Advancing Offsite Manufacturing (Industry 4.0 and Smart Factories in the UK and Ireland

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The UK construction sector struggles with long-term productivity issues, lagging behind industries such as manufacturing, which have benefited from digital technologies and smart factory methods to boost efficiency. A recommended strategy to improve performance is offsite construction (OSC), where building components are made in controlled environments before being transported for rapid assembly on-site. The UK Government has been actively encouraging OSC—also known as Modern Methods of Construction (MMC)—as it is believed to offer faster delivery, improved quality, and enhanced safety.

The factory aspect of OSC is offsite manufacturing (OSM). OSM aligns well with manufacturing practices by operating in controlled environments that facilitate automation and digitalisation. Evidence from other manufacturing sectors shows that improvements in data use and connectivity have significantly boosted productivity, suggesting that many OSM facilities may still hold substantial untapped potential. Although some have implemented digital tools and automation, many still depend predominantly on manual workflows, resembling "construction in a shed" rather than realising the capabilities of smart, data-driven factories.

This dissertation explores the adoption of Industry 4.0 technologies by UK OSM, including cloud services, Internet of Things (IoT) sensors, AI and data analytics. It addresses three questions: Which technologies are being adopted? What impact are they having? And what factors enable or hinder implementation? This research fills an important gap in the literature, which has tended to focus on theory or on-site activities rather than real-world technology adoption in OSM factories.

A mixed-methods design combined surveys of offsite manufacturers with interviews of senior professionals, analysed thematically to identify patterns in adoption. The analytical approach was guided by three well-established adoption models: the diffusion of Innovation (DOI), the Technology Acceptance Model (TAM), and the Technology Organisation Environment (TOE) framework. Together, they provide a multi-layered view of digital transformation in OSM.

Technology adoption varies among Industry 4.0 tools. Adoption is higher for established tools such as cloud computing and BIM, while advanced technologies such as AI and digital twins remain mostly at pilot stage. Adoption appears to be associated with benefits such as improved efficiency, reduced waste, and improved data quality for evolving needs such as digital product passports and traceability. Digital tools support workforce development by helping to attract and retain younger, more digitally confident talent. However, wider transformation seems to face familiar challenges, including workforce resistance, legacy systems, uncertainty around return on investment, fragmented knowledge sharing across the sector, and inconsistent client demand for digital outputs.

The research indicates barriers to adoption are mainly organisational rather than technical. Leadership commitment, clear strategy, and phased initiatives that show early value are critical, but wider progress depends on cultural fit, collaboration, and workforce capability as much as on technology itself.

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The findings provide a roadmap: focus on base Industry 4.0 technologies that provide immediate value, invest in workforce digital literacy, and promote external collaboration to share knowledge. For policymakers, the study suggests the potential value of clearer client demand signals and aligned incentives could boost sector-wide adoption.

Ultimately, while UK OSM appears to have made notable progress towards digitalisation, the research indicates it may still be at an early stage in its Industry 4.0 journey. Bridging the productivity gap with other manufacturing sectors is likely to require moving beyond isolated innovations towards a more strategic, scalable, and collaborative approach to digital transformation.

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