The value of Information Management in the construction and infrastructure sector

A report commissioned by the University of Cambridge's Centre for Digital Built Britain (CDBB)

ATKINS
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Important notice

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KPMG’s work for the Client, on which this report is based, was conducted between 30th September 2020 and 11th June 2021, and the work comprised consideration of desk-based analysis of publicly available information (related to the existing literature on the policy context and the benefits of Information Management) and of information supplied to KPMG by the Client, in addition to discussions with industry stakeholders which form the basis of the case studies presented in this report.

For the avoidance of doubt, our work is not a comprehensive analysis of all the facts and the costs related to Information Management in the construction and infrastructure sector, and we have only sought to answer the following specific questions set by the Client:

— How are construction and infrastructure organisations creating, managing and making use of quality and timely information?

— What value does this deliver for those organisations as well as their customers, wider society and the economy?

Where limitations in the information available have been identified and impacted our analysis, these have been set out in the relevant sections of this report.

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The economic analysis contained in this report is for indicative purposes only. The decision as to which items should be included or excluded in the economic analysis is judgement-based. Furthermore, the items identified are necessarily limited to those that we have identified in course of the work performed by us, which is subject to the restrictions in the scope of work, as set out in the terms of our engagement. They have also been subject to the limitations on our access to, and the nature and extent of, the information which has been made available to us. Accordingly, there is no basis on which to state whether, in the economic analysis presented, the items that have been included are appropriate, or that all items that might be appropriate have been included. KPMG have indicated in our report the basis on which items have been included, excluded or adjusted. You may choose to analyse the information presented differently.

Where the analysis in this report contains illustrative forecasts, projections or estimations, these are based on assumptions provided by the Client and stakeholder organisations involved in the case study analysis, together with models operated by KPMG. KPMG does not make any guarantee that these forecasts, projections or estimations will be achieved. It is your responsibility to assess these illustrative forecasts, projections or estimations against your requirements and to make decisions regarding your operations. The forecasts, projections or estimations should not be relied upon as a single source for any decision you make, and it is your responsibility to take all relevant factors into consideration.

Furthermore, the economic modelling presented in Section 7 is done at an aggregate industry level and at a national geographic level, and thus the calculations are not representative of any particular market participant. The estimated economic impacts are intended to be illustrative and do not constitute any form of advice.

For this report the Client has not engaged KPMG to perform an assurance engagement conducted in accordance with any generally accepted assurance standards and consequently no assurance opinion is expressed.

The opinions and conclusions expressed in this report are (subject to the foregoing) those of KPMG and do not necessarily align with those of the University of Cambridge.

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01
Executive summary

Advances in digital technologies and data are transforming the functioning of our economy and the way we live our lives. The built environment is becoming smarter, with the rise of intelligent infrastructure – enabled by the use of techniques such as machine learning and artificial intelligence – driving efficiencies, accelerating the transition to net zero and optimising the performance of the nation's built assets.

Access to information (as data) of the right quality and at the right time, in a format that is trusted by all parties, is increasingly recognised as a critical enabler of the construction sector's digital transformation, with the potential to both drive down costs in the construction and operation of built assets and drive up quality. However, there remains limited evidence on the holistic benefits of these practices.

How are construction and infrastructure organisations creating, managing and making use of quality and timely information?

What value does this deliver for those organisations as well as their customers and wider stakeholders?

This study has set out to investigate these questions and establish the value of 'Information Management' (IM) in the construction and infrastructure sector.

The evidence gathered through this study serves to identify the broad range of potential benefits of investing in IM, and how that investment can potentially contribute to the Government and industry's shared ambitions for the sector.

The economic case for investing in Information Management is threefold

Through this study we have undertaken a comprehensive review of existing literature on the benefits of IM and analysed real-world case studies of the use of IM at both the project- and organisation-levels to establish an 'Information Management Benefits Framework'. The Framework illustrates how the use of IM in the sector could help to unlock:

1. Direct productivity gains for organisations;
2. Increased growth across the wider UK economy as a result of those productivity gains; and
3. Social value to customers, wider society and the environment through enabling the delivering of higher quality and more sustainable built assets.


