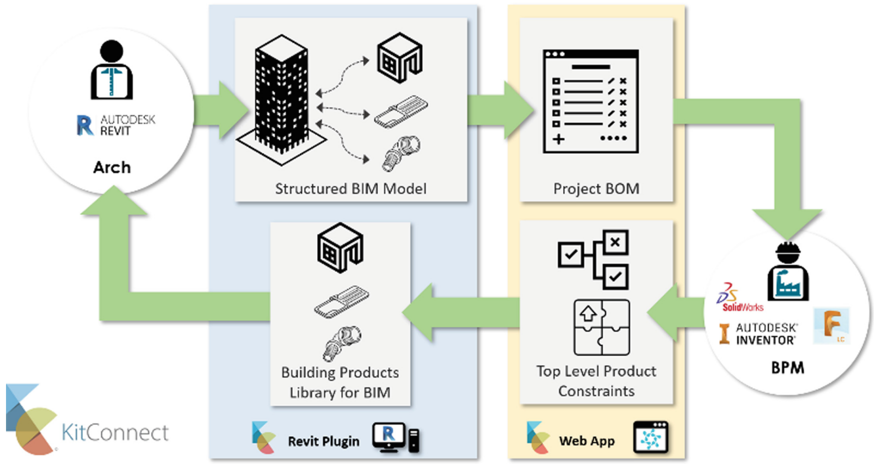


Fig. 6 Information flows in Project Frog's KitConnect Software

Fig. 7 Example of a kit-of-parts developed by Project Frog

Project Frog identifies some challenges to their industry 4.0 approach. They must manage misaligned risk allocation and do not own all the risk in one place. Project Frog also has to work to find the right partners that will embark on a mutually beneficial journey into industrialized construction. However, they find these tradeoffs to be minor compared to the agility they retain to innovate and customize the components of their industrialized building system. The resulting knowledge share between themselves and manufacturing partners results in a product optimized for scale.

Project Frog believes their platform approach can scale as more of the supply chain for digital manufacturing becomes available and is compatible with configuration and mass customization. They anticipate future products will be available as components that can be configured using the tools they create themselves. Project Frog believes they can draw from their horizontal integration and experience with manufacturing to build the infrastructure required to align the physical and technology stack for this new emerging ecosystem. Specifically, Project Frog wants to develop an open platform where they provide the core infrastructure of digital systems integration but welcome other firms to participate. The CEO of Project Frog, Drew Buechley, describes:

> Because we are not a big vertically integrated closed system, we can help more broadly move the industry forward. Our business model has forced our building platform and software products to be developed in a way that they are accessible and usable by designers and builders where they are today. It is our goal to move the ball forward, contributing to the infrastructure for the ecosystem and licensing our specific solutions to anyone who wants it. We can work with other architects, builders, and corporate developers to get people into the industrialized construction world. We are not here to just hold all the cards to our chest. This is what sets us apart from the competition - we want to share!

5.3 DPR Construction and Digital Building Components—Evolving from Projects to Product Platforms

An example of the third business model innovation—the "spinoff" factory—comes from DPR Construction and Digital Building Components. Digital Building Components are spinoff industrialized building supplier that was funded by DPR Construction. DPR Construction (DPR) is a commercial general contractor and construction management firm founded in 1990 and currently based in Redwood City, California. They rank as one of the top 50 general contractors in the United States since 1997 and operate from 28 office locations across the United States. DPR describes their value in maintaining a reputation as an industry leader in the coordination of BIM using collaborative practices such as co-location at the early stages of the project to maximize coordination efforts. The core of DPR's business is the management of projects. The firm uses a relational and customer-focused strategy to deliver projects for clients while maintaining positive and collaborative relationships with designers and trade contractors (Fig. 8).

Before 2017, DPR observed successful prefabrication strategies used by trade contractors to bring large pieces of ductwork, wall panels, or utility racks from off-site factories to onsite projects. The motivation for such new products was often driven by a strong owner client wanting to push innovation. During these projects, DPR actively coordinated the off-site work using their advanced BIM capabilities. They gained important knowledge about tolerances, logistics, and design requirements for digital manufacturing. DPR embraced the management of this type of

Fig. 8 Automated prefabrication line at Digital Building Components

innovation because it enabled observations in a project-based capacity without the need to make high-capital investments into manufacturing assets. It also leveraged DPR's relational approach and provided new opportunities for the firm to learn (Fig. 9).

