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Digital Technology and Integration in Construction: The UAE Context

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Abstract. Traditionally construction is a fragmented industry too slow in adopting new technology. As a result, construction sector productivity continues to remain stagnant. Digital technology offers a great opportunity to improve productivity by integrating many entities and functions in construction. The paper argues that integration can be achived to a large extent with proper adoption of digital technology. Technology's transformational role in construction needs to be reconginzed and harnessed by the stakeholders. The transformatons and potentials are evidenced in the construction sector of UAE, where the government is taking a proactive role in facilitating adoption of digital technologies, such as Blockchain. A conceptual model that explains the push/pull relationship between technology and integration is presented in the paper. The main conclusion of the paper is that the construction industry at all levels - firm, industry and government – must take proactive actions to foster and facilitate integration in its processes by adopting technology.

Keywords: Construction, Integration, Technology, United Arab Emirates.

1 Introduction

Two major thrusts – demands for integration and a need for technology adoption in construction have defined the construction industry for decades. Construction is known to be a traditionally fragmented industry and a low-tech sector of businesses. It is not surprising that the sector productivity in construction has remained consistently stagnant or have been declining globally over the past four decades. We argue in this paper that these two needs – integration and technology adoption – are not only interrelated but complementary.

Objective of the paper – The major objective of the paper is to present an anlysis of interrelation between integration and technology in construction. The paper puts forward the argument that a greater extent of integration can be achived with appropriate technology adoption. The ultimate goal is to emphasize on the transformational role of (digital) technology in construction.

Scope of this paper – Although, the lack of integration is mostly an internal issue at the sector level; technology (digital, in particular) is an external factor. In the sense that the construction industry is the user of technology developed in 'other' sectors. In addition, the scope of this paper is on the process technology (such as the information and communication technology or ICT) and not much on the product technology (robotics or 3D printing, for example). Although, it may be argued that at times the two can be related. As an example: prefabrication, primarily a product improvement technology which is fostered or facilitated by Building Information Modeling (BIM) or Virtual Design and Construction (VDC), a process innovation.

A World Economic Forum report [1] published in 2016 identifies the areas that falls under *Processes and Operations* as:

- front-loaded and cost-conscious design and project planning;
- innovative contracting models with balanced risk-sharing;
- enhanced management of subcontractors and suppliers;
- lean and safe construction management and operations; and
- rigorous project monitoring (scope, time and cost).

Further, we discuss the case of current state of the construction sector in UAE as an example. UAE is a part of the Middle East and North Africa, which is one of the most vibratant regions of construction globally and is poised to grow at the highest rate in the next five years. UAE is also the region that is proactively (evidenced by both private and government initiatives) looking into new technologies for implementation in its construction sector.

Organization of the paper – The rest of the paper is organized as follows: First, we present a brief overview of th global construction industry, followed by a discussion on the UAE construction market. Next, in Section 3, the issues related to construction productivity and its dependence on integration and technology are discussed. In the following section (Section 4), the current state of the UAE construction industry and the near-term outlook is presented along with a discussion on how digital technology is playing a role in the growth of the UAE construction. In Section 5, we present a conceptual model that relates integration and technology and explains how one can push or pull the other. This model is presented in order to help stakeholders understand the dynamic relationship between integration and technology. In the last section (Section 6), conclusions of this study are outlined.

2 Overview of the Construction Industry

The Construction Intelligence Center (CIC) forecasts the pace of expansion in the global construction industry to average 3.6% a year over the forecast period 2018-2022 [2]. In real value terms (measured at constant 2017 US$ exchange rates), global construction output is expected to rise to US$12.7 trillion in 2022, up from US$10.6 trillion in 2017. This represents an increase of almost 20%.

The same report forecasts, as shown in Table 1, that the Middle East and Africa region is expected to grow at a rate of 9% CAGR (Compound Average Growth Rate) between 2018 and 2022. These countries will likely spend significant amounts of their oil revenue on major infrastructure projects.

Table 1: Average Annual Construction Volume (billion US$) – 2018-2022

Region	**Annual Volume (in billion US$)**	**CAGR – Compound Average Growth Rate**
North America	$1,779	4.4%
Europe	$2,564	5%
Asia-Pacific	$5,125	6.3%
South and Central America	$486	6.3%
Middle East and Africa	$635	9%

Source: Global Data (formerly: Timetric).

As can be seen in Table 1, the construction sector will continue to be one of the most vibrant sectors globally, in general, and in the Middle East and Africa, in particular. The underlying reason for this continued growth and expansion is, increasing urbanization driving the need to build more habitable facilities and infrastructure. At the same time, advances in digital technology is having an impact on the construction sector and its entities. The demand to build sustainable and resilient buildings and facilities is another added dimension to this need. Thus, these three factors – need for building infrastructure and facilities, advances in digital technology, and demand for sustainable and resilient construction– will define the construction industry in the coming decades.

