“It's your fault!” — said a public client to modernity advocates: An exploration of UK public sector’s viewpoints on the Modern Methods of Construction

Purpose: The staggering demand for construction projects to meet a spectrum of public needs is projected to outstrip the industry’s supply capability. The Modern Methods of Construction (MMC), offers wider control due to shifting key construction processes offsite. Public clients play a significant role due to their purchasing power, however, their uptake of MMC is low, despite the benefits. The purpose of this study is to reveal the reasoning behind such low adoption. The research gap, herewith, is our lack of understanding of the influence of public clients perceptions on their adoption’s indecision.

Design/methodology/approach: This study utilised a qualitative approach to investigate the motives behind the public sector’s low MMC adoption. Semi-structured interviews with 14 of the United Kingdom’s public sector’s decision-makers, industry leaders, and experts have been conducted. Perspectives were argued against the Diffusion of Innovation theory (DOI).

Findings: Overall, the innovation’s attributes informed the authors of the positive perceptions from the public sector, demonstrating that the low adoption of MMC is not linked to any embedded issues with the innovation itself rather being predominantly related to the dynamics between supply and demand. The former (supply), reflected a failure in communicating confidence, and the latter (demand), attained characteristics that are limiting wider uptake.

Originality: This is the first study to apply the Diffusion of Innovation theory to reveal the relationship between UK public clients’ perceptions and their decision-making. Moreover, this paper addresses the scant attention to the use of theories to explain the flow of innovations in the construction context.

Introduction

The construction industry's bad reputation extends to decades of misalignment with regularities and policymakers. In the United Kingdom, the government recently released the revised version of the Construction Playbook, a document that imposes a spectrum of critical policies (HM Government, 2022), which is only one of a series of multiple governmental measures to address the underperformance of the construction industry. For instance, only 34 percent of UK construction projects have been delivered on schedule (Gledson and Greenwood, 2017), severe cost overruns that range between 50 to 100 percent above the agreed budget (Miranda Sarmento and Renneboog, 2017), and staggering carbon emissions rates that misalign with the UK requirements of at least 80 percent reduction (Papachristos et al., 2020). Such challenges are examples of why a critical necessity exists for a fundamental alternative to the presently utilised methods of construction.

Recently, particular construction methods are described as saviours in the betterment of the construction industry and described by the Modern Methods of Construction (MMC) (MHCLG, 2019). The adoption of these methods has seen a recent uprise amidst the new commitments to address the construction sector's challanges (Killingsworth et al., 2021). Reasons behind such popularity are the benefits and values offered by adding control to construction processes. For instance, MMC is reducing construction time by 50 percent (Richard, 2019), leading to cost reduction of over 10 percent (Sutrisna et al., 2022), and meeting significant carbon reduction rates (Teng et al., 2018). Such benefits led to MMC being called a credible successor over traditional methods (Killingsworth et al., 2021).

The first recorded use of comparable terms relevant to the same philosophy, i.e. offsite, prefabrication, and modular, dates back to 1910 by Walter Gropius, who advocates the need for mass production of housing to meet the spiking UK demand (Aitchison, 2014). However, the actual application of such methods has been traced back to 1851 in the development of the Crystal Palace in London (Gibb, 2001). Arguably, Arif and Egbu (2010) link MMC practices to as far and old as the construction of the pyramids. Recently, the term MMC has widely regained popularity in the UK because of the presumption of favour of the UK government, to meet its ambitious construction agenda (HM Government, 2022). However, despite the governmental support to favour these methods, MMC uptake in the construction sector is yet far from satisfactory (Taylor, 2020). To study the low uptake, this study focuses primarily on UK public clients, a social system described as a facilitator of innovation (Antoniou and Marinelli, 2020), due to their purchasing power (Walker and Brammer, 2009), having a growth proportion of over £2.7 bn (Taylor, 2020). Such client type chiefly focuses its business processes towards the public welfare rather than seeking revenue (Sutrisna and Goulding, 2019).

The novelty of this study, hence, is by being the first to investigate how MMC is perceived by the UK public body and how these perceptions are contributing to their indecision. To achieve this, a qualitative method of research has been adopted and applied through semi-structured interviews with UK public clients and industry leaders. Such an approach enables the authors to offer first-hand data and contemporary discussions to the relative body of knowledge, arguing a variety of reasoning that explain the low uptake of MMC in the UK construction sector.

Adopting a definition: The Modern Methods of Construction

To start with, it is imperative to shed light on the accurate meaning behind the use of the term 'MMC'. Adopting a precise definition is believed to be essential amidst the widespread ambiguous terminological definitions (Ofori-Kuragu and Osei-Kyei, 2021a), with a lack of one standard universally accepted definition (Taylor, 2020). The unstandardised use of definitions is causing discrepancies in the meaning behind the real connotation (Piroozfar and Farr, 2013). It is worth noting that inconsistency in naming an innovation has been argued to influence its adoption rate (Rogers, 2003). To address this, Nawi et al. (2019) suggest harmonising a terminology that is linked to all of MMC applications. Adopting a definition, therefore, is necessary to guide this study to a meaning that is approvable by both academia and the UK construction market relevant to the context of this paper.

Notionally, as evidenced in the term 'modern methods', MMC refers to modernising longstanding conventional methods. Scholar critics, however, reject the modernity of MMC, suggesting that this construction philosophy is not new but as as old as the pyramids (Arif and Egbu, 2010). Generally, scholars tend to shuffle in using terms that are highly relevant to the same meaning, such as prefabrication (Darlow et al., 2022), modular (Ofori-Kuragu and Osei-Kyei, 2021a), volumetric (Zhang et al., 2021), offsite construction (OSC) (Obi et al., 2023), and industrialised construction (IC) (Goh and Loosemore, 2017). Nevertheless, within the differences of terminological applications transpires a common undertone linked to the inversely proportional relationship between the higher use of offsite methods and the vital reduction of the onsite ones. This aligns with Ginigaddara et al. (2022), who explain that MMC comprises a range of volumetric and non-volumetric structures and components with the inclusion of modules and pods, sustaining an offsite stance. Hence, the related definition literature suggests a widespread use of terms to describe multiple ideas

related to the same innovation, in this context being under the MMC umbrella. This stance has been noted as highly feasible by Rogers (2003), inferring that it is commonly proper for one innovation to cluster a range of similar and highly relevant ideas.

