Situating MMC Within Technological Adoption: Can government and industry work together to develop policies and roadmaps for adopting emerging technologies?

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Since the middle of the twentieth century offsite manufacturing, modular and prefabricated buildings have been transforming construction like nuclear fusion has been transforming energy. The technological base of these 'modern methods of construction' (MMC) is a mix of those from the first industrial revolution, like concrete, with second and third revolution technologies like factories and lean production. This was a manufacturing-centric view of progress in construction, but MMC have a dismal track record due to the brutal economies of scale and scope in a project-based, geographically dispersed industry subject to extreme swings in demand. Despite all efforts MMC has not delivered a decisive advantage over onsite production for the great majority of projects. Instead, construction has a deep, diverse and specialised value chain that resists integration because it is flexible and adapted to economic variability.

The drivers of development for industries in the twenty-first century are technologies such as augmented reality, nanotechnology, machine intelligence, digital fabrication, robotics, automation, exoskeletons and possibly human augmentation (Sawhney et al. 2020). Collectively, these digital technologies are described as a fourth industrial revolution, and over the next decade their capabilities can be expected to significantly improve as new applications emerge with the development of intelligent machines trained in specific tasks.

The role of these technologies will be to augment human labour in construction, not replace it. Generative design software does not replace architects or engineers. Optimisation of logistics or maintenance by AI does not replace mechanics. Onsite construction is a project-based activity using standardised components to deliver a specific building or structure in a specific location. The nature of a construction site means automated machinery and equipment will have to be constantly monitored and managed by people, with many of their current skills still relevant but applied in a different way. Nevertheless, in the various forms that building information models, digital twins, 3D concrete printing and procurement platforms take on their way to the construction site, they will become central to many of the tasks and activities involved. Education and training pathways and industry policies with incentives for labour-friendly technology will be needed (Rodrik and Stantcheva 2021).

The three papers in the Special Issue on MMC reflect the complexity of this situation, as innovation and technological change impacts the long-established structure, customs and practices of construction. Broadly, Green's focus is on industry and innovation policies, Meacham discusses MMC and building standards from a regulatory viewpoint, and Dowsett et al. get industry responses to their scenarios for future construction.

The main points in the critique of MMC by Green are: the technocratic language used is a value-laden and highly flexible discourse; an embedded pro-innovation bias offsets any appetite for evidence-based research; an institutionalised preference for disruptive innovation; and a recurring tendency towards technological determinism, prone to technological optimism, with little recognition of the possibility of unintended consequences. These combine in a 'hubristic narrative' in support of digital technologies, despite the long history of failed attempts to industrialise construction.

Green argues 'Current champions of MMC arguably differ from their predecessors in the extent to which they align themselves with notions of digital transformation. The favoured narrative plays homage at the altar of the Fourth Industrial Revolution'. Is the implication here that, having failed in the third industrial revolution, construction should not attempt to adopt and adapt digital technologies? A more realistic view would be that the development path taken in construction over the next decade will be distinct and different from the technological trajectory of other industries, influenced by many factors, and will vary from firm to firm, as the paper by Dowsett et al. demonstrates.

This is not 'technological determinism with unintended consequences'. New technologies first have to demonstrate their effectiveness and then take time to diffuse through industry, because they also require parallel changes in forms of organisation and methods of production. These are not decisions firms make quickly or easily, due to the investment required, and because these decisions are made independently by many individual firms the outcome is only weakly determined. Also, this long and variable decision time limits the effectiveness of government policies.

As well as industry policies targeting innovation, training or business investment, construction is also subject to many other standards, regulations and legislation. The detailed analysis in the paper by Meacham on fire safety issues with MMC shows clearly how challenging it is to combine MMC and offsite manufacturing with onsite assembly and integration to ensure fire safety. The paper also provides a case study in the development of a new building standard, and in doing so addresses the issue of building safety and MMC on Green's research agenda.