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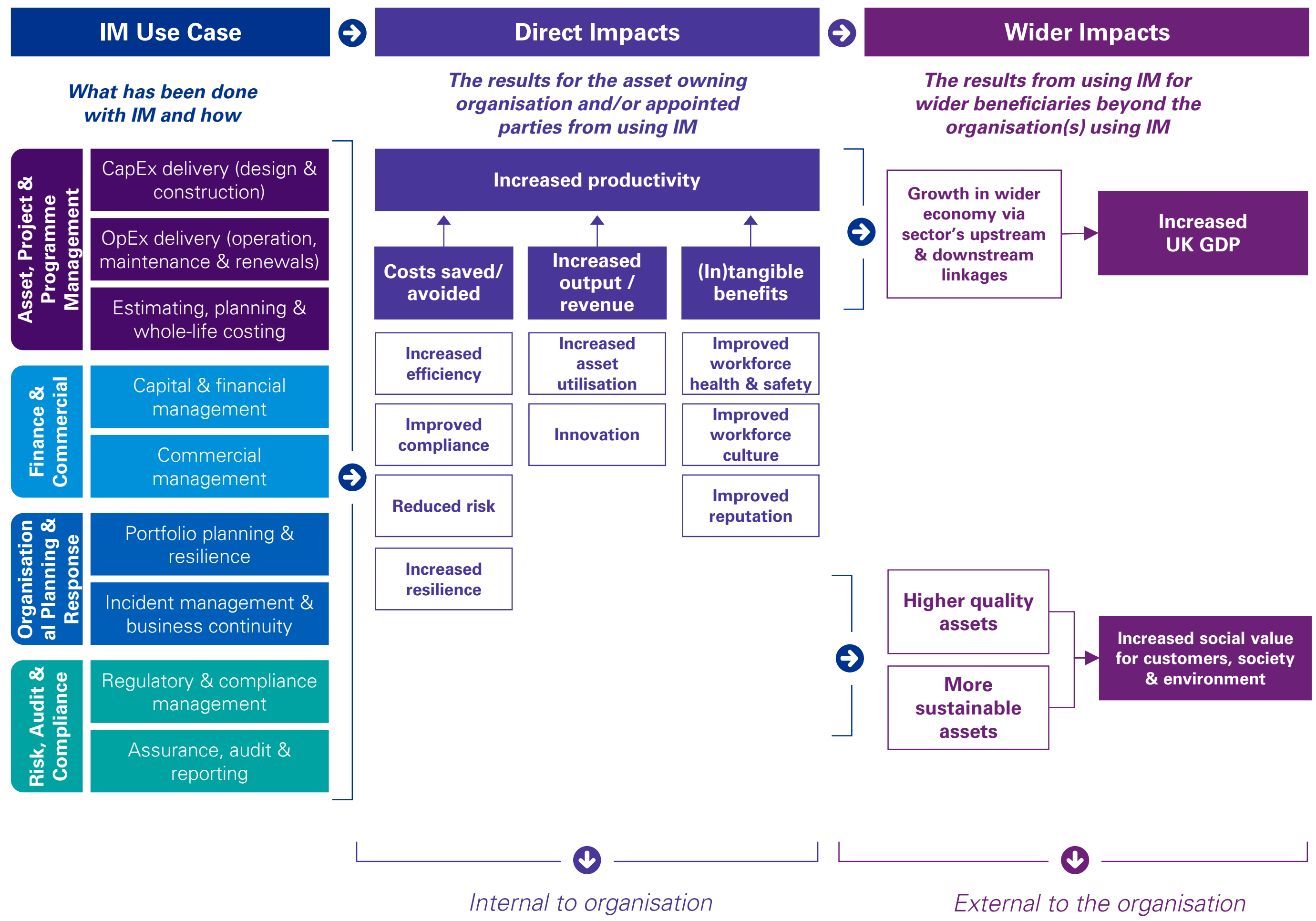
Figure 1: Information Management Benefits Framework



Source: KPMG and Atkins analysis 2021.

01 Direct productivity gains for organisations using Information Management

The construction sector faces a major (and well-documented) challenge of lagging productivity relative to other sectors of the economy, which means building and maintaining the country's built assets takes longer and costs more than it should. With the UK at the onset of a major infrastructure investment programme in the wake of COVID-19 and a bid to "**Build Back Better**" – including commitments to **Level Up the national economy** and promote a **Green Industrial Revolution** in the transition to **Net Zero** – improving the construction sector's productivity is all the more important.

The use of effective IM can play a critical role in enabling the digital economy, offsite manufacturing and improved whole life asset performance, which all have the potential to drive a step-change in the sector's productivity. The productivity gains enabled by IM can be measured through reductions in the unit cost of a project, programme or organisation's activities, and can come about as a result of:

— **Costs saved or avoided** through the use of IM, owing to its ability to increase efficiency (through savings in time, labour and materials), reduce risk contingency and compliance costs, and enhance resilience.

— **Increased revenue** through the use of IM, owing to its role in enabling better asset utilisation or the development of new, innovative products and service lines.

