

**Cambridge** Centre  
for Housing &  
Planning Research

# **Offsite manufacturing, construction and digitalisation in the UK construction industry – state of the nation report**

Dr Kwadwo Oti-Sarpong

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UNIVERSITY OF  
CAMBRIDGE

Dr Kwadwo Oti-Sarpong  
Cambridge Centre for Housing & Planning Research  
Department of Land Economy  
University of Cambridge  
19 Silver Street  
Cambridge  
CB3 9EP

[ko363@cam.ac.uk](mailto:ko363@cam.ac.uk)

Tel 01223 337124

[www.cchpr.landecon.cam.ac.uk](http://www.cchpr.landecon.cam.ac.uk)

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## 1. Summary

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The government is eager to transform the construction industry as part of the broader Digital Built Britain agenda. Opportunities for national development and global market advantages in a digitally enabled construction industry are considerable. Yet, the uptake of digital technologies, alongside modern methods of construction like offsite manufacturing (OSM), remains low.

The state of the economy, market dynamics, lack of business case, unclear policies, lack of incentives, non-adaptive regulatory frameworks, low client demand, organisational inertia, lack of capabilities and socio-cultural interpretations of value are all contributory to the lower than expected adoption of OSM. The plethora of reasons for this are multi-faceted, comprising social and technical dimensions. Further, with construction situated in the UK's socio-cultural, political and economic milieu and the industry characterised by nuanced organisational and project-based challenges, the underlying reasons are interconnected and must be understood from a sociotechnical viewpoint. This is what this report seeks to achieve. By discussing the state of OSM in the UK construction industry, the report charts the path for critical research that aims to identify ways to address the array of barriers inhibiting a wide scale uptake of OSM as part of efforts to transform the way construction works.

## 2. Introduction

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This report provides a critical overview of developments related to the uptake and use of offsite manufacturing (OSM) for construction project delivery in the UK construction industry. The report is organised around the following questions: What are the problems in the UK construction industry? How is OSM a solution? What reasons account for the state of uptake of OSM in the UK? What are the policy and industry initiatives that can be identified around the use of OSM and digital technologies? What is the way forward to improve the industry-wide adoption and use of digital technologies and OSM?

The sections that follow respectively: highlight key problems the industry and its actors have been grappling with for decades, discuss government attempts to tackle them, highlight how modern methods of construction (MMCs) are being championed across the country in a bid to address the 'ills' of construction, examine the low uptake of OSM in the UK and finally discuss how the situation can be improved through research. To better discuss the central questions underpinning this report the section below 'sets the scene' with some background information.

### 3. Background

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The UK construction industry is often berated for delayed projects and a slow work pace, unsafe work practices and delivering projects that exceed planned costs, among others (Farmer, 2016; Wolstenholme, 2009). For several decades, the challenge has been to find ways of transforming the industry in order to deal with these 'ills' by improving productivity, safety, timely delivery and cost-effectiveness (Wolstenholme, 2009; Dainty et al., 2017). The approaches deployed to improve the industry's performance comprise a variety of government-mandated (e.g. compulsory use of BIM<sup>1</sup> for all public projects in 2016) and voluntary industry-driven solutions, all having 'innovation' at the centre. The phrase 'modern methods of construction' (MMC) has been used to capture a repertoire of technological innovations deployed to transform the way construction works in the country. MMC accordingly encapsulates offsite manufacturing (volumetric construction, the use of panellised systems, hybridisation – between offsite and existing techniques, sub-assemblies and component-based systems), the use of digital technologies and other non-offsite innovations for construction projects delivery (Farmer, 2016).

The agenda to transform construction through technological innovation has gained significant traction with both government and private industry players. The government has laid out an array of plans describing strategic partnerships with the industry to achieve ambitious targets (e.g. HM Government, 2013, 2017, 2018). In the most recent Industrial Strategy (IS) the government's vision is to transform construction into "a sector that can build new homes in weeks – and even days – rather than months; that can deliver new buildings at a third of the cost; that can provide affordable, energy efficient homes" (HM Government, 2018, p.3). The preceding vision, according to the industry strategy, will be achieved through: Digitalisation - to improve certainty of details needed for the construction, management and disposal of buildings; Offsite manufacturing for construction - to improve construction speed, minimise waste and minimise potential disruptions in project delivery; and Whole life asset performance - to improve client awareness of costs involved in projects, including running and energy costs. Private sector players also recognise the potential digitalisation and OSM hold for the transformation of the industry and have begun taking steps to use them in order to get ahead of their competitors (BCG, 2019; KPMG, 2016).

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<sup>1</sup> Building Information Modelling

## 4. Offsite manufacturing, digital technologies and construction industry transformation

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Offsite manufacturing (OSM) – also known as offsite construction – is increasingly being put forward as the ‘future’ of construction because of its espoused benefits when deployed for project delivery. Using OSM, according to KPMG (2016, p.3), “offers an alternative to this current construction status-quo by promising transformative improvements across the asset lifecycle in time, cost, quality and health and safety”. The potential and actual (albeit from anecdotal cases) benefits of using OSM are widely described in academic literature (e.g. Goodier and Gibb, 2007; Taylor, 2010; Kamli and Hewage, 2016; Hosseini et al., 2018; Camacho et al., 2018; Jin et al., 2018) and industry reports (e.g. House of Lords, 2018; BCG, 2019; WPI Economics, 2019; Welsh Government, 2019; The Housing Forum, 2019; KPMG, 2016). In addition to the benefits highlighted, the implementation of OSM for project delivery is considered to hold the potential to nudge the industry towards significant productivity improvement and away from the preferred traditional methods of construction that create problems of cost overruns, delays and pose safety concerns, among others.

