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A sustainable built environment for healthcare: generative mechanisms for future-proofing

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A sustainable built environment for healthcare: generative mechanisms for future-proofing

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Abstract. Construction projects are planned from a set of deterministic objectives and constraints that dictates what designers must accomplish. In the case of healthcare facilities, where the policy environment is characterized by change on several fronts, fixed requirements could constrain their evolvability and sustainability. Future-proofing is a response to uncertainty whereby a physical structure is designed to respond to future changes in requirements, change of use, strategic perspectives, business drivers, new policies and changing climate. The paper investigates the causal powers that explain how and why future-proofing decisions achieve a sustainable outcome. A critical realist lens is adopted to develop a configurational perspective of future-proofing design evolution. Critical Realism's open systems ontology of social reality can account for the fact that outcomes are not predictable and can better explain the nature of causation in complex social interactions such as construction projects. A case study research design was conducted comprising in-depth interviews with healthcare construction professionals in a UK setting. The study contributes to the sustainability literature by offering four generative mechanisms of future-proofing decision making and how they contingently lead – or fail to lead - to future-proof outcomes. Two change mechanisms and two problem mechanisms are presented, together with their configuration under the right conditions and context to lead to design decisions for construction projects capable of adapting to a range of possible futures.

1. Introduction

Large construction projects are complex systems at the intersection of engineering, management and social sciences [1]. Developing such complex systems requires not only skills such as architectural and engineering design, but also knowledge of policy issues, societal norms and trends [2]. In addition, these systems include challenges that need to be dealt with due to their size [3], complexity, and technological change [4]. Further, sustainability objectives must be met, with national legislation and strategies, such as the UK's Climate Change Act (2008) and Clean Growth Strategy [5], paving the way for businesses and industries including the construction sector to invest in and deliver sustainable developments.

One type of large and complex construction system is the healthcare estate, which has become less flexible compared to a few decades ago [6]. Healthcare and its executive teams face a policy environment characterized by change on several fronts (e.g. reforms in health services, medical technology [7]. Healthcare building assets exist in a complex operational and technological environment and consequently identifying the requirements from a whole-life management perspective is crucial for ensuring these assets will meet their design life [8]. Additionally, for a physical asset to achieve sustainability, designers and investors alike recognize that it has to be also future-proofed [9].

In this paper, the concept of future-proofing (FP) is considered as a ‘shield’ against uncertainty. Recent studies suggest that FP is a phenomenon that can only exist in an open system [2], [10]. However, the traditional approach is to procure and deliver healthcare facilities as ‘complete’ projects, in other words, projects with fixed requirements or closed systems. Standard practice proceeds from a set of deterministic objectives and constraints that defines what designers must accomplish, thus standard practice does not deal with rapid change [2]. FP may be considered as an essential feature of “true sustainability” [11] – the notion of persistence over time without input of limited or non-renewable resources. In terms of construction, a project in which FP has influenced decision making is expected to remain in operational use beyond its initial span. This results, at least, in minimization of additional resources to reconfigure the development and, at best, avoidance of demolition waste and embodied carbon of materials for a new building. Our research question is: “Which mechanisms cause future-proof outcomes?”. The study aims to contribute by identifying of generative mechanisms within a configurational approach. The adopted approach advances current knowledge about why some complex systems are future-proofed while other systems are not.

2. Literature review

Planning is a process that involves making decisions about future actions [12], often characterized by uncertainty due to incomplete knowledge. Numerous factors contribute to uncertainty in construction projects, such as, but not limited to, climate change and sustainability challenges, digitalization of the built environment and change in regulations. Planning for projects under conditions of uncertainty is challenging, as many of the decisions are interconnected. Strategic planning decisions are actions that pave the way and are irreversible. In situations where they are not compatible with future circumstances, subsequent interdependent decisions are also incompatible [12]. This poses significant challenges for practitioners. The flexibility perspective of planning adopts approaches that accommodate future changes. The intellectual basis of flexibility includes contingency theory [13], and evolutionary theory [14], based on the notion that practices need to be adaptable and compatible with a changing and uncertain future. This approach recognizes the need for being future ready – as the project evolves, unexpected challenges, requirements or opportunities, such as new technology, could emerge. Flexible design approaches are decisions that can either accommodate flexibility during project implementation or after completion, for example, embedding options, modularity and late design freeze [15], [16]. Planning for flexible approaches, such as flexible designs, implementation tends to enable smoother and adaptive working practices, which reduces the risk of time and cost overruns. Approaches that contribute to flexibility in the long-term and after project implementation (are referred to as FP, which enable projects to accommodate future needs [10].