Through our analysis of eleven case studies we have found widespread examples of these IM-enabled productivity gains. This includes quantitative evidence which suggests **the use of IM could potentially secure between £5.10 and £6.00 of direct labour productivity gains for every £1 invested in IM, and between £6.90 and £7.40 in direct cost savings** (from reductions in delivery time, labour time and materials). We have also found evidence of **costs savings at various stages of the asset lifecycle, ranging from 1.6% to 18%[1,2], depending on the lifecycle stage.**

Notes: (1) Note that the different approaches used by stakeholders to measure or estimate the benefits of their IM investments (as well as limitations in what could be shared for commercial sensitivity reasons) makes comparisons across the case studies difficult. The cost savings quoted also relate to different stages of the asset lifecycle – e.g. cost savings in design vs. cost savings in construction vs. savings in total design and build costs. Therefore these results should be interpreted with caution, and read alongside Section 6.5.2 of this report and the detailed explanation of the benefits under each case study in the separately published Case Study Annex.
(2) These savings often come from IM's role in enabling wider digital transformation approaches and modern methods of construction, rather than the use of IM alone.

02 Increased growth across the wider UK economy

The strength of the construction sector's linkages with the rest of the economy means that, as IM is adopted by entire organisations and between organisations (as envisaged by the Government's National Digital Twin agenda), any step-change achieved in the sector's productivity could potentially drive additional, long-term growth in the wider UK economy.

These wider impacts could potentially come about through two main types of effect (as evidenced in the existing literature and through the economic modelling conducted for this study). Firstly, increased output in the construction sector means it is likely to demand more inputs from upstream suppliers, which could enable those firms to increase their production of goods and services (with knock-on benefits to other sectors linked to those firms). Secondly, competition in the construction sector means that much of the productivity gains enabled by IM could lead to lower prices for both firms and households (asset owners), with potential knock-on effects for household consumption, private investment and the output of other sectors in the economy. Under each of these two effects, the growth of other sectors could increase the demand for labour and push up wages. It could also increase the returns to private investment for capital owners (i.e. the savers and shareholders in the economy), which could in turn incentivise greater investment in capital and, thereby, growth in the UK's capital stock[3]. This latter effect is particularly relevant to the construction sector, given that around 50%[4] of the UK's annual investment in capital comes from the sector. This means that any IM-enabled productivity gains in the construction sector translate into productivity gains in the UK's capital stock, which supports additional, long-term growth in national GDP.

Using KPMG's Computable General Equilibrium (CGE)[5] Model, which adheres to the economic disciplines of HM Treasury's Green Book[6], **we have analysed these potential long term impacts on the UK economy using a series of hypothetical scenarios** which represent the different types of productivity gains that could be enabled by widespread adoption of IM across the sector. **Compared to a baseline scenario without sector-wide IM adoption, we find:**

Every £1 of direct productivity gain in the design, construction and maintenance of newly built assets enabled by IM today (2021) could potentially translate into an additional £3.70 in annual UK GDP in 2051 (expressed in real terms in 2021 prices). This suggests that the returns to the UK economy could be a multiple of any direct productivity gains in the construction sector that are enabled by IM.

A significant driver of this estimated wider impact is the role of the construction sector in supporting growth in the UK's capital stock across all sectors of the economy. We estimate that a 1% productivity improvement in the design, construction and maintenance of newly built assets in 2021 (£2.3bn) could potentially increase the UK's capital stock by some 0.25% (£32bn) in 2051. This highlights the important role of IM and other productivity-focused interventions in the construction sector in helping to address the Government's ambitions to Build Back Better, Level Up and transition to Net Zero by 2050, which require substantial levels of private investment sustained for future decades[7,8].

Estimated net increases in household consumption, employee wages and exports, with most of these gains being in sectors outside of construction. These effects are driven by the impact of a more productive construction sector on the competitiveness and economic output of other sectors.

A greater long-term increase in total additional UK GDP when IM-enabled productivity gains are realised in *both* the design/construction *and* maintenance of built assets. This underlines the importance of a continued focus on a whole life cost approach to improving productivity and advancing the emerging use cases for IM in the operation of assets.

Notes:
(3) Capital stock is a measurement of physical capital within the economy at a point in time. It includes any non-financial assets that are used by firms in the production of goods and services with a lifespan of greater than a year (for example, buildings and machinery).
(4) KPMG 2021, Analysis of ONS (1997 – 2018) Input-Output Supply and Use Tables, link.
(5) KPMG's CGE model uses GEMPACK software; Horridge, Jerie, Mustakinov & Schiffmann 2018, GEMPACK manual, GEMPACK Software, ISBN 978-1-921654-34-3.
(6) CGE modelling offers a robust way to address the impacts of IM-enabled productivity gains in the construction sector on the wider economy as it addresses critical interactions between sectors and markets. CGE modelling is commonly used by HM Treasury to analyse the impact of tax and trade policies, and is also seen by HM Treasury to have an important role in analysing the macro-economic impacts of the policy choices necessary to deliver the transition to Net Zero.
(7) Climate Change Committee 2021, Sixth Carbon Budget, Chapter 5 link.
(8) HMT 2021, Build Back Better: our plan for growth, link.