Off-site manufacturing (OSM) generally refers to an approach to construction involving the production of non-volumetric (non) structural components or volumetric units in a factory for subsequent installation in their final positions in a structure on site (cf. Goodier and Gibb, 2007). Regardless of terminology, a fundamental principle of this non-conventional method of construction is to move as many ‘traditional’ construction activities typically executed *in-situ* in the construction process to a regulated factory environment situated in a place different from the final project site (House of Lords, 2018). Although presently viewed as a modern method of construction (MMC), off-site manufacturing for construction has been in use for several decades, dating to post-World War 2 times where rapid construction of housing was a major societal need in rebuilding destroyed cities (Taylor, 2010). The approach is perceived to hold several benefits as opposed to traditional construction methods. Anecdotal evidence suggests that using OSM for construction can improve planning, cash-flow forecasting, productivity, safety, waste-reduction, timely delivery and lead to lesser environmental disruption and cost savings as there is more certainty associated with the method (KPMG, 2016; WPI Economics, 2019). These espoused benefits are argued to accrue to the different parties (e.g. contractors, clients, manufacturers and end-users) involved in project delivery and so deemed a ‘win-win’ approach (The Housing Forum, 2019).

Digital technologies encompass a wide array of technologies that harness ever-expanding computing capacities to aid or improve the execution of tasks or to realise a desired outcome (Griffin et al., 2019). Applications of digital technologies in the construction industry include

the use of n-D BIM, geographic information systems (GIS), photogrammetry, radio frequency identification (RFID), 3-D printing, artificial intelligence (AI) and other forms of technology requiring (in)direct human-computer interface, data harvesting, processing and storage (cf. Tetik et al., 2019; Camacho et al., 2018; Isaac et al., 2016). Within the past two decades, there has been an increase in technically oriented studies that are exploring ways that different digital technologies can be used in improving the deployment of OSM for construction projects (e.g. Gbadamosi et al., 2019; Rausch et al., 2019; Wang et al., 2018). In practice, some leading UK firms (e.g. Bryden Wood, Ilke Homes, Urban Splash and TopHat) are exploring and applying a range of digital technologies (including BIM, augmented and virtual realities and automated design) in the use of OSM for project delivery using investments received from partners (Offsite Hub, 2019; PBC Today, 2019). In the public sector the government is taking steps to promote the use of digital technologies for the delivery of certain projects under five departments from 2019 with the hope to trigger a more substantial industry transition towards technological innovation. Indeed, digital technologies are changing significantly the way construction works (Ostarvik, 2014; Whyte, 2019) and their continuous deployment in the 21<sup>st</sup> century is recognised as critical for the achievement of anticipated step changes as part of creating industry-wide innovations (WEF, 2018; McKinsey & Company, 2018).

Unlike over three decades ago, the present-day deployment of OSM has been embedded in applications of digital technologies (Jin et al., 2018). Designs for built assets are now commonly completed using computer-aided design (CAD) platforms, standardised object models are used in these designs to facilitate easy cross-platform communication between designers and manufacturers (cf. Tetik et al., 2019). The past two decades have seen a gradual (albeit very slow) shift in the deployment of OSM from solutions for simple building elements (e.g. frames and cladding) to elaborate volumetric configurations (e.g. complete bathroom and kitchen pods) and complete factory-manufactured on-site home installations (Kamali and Hewage, 2016). Although an increase in computing power in the 21<sup>st</sup> century is credited for enabling such advancements in the deployment of OSM, knowledge about the range of digital technologies used is relatively scarce. The absence of such knowledge further contributes to stalling how the transformative abilities of OSM and digital technologies could be harnessed to deliver the desired step changes of innovation in construction (House of Lords, 2018).

#### 4.1. Uptake of OSM in the UK construction industry – state of play

All construction projects currently include some form of offsite manufactured components (cf. Griffin et al., 2016). Progress in standardisation and precision-engineering has facilitated the design and fabrication of construction elements for buildings and civil works in factories for subsequent on-site installation. Steel frames, cladding, fenestrations and electro-mechanical components are now largely made in factories and installed in their designated locations in a



structure on-site. Similarly, bridge sections, culverts and tunnel tubes are manufactured in factories using steel or reinforced concrete, transported to and fixed on sites in civil works (Jin et al., 2018). Despite these avenues for the use of OSM in construction, KPMG (2016) reports that it forms only 7% (i.e., about £6bn) of the total value of the industry (i.e., approximately £86bn). This suggests that a significant percentage of the industry's value remains tied to the traditional ways of project delivery (i.e., on-site construction) which is characterised by inconsistent and low productivity, convoluted supply-chain networks and adversarial relations, high levels of waste and negative environmental impacts, poor safety and health practices, high delivery uncertainty and prone to the negative effects of labour shortages (cf. Farmer, 2016). The persistence of the low uptake has implications for the UK construction industry. This includes the risk of missing out on the vast opportunities to exploit OSM in meeting infrastructure that would arise from the projected £49tn global construction market expansion in the coming decade is a real potential implication (HM Government, 2018).

To make progress in transforming the UK construction industry through a widespread uptake of OSM, there have been efforts to identify the reasons underpinning the very low adoption of this modern construction method despite the potential benefits it holds.

## 4.2. Why the low uptake of OSM in the UK?

A wide range of factors have been identified as underpinning the low uptake of OSM across the UK through industry reports and academic studies. The reasons identified are summarised below under 'wider context', 'industry configuration' and 'organisational/project' levels. Their overlapping relationships are subsequently discussed.

### 4.3. Wider context factors

The term wider context is used here to delineate all factors that shape the context within which the construction industry plays out.