Construction in UAE - The construction industry contributes more than 10% to the United Arab Emirates' (UAE) gross domestic production (GDP). The UAE construction industry is growing consistently and expected to grow more in the near future to accommodate the UAE's strategic goals that includes significant spending in infrastructure construction. As for example, in 2015, the government announced its plans to invest over AED 32.0 billion (US$8.7 billion) to construct the Expo (Dubai Expo 2020) site on a 4.3 million m2 area, as well as other related infrastructure facilities in the Dubai South district [3]. Another example, the UAE has approved the construction of 7,200 housing units for Emiratis across different parts of the UAE at a total cost of US$1.9 billion, with projected completion time by 2021 [4]. The construction activity is projected to continue rising as a percentage of real GDP in the UAE; from 10.3% in 2011, to 11.3% in 2015, on to 11.5% in 2021 [5].

Against this backdrop, however, we see a bleak picture when it comes to construction productivity. For decades, construction productivity remained stagnant or even declining in many regions.

3 Construction Productivity

Despite all the advances in construction technology, digitization of the products and processes in a frantic pace, construction of many spectacular buildings and infrastructures and impressive megaprojects, construction productivity actually declined in the US over the forty-eight years from 1964 to 2012. According to the afore-mentioned World Economic Forum Report [1] "Shaping the Future of Construction: Future Scenarios and Implications", construction labor productivity in the US has declined by 19% between 1964 and 2012 with a corresponding Compound Average

Growth Rate or CAGR of − 0.4%. During the same period, non-farm business labor productivity rose by 153% with a CAGR of +1.9%. (These figures are inflation adjusted and indexed to 1964). This is a matter of concern. Globally, according to a 2017 report by McKinsey Global Initiative [6], during the twenty years from 1995 to 2014, construction productivity rose by CAGR of only 1%.

The Report concludes, "The Engineering and Construction (E&C) sector has been slower to adopt and adapt to new technologies than other global sectors. While innovation has occurred to some extent on the enterprise or company level, overall productivity in the sector has remained nearly flat for the last 50 years."

McKinsey report [6] asserts that construction sector productivity can be improved by 50 to 60% with actions in the following seven areas:

- Reshape regulation (External Forces – Government)
- Rewire contracts (Industry Dynamics)
  - Collaboration
  - Contracting
- Rethink design and engineering (Industry Dynamics)
- Improve procurement and supply chain (Firm-level operational factors)
- Improve onsite execution (Firm-level operational factors)
- Infuse technology and innovation (Firm-level operational factors)
- Reskill workers or capability building (Frim-level operational factors)

Also estimated in the report, 'technology' has the highest contribution to improving productivity – 14 to 15%. It is revealing to note that other six recommended actions fall under the premise of process improvement, as opposed to products. It should be noted that in the above list of actions, the major responsible parties indicated in the parenthesis are: External Forces (Government), Industry Dynamics, and Firm-level operational factors. This is an important issue as productivity must be understood at different hierarchical levels or layers – first, firm-level or intra-organizational; second, industry-level or inter-organizational; and third, regulatory-level or governmental. Thus, the issue of integration, or lack thereof, must also be considered along with productivity measures at these levels for possible and potential actions. We need to consider integration in construction at these three distinct but interrelated levels - informational, organizational and contractual.

3.1 Integration in Construction

Informational integration refers to integration of functions within an organization (intra-organization). Informational integration supports communication functions, promotes collaboration and facilitates formation of virtual teams, and is usually achieved by developing effective information systems [7].

Organizational integration is inter-organizational (between organizations) in nature and is a response to the needs of coordination and collaboration. Integration of this type usually implies design and production (construction) functions physically in one organizational boundary under a common leadership. Design-build project delivery system, combining engineering design and construction under the same entity is an example of organizational integration in construction.

Contractual integration evolved in response to the need for making organizational integration more effective. For, without backing of appropriate contractual languages, organizational integration cannot be effective. Integrated Project Delivery (IPD), for example, is a project delivery system that promotes integration of contracting parties.

3.2 Digital Technology

Full-scale digitization of the construction industry – including 3D printing, AR (augmented reality) and even autonomous construction – could save up to $1.7 trillion globally within 10 years, as the aforementioned World Economic Forum report (2016) [1] asserts. As John M. Beck, Executive Chairman Aecon Group states in the Foreword of the Report, "Any improvement in productivity and successful adoption of modern innovative processes facilitated by the digital technology will have a major impact. For example, a 1% rise in productivity worldwide could save $100 billion a year."