The MMC guidance, a recently issued document by the UK government as a supplement to the revised Construction Playbook (HM Government, 2022), defines MMC as “a wide term, covering a range of offsite and onsite techniques. MMC provides alternatives to traditional methods and has the potential to deliver significant improvements in productivity, efficiency and quality for both the construction industry and public sector” (Government Commercial Function, 2022, p.5). Such definition, moreover, attributes to the UK governmental publication, which proposes a definition framework, classifying MMC into seven different categories (MHCLG, 2019), namely:

- **Category 1**: *Pre-Manufacturing - 3D primary structural systems*
- **Category 2**: *Pre-Manufacturing - 2D primary structural systems*
- **Category 3**: *Pre-Manufacturing - Non-systemised structural components*
- **Category 4**: *Pre-Manufacturing - Additive Manufacturing*
- **Category 5**: *Pre-Manufacturing – Non-structural assemblies and sub-assemblies*
- **Category 6**: *Traditional building product-led site labour reduction/productivity improvements*
- **Category 7**: *Site process-led labour reduction/productivity improvements*

This study, hereby, conceptualises MMC from the lenses of both the DOI theory and the UK public sector, as a cluster that encompasses multiple construction innovations that are different as methods, but common as a philosophy.

Literature review and theoretical underpinning

Although multiple opportunities associated with MMC exist in literature (Choi et al., 2019), Rogers (2003) explains that benefits alone do not necessarily comprise sufficient cognition to drive innovation-adoption. The Diffusion of Innovation theory (DOI), encompasses a widely utilised set of constructs to predict the flow of innovation across vast industries. The constructs, as shown in Figure 1, have been described as the innovation's attributes. Ehwi et al. (2022) reveal limited use of theories in MMC research, delimiting wider coherence. The DOI theory is not contemporary in construction research, in fact, Mead et al. (2020) used it to study sustainable construction practices, Besklubova et al. (2021) to investigate 3D printing technology, and Xu et al. (2020) to explore the adoption of Building Information Modelling.

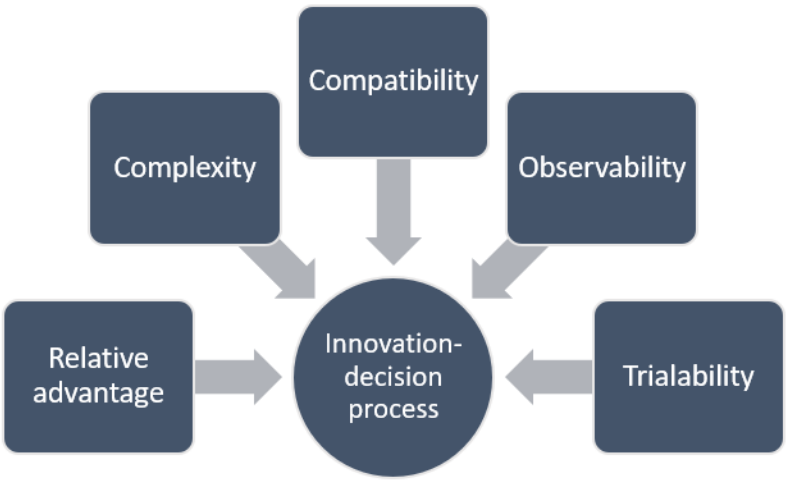

Figure 1. Innovation's attributes (Adapted from Rogers (2003))

An innovation's relative advantage distinguishes it as superior to other adopted practices perceived as traditional (Rogers, 2003). The matter of cost emerges as a critical determinant that dictates this comparison. Such methods are being argued by literature to be "cost-effective" compared to traditionally adopted construction methods (Goulding et al., 2015, p.181), being an empirical key factor that influenced clients'

adoption of three projects (O'Connor et al., 2014). Statistically, cost savings account for over 25 percent reduction compared to the traditional methods (Pan and Sidwell, 2011, p.1083). Moreover, MMC has been discussed to meet critical sustainability goals (Goulding et al., 2015); such as achieving 51 percent carbon reduction (Monahan and Powell, 2011), and favouring of smaller companies (Pablo and London, 2020); such as lowering the entry points for smaller firms (Gbadamosi et al., 2020). In addition, MMC has been linked to promoting digitalisation in construction (Malik et al., 2019); such as the expanded use of virtual reality (Iuorio et al., 2019), and the enhanced use of BIM (Yang and Pan, 2021). Productivity, furthermore, emerges as another relative advantage of MMC (Wasim et al., 2020); where it achieves 400 percent improvement in labour productivity (Goh and Goh, 2019). Albeit vast relative advantages, it is unclear whether the same is perceived by public clients.

The more complex an innovation is, the fewer prospects it has when influencing an innovation-decision. For instance, fire resistance grows as a concern due to the nature of how modules are connected (Liew et al., 2019), thermal comfort due to lack of insulations (Tažiková et al., 2020), and waterproofing due to gaps between panels (Orlowski et al., 2018). Moreover, design complexities exist with the adoption of MMC; such as the requirement of design freeze, which limits clients' inputs (Sutrisna and Goulding, 2019), the multiple MMC options that stimulate confusion (Gbadamosi et al., 2020), and the misalignment of MMC with public clients' past experience (Gao et al., 2020). Furthermore, the offsite nature of MMC, with minimum onsite activities, may lead to potential delivery complexities (Tavares et al., 2019); such as module dimensions and road appropriateness (Salama et al., 2017). Our understanding, therefore, is limited to whether MMC is perceived to make public clients' projects more complex and difficult to use.

An innovation's compatibility with adopter's norms, needs, and past experience enhances its adoptability (Rogers, 2003). Contractually, MMC may require amendments to the standard forms of contracts due to changes compared to traditional methods (Charlson and Dimka, 2021), as fewer onsite activities may require a different contractual approach (Duncheva and Bradley, 2019). Moreover, less onsite work may mean less job opportunities, which influence existing skill sets (Pablo and London, 2020); for instance, the new need for assemblers, a role that is MMC-relevant (Hairstans and Smith, 2018). Other compatibility determinants are the consistency of MMC with the surrounding; in appearing "less modular" (Ofori-Kuragu and Osei-Kyei, 2021b, p.8), and the compatibility of MMC with warranty schemes (Taylor, 2020). Our understanding, however, of whether public client organisation's perceive MMC as consistent is limited.

The more adopters can observe the emergence of an innovation, the more favourable the innovation-decision (Rogers, 2003). The exposure of MMC has been argued to be a contractor's responsibility (Mandicak et al., 2017), where the availability of public MMC data has been emphasised (Pan and Sidwell, 2011). Effective exposure, in this context, means that clients would be more aware of the values being proposed by the shift from conventional methods (Hairstans and Smith, 2018). Kuragu (2021b, p.2) reports the critical need for explicit articulation of "what exactly MMC is". Our knowledge, therefore, is significantly limited on whether public clients can observe the benefits of MMC in practice.

Trialability examines whether an innovation is easily experimented and tested before adoption (Rogers, 2003). Literature, however, is discreet in capturing whether MMC could be easily trailed by public client organisations. Technological advancements emerge to shape trails, as visualisation and simulation technologies

are excelling in this direction (Iuorio et al., 2019). Moreover, the use of technologies to detect and predict uncertainties of MMC has been recorded in literature (Hasan and Lu, 2021). For instance, uncertainties like the breakdown of manufacturing machines and lead times for delivery and assembly (Yang et al., 2021). Literature, therefore, it is not clear whether public clients' perceive MMC as easily trailable and whether they can easily recoup their investment.