#### 4.3.1. Policy, regulations, incentives and mandates

A clear policy provides the needed framework within which developments across industries take place. The impact of government policies and directives on industry transformation is well-known (Green, 2016) and so the declaration of intent by the government to transform construction in the recent Industrial Strategy was a welcome development. There are however gaps in policy that pose significant challenges to industry actors to fully embrace the transformation the deployment of OSM and digital technologies would bring.

There are concerns around government incentives (e.g. tax cuts, funding support and enabling provisions) to support investment in the erection of factories, re-training and skills development and capabilities diversification for contractors (House of Lords, 2018). The absence of a clear government position on the formulation and implementation of favourable policies to stimulate interest is identified as a real challenge and so the uptake of digital technologies and OSM remains low.

To drive 'real' transformation in the construction industry, KPMG (2016), for instance, proposes that the use of offsite construction on infrastructure projects meeting certain spatial requirements be made mandatory, similar to the precedent set in 2016 concerning BIM use. This recommendation is based on the fact that the government, as a large construction client can leverage its position in the industry to demand changes from its suppliers (McKinsey & Company, 2018). There are clear benefits in mandating the use of OSM for the delivery of construction projects that are repetitive in nature (e.g. social housing, prisons, schools and hospitals) to promote adoption of digital technologies and OSM across the industry (cf. Hosseini et al., 2018). However, this approach has its risks as there are several layers of challenges that the BIM mandate has encountered in its implementation. There is still a slow uptake because public sector clients do not (yet) have the capabilities needed to properly demand for its use from their supply chain (cf. Vass and Gustavsson, 2017; Aksenova et al., 2019). A rushed mandate could therefore spell similar problems for OSM deployment.

#### 4.3.2. Lack of clear standards for offsite products

Standards exist for several components and materials used in the built environment. At the moment, there are no clear guidelines existing to guide the fabrication of offsite manufactured products. The absence of standards pose problems for regulatory design evaluations, creates uncertainties for potential investors, manufacturers and deepens the scepticism of potential end-users about OSM built assets. Although standards exist in isolation for each constituent material, as combined units/components/pods, there is no identifiable standards regulating their production. This has raised fire safety and structural stability concerns that challenge efforts to promote widespread use of OSM in the UK (cf. Pan et al., 2007; Jin et al., 2018; Green, 2019).

#### 4.3.3. Economic trends on investment and market dynamics for construction demand

Construction as an industry is significantly impacted by economic trends. The global economic downturn between 2007 and 2009, for instance, caused a dip in demand for construction products as spending capacities by governments shrank. Without a stable economic outlook, clients will remain reluctant to invest in MMCs (including OSM and digital technologies) that are not 'tried and tested' in an industry as complex and dynamic as construction.

Across several reports (e.g. KPMG, 2016; House of Lords, 2018; BCG, 2019) and studies (Hosseinin et al., 2018; Gan et al., 2018; Pan et al., 2007), there are firm calls for client-led demand for the use of OSM for project delivery and across portfolios. However, clients' decisions are influenced by the dynamics in the wider environment, including financial incentives for deploying OSM, availability of capable supply chains and awareness of substantial gains to be made from deploying the approach (cf. Lines et al., 2015; Vass and Gustavsson, 2017).

#### 4.3.4. Societal preferences: values, meanings ascribed

Negative socially constructed interpretations exist around offsite manufactured buildings in the UK. The negative collective views linger from the post-world war 2 era where the pressing need for the provision of housing promoted the use of pre-fabrication which later collapsed (causing deaths and injuries) or demolished (leading to losses for families) (Nadim and Goulding, 2011; Rahman, 2013; Goulding et al., 2015). There is therefore a strong collection of negative shared views about OSM-produced houses and buildings in general. Linked to the foregoing, a cultural preference for 'brick and mortar' traditionally built homes also exists, creating the notion that OSM-produced houses are inferior. Thus, to own a traditionally built home remains a culturally informed aspiration passed on across generations as a prestigious state of self-actualisation (Nadim and Goulding, 2011). The construction of such values, meanings and sense of 'worth' in owning buildings delivered using OSM is yet to emerge and become mainstream and that challenges demand and subsequent widespread use.

For OSM to thrive, there must be the need for end-users to accept the final products as socially legitimate and suitable for their use. Without a society willing to (re)ascribe positive interpretations to OSM-produced houses or commercial facilities, for instance, demand will remain low and industry-wide uptake will be severely challenged.

## 4.4. Industry level factors

### 4.4.1. Preference for existing procurement methods

Procurement methods currently in use in the construction industry have evolved over decades. From segregated, adversarial and competition-based approaches, procurement methods have been modified over several decades to become more integrated, collaborative and partnership-based. Construction being a 'slow mover' industry, in terms of adopting new approaches to deliver projects, is still struggling to fully operate around such procurement methods (cf. Xue et al., 2010; HM Government, 2013).

Deploying OSM alongside digital technologies presents opportunities for the use of "compatible procurement and contractual strategies to enable more collaborative investments

in offsite" (KPMG, 2016, p.5). These new procurement methods would include some form of digitalisation to aid in transparent dealing based on data and accurate pricing (WEF, 2016). Despite the usefulness of such opportunities, scepticism is a key feature of the industry towards anything new. This aversion to trying new things poses a significant challenge to the uptake of new construction techniques that will transform the way procurement is handled in the industry. Since procurement is primarily client-driven, several reports place the onus on these actors of the industry to make demands on their supply chains to work according to these new models of project delivery (e.g. House of Lords, 2018; WEF, 2017; KPMG, 2016; BCG, 2019). Particular demand is placed on public sector clients to capitalise on their dominance as large construction clients to start deploying new models of procurement around the use of OSM and digital technologies. In doing so, they create a pattern for the rest of the industry to follow.