A technocratic system of production like construction is based on product standards, building codes and professional licensing, backed up by extensive regulation that, as Grenfell Towers shows, has to be enforced to be effective. The long process described by Meacham documents the scientific research and technological trial and error needed to get a new building standard to the point where it is accepted by the international community of researchers. As a book title *Standards Rule the World* (Gustafsson 2020) is a bit grandiose, but standards certainly rule in construction, and will be central to decarbonisation of the built environment for example. Although agreeing new standards is a lengthy process, they are universally accepted and applied because of the rigorous scientific and engineering research they are based on. Therefore, an important element in a strategy to increase innovation in construction of the built environment is to increase funding for testing laboratories.

Meacham's example of slow building of consensus based on experiment and shared information also provides an alternative to the "hubristic narrative' of the fourth industrial revolution. While it is a fact that governments can have major impacts through regulation, tax, innovation and R&D policies, their effect is uneven. For example, large firms in capital intensive industries like cement respond to industry policies differently to large contractors, as do professional service SMEs compared to construction trade SMEs. The paper by Dowsett et al. explores some of these differences. By using a 'foresight approach based on storytelling' that is 'contrary to trajectorial predictions of technology dominant in construction foresight', this paper highlights the challenges involved in navigating a changing system of production and indirectly supports Green's argument on the importance of narrative and the narrowness of the narrative from the World Economic Forum (WEF).

Comparing the different scenarios is revealing. The three in *Future Scenarios and Implications for the Construction Industry* (WEF 2017), which followed the *Shaping the Future of Construction* (WEF 2016) report cited by Green, are generally optimistic and of the 'sunny uplands' variety: the digital transition succeeds; buildings become cheaper; and the environment wins. There are good reasons for Green's view that this is digital boosterism, and compared to the Dowsett et al. scenarios WEF's big-picture approach clearly over-simplifies the issues involved. Because a low-tech future is missing from these studies, a 2016 Australian analysis called *Farsight for Construction* (Quezada et al. 2016) is also included in the table. Their scenarios describe 'four plausible futures' with a focus on impacts for jobs and skills, and the differences to both the other two show how flexible scenario analysis can be.

Table 1. Future construction scenarios

Author	Scenario synopsis
Dowsett et al.	
Scenario 1	*Vertical integration* - Five large contractors control end-to-end production with standardised product platforms, design templates and automation/robotics. Each company focuses on a sector - residential, commercial, heavy civil, industrial and environmental. The workforce remains diverse with traditional roles, but automation skills develop as planning and design become standardised with each company.
Scenario 2	*Software and robotic corporations dominate* - With a fully automated design, manufacture and construction process, Construction Robotics' mega-factories can deliver buildings within five working days. The company offers 'click & deliver' for modular elements delivered to distribution hubs or directly to site, with the option to upgrade to 'click & construct'. PropTech and AI have automated planning and design, and workforce diversity has been thinned out, except specialist quality control roles.
Scenario 3	*The construction industry is dominated by networks of SMEs* - SME collectives distribute risk and reward through shared rental of robotic systems with a cooperatively owned manufacturing hub and robotic systems. SMEs diversify their portfolios which allows expertise to flourish and encourages new generations into the industry in collaboration with colleges and universities.
Scenario 4	*Nationalisation of the construction industry* - In 2030 UK factories and machinery have been nationalised and the National Construction Board will distribute robotics and automation throughout the UK to deliver the scale of regional development required to meet the needs of the nation. Subsidies and employment systems have been introduced for the new types of construction professionals required in an automated supply chain.
WEF	