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03 Increased social value for customers, wider society and the environment

The availability of built assets and the way in which they are designed, constructed and operated can have significant implications for the economic wellbeing of customers (end users of assets), wider society (individuals, businesses and households) and the environment. This is recognised in national policy, with the Government highlighting infrastructure investment as being "central to meeting our net-zero objectives" by 2050 and "improving everyday life" through the Levelling Up agenda. It is also central to private sector organisations' Environmental, Social and Corporate Governance objectives, which have risen to the top of board-level agendas. These effects have an important public value, or 'social value', even if they do not have a market price that allows them to be traded in the economy.

As evidenced in the existing literature and through the case studies analysed for this study, **the use of IM has the potential to influence the quality and sustainability of the assets and services produced by the construction sector, and thus offers the opportunity to drive more social value from the country's built assets.** This social value can broadly come about in two ways:

Private benefits for customers/ end-users of assets from the direct consumption of an asset once it is operational, where the use of IM enables a higher quality asset or service. For example, IM's role in enhancing the design of assets can generate journey time savings for transport users, improved health outcomes for hospital patients, improved educational outcomes in schools, or less crowded housing/ buildings for tenants.

Externalities in the construction and operation of built assets which represent an economic cost or benefit to society and the environment beyond any private costs/ benefits for asset users. These externalities can arise through: (i) the construction of an asset (e.g. the use of IM enabling reductions in materials waste or construction blight); (ii) the operation of an asset (e.g. the use of IM enabling reductions in noise and carbon emissions); and (iii) the permanent effects on the local area surrounding an asset once built (e.g. the use of IM enabling the delivery of a better designed asset and in turn visual amenity for surrounding land/property owners).

Through our case study analysis, we have found a breadth of examples of how IM can enable this social value in both the construction and operation of built assets. In the few cases where it has been possible to quantitively estimate these benefits, our analysis demonstrates that relatively modest investments in IM have the potential to unlock significant social value.

However, on the whole, we find organisations are not fully considering the breadth of social value that could be unlocked by investing in IM, with internal business cases primarily focused on the productivity gains that IM unlocks for the organisation. Organisations are more inclined to prioritise and thus measure social value metrics which yield enterprise value, such as those affecting their reputation or long-term customer demand/ revenue, compared to those which relate to wider environmental or societal impacts that do not have direct financial implications for the organisation (such as promoting economic inclusion).

In practice, all dimensions of social value are critical to achieving the Government and industry's shared aims for the sector. There is therefore a need for more extensive evidence and awareness of the range of use cases for IM in the context of driving social value, as well as more clarity in who holds responsibility for capturing and investing against these impacts.

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Continuing to advance the sector's adoption of Information Management

Through our analysis of real-world case studies, we have seen a step change in the volume, complexity, and variety of use cases of IM across both asset owners and contractors in recent years. Organisations are seizing IM as a key enabler to digital transformation and the economic opportunities it unlocks. Our analysis shows how organisations are utilising IM to enable Design for Manufacture and Assembly, further Modern Methods of Construction, and innovative new services in the market – bringing life into projects that were once simply too costly. The clarity provided by centralised information approaches equips organisations to drive closer engagement with global supply chains, streamline the manufacturing process and improve the quality of outcomes for the end customer.

To help achieve the wider economic benefits identified in our analysis, Government and industry should remain focused on measures which expand and accelerate the adoption of IM across the sector and thus the direct productivity gains this unlocks. Over time, as our economic modelling highlights, market forces should mean that more investment and economic growth across the wider economy will follow.

However, the wider economic returns we have estimated rely on the productivity gains of IM being realised by organisations of all sizes, including the sector's 'long tail' of SMEs. Meanwhile the existing literature highlights that there are particular barriers for smaller firms adopting IM which still need to be overcome. Our analysis also highlights the value of using IM across the whole lifecycle of assets for maximising both the direct productivity gains to organisations and the potential total long-term GDP gains to the UK economy. However, as highlighted in our case study analysis, the use cases for IM in operations are still emerging – underlining the importance of a continued focus from the sector on adopting the UK BIM Framework's latest standards across the asset lifecycle.

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02 Context and purpose of the study

2.1 Introduction

In this section we provide an overview of the purpose of this study, which was commissioned by the Centre for Digital Built Britain (CDBB) as a core partner in the Construction Innovation Hub (the Hub) (Section 2.2) and how it fits within their wider programme of work (Section 2.3). We then go on to provide detailed context on the economic case for investing in Information Management (IM) in the construction and infrastructure sector (Section 2.4) – setting out: the economic and policy context; the challenges and opportunities facing the sector; and the role of IM in helping to address these through the value it creates both within and beyond the organisations using IM.