This paper, hereby, builds upon MMC literature by applying the five innovation attributes of the DOI theory to unravel what MMC mean to UK public clients, responding to recent calls for the need to better study the adoption of MMC across the construction sector (Abdul Nabi and El-adaway, 2020; Oti-Sarpong et al., 2022; Darlow et al., 2022; Ayinla et al., 2022). The novelty of this paper, therefore, is the exploration, through theoretical means, of the indecision of public client organisations to enhance their uptake of MMC despite the demonstrated values and benefits.

Methodology

The interest in MMC has recently resurfaced by researchers seeking to explore its potential as a construction alternative (Jin et al., 2019). Overall, a systematic review of MMC-related methodologies revealed the limited use of qualitative and theoretical arguments in recent research (Ehwi et al., 2022). The qualitative research methodology is best suited to investigate and explain a phenomenon (Eisenhardt, 1989), and deeply understand a given subject's views and perceptions (Hoepfl, 1997). Compared to quantitative research methods, a qualitative approach enables participants to freely share their views and conceptions (Meissner et al., 2011). The choice of pursuing this paper's aim through qualitative means would fit with this paper's exploratory nature.

Data collection

The DOI theory apprises research on the critical relationship between an adopters' perception and their decision-making, questioning how such theoretical underpinnings relate to the case of MMC in the UK public sector, and whether any particular perceptions are contributing to the low rates of MMC adoption. As shown in Figure 2, the methodological process passes through a literature review, data collection, data analysis, and results.

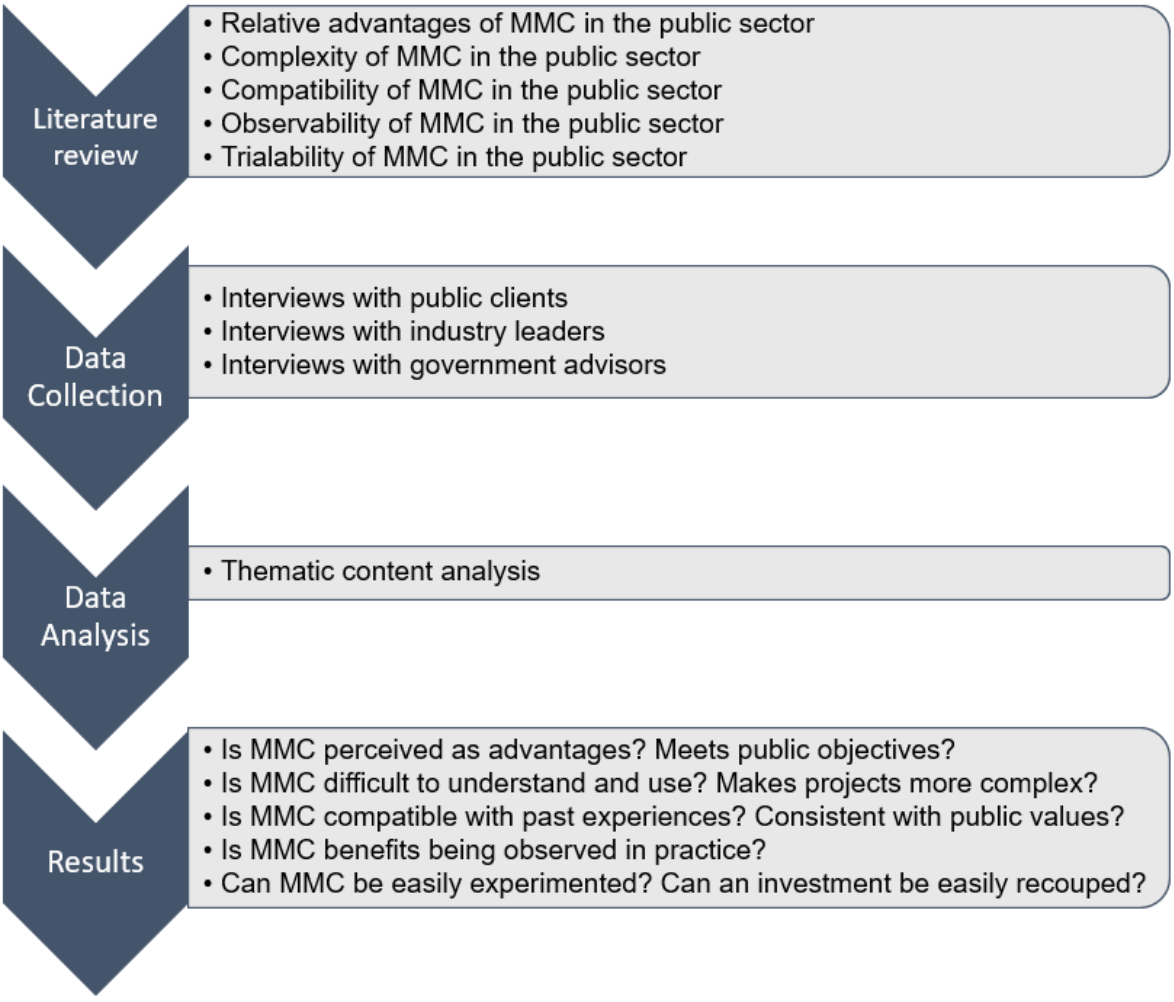

Figure 2. Methodology process

Sampling strategy

This paper utilised a purposive sampling method to collect the qualitative data. Purposive sampling is a non-probabilistic approach where scholars select individuals based on their characteristics that are not easily accessible through other random sampling approaches (Tongco, 2007). In the context of this paper, individuals needed for an adequate study must attain a status that reflects the viewpoints of UK public construction clients. The purposive approach, hereby, is useful due to the limited nature of individuals required, allowing the researcher to sample participants based on their influence, role, and position in the UK construction sector, which are key aspects for offering targeted, informative, and in-depth qualitative data. This approach led to a total of fourteen interviews with decision-makers and industry leaders seen as highly qualified to take part in this research. In terms of validity and reliability, no set of widely utilised tests exists to determine how valid and reliable a qualitative method is (Patton, 1982). However, the strength of these methods has been argued to be through their data saturation (O'Reilly and Parker, 2013). Albeit no consensus on a rule of thumb number of interviews needed for saturation, nevertheless, Galvin (2015) infers that saturation is highly achieved after exceeding 12 interviews.

The interviewees are previously known by the authors due to their popularity in, holding roles that influence policies, represent public clients, and advise the government. Such diversification allows the authors to explore the perception of public clients, but also add arguments from other experts that amplified value to the same context, achieving less bias (Qu and Dumay, 2011). Generally, the interview lengths varied between forty-five minutes to over an hour, where interviewees expressed their perceptions and views on what MMC mean to UK public sector organisations, giving meaning to the context as they see fit (Diefenbach, 2009). As shown in Table 1,

interviewees have extensive years of experience in either or both the industry and the public sector, additionally pinpointing the importance of their views.