Within the flexibility perspective, real-options theory examines the role of embedded options [2]. The term real-options refers to the “right, but not an obligation, to take some future specified action at a specified cost” related to a physical asset [17]. The theory originates from the financial options logic. Embedded options increase the flexibility of construction projects and can result in less disruption during project operations [18]. FP of a project can be conceptualized as embedding options that could be used by the users/owners in the later life-cycle of projects [16]. These options could be dealing with downside situations (e.g. change of use, due to shift in customer requirements) or upside opportunities (e.g. exploiting new technologies) [19].

3. Research Methodology

Considering the above, our research question is: *“Which mechanisms contingently cause future-proof outcomes?”*. We addressed the question by adopting case study research and applied previously established methodological principles [20]. A total of 26 interviews of between 60 and 240 minutes were conducted with senior managers from procurers and supply chain organizations (suppliers) engaged in health estate projects for the UK National Health Service (NHS) who had experience in future-proofing.

Secondary data were also used, including direct reports and papers from the NHS and the Department of Health (DH), and third-party reports which reviewed NHS estate investment strategies and processes. Methodologically, we used Wynn and Williams [20] four-step approach to report the findings, as summarized in Table 1. In analyzing the transcripts and secondary data, the NVivo qualitative package software was used.

Table 1. Methodological stages of Critical Realism (adapted from Wynn and Williams, 2012)

Methodological stage	Outputs and evaluation criteria
Explication of Events	• Basic description of case study, setting the scene • Summary and streamlined version of events as they occurred. Use of direct quotes to show perception in the empirical domain • Description of events includes details of key actions and outcomes • Documentation of the effects (or not) of change
Explication of Structures and Context	• Identification of social and physical structures (actors, rules), and relationships among them • Identification of context and necessary conditions (tendencies) • Description of causal tendencies that caused the events • Identification of changes (or not) to the structure • Description of emergent properties
Explication of mechanisms	• Identification of proposed mechanisms that emerged in the real domain • Use of abduction reasoning to logically support the mechanisms • Identify *problem* mechanisms and *change* mechanisms
Alternative mechanisms	• Identification of alternative mechanisms that could exist • Validation of proposed mechanisms over alternative mechanisms

Configurational approach

Working within a stratified CR framework, a configurational approach [21], distils the philosophical stance into a methodological framework. Key terms are mechanisms, objects, context and conditions, which will now be explained. This approach enables outcomes to be explained by analyzing configurations of possible mechanisms and context-variations. A generative mechanism may be *active* or *passive* in a system - its activation can lead to a desired outcome if that mechanism operates within an appropriate context. Context is a general concept that encapsulates the 'relevant circumstances. The mechanisms exist in a given context and under the right conditions become enacted. If the context/conditions are not in place the mechanism's causal powers have no impact.

The context of this study is the construction contract. The entities include both agents such as procurers and supply chain consultants and contractors, and the relationships between them. Both agent types, procurers and suppliers have powers. In this context, a supply chain consultant can take actions in the best interests of the procurer, and the procurer can make decisions based on the recommendations made by the consultant and what is exchanged has the power to influence both parties. Future-proofing decision-making is enacted within this context. conditions that directly or indirectly lead to the success of a construction project are deemed *success factors* [22].

4. Case Study Findings

4.1 Background

The setting of this case study was a large-scale public service organization, the UK NHS which delivers (predominantly) free healthcare nationally. The service, to meet demand and become proactive in terms of responding to change, has developed capital plans which aim to maximize value for money. All proposed plans must be supported via business cases which are compliant with Department of Health guidelines. However, the consensus is that the current capital investment is insufficient to fund transformation and maintain the current and future estate business.