Scenario 1	*Building in a virtual world* - virtual reality touches all aspects of life, interconnected intelligent systems and robots run industry, software players gain power, and new businesses emerge around data and services.
Scenario 2	*Factories run the world* - a corporate-dominated society uses prefabrication and modularization to create cost-efficient structures. The entire value chain adopts prefabrication, lean processes, and mass customization, with suppliers benefiting the most from the transition and new business opportunities through integrated system offerings and logistics requirements.
Scenario 3	*A green reboot* - a world addressing scarce natural resources and climate change rebuilds using eco-friendly methods and sustainable materials. Innovative technologies, new materials and sensor-based surveillance ensure low environmental impacts, players with deep knowledge of materials and local brownfield portfolios thrive on opportunities around environmental-focused services and material recycling.
Quezada et al.	
Scenario 1	*Digital evolution* – BIM is widely used and exoskeletons are used onsite, but 'robot labour' has not progressed as quickly as expected.
Scenario 2	*Smart collaboration* - Industry embraces advanced manufacturing technology and new tools, making construction safer, more productive and less labour intensive.
Scenario 3	*Globally challenged* – Overseas entrants are introducing new construction technologies as local companies turn to outsourcing from Asia
Scenario 4	*Rise of the robot* – Automation is mature and Australia has emerged as a global construction hub and developer of exoskeletons, intelligent robots, advanced manufacturing and materials.

The paper by Dowsett et al. provides reactions by 20 experienced industry practitioners, from seven SME manufacturers and a tier one contractor, to four scenarios that 'explore how the industry may be constituted differently if robotics and automation became more widespread'. These reactions are, in the main, a reality check for advocates of digital transformation with an optimistic view of diffusion as continuing development of applications followed by more diffusion to more users, with a feedback loop leading to a widening set of applications. Their pessimistic view emphasises the barriers to change and the difficulty of reaching viable economies of scale, shortages of skills and lack of training.

Old technologies can survive long after the innovations that eventually replace them arrive, such as the telegraph, fax machine and vinyl records with telephones, email and CDs (Edgerton 2007). Stone, tile, brick and wood have been widely used materials for millennia, and industrialised materials like corrugated iron and concrete are ubiquitous. For maintaining and repairing the existing stock of buildings and structures, many of the skills, technologies and materials found today will continue to be used far into the future. That does not mean, however, that the firms and people involved in repair and maintenance will not also be affected in some way by the fourth industrial revolution (Charlton 2021).

How firms use technology and the ways it is adopted, adapted and applied, varies widely within construction. Studies of historical cases like steam power, tractors, electricity, TV and phones are good examples of technology diffusion, which typically takes two to three decades (Helpman and Trajtenberg 1990). Machine learning, automation and robotics are an interconnected set of technologies that are now a decade into their development, and their use is increasing as their performance improves.

Because construction involves so many firms and people these new technologies will have significant and profound economic and social consequences. This would be a good opportunity for government and industry to work together to develop policies and roadmaps for firms and the people employed in construction of the built environment who will be affected by them. The future is not determined, decisions made today create the future.

References

Charlton, J., Kelly, K., Greenwood, D. and Moreton, L. 2021. The complexities of managing historic buildings with BIM, *Engineering, Construction and Architectural Management*, Vol. 28 No. 2, pp. 570-583.

Edgerton, D. 2007. *The Shock of the Old: Technology and Global History since 1900*. Oxford: Oxford University Press.

Gustafsson, I. 2020. *How Standards Rule the World: The Construction of a Global Control regime*, Cheltenham: Edward Elgar.

Helpman. E. and Trajtenberg, J. 1990. Diffusion of General Purpose Technologies, in Helpman, E. (ed.), *General Purpose Technologies and Economic Growth*, Cambridge Mass.: MIT Press. 85-119.

Quezada, G., Bratanova, A., Boughen, N. and Hajowicz, S. 2016. *Farsight for Construction: Exploratory scenarios for Queensland's construction industry to 2036,* CSIRO, Australia.

Rodrik, D. and Stantcheva, S. 2021. Fixing capitalism's good jobs problem, *Oxford Review of Economic Policy,* 37: 824-837.

Sawhney, A., Riley, M. and Irizarry, J. (eds.) 2020. *Construction 4.0: An Innovation Platform for the Built Environment*, Abingdon: Routledge.

WEF, 2017. *Future Scenarios and Implications for the Construction Industry,* World Economic Forum and the Boston Consulting Group, Geneva.

WEF, 2016. *Shaping the Future of Construction: A Breakthrough in Mindset and Technology*, World Economic Forum and the Boston Consulting Group, Geneva