Table 1. Sample characteristics

Number	Job role/description	Years of experience
1	Technical Director in an Innovation and Construction firm	38 years
2	Policy and Public Affairs Manager	13 years
3	UK Government Official	20 years
4	UK Leader of Industry Transformation	20 years
5	UK MMC Expert	22 years
6	Public Client Principal Architecture	24 years
7	Public Client Development Director	15 years
8	Technical Director in a UK-based Multinational Consultancy	10 years
9	Public Client Senior Development Manager	30 years
10	Public Client Chief Executive	35 years
11	Managing Director of a Wholly Owned Local Housing Firm	25 years
12	Partner (Residential Designer) in UK Construction Industry	40 years
13	CEO of UK consultancy and UK government advisor	35 years
14	Department for Education (DfE) Representative	30 years

Data analysis

The initial approach of a qualitative analysis includes condensing the findings because of the overwhelming amount of data (Rabiee, 2004). Due to adopting a theoretical argument, findings are classified in their relevancy to textual data, following the set of procedures reported by Braun (2021). Descriptions that have been relevant to each of the DOI theory's innovation attributes construct have been extracted and aligned to best suit the context of this study. The process of the thematic analysis of data is shown in Figure 3. In analysing of the interview data, this paper utilised an inductive reasoning approach. This means that inspite utilising the constructs from the DOI theory, themes within each construct emerge from the analysis upon the identification of patterns and trends among the data (Boyd and Ashley, 2006), and not relying on

any pre-determined themes, but rather extending existing knowledge (Hayes et al., 2010). In this sense, Nvivo software has been utilised in the coding of data, allowing the researcher to visualise information and sumplify the complexity associated with qualitative analysis (Dalkin et al., 2021). Therefore, the grouping of discussions into themes, as seen in the following section, is iterative and is refined based on the commonality of data analysed, fitting each under its relative construct from the five constructs offered by the theory.

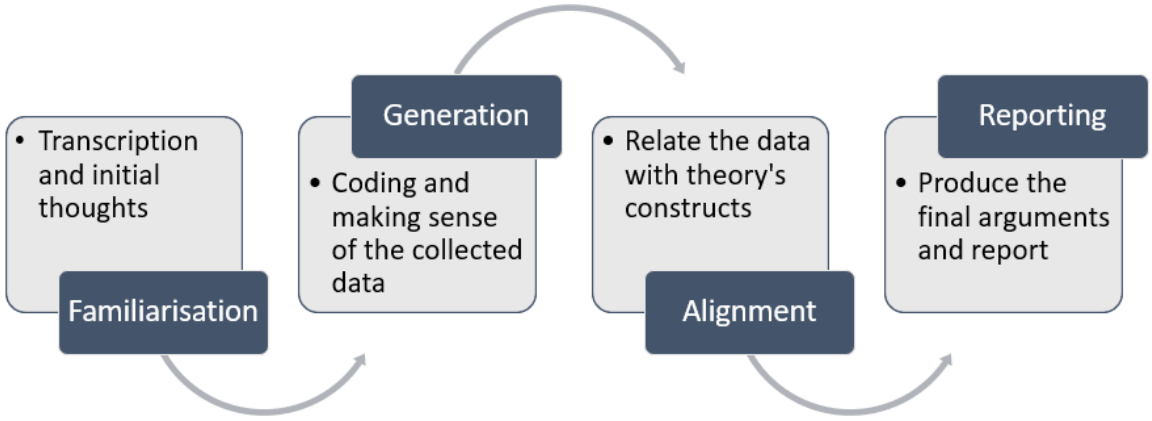

Figure 3. Qualitative thematic analysis process

Empirical findings

1. ***Relative advantage***. The initial questioning is whether MMC is perceived as advantageous by the UK public construction sector. To capture the relative information, questions focus if MMC benefits can help public clients achieve their public goals. The following subsections include the themes under the relative advantages construct.

Cost: "The obsession with cheapness"

The arguments develop to flag cost as enough reason to "*put local authorities off*" as noted by Participant 9 (P9). Similarly, cost comparisons place MMC as more

expensive, being described as "*a stumbling block*" by (P6). In contrast, others did not find cost as less advantageous compared to traditional construction; "*it's actually not more expensive, it's sort of the wrong conception*" (P1). The findings, however, reflect a view where cost is not necessarily linked to MMC, but may be influenced by other factors. For instance, (P12) argues that "*local authorities who have ended up paying far too much for MMC, primarily because they go to the wrong frameworks".* This has been supported by (P13), who illustrates "*if you want a capex saving, then it won't be advantageous, and our industry is dominated by people, including in the public sector, who think about capex and they don't think about total*". The perception that MMC is more expensive is being shaped by a generic comparison with the traditional ways, influencing a state of unfairness to the innovation; "*what we are, as we were, campaigning against this obsession with cheapness or with low tenders*" (P4), aligning with (P14), who illustrates; "*first projects were more costly than traditional, but with that learning curve effect and with increased volume, the unit cost has come down and is projected to continue to come down later"*.

Certainty and control: "We know exactly what's going to happen"

Unsurprisingly, the controlled environment fostered by the adoption of MMC emerges as a key advantage perceived by public clients. For instance, participants pinpoint the ability of public clients to perceive MMC as advantageous in dealing with external and force majeure events; "*You don't have down days because of rain*" (P1), compared to traditional construction that has been described to be associated with "*delays due to weather disruption, people not turning up on site*" (P3), a factor that has been described by the same participant to "*push us the client public towards looking at MMC, because you're producing it in controlled conditions*". Moreover, the interviewees have noted the enhanced certainly as another value facilitated by

fostering more control; "*know exactly what's going to happen*" (P5). This has been described as a luxury compared to traditional construction, making MMC advantageous in a critical construction concern; "*we know what product we're getting, how will that then looks, feels, and performs when it's on site and when it's being lived in*" (P7). Hence, another relative advantage differentiating MMC from traditional methods is the controlled aspect offered by the former and lagged by the latter.

Faster project delivery: "the magic button"

Speed in MMC has been advocated as a critical relative advantage; "*if we could push a magic button and get everyone switched over to MMC, the build rate would go up*" (P10), adding that the quicker the delivery, the faster the ability for public organisations to realise value. For instance, (P2) discusses that the "*Department for Education needs to produce x amount of schools over the course of five years in order to do its function, which is educate the population, and MMC could be hugely effective*". Similarly, this extends beyond education to cover health and justice; "*a program like the hospitals program or the prison program, ultimately, they're trying to drive speed, they don't have the capacity in those states they need, it's an aging estate*" (P8). Public client organisations looking for speed as an innovation characteristic is promoting MMC as an advantageous option in their innovation-decision.