#### 4.4.2. Planning and approval constraints

The delivery of projects is situated in the broader picture of planning urban and rural schemes in any location. Planning and regulatory frameworks that guide how cities are shaped bear on the kinds of developments that may occur in a place. Therefore, the realisation of a widespread uptake of OSM and an industry-wide deployment of digital technologies is, in part, hinged on the adaptability of planning and approval systems for construction projects to the emerging repertoire of technologies and MMCs. For a long time, the planning and regulatory system in place fall behind the technological advancements being exploited in the construction industry (Pan et al., 2007; House of Lords, 2018). Achieving harmony between projects delivered using MMCs and planning and approval regulatory systems would facilitate progress towards the creation of a well-connected internet of things (IoT) in a Digital Built Britain. An example of how a progressive regulatory framework may be developed to facilitate a widespread uptake of OSM could be gleaned from Singapore and Hong Kong (McKinsey & Company, 2016).

#### 4.4.3. Non-existent training and apprenticeship schemes

It is well-known that the UK construction industry is facing labour crises – ageing, shortage of skilled workers, uncertainties for foreign labour arising from Brexit, dwindling numbers of apprenticeships, among others (House of Lords, 2018). Apprenticeship programs have been lauded as a one-time pipeline for the supply of qualified labour within firms and across the industry. Construction colleges used to be reliable in the production of skilled labour in specific trades and helped fill industry skills gaps. A mix of ill-informed government policies and economic dynamics have contributed to the collapse of some of the 21 construction training colleges established around the UK (Green, 2013, 2016, 2019). This, alongside budget cuts, have crippled the ability of these training institutions to evolve with the times and provide relevant training to create a pool of labour equipped with the needed digital and operational

skills. This shortage impacts the ability of firms to hire workers who can deliver on OSM- and digital technology- driven projects across the industry in the 21<sup>st</sup> century.

#### 4.4.4. Project-centric industry

The construction industry at the moment is highly project-centric, as it has been for decades. The delivery of client needs strongly revolves around loosely coupled firms operating as a temporary organisation to meet a specified need (cf. Dainty et al., 2017). A gradual shift towards a manufacturing and assembly-based organisation for the delivery of projects is yet to take root and gain traction across the industry (Jones et al., 2019). The observed reluctance of actors to modify business models to meet the needs of transformation attendant with OSM and digital technologies remains a significant hindrance to a wide scale uptake of the MMC across the industry.

#### 4.4.5. Lack of information about existing manufacturing capacity

There is a lack of reliable data to demonstrate the manufacturing power of firms in the OSM sector of the UK construction industry. This absence of data fuels the notion that the industry as a whole is unprepared for demand that would arise from a largescale deployment of OSM for project delivery. Consequently, disinterest in the use of OSM and digital technologies grows, sustaining the reliance on traditional methods of construction. KPMG (2016) reports that the UK construction market is ripe to take advantage of the untapped capacity of manufacturing suppliers who reported production output of 72% using a single-shift approach to fabricate offsite building components and volumetric units. Now, with higher computing power and improved technologies for the manufacturing of components and volumetric units, this production output may very likely be higher, making an increased use of offsite construction for project delivery very welcome. Awareness of the latent capacity of offsite manufacturing suppliers could help clients and investors find ways to exploit the opportunities awaiting.

#### 4.4.6. No 'order book' to drive industry interest

Calls for the UK government to spearhead initiatives to drive the adoption of OSM across the construction industry highlight the need for the public sector to create a pipeline of work that favours the use of the method (KPMG, 2016; House of Lords, 2018). Critics often cite an 'all talk no action' posture of the government after promoting the use of modern approaches for project delivery., Green (2013, 2016, 2019) and NFB (2018) for instance, scrutinise the government's approach in calling for an industry 'transformation' without a clear commitment to the provision of an order book that will encourage the industry's actors to take steps to adopt digital technologies and develop capabilities around the use of OSM. The absence of a reliable pipeline of works creates uncertainty in the industry and hampers a wide scale move towards their uptake. The government has arguably sought to address this concern by

publishing the 'National Infrastructure Delivery Plan and Pipeline' since 2013, with the latest one providing projections for construction projects lined up from 2016 to 2021 (IPA, 2016).

## 4.5. Organisational/Project level factors

### 4.5.1. Absence of substantial 'business case' evidence to support project-level deployment

A critical challenge to a wide scale industry interest in using digital technologies and OSM is the lack of 'hard' evidence to justify a business case (BCG, 2019). Why should construction organisations invest in developing capabilities for the use of MMCs? The lack of substantial evidence to this critical question remains a strong disincentive for firms to invest resources in using these MMCs as there is no reliable data of positive returns. According to KPMG (2016), the slow uptake of offsite construction is mainly attributable to the lack of substantial evidence for its value at project, portfolio and asset-whole life levels. In the absence of such convincing information uptake will continue to be slow, patchy and anecdotal. For construction firms, investment in modern technologies is deemed a risk and so the need for substantial evidence of success and benefits across projects and portfolios is very important.

### 4.5.2. Decision-making metrics: value vs cost

Traditionally, organisations have been found to favour cost-based models to inform investment decisions – particularly in modern technology-driven construction methods. In addition to the lack of substantial evidence to form a business case, evaluation methods based on which decisions are made by organisations to (not) use OSM are narrow and leave out assessments for health and safety, site facilities, crane costs and rectification costs. Benefits of offsite production for construction is project-specific, but the complexities of interdependent task execution and project decision making compound difficulties faced in making a holistically informed choice about using OSM (Blismas et al., 2006; Arashpour et al., 2016).