In this paper, however, we will keep the discussion on digital technology limited to Information and Communication Technology (ICT) as the scope of this paper is focused on mainly process improvement in construction. ICT can contribute tremendosusly to increase in construction productivity. The seven action items recommended in the McKinsey report can be effectivey pursued using ICT. ICT provides the impetus to foster integration at all three layers– informational, organizational, and contractual - in the construction sector.

The construction industry already embraced many ICT techniques and tools in the area of visualization, data analysis, communications and collaboration, information sharing and management, and information modeling. Rapid adoption of smart phones and tablet devices in the industry not only confirmed the need of quick information sharing but has also changed the mode of work practices at construction jobsites and offices. Similarly, Building Information Modeling (BIM) has changed the way the buildings are conceived, designed, constructed and operated. The use of BIM has encouraged the integration of the roles of all stakeholders in a project. This integration has brought greater efficiency and harmony among players who all too often in the past saw themselves as adversaries.

Based on the discussion above, it can be expected that a symbiotic combination of *technology* and *integration* in a construction project can foster better coordination processes and collaboration among the project participants.

3.3 The UAE Context

Let us consider the case of *Blockchain* technology in UAE. First of all, a brief definition [8], "Fundamentally, blockchain is a distributed ledger of information, such as transactions of agreements, that are stored across a network of computers. That information is stored chronologically, can be viewed by a community of users, but is decentralized and is not usually managed by a central authority such as a bank or a government, and once published, the information on the blockchain cannot be changed."

In Dubai, one of the seven Emirates in UAE and the largest urban area, has an ambition to be the first city in the world powered by blockchain [9]. Accoding to one of the proponents (Prashant Gulati founder of the community innovation hub, The Assembly), "Blockchains has the potential to making the supply chains more efficient and secue, increasing transparency, boosting productivity, and making documents accessible to all parties in a project."

Since blockchain establishes a shared network for all stakholders, the Dubai Land Department (DLD) adopted this technology to improve, secure and simplify property transactions [10]. According to its proponent, Tom Rhodes of Cityscape Global, "The technology will drive an era of 'smart contracts' due to its ability to create, authenticate and audit contracts in real-time, across the world."

According to [11]. " Digital transformation is happening everywhere and is being driven by many factors, including changing economic necessities, societal shifts and new technologies." It was correctly pointed out that new technologies and commercial pressures are forcing the industry to rethink the way it works.

The assimilation of the digital technologies is dependent on the regulatory support with appropriate laws and regulations to facilitate AI, Blockchain, Big Data, and similar technologies. The goal is to integrate and link public and private sector databases and information portals through digital technologies. Without such integration, supported by regulations, the technology will remain mostly ineffective and underutilized.

Fortunatley, in UAE the pace is much faster compared to other global regions in incorporating digital technologies. The government takes a keen interest in proactively implementing digital technology. The question for the companies (firms and other organizations belonging to the construction industry), the industry and the public (regulatory/governing) entities is: are they working together to facilitate the 'push' of technology and accommodate the market 'pull' (commercial pressures as mentioned above)?

4 Discussion

As pointed out above, there is a 'push/pull' effect between technology and market forces (integration). Technology as an external force *pushes* improvements; and market forces (commercial pressures, profit motives, and completion) *pulls* technology adoption. Market forces are internal to the sector, while technology forces are external. It should be realized that only external push will not be effetive, if there is no corresponding internal pull. A case in point is artificial intelligence or AI. The concept of AI is not new, but it failed to take off until market pull forces (from a business standpoint) became effective. The Model in Fig. 1 below illustrates this concept.

As shown, technology pushes integration to take place, and integration pulls technology up in order to be effective. It is important to note that, as depicted in the figure, to achieve a high-level of integration, effective technology must be deployed. If not, integration will not be effective as indicated in the lower-right corner area in the figure. Conversely, the upper-left corner, denotes the situation when a high level of technology is not effective due to a low level of integration. The conceptual model, illustrated in Fig. 1 can be useful in order to understand, describe, prescribe, and/or formulate a strategy for adoption of digital technology at all three levels - organizational, industry-wide and governmental.