Reducing environmental impacts: "really, really high on the agenda"

A particular interest of public clients is the ability to minimise the carbon footprint and sustain zero emissions and waste; "*it's far easier to measure and monitor carbon emissions, you can improve the design to minimise material use, reduce the requirements for energy intensive material like steel that pulls down emissions, minimise waste, and design for re-use and recycling, which again it just reduces the*

environmental impact" (P3). The aspect of carbon, and it's impact, has long been a concern nurtured by the traditional ways of constructing new projects, where MMC is realised as a potential solution; "*public sector clients are buying into MMC when they're looking at the carbon side, the energy efficiency is really, really high on the agenda for local authorities and housing associations*" (P5). Hence, harvesting MMC advantages is perceived by public clients as a reliable route to meet their objectives; "*Scottish Government is saying, by 2030 that all publicly funded housing should have zero carbon emissions, and really the only way to do that is to use MMC*" (P9).

MMC meeting public clients' objectives: "it's not a panacea"

There is a consensus among the interviewees that MMC is effectively meeting their objectives; "*MMC is not only helping us achieve the traditional objectives, it's helping us achieve some of our broader social objectives*" (P3). Overall, there is a positive perception that MMC align with public clients' objectives; "*we have seen MMC achieve the objectives of good quality design, good quality spaces, added to the energy efficiency of low bills, low maintenance and numerous other things*" (P6). However, the interviewees reflected the need for cautiousness when governing these processes; "*it's not a panacea, if you select the wrong supply chain, if you procure in the wrong way, if your design isn't aligned to manufacturing, then sometimes you're going to end up with just as a bad solution as if you'd just build it traditionally*" (P13). To achieve such an alignment, therefore, (P8) calls for contingency between MMC and setting up clear commitments and values as needed by public clients; "*they're almost blindly after the advantages without really understanding what they're trying to drive, if they are using it in the wrong scenarios and they don't see the benefits they're expecting, then we've got pretty good tarnished the reputation of these approaches*".

2. ***Complexity***. Unsurprisingly, MMC dictates a new way of construction, and it is logical that the shift from conventionality towards modernisation is associated with perceived complexities. This subsection aims to explore whether MMC makes public projects more complex, and whether MMC is more difficult to use and understand compared to the traditional methods.

Perceived technical complexities: "they all do the same thing, but differently"

Public clients have land banks, and sometimes, the sloping of some sites, or the overall confinement, would mean that some MMC solutions may not be appropriate; "*they tend to have is slightly more difficult sites*" (P10). Such difficulties are argued to be resolved by experienced contractors; "*the solution is brought by the contractor, i.e. as an as-built solution*" (P11). However, this is not always the case, (P9) shares; "*services like drainage didn't match with the pop ups on the factory, the tolerances were so tight that the guys on site needed to put the pop ups in place and that created a hell of a lot of problems in terms of bastardizing the kit to make it fit*". Moreover, another perceived technical complexity is that the solutions being offered by the providers cannot be extended to others, (P1) illustrates this by stating; "*they all do the same thing, but differently, this is the inconsistency of MMC. If they could standardise, then they would be on to a winner*". Similarly, (P6) adds on the same issue by stating; "*different modular companies build things in different manner, and that lack of consistency in those elements causes us problems*".

Perceived design complexities: "It's not just a one stop shop"

As part of the overall transformation to minimise onsite activities, as a key feature of MMC, ensuring an early design freeze is essential; "*they design it once and it's going to get built many times*" (P4). Such advantage, however, may not be understood by

the public sector; "*they don't necessarily understand the need for early design freeze, and that's where it tends to go wrong, Public sector clients think: well, further down the line, we can change it, if we don't like it. Well, no you can't*" (P5). Such restriction on the design is not being appreciated by public clients; "*I understand why they kick back, because they are trying to make certain economies of scale and cost. But sometimes this takes the imagination away from certain elements, even though their product may be considered innovative, they may take a more fluid design, maybe option that could be there a way to meet what clients need or want. It's not just a one stop shop*" (P6).

Perceived delivery complexities: "moving MMC is moving lots of air"

In MMC, the transportation phase includes whole structures, rather than the normally delivered material in small batches. (P7) shares; "*we've had issues regarding the transport accessibility to the sites or variations that might be required through planning that just can't be accommodated in volumetric*". The importance of the transportation phase is due to the influence of this stage on the overall benefits of MMC; "*if you think about the logistics of the thing, a lot of moving MMC around is moving lots of air around, there's a lot, a lot of product, but there's an awful lot of air. So you want to keep the logistics as low as possible, which is going to cut down on carbon footprint and everything else*" (P10).

Coherence and ease of understanding: "it's black magic"

The public sector was argued to be lagging in understanding the benefits of MMC; "*very few people in the public sector even know what MMC means, let alone what is encompassed within MMC*" (P10). Moreover, (P13) calls for more connectiveness; "*It's about public clients doing more market intelligent research, going out and doing market engagement, meeting MMC manufacturers, meeting specialists,*

understanding the products, going and seeing them in the factory and seeing completed schemes. And potentially, it's a theory, but wouldn't it be great if some public clients spoke to each other?". In a supply context, (P11) illustrates; "*the challenge that we have is how MMC is communicated to clients, the success or otherwise in terms of the uptake of MMC is largely in the control of consultants and/or contractors*". This aligns with the arguments made by (P9), who states; "*it's still black magic, and if you ask consultants to come up with a proposal to meet a specification to meet zero carbon, you'll get different views, it's all a bit vague*".

3. ***Compatibility***. The consistency of an innovation with the needs, values, and past experience of adopters facilitates its adoption rates. This subsection, hereby, includes the themes that relates to MMC compatibility with the public sector.

Positioning of an innovation: "The skewed view of it"

Certainly, MMC is associated with a fundamental transformation, and such a change has been described as "*labour intensive*" by (P2), who illustrated; "*the change that's required to embed MMC makes things much more complex*". A reasonable question, therefore, is what encompasses this change, and whether the dynamics of MMC makes it difficult for clients to accept it; "*to show you the skewed view of it, for example, a lot of public sector clients have gone to manufacturers wanting them to build it, and the manufacturers have gone: Well, we don't build stuff, we just make stuff in factories. You wouldn't expect a BMW dealership to build the car*" (P10). Such arguments, overall, suggest a change resistance rather than an innovation incompataibility; "*I don't think MMC per se is making it more complex, I think they are not sufficiently familiar with the process of commissioning MMC*" (P5). The government recognises such change and are introducing measures to encourage MMC adoption; "*I'm quite hopeful*

that the new guidelines the Government's bringing out next year will help in that, with much more of a focus on collaboration" (P12).