4.2. Explication of events

In the first step of analysis (see Table 1), a series of events is described, derived from the participants' accounts of experiences on healthcare projects procured around the UK.

4.2.1 Initiating the Business case

For NHS England, business case development is triggered by the need for a new service and estate. A business case must comply with a series of guiding principles. National data are used for the development of the business case which will cover current healthcare and new treatments. The appraisal of business case options must demonstrate that various options have been informed by stakeholder consultation, lessons learnt from past projects, and international comparative cases.

4.2.2 Establishing the Procurement route

As part of the tender process, the briefing document outlines the technical requirements the design must meet. The brief will describe the current needs including any aspects of future-proofing and sustainability goals the design should address. If NHS England is procuring with its own capital, then the supply chain interviewees claim it will go for the cheapest solution.: "To put it simply, the Trusts decide … the design with the lowest price wins" [S-HDiv]. If on the other hand, it is some form of public–private partnerships (PPP) project, then, potential investors look for the most economical solution over the whole life of the investment. In this case, the investors will be interested to explore what flexibility could offer in terms of return on investment (RO):

"The drivers for PFI [Private Finance Initiative] are totally different than NHS Capital Procurement, the PFI is driven by the banks and how much return on investment they can get. And if they are prepared to put some additional money up front to save a lot of money in the long term" [S-MD]

4.2.3 Preparing the Supply Chain Response

Once the tender documents are released, the supply chains form teams to respond to tender requirements with a proposal. During this stage, the team will formulate decisions around technical and commercial requirements to win the project. In going through this short term but demanding process, the main issues can be grouped into three broad categories. The first category is around prejudices on the concept of FP - stakeholders in both the procurers and supply chain involved in the project can see FP as a simple tick box exercise. The second category is around existing processes. The supply chain must convey their thinking against existing processes. For example, a supply side Design Director identified the constraints due to the brief content as limiting the ability of the technical response to accommodate options thinking: "The briefing is the main barrier, it constrains the approach. This is the primary concern… we would include flexibility in its full form [if not constrained by the brief]" [S-DirDes]. The third category is around financial issues. The supply chain struggles to justify offerings of value against offerings that are built on price. All participants highlighted financial issues that exist in incorporating options thinking in the technical solution, specifically the potential for higher construction costs. A development director noted: "The drivers of course are always cost related. It is cost, it is time! Why would we do anything like [future-proofing]?" [S-DirDev]. Despite these issues, technical solutions for FP are sought, and the teams respond in the best way possible in what they hope will be the winning solution. A sector director added: "you will win the work because you are the cheapest. So, you are not looking to duplicate anything when you are bidding" [S-SDir].

4.2.4 Initiating the Project

NHS England assesses all submissions and evaluates the value propositions based on two key categories: technical criteria and commercial criteria. The proposal which achieves the highest marks will be awarded the project. The supply chain team will try to incorporate FP after understanding where FP is needed. However, challenges emerge as additional funding for FP, improving quality or meeting sustainability standards is difficult to secure. Some of the participants felt that the only way that additional funding could be achieved was on the grounds of increased patient capacity and so FP becomes very difficult to justify. Changing old ways of thinking can be a challenging task for the supply chain team and as a result these conversations often fail. As a result, these complex capital investments in most cases do not have FP embedded in them and face risks of becoming obsolete before the end of their assumed design life.

4.3 Explication of Structure and Context

Having unpacked the sequence of events, we now turn to the explication of structure and context, the relationships of actors and identification of necessary conditions (Table 1, stage 2).

With regards to objects (e.g. actors) and the relationships amongst them, the supply chain actors act on behalf of the procurers' team to produce design solutions according to the specifications of the brief requirements. At first glance, this relationship may be perceived as a peer to peer relationship. However, the relationship between the two agents is directive. The structural relationship between those two actors is summarized by a managing director of a major UK contractor where he puts into perspective how the relational model may be formed:

"I think it [future-proofing] is very difficult …It is like one of those things where an editor can always tell you what you should have done previously rather [than] tell you what you need to do to go forward" [S-MD].