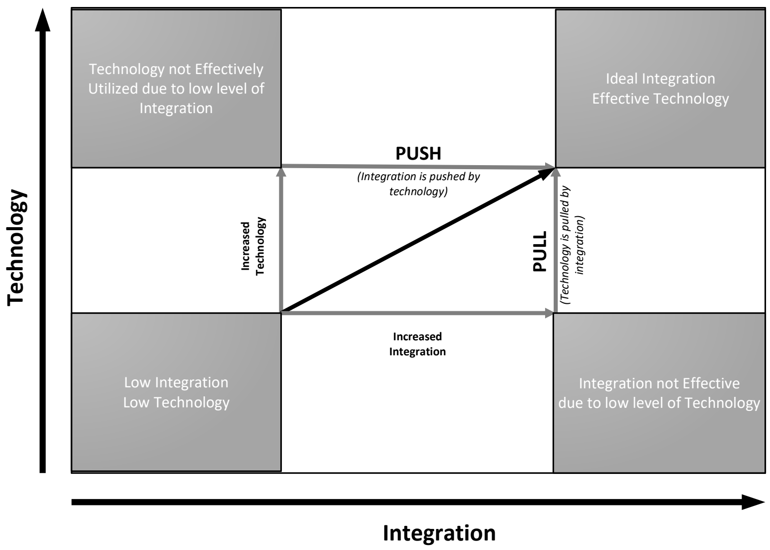

Fig. 1. Technology-Integration Interaction Model (Adapted from Ahmad, et al 2019 [7].

5 Concluding Remarks

The construction industry worldwide is characterized by two endemic issues – fragmentation and low level of technology. The consequence is a pervasive state of low and, in some regions, declining sector productivity. We argue that these two issues although distinct, are interrelated.

Fascinating new digital technologies are becoming available and at the same time new market demands are arising in the construction industry. Today's construction projects are not just larger in size, but also more complex than ever before. The pressure to deliver quality projects on time and at cost is immense. On top of that thay must also be sustainable and resilient. Thus, today's reality offers opportunities (technology) as well as challenges (market demands).

New digital technologies are available to provide the impetus needed for these actions, but industry must provide the conducive atmosphere and embrace the new reality. For example, in order to effectively incorporate the Blockchain technology, certain rules and regualations will have to be adjusted or modified at the government and regulatory levels. The stakeholders (owners, engineers, architects, contractors, subcontractors, suppliers, etc.) must also be willing to accept and use the new technology. This is only possible with certain specific changes in organizational norms and procedures as well as modifications in contractual languages. Thus, not just a desire but a paradigm shift in mindset will be necessary.

With proper recognition by the stakeholders, the construction industry can overcome these challenges by taking advantage of the opportunities. The industry, at all levels – firm, industry and government – must take proactive actions to foster and facilitate a greater extent of *integration* by implementing and adopting *technology*.

Acknowledgments

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References

1. World Economic Forum report (2016), "Shaping the Future of Construction: A Breakthrough in Mindset and Technology," World Economic Forum. Article page, http://www3.weforum.org/docs/WEF_Shaping_the_Future_of_Construction_full_report__.pdf, last accessed: 2019/8/16.
2. Timetric-Construction Intelligence Center (2018), : "Global Construction Outlook to 2022." Article page, https://www.globaldata.com/store/report/gdcn0012go--global-construction-outlook-to-2022-q4-2018-update/, last accessed: 2019/8/17.
3. Newswire (2017), Article page, https://www.prnewswire.com/news-releases/construction-in-the-uae-key-trends-and-opportunities-to-2021-300417471.html, last accessed: 2019/8/15.
4. News (2018). Article page, http://meconstructionnews.com/27419/three-year-1-9bn-budget-approved-for-7200-emirati-homes, last accessed 2019/8/15.
5. Dubai (2012). Dubai Chamber of Commerce Study, December 2012.
6. McKinsey Global Institute (2017), "Reinventing Construction: A Route to Higher Productivity," Article page, https://www.mckinsey.com/~/media/McKinsey/Industries/Capital%20Projects%20and%20Infrastructure/Our%20Insights/Reinventing%20construction%20through%20a%20productivity%20revolution/MGI-Reinventing-Construction-Executive-summary.ashx, last accessed: 2019/8/14.
7. Ahmad, I, Azhar, N. and Chowdhury, A. (2019). "Enhancement of IPD Characteristics as Impelled by Information and Communication Technology," *Journal of Management in Engineering*, 35(1), pp. 04018055-1-12.
8. ICE (2018), "Can Blockchain Transform Construction?" Article page, https://www.ice.org.uk/news-and-insight/the-civil-engineer/december-2018/can-blockchain-transform-construction, last accessed: 2019/8/16.
9. Construction Week Online (2019), "What does blockchain mean for construction payments in the GCC?" Article page, https://www.constructionweekonline.com/products-services/169055-what-does-blockchain-mean-for-construction-payments-in-the-gcc, last accessed: 2019/8/16.
10. ME Construction News (2018), "Dubai Blockchain Strategy in focus at Cityscape global", Article page, https://meconstructionnews.com/31466/dubai-blockchain-strategy-in-focus-at-cityscape-global, last accessed: 2019/8/17.
11. Middle East Business Intelligence (2018), "UAE construction faces up to the digital storm", Article page, https://www.meed.com/uae-construction-faces-up-to-the-digital-storm/, last accessed: 2019/8/16.