Compatibility with regularities: "there's no carrot and there's no stick"

To start with, (P2) details the changing objectives of the public sector; "*ten years ago it was all about being cost effective and making sure that you were delivering projects to time and to budget. Now, the public sector's perception of value has changed dramatically, we are more focused on achieving outcomes like net zero, and we're going to do it through MMC*". However, regulatory bodies are yet to adapt to change; "*the other issue that crop up a little bit is the authority's insurance body, so as they start seeing things which are not bricks and mortar, they start to panic and almost in some cases scuppered the scheme*" (P6). Such misalignment extends to the standard forms of contracts; "*the contracts and the payment methodologies are slightly different because you're paying for products that's not on your land because of the way it's constructed*" (P7). It is logical to state that despite the mentioned misalignments, the issues tend to be externally driven than being MMC-relevant; "*MMC is seen as an important tool, but it's not being seen as a kind of legal necessity legislatively, there's no carrot and there's no stick*" (P2).

Compatibility with localism: "it benefited the folks in Wales"

The ability for an innovation to substantiate local value and the creation of opportunities may promote its perceived compatibility standing; "*a local authority will want to have a minimum number of apprentices being trained at in that borough and that could be difficult to do if you're doing it offsite*" (P13). Similarly, this concern has been pinpointed by (P5), who states; "*if they are being very precise and saying as part of the contract, we expect that you'll bring in 20 apprenticeships and the organisations*

say, well no we won't, we can't do that. So that might be a misalignment certainly from value for money point of view". Moreover, the location of the manufacturers also places a concern for public client organisations looking for social value and localism; "*in MMC, if they get made in a factory miles away from where these things are built, the only thing that's going to benefit is the owners of the factory, and in our instance they were built in Wales, so building 50 houses in Clackmannanshire, what benefit did it have on the local economy? None, because it benefited the folks in Wales*" (P9).

Compatibility with past experience: "meet their half of the bargain"

The use of past experience to judge new practices and innovations is another compatibility aspect to consider within the innovation's attributes. In the construction context, public clients' may be required to compromise on normal activities to embrace MMC, raising questions on the consistency of such innovations with client's normal line of work; "*public sector are used to procuring lots of things very traditionally over many hundreds of years, this is different and they haven't got huge experience to lean on"* (P8). This adds narrative to the arguments by (P5), who states, "*public sector clients procuring it need to understand that they can't change their mind, this is the design, this is what's been agreed, they need to meet their half of the bargain*". Overall, clients' tend to be conservative in accepting such fundamental change to past experience; "*they were trying to dictate the design, specification, materials, etc. to us rather than us as the authority in the client dictating to them*" (P6). Hence, past experience of public clients' may misalign with MMC processes.

Compatibility with public values and needs: "the bitter pill"

MMC is excelling in meeting public sector's values and needs; "*it does align with our values because it's a routine to delivering better, more sustainable buildings that*

enable us to deliver better quality public services" (P3). The key value that MMC is achieving is relative to sustainability; "*if MMC organisations are able to demonstrate with data that their building is able to achieve carbon reduction or energy efficiency, then that will very much align with needs and values*" (P5). Arguably, public clients reflect their readiness to overcome the unfavourable aspects of MMC in favour of the values associated; "*it might be a bitter pill, in fact, we commissioned architects to do a feasibility study to look at MMC in the sense that, by 2030, be zero carbon, and the consultants looked at the current building that we do, then they looked at 2025 specification and then the 2030 specification and told us what we needed to do to achieve zero carbon, and it only goes one way - It's MMC*" (P7).

Naming an innovation: "a very broad terminology"

Rogers (2003, p.229) notes the importance of compatibly naming an innovation that is desirable and clear to the audience, being "receiver-oriented". Generally, our findings suggest the wide acceptance of the use of MMC as a term, as all interviewees use the same term interchangeably throughout the research. The methods that MMC encompasses, however, has been identified to contribute to misunderstandings; "*It's a very broad terminology. We talk about prefabrication, modular, modernisation, personalisation. You can imagine public sector clients not knowing one from the other, people, naturally, if they don't understand something, they won't adopt it*" (P11). The confusion transpires to what is included in MMC, technically, rather than the overall concept; "*I struggle with some of the closed panel timber frame calling them MMC because it's just cobbled together, it is not terribly effective, I only consider it as MMC if it is properly built in factories*" (P10). In a policy context, same arguments emerge to identify the broad terminology adopted within the sector; "*it's not clearly defined in policy, so when we say MMC, we are not very clear on whether we mean specific*

technologies, at the policy level of what it is, it's rather seen as one of a kind solution for driving efficiency" (P2).

4. **Observability**. The better an innovation is observed the easier decisions could be formulated, particularly if adoption is initiated by peers. In this section, interviewees are asked to provide their views on whether they can easily observe the emergence and adoption of MMC.

MMC exposure: "it's your fault!"

The clarity associated with an innovation, and the way the same is communicated, plays a significant role in abolishing vast confusions and misconceptions; "*I stood up in the offsite manufacturing conference a few years ago, and I pointed at all of the contractors and manufacturers there, and I said, it's your fault, why aren't you telling people? why aren't you briefing your clients? why aren't you almost force feeding this information to them? And there is just stunned silence*" (P10). In an observability context, the lack of means to transfer credible information and data seems to transpire in public clients view; "*I don't think anyone has done a website, forum, or magazine that showcases what MMC does, there's no one depository where you can go and look at all these MMC buildings*" (P1). As a benchmark, (P2) sets another construction innovation, Building Information Modelling (BIM), and relates the same to context; "*Why is BIM so transformational and not MMC? There are these we call them BIM trolls, like people who are so passionate, they dedicate their whole career to kind of not only doing the doing, but actually having an opinion and being a thought leader. I don't know if there's the equivalent in MMC I'm thinking kind of like from a government perspective, some of the kind of industry leaders*".

Observability through exemplars: "none of its directors live in their own product"

It is logical to relate the existence of exemplars to aid adopters' informed decisions when observing an innovation; "*I went to one MMC factory that will remain nameless in the UK, and the very fact that none of its directors live in their own product says volumes to me*" (P11). Moreover, (P12) relates confidence to the existence of suitable exemplars, who states, "*we've had these exemplars in the past, which are examples of nothing. The examples of how to spend a lot of money on things which never get repeated*". Similarly, (P10) argues, "*well, where are the exemplars? do you even know what you're looking at? it's very difficult for people to see what's going on".* This aligns with what has been stated by (P11), who argues that the existing exemplars are not promoting confidence; "*I don't think there is much exposure for the public sector to MMC in practice, there'll be case studies, but the trouble is all these case studies tend to be one offs*".

Observability through data: "talk is cheap"

In the MMC context, public clients note the lack of data that would inform them of the reliability of MMC in practice; "*we don't have the historical data; we don't have evidence of stuff*" (P8). The lack of communication of reliable data emerges to influence MMC observability; "*talk is cheap, as a client, I'm interested in performance, qualitative data, but also the quantitative data*" (P11). Moreover, intervewees questioned the existence of case studies; "*You've got the lagging metrics of being able to point to a building that has been procured and built through MMC and say: Look, that works. that's a good building.*" (P4). *Such case studies, however, have been argued to be unsuitable in their current state; "*mostly evidence is provided by industry in the form of case studies that actually are more like marketing than case studies, and I don't think that's a very good way to proportion evidence to the public sector*" (P2). The issue of lack of data that builds confidence, therefore, is argued to be

lagging, a stance that may be influencing observability; "*they have been around for long enough, but the data isn't there*" (P5).