Clients have a strong role to play in the production of detailed comparison notes prior to selecting an approach to be used on a project. If the request does not come from them, nothing is done (cf. Lines et al., 2015). In many cases where offsite production is used for parts of a project, there are no formal procedures and records that provide detailed comparisons between alternatives considered and so future decision-making is made more difficult (Blismas et al., 2006). In deciding whether to use offsite for some portions of building projects instead of traditional methods, there is a lot of emphasis on simple monetary measures that are easily calculable. Implications of the choice of method for construction on health, safety, work and environmental practices, often fall under the radar. Other cost elements, including reworks arising from adjustments on-site are also neglected and deemed to be included in claims that will be negotiated when a project ends.

Existing lowest-cost based tendering frameworks that are preferred do not encourage the incorporation of detailed evaluations by tenderers. The uncertainty surrounding the tendering process (win or loss) further serves as a disincentive for bidders, knowing that clients tend to make decisions based on the lowest cost. Codified knowledge accumulation at organisational levels is important if offsite manufacturing should be deployed effectively as an alternative to traditional methods (Gan et al., 2018). The creation of a clear evaluation method is important to enable detailed evaluations and future decision-making. The usefulness of such a database extends to intra-organisational and project-based benchmarking in considering the use of offsite manufacturing for projects.

#### 4.5.3. Lack of capabilities to effectively deploy OSM

The construction industry is generally considered a laggard in the use of digital technologies and the deployment of new innovative methods for project delivery (McKinsey & Company, 2016, 2017). This feature of the industry is underpinned in part by the fixation of the industry's actors on the use of traditionally acquired skills in day-to-day operations based on the needs clients present. As a result, in this age of 'digital revolution', construction is one of the worst-placed in terms of preparedness of its labour power (McKinsey & Company, 2017, 2018).

Globally, the lack of digital capabilities in the construction industry is well-known (Vass and Gustavsson, 2017; Aksenova et al., 2019). Generally, the capabilities needed to effectively deploy MMCs like OSM from clients, consultants and contractors is no different. The foregoing situation prevails in a place like the UK where construction labour is ageing, there is shortage in supply of well-trained workers, gradual decline of construction apprenticeship programs and there is increasing uncertainty around foreign labour in the face of Brexit (cf. House of Lords, 2018). These problems, coupled with increased casualisation of labour severely hamper any attempt to develop a sustainable program across organisations to develop the needed digital capabilities to deploy MMCs like OSM in a digitally enabled construction environment under the Digital Built Britain program.

#### 4.5.4. Low client demand for OSM-delivered projects

A common practice in the delivery of construction projects is that the client or owner (or their representatives) dictate a brief for consultants and contractors to execute. Even with new models of procurement that encourage early interdisciplinary involvement from the project team, the interests and demands of clients remain parochial. Put differently, supply chains simply respond to the demands of clients and work accordingly.

Presently, project clients (e.g. Government bodies, private individuals, corporate entities, Housing Associations) still have high preference for the 'tried and tested' traditional construction method – despite the espoused benefits of OSM (KPMG, 2016). The lack of client

demand exists for a wide range of reasons, primary amongst which is the lack of convincing evidence to choose OSM. The 'Smart Construction Report' places a firm demand on clients (public and private) to re-think their project briefs in order to incorporate modern methods of construction for their projects (*ibid*). Such a change in thinking, according to McKinsey (2018), would place a demand on the construction supply chain to deliver using techniques such as OSM and digital technologies, leading to organisational transitions towards their deployment.

#### 4.5.5. Inadequate expertise for efficient project planning around OSM

Skills gaps have been identified between existing professional disciplines functioning in construction firms and the capabilities required for contractors and consultants to effectively deploy OSM alongside digital technologies (cf. Ayinla and Adamu, 2018). Preparation of detailed drawings, project costing, scheduling, site planning, monitoring and quality assurance requirements that accompany the use of OSM vary to some degree from those for traditionally delivered projects (House of Lords, 2018). With OSM closely aligned with manufacturing and assembly principles, existing expertise in construction – a project-centric industry – would need to undergo some transformation for firms to effectively deploy this technique in delivering projects (HM Government, 2018). This expertise gap forms one reason why the use of OSM alongside digital technologies remains low in the UK.

#### 4.5.6. Organisational inertia and professional identity crises

The deployment of OSM and digital technologies challenges the status quo of business models and nudges organisations to change their internal configurations (e.g. hierarchies, roles and responsibilities, business focus, etc.). More often than not, evidence about construction firms show that they are less flexible to change (Goulding et al., 2015; Jones et al., 2019). Firms would rather modify a technology or adapt a new technique to suit existing arrangements to achieve better outcomes, than to alter (inter)organisational practices to accommodate new methods of construction (Vass and Gustavsson, 2017). This deeply ingrained feature of contractors and consultants exacerbate the difficulties associated with adopting modern methods of construction.