This 'case for change' is based on our review of existing literature (detailed in Section 4) and the new evidence we have established through this study in the analysis of real-world case studies (Section 6) and economic impact modelling (Section 7) of the potential direct and wider impacts of using IM in the construction and operation of built assets.

2.2 Purpose of this study

Advances in digital technologies and data are transforming the functioning of our economy and the way we live our lives. The built environment is becoming smarter, with the rise of intelligent infrastructure, enabled by the use of techniques such as machine learning and artificial intelligence, driving efficiencies and optimising the performance of the nation's built assets. Meanwhile digital transformation is central to the drive to modernise the construction sector and derive more value from the built assets it produces and maintains[9].

The 'new normal' in the wake of the COVID-19 pandemic is also expected to accelerate underlying trends in digital adoption across the economy. The pandemic has changed the way we view the nature of work, with the boundaries between home, the office and the construction site becoming blurred thanks to the capabilities of technology. It has also underlined the importance of both economic and organisational resilience to external events.

Access to information (as data) of the right quality and at the right time, in a format that is trusted by all parties, is increasingly recognised as a critical enabler to the construction sector's digital transformation and optimisation of the performance of built assets. And whilst there has been a step-change in the way that information is created and used by the sector over the last ten years, there remains limited evidence on the holistic benefits of these practices.

How are construction and infrastructure organisations creating, managing and making use of quality and timely information?

What value does this deliver for those organisations as well as their customers and wider stakeholders?

This study has set out to investigate these questions and establish the value of IM in the construction and infrastructure sector, considering the potential benefits of investing in IM both within and beyond the sector itself.

Our hypothesis is that effective use of IM delivers direct value for organisations through enhanced productivity and competitiveness; wider value to the UK economy by supporting long-term economic growth; and wider value to customers, wider society and the environment through enhancing the quality and sustainability of built assets.

Notes: (9) Department for Business, Energy & Industrial Strategy (BEIS) 2018, Construction Sector Deal, link.

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In order to test our hypothesis, through this study we have:

01 **Established a bespoke definition of IM within the context of the construction and infrastructure sector which captures the use of IM principles at both the project-level (across the asset lifecycle) and organisation-level (across functions).** This definition serves to bridge the gap from Building Information Modelling, or 'BIM' (as described by the UK BIM Framework)[10], which is typically applied at the project-level, to the role of effective information in enabling wider organisational change through the principles of digital transformation. Section 3 provides the details of our definition and clarifies how this relates to the UK BIM Framework;

02 **Undertaken a comprehensive review of existing literature on the value derived from the use of IM in the construction and infrastructure sector.** In doing so we have considered both the direct benefits generated for asset owners and contractors from their use of IM, as well as the wider benefits generated for the users of built assets (customers), society, the environment and, through widespread IM adoption, the wider economy. The findings from this review are detailed in Section 4;

03 **Developed an Information Management Benefits Framework,** based on this literature review and detailed analysis of case studies (see below). The Framework provides a logic flow for how IM activities can result in direct productivity gains across the asset lifecycle for organisations and wider value for beneficiaries beyond construction organisations. See Section 5 for further details;

04 **Undertaken bottom-up analysis of real-world case studies (eleven in total) to provide new qualitative and quantitative evidence of the potential value of IM**, considering both the direct productivity gains to projects and organisations, as well as wider social value for customers, society and the environment. Section 6 provides a summary of our approach and findings, whilst the separate Case Studies Annex published alongside this report provides a more detailed analysis of each of case study;

05 **Undertaken top-down economic impact modelling to investigate the potential scale of the wider benefits to the UK economy under hypothetical scenarios of widespread IM adoption across the sector.** Our approach and findings are outlined in Section 7. This analysis has been informed by our review of existing literature (Section 4) and new case study evidence (Section 6) on the type of productivity gains enabled by IM. We have undertaken the analysis using KPMG's Computable General Equilibrium (CGE) model, which aligns with the economic disciplines of HM Treasury's Green Book appraisal guidance. Further details of our modelling approach are also provided in Appendix A4; and

06 **Drawn together the key findings from this combined evidence base and identified the key implications for the Government and industry's shared ambitions for the sector.** Section 8 sets these out these findings, grouped under five key themes.

Throughout the study, we have used several definitions to guide our analysis, including the scope of the construction and infrastructure sector and the different stages of the asset lifecycle across which IM is used. These definitions are set out in Appendix A3.

Notes: (10) The ISO 19650 Series is an international standard of good practice. It defines IM principles and requirements within a broader context of digital transformation in the disciplines and sectors of the built environment (including construction and asset management industries). Its implementation in the UK is supported by UK National Forewords in ISO 19650 Parts 1 and 2, and a UK National Annex in ISO 19650 Part 2.