Demand's motive to observe: "it's there to be seen"

Another dimension of MMC observability could be argued to be the motivation of clients to seek adoption; "*they watch it, they see people living in the homes, they can talk to them, they wouldn't know the homes are modular because they're just beautiful buildings*" (P12). Upon the arguments, an interesting statement emerge to describe the need for public clients' to play a role in enhancing the overall observability; "*it links to their proactivity in wanting to go out and learn, the more proactive clients who are looking at MMC will go out and visit factories, they will visit completed projects, they will go and ask other public clients their experiences, and they will share that learning, there's no reason why you can't go and see completed MMC buildings, it's there to be seen*" (P13). As an example, (P10) shares a situation where proactivity, despite slow, has led to a favourable decision; "*they bumped into each other at a conference, got chatting: Oh, that's a good idea, how do we do this?; And six years later, something happens, and that's not good enough*".

Past failures and historical observability: "the bane of their lives"

Another factor that shapes the observability of an innovation is the ability of adopters is being up to date rather than benchmarking past failures; "*the history of MMC in the post-war years, initially, it was very good, then it escalated and got into the race for delivery of numbers and it was adopted by UK contractors, it went very bad and we knocked a lot of it down*" (P12). Such perception has been developed due to MMC previous failures in the public sector; "*public sector clients have lots of post-war prefab houses that have been the bane of their lives for several decades*" (P11). This aligns

with (P13), who states, "*public client organizations may have a different story in terms of their own personal relationship with MMC in the past that has gone wrong. I see some people that can't be bothered to even test it because they had such a bad experience that they think it will happen again*". However, there was a lack of generalisation between how past failures prevail today; "*it fits very well, our experience of it has been that it worked, people living in them have no general idea how their home may be constructed. It definitely worked consistently, it performed reliably, and we're quite keen to scale it up*" (P7).

Observability amidst collapsing firms: "on front of the construction press"

A logical stance that may link to an innovation's observability is the collapse of vast organisations supplying the innovation. Findings suggest public sector's resistance to embrace MMC amidst the multiple liquidation of MMC firms; "*there's no confidence in the market that these players are going to be round beyond probably the first ten years of the lifetime of this building*" (P11). Moreover, (P10) tend to point out the supply side to elaborate on this matter, stating, "*we've seen so many fold over the last 20 years, they just crashed and burned because no one understood about manufacturing*" (P10). The difference, in this narrative, is the observability noted by (P8), who states, "*we see construction companies go bust over time, but when an MMC construction company goes bust, it seems to be on front of the construction press, which is frustrating because for every one MMC company, there's probably been 100 traditional companies that have gone down*".

5. ***Trialability***. An innovation that is effectively and easily experimented would enhance its adoption prospects. This section questions the views on whether public

clients' perceive MMC as easily trialled, and the extent where public clients can recoup their investment in the situation where MMC does not meet their needs.

Ease of MMC trials: "putting their toe in the water"

The ability of public clients to trial MMC can be argued to facilitate it's adoption across the public sector; "*experimentation is relatively easily straightforward and when we've done that, it's been successful*" (P3). Public clients, however, tend to place the cost of these trials as barriers for wider experimentation; "*who's paying for those trials? once the risks are removed from the public sector for that trial, then you may be successful in driving people to putting their toe in the water*" (P11). Tentatively, (P10) proposes less costly procedures to trial MMC; "*If you want to try it, put people on a plane to Scandinavia, show them all the units out on site, manufactured, and being built. It's a lot cheaper than trialling. And once they see it working and that local authorities in Holland and Scandinavia are using it, why wouldn't they?"*. Moreover, (P5) argues that trailing MMC is not as easily perceived; "*I think it's going to jump through a lot of procurement barriers and procurement hoops*".

The effectiveness of experimentation: "a leap of faith"

The interviewees questioned the effectiveness of investing in trials, with a consensus that trailing MMC may not yield any advantages; "*would you trial a new three series BMW? No, you wouldn't, you'd build it and you'd commit and then you would produce hundreds of thousands, that's the only way you can manufacture stuff. There's been so many trials in the public sector for MMC and that's why it's failed because they've been trials. We've been trialling it in Scandinavia and Germany for 130 years. Why have we got to trial it here? What are you going to learn? Nothing*" (P10). The low effectiveness associated with doing trials is linked to the nature of MMC, where

benefits are revealed based on volume; "*if you're building 15 houses, that's quite a small trial, arguably, how much evidence does that really give you?"* (P5). Similarly, (P7) relates this to the need for commitment; "*what the factories need now is scale, they need people to commit*". This also aligns with (P12), who states, "*each local authority can't procure enough to really get the true benefits*". These arguments support the longitudinal stance to capturing MMC values; "*the real benefit of MMC is not just in the construction phase*" (P3). Where (P2) emphasises the need for a "*a leap of faith*" in pursuing long-term transformational outcomes.

Recouping the investment: "melt it down and turn it into a fridge"

The ability to recoup an investment in an innovation would act as a reassurance trialability attribute. Interviewees reflected confidence in contracts to secure their investments; "*our contracts contain all of the usual remedies, we can pursue them under the terms of the contract for failing to deliver*" (P3). Similarly, (P4) states; "*the way the contracts are written, then the supplier will be liable for that*". Arguably, (P8) discusses the matter of ownership as a critical reassurance; "*there is more ownership, you understand where that starts and finishes, looking at Grenfell, you bring lots and lots of different products together in a bespoke fashion on a particular job. How do you understand who's responsible for that total solution working?*". Moreover, in the unlikely situation where MMC fails to meet client's preferences, interviewees argue the ability to easily use the material compared to traditional construction; "*just lift it up, put it on the back of the lorry and remove it, resell it, recycle it. You can't do that with a traditional building*" (P1). Therefore, in general, the concept of recouping investment in construction may not emerge as a matter of significance; "*you don't build most buildings on the assumption that like a car in ten years' time it will be turned into scrap metal, melt it down and turn it into a fridge, you produce buildings to last*" (P3).