4.3.1 Contextual conditions

Having analyzed the context and structural relationships of objects, we turn to the critical success factors that actualized the FP configuration. Two conditions have been identified through our analysis.

Condition #1 Capital targets versus whole-life targets

This condition in the case study setting originates in the relationship between the Government's policy directives and the service's performance. The service's delivery performance was aimed to meet the government targets, hence reducing capital cost to meet set targets was more important than achieving whole-life targets. For the above reasons, justifying investment in the estate business, particularly in improving the future performance of the estate, received lower priority than performance of the service delivery, although arguably these are interrelated. On the other hand, having whole-life targets to identify where investment now would achieve savings later was identified as an enabling condition in the analysis.

Condition #2 Tight brief versus loosely-defined brief

This condition relates to the opposing tendencies of tight versus loosely-defined brief from the outset of the business case. In the case study, in general, client requirements for FP were superficial. Thus, when such solutions were proposed, they tended to be rejected, because the solutions were outside of the scope of the brief requirements. Instead, the brief was tightly focused on what was needed at that point in time. This tendency runs counter to a more loosely-defined approach, where the brief did not freeze prior to entering the design phase. An example of such approach was presented by the sector director of a consultancy firm:

"But FP should really come from designing a building such as the [Project N] Hospital which was allowed fast track construction. It was designed by not knowing were the departments will be, so it ended up with having huge floor plates, ducts on a regular basis and you could do what you like" [S-SDir].

During the development activity, a detailed account of solutions is developed. This detailed account in turn could feed back and redefine the requirements and thus lock-in of the baseline design would emerge at a more developed stage. In the above example, the team challenged the brief and shifted its focus from being capital driven to being operations driven. This would not have been possible if the procurement followed a tight brief schedule.

4.4 Explication of generative mechanisms

In the next stage of analysis, we tested various generative mechanisms (Table 1, stage 3) against the events of the case study. We adopted a backward-chaining approach [23], looking at the two outcomes of interest (obsolete systems; future-proof systems) and the causes that drive towards these outcomes. In total, we identified four generative mechanisms. We further analyzed them into two categories depending on their powers to influence an outcome. These mechanisms are now described.

Change mechanism #1 – Iteration between problem, design and solution spaces

In the in-depth interviews of this case study, there existed an insightful optimism that a construction system could expand its service life and offer best value. Not freezing the brief (condition #2) before the design solution reaches the required maturity created a loop of iterations between problem space and solution space [24]. These iterations result in both spaces being continually informed as the project matures. As a result, the two spaces feed back into the design space, where solutions can mature and be checked against the latest set of requirements. The participants described how a conversation between principal and agent takes place to discuss possible options enacted by the interplay of repeatable standardized design elements, overengineering and flexible design elements. Through this mechanism, the teams implemented an FP approach which resulted in numerous design solutions being assembled.

Change mechanism #2 – Making the case for affordability

The outcome of the first mechanism is the solution space, in other words, the number of candidate solutions that could become plausible scenarios for implementation. Yet, it is not determined at this point that these options will be implemented. The outcome of the second mechanism is the ultimate decision whether a combination of plausible interconnected solutions is affordable. The participants' propositions for affordable solutions to the client were also informed by previous cases.

In this mechanism, the case study findings indicate that the design which incorporates FP need to be perceived to be affordable to be attractive. Furthermore, the solution should feature payment-by-results, whereby additional investment to justify the business case to include FP thinking is contingent on the independent verification of results. A participant added: "The concept of Payment-by-results … implies that the only way that you afford anything … by saying 'I am going to put more patients through' so [FP] becomes very difficult to justify" [S-MD].

The participants identified that financial issues could stall approval and funding of a potential development. The dominant view was that budgets on a potential development are often already under financial pressure and thus clients would not decide on design choices for the future unless these were perceived as affordable.

Problem mechanism #1 – Cognitively-bounded decision-making

Having identified two mechanisms that could enact future-proof outcomes, we now turn to the resident problem mechanisms that may prevent successful outcomes. The first problem mechanism is that of cognitively-bounded decision-making. This draws on the long-established notion of bounded rationality [25]. Bounded rationality acknowledges that much human decision-making is highly complex and inevitably involves uncertainty but that people's abilities to deal with uncertainty, to identify options, to foresee consequences and to prioritize competing goals are very limited. To cope, the problem is simplified to be manageable and a 'satisficing' or 'good enough' outcome is pursued.