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2.3 About CDBB, the Hub and the rationale for this study

The Hub's core partners comprise CDBB, the Building Research Establishment (BRE) and the Manufacturing Technology Centre (MTC). The Hub collaborates with a range of other partners to the 2018 Construction Sector Deal – a partnership between Government and industry which aims to transform the sector's productivity through innovative technologies and a more highly skilled workforce. The Hub's work programme also sits within the context of the Government's Transforming Infrastructure Performance (TIP) agenda, which is due to be updated in 2021. TIP sets out a ten-year programme to increase the effectiveness of investment in economic and social infrastructure by improving the way in which built assets are designed, built and operated.

CDBB is a partnership between the Department of Business, Energy and Industrial Strategy (BEIS) and the University of Cambridge to understand how the construction and infrastructure sectors could use a digital approach to improve the construction, operation and use of built assets and consider the wider effects of this digital agenda on society and the economy. CDBB was established by the Government in 2018 with responsibility for the UK BIM Programme and Digital Built Britain Programme.

CDBB's founding mission is to:

"develop and demonstrate policy and practical insights that will enable the exploitation of new and emerging technologies, data and analytics to enhance the natural and built environment, thereby driving up commercial competitiveness and productivity, as well as citizen quality of life and well-being".

A critical element of CDBB's work programme is supporting the advancement of effective IM across the construction and infrastructure sector. This includes management of the UK BIM Framework (working with BSI and the UK BIM Alliance) and the progression of a National Digital Twin on behalf of Government, along with the continuous development of guidance material, research and tools to disseminate good practice across the sector. This includes providing guidance and evidence on the benefits of adopting IM.

While there are studies (including those commissioned by CDBB) which have investigated the project-level benefits of BIM, this study serves to provide a holistic and integrated approach to identifying the different types of value created by the broader use of IM at both the project-level and organisation-level. Further details on the existing literature which has informed this study and the key gaps in this evidence are discussed in Section 4.

2.4 The economic case for investing in Information Management

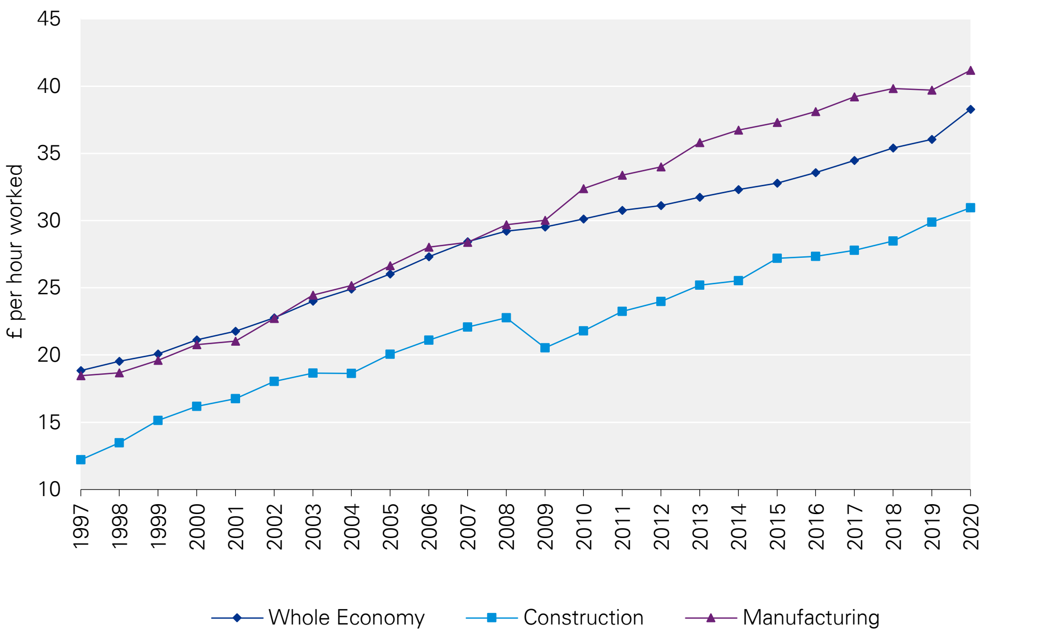
2.4.1 The policy agenda to raise the productivity of the sector

2.4.1.1 The national policy context

The construction sector contributes some £334 billion to the national economy[11] (9% of UK GDP) and employs roughly 2.2 million people (6.4% of the UK's workforce)[12]. However, the industry faces a significant (and well-documented) challenge of lagging productivity relative to other sectors of the economy.