In addition to challenging existing business models, new technologically driven methods of construction, including OSM, have implications for internal and project role definitions. The deployment of new methods of construction have been found to change project team dynamics and internal role definitions that have become accepted over long years (cf. Whyte, 2019). The introduction of BIM, for instance, led to project teams being reconfigured to have 'BIM managers' as leaders, relegating the traditional architects and engineers from their traditionally-recognised leadership roles on such teams (cf. Akintola et al., 2017; Oraee et al., 2019). Traditional professions (eg. Architects, Civil Engineers and Quantity Surveyors/Cost Managers) are therefore found to typically oppose new methods that 'threaten' their



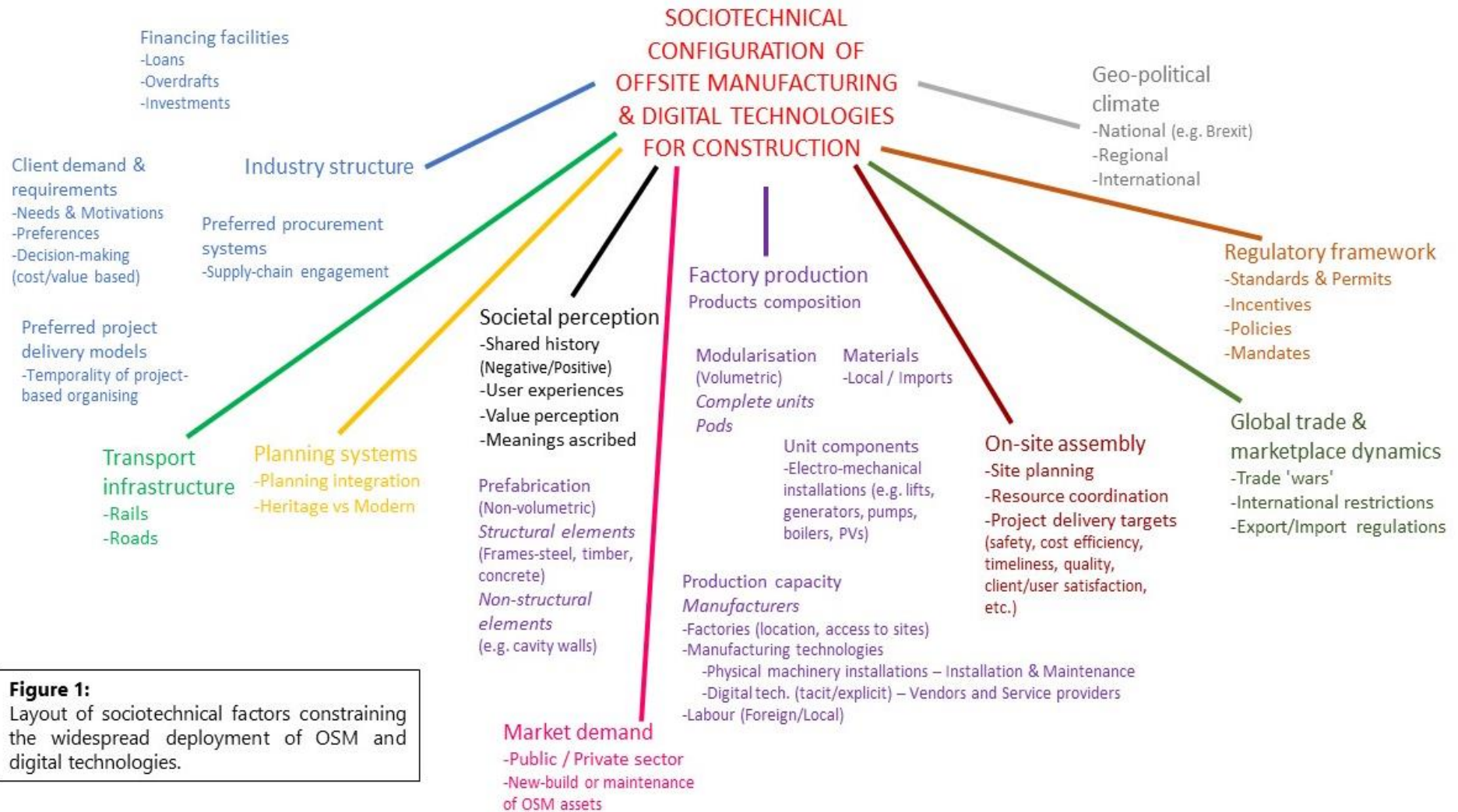
established positions of leadership based on their discipline expertise (cf. Akintola et al., 2017; Hosseini et al., 2018; Akintola et al., 2019). Here, parallels can be drawn from the preceding to understand how, *inter alia*, issues of professional identity contribute to organisational inertia towards the uptake of OSM.

#### 4.5.7. Lack of knowledge to guide intra and inter-organisational modifications

Linked to the preceding is the lack of adequate knowledge to manage the interface between the new models of supply chains expected to emerge with the deployment of digital technologies and OSM for the delivery of projects.

Supply chain management is critical for the successful delivery of construction projects. Procurement models currently preferred in the industry require main contractors to manage multiple layers of subcontractors in various trades. This complexity often poses challenges to project quality and timely delivery (Xue et al., 2018; Xue et al., 2010). The emergence of digital technologies and OSM as new construction techniques presents new forms of challenges for supply chain management – which requires managing intra- and inter-organisational interfaces (cf. Cidik et al., 2017). Instead of managing multiple trades under different contracts, main contractors would now be required to coordinate technical skills and capacities for specific manufacturers and on-site assembling firms (Jones et al., 2019). To effectively manage these interfaces requires knowledge that is rooted in manufacturing for effective project delivery (BCG, 2019; WEF, 2018; The Housing Forum, 2019). The industry's knowledge base, however, is deeply rooted in the traditional subcontracting management and so the knowledge gap poses a challenge for firms to embrace the deployment of OSM and digital technologies.

The layout in Figure 1 below highlights the mix of elements that impact the uptake of OSM and digital technologies in the UK. The factors discussed under the three (wider context, industry and organisational/project) levels do not impact the state of OSM adoption in isolation. They share connections that can be understood through a lens that brings the multi-faceted dimensions of technical and non-technical elements together in a way that makes their complex interdependencies clearer.