The interviewees alluded to the complexity of the problem, as a Development Director argued:

"Everything needs to account together… so that we can use [the building] at any given point in time in the future. And it is that bit that people do not get and they do not think about… we just do not think about it enough as a process." [S-DirDev].

The speaker here recognizes the complex, interconnected nature of FP and the bounded nature of thinking, suggesting that decision makers on project teams do not even address the more complex requirements. A programme manager for NHS estate stated: “I do not think we do it in detail” [P-PgmM] – a reference to simplifying the problem.

The problem of uncertainty was addressed explicitly in the interviews– uncertainty of outcomes and uncertainty over the meaning and value of FP. There was recognition that a simplified, all-or-nothing understanding of FP is inadequate, that the actors in the given context have not thought about it enough, and the problem lies in limited cognition (an interviewee referred to “insufficient thinking” [S-SDir].

Problem mechanism #2 – Motivational gap

The second problem mechanism’s causal powers stem from the lack of personal commitment which was in evidence in the interviews. The interviewees highlighted that actors in the social system of the construction project have different values. For instance, according to a managing director and owner of an architectural practice, the Tier 1 actors who are leading the process lack personal commitment, thus he and his team try to push different agendas such as sustainability and FP: “But the truth is, those end up being words in a presentation to win the job and then after that the contractor is not interested. It is very frustrating” [S-MD2].

5. Discussion and Conclusions

From this study, we sought to explain why some construction projects are future-proofed whilst others become obsolete. We described two change and two problem mechanisms behind future-proofed outcomes and the configurational setting and the context within which they operate.

We now turn to assess what alternative mechanisms could explain the occurrences of the observed events (Table 1, stage 4). From the literature, optimism bias emerged as an alternative mechanism. In the findings here, the interviewees did not underestimate how complex FP is, nor did they overestimate the beneficial outcomes of implementing FP. On the contrary, they criticized the current level of thinking on FP as inadequate. This inadequate thinking went beyond a simple cognitive bias and in fact the participants recognized varied cognitive limitations with regards to taking actions to pursue FP.

The second alternative mechanism explored was that of strategic misrepresentation. Strategic misrepresentation assumes a deterministic view of the outcome created by the planner’s conscious intent. However, our findings did not support a tendency by the supply chain deliberately to underestimate efforts required with regards to planning for FP.

In addition to the above, optimism bias and strategic representation can be rejected as potential alternative mechanisms because of their underlying assumption of a closed system approach. The two candidate mechanisms assume requirements fixation at pre-acquisition stage, whereas in complex projects such as healthcare requirement evolve over long time-spans of definition and development stages. Thus, whereas these projects should be treated as open systems, the above candidate mechanisms assume the planning activity takes place in a closed system.

We theorize that a construction system can be made sustainable as well as future-proof if the right conditions and the two change mechanisms identified above are enacted. Our findings suggest that decisions could lead to non-FP outcomes if the change mechanisms are insufficiently strong or if the necessary conditions are not in place. With regards to implication for policy, our findings have shown that policymakers need to allow for budget flexibility in the way funds are released, in order construction capital investments to achieve sustainability targets and be benchmarked beyond time, cost and quality. Allowing for a loose-fitting brief will contribute towards project success. Shifting assurance procedures towards whole-life targets instead of capital targets should be considered. Awareness of cognitive boundaries and personal commitment in FP agendas can enhance policy makers’ understanding of how procurers and supply chain partners will develop future-proof solutions and avert uncertainty.

Future research could broaden this study’s empirical and theoretical approach. Empirically, settings other than healthcare projects could be examined from a CR perspective. In addition, there is more work to be done with regards to CR and the literature on uncertainty in decision-making. Underlying each mechanism and condition there may lie other powers waiting to be discovered [26]. Investigating further the mechanisms outlined in this study using CR would offer valuable insights to rethink about how FP might be applied in the built environment.

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