As illustrated in Figure 2, the construction sector's productivity lags behind the average productivity of the whole economy and remains well below the manufacturing sector[13]. This means **building and maintaining the country's built assets takes longer and costs more than it should**. Indeed, the IPA's 2017 Transforming Infrastructure Performance report highlights that the sector's poor productivity performance "harms wages, long-term economic growth and living standards, and increases the cost of construction"[14].

Figure 2: Lagging productivity in the construction sector (Nominal, 1997 – 2020)



Source: KPMG analysis of ONS (1997 – 2020) Labour Productivity by Industry Division, link.

With the UK at the onset of a major infrastructure investment programme in the wake of COVID-19 in a bid to **"Build Back Better"**[15,16], – including commitments to **Level Up the national econom**y and promote a Green Industrial Revolution in the transition to **Net Zero – improving the construction sector's productivity is all the more important.**

Notes:
(11) KPMG 2021, Analysis of ONS (1997 – 2018) Input-Output Supply and Use Tables, link.
(12) ONS 2021, Workforce Jobs by Industry (SIC 2007) seasonally adjusted, link.
(13) It is worth noting that the productivity performance of the construction sector is difficult to measure or compare with other sectors for several reasons, including: the exclusion of value-added away from the construction site in official statistics, the sector's labour intensity, the challenge with factoring in quality or utility improvements of outputs (e.g. buildings) over time and the complex interplay between land prices and build costs (for a more detailed discussion see CIOB 2016, Productivity in Construction: Creating a Framework for the Industry to Thrive, link). That said, it is widely held that productivity growth in the construction sector has remained poor for many advanced countries (including the UK).
(14) IPA 2017, Transforming Infrastructure Performance, p. 7, link .
(15) HMT 2021, Build Back Better: our plan for growth, link.
(16) An interesting feature of the construction industry is that the public sector is a major buyer of its outputs. For example, the latest infrastructure pipeline released by the IPA 2020/21 has an estimated total contract value of between £29bn and £37bn. This gives the Government a unique position to influence the priorities of the sector.

Over the last c5 years, the Government and industry have come together to modernise the sector and establish initiatives aimed at transforming the sector's productivity and competitiveness. At a broad level, **the Government's TIP initiative** has highlighted the potential growth opportunity from enhancing productivity in the delivery of infrastructure. Its priorities include supporting the adoption of digital technology within the sector to help maximise the whole life value of infrastructure[17]. Meanwhile in response to the call for 'shared leadership' in the Farmer Review[18], the industry has come together via the **Construction Leadership Council (CLC)** – comprising construction professionals, contractors and product suppliers – to address the challenges in the sector. The CLC's vision is laid out in the **Construction Sector Deal with Government**, published in 2018[19], which was supported by a £420 million joint investment[20] in new technology and techniques.

The Construction Sector Deal reaffirmed the key goals for the sector which were laid out in the Government's Construction 2025 Strategy, which are:

33% — A 33% reduction in the cost of construction and the whole life cost of assets;

50% — A 50% reduction in the time taken from the beginning-to-end of new build and refurbished assets;

50% — A 50% reduction in greenhouse gas emissions in the built environment; and

50% — A 50% reduction in the trade gap between total exports and total imports of construction products and materials.

For its part of the Sector Deal, the Government is investing £170 million through the **Transforming Construction Programme**, which includes £72 million of funding for the **Construction Innovation Hub** (comprising CDBB, MTC and BRE, as described previously in Section 2.3).

The Hub's member organisations are tasked with progressing the three strategic ambitions of the Sector Deal, outlined below, which are also closely aligned with the Modern Methods of Construction (MMC) objectives recently published as part of the Government's Construction Playbook 2020[21]:

1. **Deployment of digital techniques** at all phases of design to deliver better, more certain results during the construction and operations of assets;

2. **Embedding offsite manufacturing technologies** to help minimise the wastage, inefficiencies and delays that affect online construction, and enable production to happen in parallel with site preparation; and

3. **A focus on whole life asset performance**, moving away from focusing solely on the costs of construction to the costs of an asset across its lifecycle, particularly in terms of energy use.

As is discussed later in Section 2.4.2 and throughout the rest of this report, the use of effective IM can play a critical role in enabling all three of these strategic ambitions (see Section 3 for how IM is defined in this study).

Notes:
(17) IPA 2017, Transforming Infrastructure Performance, p. 7, link.
(18) Farmer. M 2016, The Farmer Review of the UK Construction Labour Model 2016, link.
(19) Department for Business, Energy & Industrial Strategy (BEIS) 2018, Construction Sector Deal, link.
(20) Co-investment between the Government and industry.
(21) HMG 2020, The Construction Playbook, p.18, link.