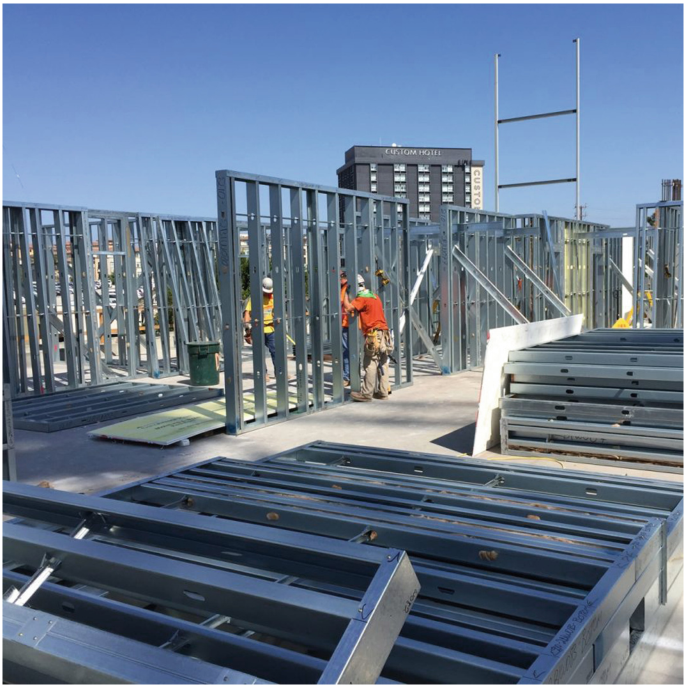


Fig. 9 Workers install one of DBC's wall panels

However, DPR also perceived that the project-based business model was not necessarily the best way to capture value from industrialized construction. DPR's costs are accounted on a project-by-project basis. Project teams would question how the use of industrialization would impact the project's bottom line. They were often unwilling to bet the success of the project on an unproven concept. Therefore, DPR made the strategic decision to financially invest in digital manufacturing as a spinoff factory that was financially and organizationally separated from the primary project-based business. Atul Khanzode, Chief Technology Officer and Member of the Management Committee, describes this decision as an attempt to become "more builders than brokers in the supply chain."

In 2017, DPR invested equity from a new internal innovation fund into a new spinoff firm. The vision for the new firm—called Digital Building Components (DBC)—is to combine DPR's knowledge of BIM coordination with its observed learnings about digital manufacturing from past projects. DBC does not just focus on off-site fabrication but leverages the use of a highly-coordinated BIM model. DBC operates a large factory in Phoenix, Arizona where the firm manufactures light-gage steel framing and assembles three new industrialized product lines: (1) a digitally-fabricated load-bearing structural panel system, (2) exterior wall panels and (3) interior wall panels with in-wall MEP systems.

Although the concept remains new, participants from both DPR and DBC agree that there are benefits to the relational setup between the two firms. DPR has experience and expertise to fully coordinate the fabrication information that DBC needs to take directly from the model. DPR can take more control of the value chain, expand their knowledge and capabilities, and become "organized learners" without abandoning their core project-based business model. D BC benefits because when DPR coordinates their project management in such a way that benefits a digital fabrication process. Moving forward, both sides express the desire to build on the relational foundation established through the spinoff factory. Overall, DPR benefits from an industrialized construction approach without the difficult work to change the existing project-based business model of the company.

6 Can These New Business Models "Disrupt" Construction?

There is a well-known theory of industry disruption known as *the innovator's dilemma* [26]. When new technologies emerge, they often do not immediately enter and disrupt a market. They will often instead find application within small, niche, or less complex areas of a market. Meanwhile, large incumbent firms focus on the larger market and main customer segments. They do not have time to focus on new technologies that might meet the needs of only a few niche customers. Over time, however, the technologies cultivated in the niche become more developed. When the technologies scale toward the larger and more complex market, they can eventually displace the incumbents and cause wide-scale industry disruption.

It is possible that such an innovator's dilemma scenario may occur in today's construction sector [27]. New industrialized construction entrants begin at the less "complex" end of the market. For example, many new entrants in Silicon Valley are entering the residential housing market. This is one of the least complex and most repetitive markets of the construction sector. Large, project-based firms that manage complex mega-projects will see little competition from startup firms in the near future. Relatively small housing projects do not interest or attract the core business of entrenched industry players. Yet should these new firms derive higher productivity using new technologies and integrated business models, they may eventually be able to move up from the lower end of the value chain to more complex projects and disrupt more established firms in the sector.

It should be noted that the business models of spinoff factories from project-based firms, vertical integration, and digital systems integration do not represent all potential business models for industrialized construction. In such a disruption scenario as presented above, it is possible that other business models not previously imagined might emerge.

The disruption described above might be accelerated by trends such as robotics and additive manufacturing (see Chapter "Cyber-Physical Construction and Computational Manufacturing"). These systemic innovations offer great potential for the future of construction [28]. They also have new technical requirements and drive new organizational arrangements. For example, research conducted at the NCCR digital fabrication at ETH Zürich demonstrates that these innovations require intense cross-discipline collaboration between architects, material scientists, structural engineers, construction engineers, and roboticists [29]. It will require a systemic re-orientation of the supply chain to diffuse in the construction sector. New business models such as vertical integration and digital systems integration might have the ability to more rapidly adjust organizational structure. This can allow these firms to better align the required product knowledge with technical dependencies required for these innovations. It is more difficult for established project-based contractors to do this due to the longitudinal fragmentation that occurs when teams move from project to project. Furthermore, vertically integrated firms can better invest in expensive manufacturing technologies and distribute the costs over several years, where project-based firms often hesitate to make significant investments beyond any one project.

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