Discussion

This exploratory paper establishes a key thread of arguments that enable research to overview public clients' perceptions of a construction innovation, focusing on the link between their perceptions and their decision-making. The first promising contribution is that public clients perceive MMC as advantageous in meeting their objectives, a stance argued by innovation scholars to emerge as the best prediction of an innovation's diffusion (Rogers, 2003). However, the conception that MMC is more expensive than traditional methods prevails to shape the overall public sector's perception, nurtured by the advocated generic comparison. Our findings inform us that measuring cost cross-sectionally results in an incomplete image of reality, where insights are instead encouraged to form based on a lifecycle and longitudinal comparison to realise the values of MMC. Another aspect is what economics phrase as "learning by doing" (Chang et al., 2001, p.2), where the processes of value offering evolve with time, and scale, as adoption increases, yielding lower costs for demand upon meeting an economy of scale. Moreover, findings suggest the preventive status of MMC as an innovation, where its adoption is promoted to avoid future unwanted events (Rogers, 2003), i.e. environmental degradation (Piroozfar et al., 2012), housing crises (Iuorio et al., 2019), and construction causalities (Ahn et al., 2020). This finding narrates to us a two-dimensional paradigm where the adoption of MMC is limited by the fear of fundamental change but is also driven by the fear of the consequences associated with rejecting change.

Secondly, our results indicate that MMC is not generally perceived as complex and difficult to understand by the public sector. The lurking issue, herewith, is through the meaning given to the innovation by both supply and demand (Edler and Georghiou, 2007). To start with the supply side, providers are argued to pioneer standardisation

to their clients' choices, however, they lack the ability to achieve the same among themselves, the limited coordination among providers means that solutions can not extend from one provider to another, nurturing the perception that a change in the MMC solution is required with every change in the supply. Moreover, from a demand side, public clients are yet to perceive the benefits of an early design freeze, in balance with their traditionally preferred direction of seeking uniqueness, in addition to their lack of connectiveness among other clients from the same social system. Such characteristics, from both supply and demand, inform us that complexity is fostered, rather than embedded, with the absence of a complexity-simplicity continuum (Rogers, 2003), where issues identified from literature such as fire resistance (Liew et al., 2019), thermal comfort (Tažiková et al., 2020), and water proofing (Orlowski et al., 2018), are not perceived by public clients as complexities that negatively influence their innovation-decision.

Thirdly, our findings suggest the general consistency of MMC with public clients' needs and values. Overall, the perspectives inform us that MMC has met the need felt by the public sector, where adopters tend to recognise their needs (Rogers, 2003). This, however, is not void from inconsistencies, in this context, it is through viewing and assessing MMC from the lens of old ideas and familiar standards, which leads to an old-fashioned approach when interpreting the relevancy of an innovation (Rogers, 2003), in turn, promoting uncertainty rather than minimising it. Such inconsistency of MMC with public clients' past experience, is promoting a stance of innovation negativism, where the failure of an innovation dictates inhibits future adoption (Rogers, 2003), conditioning the public sector to view MMC from the reasoning of its first emergence and realised historical failures. Moreover, confusion emerge under this construct to inform us of the interrelated nature of MMC to encompass a variety of

solutions, and systems i.e. volumetric, modular, etc., acting as a bundle of new ideas rather than one innovation, raising the argument to whether these different solutions under MMC may be treated separately, or the formation of an “easier-to-adopt” package (Rogers, 2003, p.227). This argument relates to the provided name of the innovation, as the given innovation name is argued to influence its compatibility (Rogers, 2003). Commonly, all participants tend to be aware of the term MMC, and what it comprises. However, our findings suggest that concerns exist with this wording, in terms of clarity, or distinctness, as the expression of the term acts as a thought unit that influences the perception of what it precisely means (Rogers, 2003).

Fourthly, MMC has been perceived as easily trialled by the public client organisation, however, concerns emerge on the necessity and effectiveness of these trials. Rogers (2003) touches on this and argues that if an innovation has been adopted by peers, in our context being other public clients, newer trails are then less significant. Our findings suggest that despite the ease of experimenting MMC, knowledge gained from these trials are reasoned to be of no considerable value. This links to what has been discussed in realising the relative advantages, as the nature of MMC dictates that values are not sensed entirely through a short period, or with limited quantities. Moreover, the argument where, in an MMC context, investments would be easily recovered, a lack of consensus on the feasibility of such a claim, as the public sector’s sureness of the robustness of their contracts limits potential failures where recouping an investment claim is likely to happen.

Finally, MMC reflected good observability among public client organisations. However, the emerging concern relating to observability is the issue of confidence, and how this confidence is flowing in the construction sector. Generally, there seems to be an internal communication problem that is delimiting a stream of reliable

information through connectiveness. Our findings suggest that the transmittal of network messages between supply and demand, and between demand and demand, are limited and are restraining an effective knowledge exchange and transfer of reliable data (Rogers, 2003). Such an issue is contributing to the static image of MMC, being observed from the lens of history rather than from that of the present. These perceptions, moreover, are being nurtured by construction press, as any failure linked to MMC is being leveraged as scoops of news that misleads decision-makers from reality and actual occurrences, primarily relating construction issues as MMC issues. The efforts, in this context, from the supply side have been argued to be lagging and ineffective, as their exemplar campaigns are being based on their needs as providers rather than the needs of the clients, converting exertions from informative case studies to marketing attempts.

Conclusion

Critics of the construction industry relate its lag compared to other industries to the lack of innovating. This paper provides evidence that MMC, a cluster encompassing multiple new ideas that are seeking more control by maximising offsite value, is nominated as an innovation believed to prevail in shaping the industry's future. Literature uncovers that a good knowledge base exists in relation to MMC, however, little research focuses on its adoption particularly in relation to classic theories. This study draws on the viewpoints of fourteen UK industry leaders and demonstrates that the low adoption of MMC is not related to the innovation's attributes that are conveyed in the DOI theory, but rather to how a common meaning is pursued by both supply and demand. Our interpretation, based on empirical findings, is that the characteristics of public clients influence their decision-making, an aspect that is cultivated by the means in which supply communicates confidence to the public sector. Public clients wishing

to achieve wider use of MMC in their projects are encouraged to focus less on the innovation's features, and more on their own characteristics that are seen to limit their innovation-decision. For example, the cross-sectional criteria in their cost judgements, the lack of connectiveness with other public clients, and the non-realisation of the benefits of design freeze and standardisation. Additionally, it is imperative for MMC businesses seeking commercial advantage in the public sector to carefully consider altering their business models to embrace the decision-making of public clients. The study reveals that such business model alterations must focus on the factors delimiting the effective communication of confidence through substantiating an adequate ability to meet clients' needs and wants through this construction methodology. In turn, this may lead to outspreading trust in MMC, increasing its adoption, and bridging any turmoil in the relationship between innovation providers and the public construction sector.

Despite the realisation of this paper's aim and objectives, multiple limitations exist. To start with, although the sample size reaching saturation and yielding a generous set of qualitative data, more inputs from decision-makers and industry leaders from the UK public sector would have resulted in a more in-depth overview of the pursued viewpoints. Secondly, despite that the term 'MMC' is widely known and adopted in the UK, as evidenced in the relative definition section, the use of the term may influence the overall generalisation to audiences from other countries. Finally, the reasoning approach utilised to fit themes under each of the theory's constructs can be argued as subjective, and therefore, this paper would benefit from future studies validating the groupings done in this theme through quantitative and statistical methods, by using this paper as a critical foundation.

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