**Figure 1:** Layout of sociotechnical factors constraining the widespread deployment of OSM and digital technologies.

## 4.6. Current developments to improve uptake of OSM in the UK

A survey of the current construction landscape in the UK reveals a number of initiatives being advanced to increase the uptake of OSM alongside digital technologies for the delivery of projects. These developments, encompassing policy clarity, investments and partnerships, are both government and industry led and underpinned by a range of commercial interests, social needs and strategic motives with organisational, national and international implications.

### 4.6.1. Policy developments

#### *Industry strategy and policy-backed government commitment*

The UK government recognises the need for strategic partnership with actors in the industry to create change through innovation. Adopting a partnering framework, the government in the 2013 Industrial Strategy – Construction 2025 outlined a broad agenda for how the construction industry can be transformed to take advantage of the industry's growth globally and locally by harnessing the untapped potential of technological innovation. Following the broad agenda laid out in the Industrial Strategy (IS) 2013, the government has made clearer its intentions on how to 'radically' transform the construction industry in the latest strategy document, the Construction Sector Deal (HM Government, 2018).

The government has prioritised construction as one of the sectors for strategic investment to grow the country's economy and make it a leader in digital innovation. Specifically, the latest IS identifies digitalisation and offsite manufacturing for construction as two out of three strategic areas of focus for the government's investments. At the centre of the radical transformation agenda the government has stated intentions to invest, over the next decade, £600bn in construction infrastructure, including over £44bn committed to the provision of housing that people can afford and in places that are liveable. These investments place the deployment of MMCs at the forefront, with OSM and digitalisation forming the centrepiece. Accordingly, the vision of the government is to transform construction into "a sector that can build new homes in weeks – and even days – rather than months; that can deliver new buildings at a third of the cost; that can provide affordable, energy efficient homes" (HM Government, 2018, p.3). A £170m investment is also planned for the 'Better Buildings' programme to cater for digital technologies, manufacturing technologies and energy-reducing technologies for the construction of homes and other built assets. To ensure the supply of relevant labour for the attainment of these goals an attendant initiative here aimed at driving the transformation in the construction sector is a £64m investment in a national retraining scheme to re-skill workers to make them proficient in digital construction.

In addition to the investment plans laid out in the construction sector deal, the government is working across the industry through a number of initiatives. These include: the provision of

long-term financing for small construction firms, training and skills development for current needs and future demand, creation of more collaborative business environments that are fair for small players and investing in procuring using digital mechanisms through public sector clients (HM Government, 2018). To support the clear implementation of these plans outlined in the IS, the government has set up a 'Centre of Excellence' for the deployment of MMCs in northern England and appointed an MMC 'Champion' who will work with industry partners and the Construction Leadership Council (CLC) to accomplish the vision of a radically transformed construction industry (McVey, 2019).

#### 4.6.2. Public sector demand 'push'

The lack of demand for OSM-driven projects in the construction industry has been found as a major setback in attempts to increase widespread uptake (Green, 2013, 2016, 2019). There are persistent calls for the government, as the largest construction client in the UK, to trigger changes by assuring industry actors of a sustained demand for the use of digital technologies and OSM (House of Lords, 2018). In response to persistent calls for such an 'order book' the government is taking steps to promote the use of digital technologies for the delivery of construction projects through five departments from 2019. The aim of this move is to create the needed demand push to trigger a gradual industry transition towards technological innovation.

Five government departments (i.e., the Departments for Transport, Health and Social Care, Education, and the Ministries of Justice and Defence) will "use the presumption in favour of offsite construction by 2019 across suitable capital programmes, where it represents best value for money" as a means to create a market incentive for industry players to invest in OSM (HM Government, 2018, p. 17). The desire to promote OSM and digitalisation is premised on the aspiration that it will "help to minimise the wastage, inefficiencies and delays that affect onsite construction, and enable production to happen in parallel with site preparation – speeding up construction and reducing disruption" (*ibid*, p.7).

Creating this demand push in the industry towards the deployment of digital technologies and OSM for construction projects is anticipated to trickle down across supply chains engaged with public sector clients, with the ultimate goal of triggering widespread changes to reconfigure the industry. Concomitantly, the gradual incremental deployment of such innovative approaches will contribute to efforts at solving the housing supply problem facing the UK (DCLG, 2017) and provide better infrastructure for schools, hospitals and correctional facilities for a prosperous society in a more cost efficient, safe and timely fashion.

#### 4.6.3. Direct government investments in OSM and digitalisation

The government is often criticised for not taking tangible steps to invest in the innovations it promotes in the industry (Green, 2016; NHBC, 2016; House of Lords, 2018). Linked with the

creation of a demand push, the government, through the Housing Ministry recently made an investment of £30m into Ilke Homes, one of the country's leading housing organisations, to expand their use of OSM and digital technologies to delivery more affordable homes at a faster rate (HM Government, 2019). This move is part of the government's approaches to tackle the problem of inadequate housing. There is a need to meet the about 250,000 units per year gap between population growth and housing supply (DCLG, 2017) and the deployment of OSM solutions for housing provision is considered a useful solution.

Another direct government investment to promote the use of OSM and digital technologies is the £38m funding deal with six local authorities for the provision of over 2000 homes through Homes England. Per the deal the local authorities are encourage to adopt, "modern methods of construction (MMC) – from factory fabricated components to 3D modular construction – on their sites, to reflect the Government's commitment to investing in infrastructure" (Homes England, 2019, p.1). This investment is part of efforts to demonstrate the commitment of the government to promote the widespread use of OSM and digital technologies in every way possible.

#### 4.6.4. Industry initiatives

Interests of private actors in exploiting the benefits of OSM for the delivery of projects is growing. Organisations are taking risks to invest in the deployment of OSM for their own projects or setting up factories in anticipation of a boost in market demand for OSM-driven projects. According to KPMG (2016), that the use of OSM to deliver projects holds the potential to generate about 7% net financial gains and around 30% savings in processual efficiency when deployed across portfolios for standardisation. These benefits from the use of OSM, although anecdotal, have been recognised by both conventional and non-conventional construction industry investors as beneficial for the future. Actors hitherto uninvolved in construction project delivery are also making gradual entries into the sphere of OSM and digitalisation for the commercial rewards it promises.

Industry partnerships have been formed between organisations to either set up manufacturing factories, or harness resources for the deployment of digital technologies and OSM for their own needs or to meet the construction needs of others (Burgess et al., 2018; Offsite Hub, 2019; PBC Today, 2019). Examples of strategic alliances and individual initiatives in the preceding regard include:

- Laing O'Rourke, Legal & General and Touchstone forming a housing delivery model based on the deployment of OSM and digital technologies to meet housing needs for local authorities

- Top Hat, a manufacturing firm using digital technologies for the fabrication of offsite products receiving a £75m investment from Goldman Sachs boost its OSM production
- Department for Business Innovation and Skills giving a £22.1m grant to Laing O'Rourke for the development of an advanced manufacturing supply chain (AMSCI) initiative that exploits the deployment of MMCs (including OSM) and digital technologies
- Skanska and IKEA establishing BoKlok UK Limited as an OSM and digital technologies solutions provider for housing production
- Kier Construction setting up 'The Choice Factory', an award-winning manufacturing facility for offsite solutions

The developments highlighted give an indication of growing interest among industry actors to invest in the use of OSM and digital technologies now in order to reap the benefits in the future. Investments in digital technologies and OSM also reveal how organisations are taking steps to strategically position themselves as 'first entrants' who tend to hold larger market shares in new technology-driven product or service delivery sectors (cf. KPMG, 2016: Farmer, 2016).

## 5. The need for widespread uptake of OSM and digital technologies in the UK

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The benefits of an industry that is transformed via the use of digital technologies and OSM have been widely promoted and discussed in academic literature (e.g. Kimali et al., 2019; Hall et al., 2019; Gan et al., 2018; Jin et al., 2018) and industry reports (e.g. House of Lords, 2018; KPMG, 2016; BCG, 2019; Farmer, 2016). For the UK in particular, achieving a wide scale industry adoption of OSM deployed with digital technologies holds benefits for:

- The provision of adequate homes to meet the growing housing needs (DCLG, 2017)
- Promoting the delivery more *affordable* homes at a faster rate (HM Government, 2019)
- The provision of adequate infrastructure for education, health care, correctional facilities (HM Government, 2018)
- Creating opportunities for construction firms to develop capabilities in the area of OSM to increase construction skills exports to other countries in the wake of growing infrastructure needs (the global infrastructure and construction market is estimated to be worth \$2.5tn and projected to grow to \$49tn by 2030) (HM Government, 2018)
- Contributing to efforts at lowering capital expenditure by about a third, and to halve the following: project delivery times for new-builds and refurbishments, greenhouse emissions resulting from project delivery and building operations (HM Government, 2013, 2018)
- Reducing the amount of waste and environmental impact created by the construction industry (120m tonnes, making about 60% of total waste in the UK) (HM Government, 2018)

The preceding points highlight the clear benefits a widespread uptake of OSM alongside digital technologies holds for the development of the UK construction industry. To better position the industry to realise all these benefits, the problem of a low uptake calls for critical research and industry attention.

## 6. Research direction: Towards widespread industry uptake

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The current industry strategy of the UK government is poised to place the country's construction industry at the forefront of digital innovation. This ambition has triggered several initiatives that revolve around digitisation, innovation and the exploitation of modern methods of construction. The desired step changes in the implementation of initiatives would have significant implications for how construction projects are delivered and how contractors, clients and other stakeholders will operate. Like other innovation-backed attempts, achieving the goal of an industry where OSM is the 'new norm' is bound to face barriers owing to, among other reasons, the nature of the industry, social and cultural (human) issues. These potential barriers and others have been highlighted elsewhere in technology adoption and industry-wide innovation studies. The intricate nature of the construction industry and how it responds to the uptake of modern construction techniques or technologies has attracted and sustained decades of research (cf. Hosseini et al., 2018; Wang et al., 2018; Jin et al., 2018). The challenge, however, remains how to understand and address better the barriers related to the uptake of modern and technology-driven approaches for the delivery of projects taking into consideration the multi-faceted and dynamic nature of the industry.

The proposed study will contribute to that by focusing on digital technologies and OSM in the UK construction industry. By explaining the socio-technical, cultural and human-related dimensions, the findings from the study will complement the existing techno-centric understanding of barriers that face the wide-scale adoption of OSM and digital technologies. As noted earlier, the uptake of any new or modern approach to construction that is different from the preferred existing methods faces a number of challenges in becoming 'mainstream' in the industry. This situation persists regardless of the (potential) benefits an approach may hold in making the industry safer, more productive and cost-efficient. With ambitious government initiatives in motion to promote an industry-wide uptake of a modern construction method like OSM for construction in the UK, gaining an understanding of challenges holding back its widespread adoption holds relevance.

Drawing on the preceding understanding of the construction industry with respect to embracing technologically-driven innovations for project delivery, this research will investigate how to address challenges related to the implementation of OSM through emerging digital technologies in order to help make it a more viable alternative to traditional methods of on-site construction. Practically, insights from the study could inform how barriers that would be identified may be addressed to promote industry uptake of off-site manufacturing for construction projects.



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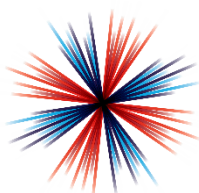
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