2.4.1.2 The key barriers to productivity

There are several factors typically cited for the sector's poor productivity performance relative to other sectors, including: extensive regulation; the dependence on cyclical public-sector demand; and misaligned incentives among owners and contractors which leads to an underinvestment in skills, R&D and innovation[22], as well as the boom-bust nature of the sector[23]. The construction industry has also been unable to take advantage of the automation, planning and coordination activities made possible by computerisation to the same extent as other sectors, such as manufacturing[24,25]. The twin market failures of hyper-fragmentation and opacity across the industry have also contributed towards these coordination inefficiencies[26].

However, **these barriers to productivity play out differently across the sector**. Research by McKinsey[27] highlights that there is significant variation in productivity between:

— **Large-scale businesses engaged in heavy construction** (e.g. large scale civil, industrial and residential activity); and

— **Small-to-Medium Enterprises (SMEs)** engaged in fragmented specialised trades (e.g. smaller scale mechanical and electrical maintenance, household refurbishments, etc).

In the UK, some 94% of all firms in the sector employ less than 10 workers and some 99% employ 49 workers or less[28]. Addressing the challenges associated with the sector's 'long tail' of small, lower productivity firms is a key consideration in the Construction Sector Deal. The productivity of SMEs is typically c20% below the sector average[29] and a range of evidence suggests these firms are less prone to automation[30], among other factors. Indeed, KPMG's Global Construction Survey in 2016 found that technology adoption in the sector was strongly correlated with company size, with c75% of smaller firms either behind the curve or following the industry in relation to the technology adoption curve[31].

2.4.2 Using Information Management to improve the sector's productivity

Vast amounts of data are generated throughout the asset lifecycle. During interactions between parties in the sector, **the quality of the information exchange process can have a significant knock-on effect to an organisation's ability to gather, analyse and make decisions around its built assets**[32].

Critically, the use of IM enables organisations to obtain information (as data) of the right quality and at the right time, in a format that is trusted by all parties. This in turn enables organisations to take more cost-effective decisions across asset lifecycle activities.

Effective IM allows organisations to do more (output) with less effort (labour and materials inputs) – freeing up resources to either do more of the same or re-deploy those resources towards more productive activities. In both instances, the productivity of the organisation(s) using IM can be expected to increase. The existing evidence on the scale and nature of these IM-enabled productivity gains, and how these can come about, is summarised later in this report in Section 4.2.

Notes:
(22) McKinsey Global Institute, 2017, Reinventing Construction: A Route to Higher Productivity, link.
(23) Barras. R, 2009, Building Cycles – Growth & Instability.
(24) Teicholz, Paul M, 1999, 2003, Viewpoint: Reverse Productivity Declines, ENR.
(25) McKinsey Global Institute, 2017, Reinventing Construction: A Route to Higher Productivity, link.
(26) Ibid.
(27) Ibid.
(28) ONS 2019, UK Business Counts – Enterprises by Industry and Employment Size Band, link.
(29) McKinsey Global Institute, 2017, Reinventing Construction: A Route to Higher Productivity, link.
(30) Teicholz, Paul M, 1999, 2003, Viewpoint: Reverse Productivity Declines, ENR.
(31) KPMG 2016, Global Construction Survey, Building a Technology Advantage: Harnessing the potential of technology to improve the performance of major projects, link.
(32) Construction Innovation Hub 2020, BIM Interoperability Expert Group (BIEG), link.

2.4.3 The wider case for investing in IM beyond the direct productivity gains for the construction sector

The construction sector's unique interdependence with the rest of the economy and our society means the case for investing IM does not stop at improving productivity. The sector builds the infrastructure that helps connect people, businesses and markets, "forming a foundation for economic activity and community prosperity"[33] .

The use of IM can be a key enabler in improving the efficiency and effectiveness of how the country's built assets are designed, built and operated. This is not only crucial for the UK's economic growth and competitiveness, but also the economic wellbeing of the UK population. The existing literature on these potential wider benefits of IM is summarised later in this report in Section 4.2. This existing literature, together with the new evidence established through this study, suggests the wider case for advancing the adoption of IM across the sector is twofold:

01

Driving growth in the wider economy

— The 'economic footprint' of the sector extends beyond traditional construction firms into design and architecture, professional services, product manufacturing and raw materials. This means **productivity gains enabled by IM for one type of organisation has positive economic consequences for other firms that it typically trades with**; and

— The sector creates the physical capital that firms and households rely on to produce and consume goods and services in the economy. This means **IM-enabled productivity gains in the construction of built assets are equivalent to productivity gains in the UK's capital stock[34], unlocking long-term and widespread GDP growth in the 'real economy'.**

02

Driving social value

— The built assets produced by the sector perform important economic and social functions in our society, well as impact on the environment. This means built assets provide 'public value' or 'social value' (or potentially public costs) as they are constructed, operated and used by customers and the wider public. Therefore any **IM-enabled improvements in the quality and/or sustainability of built assets will affect the economic wellbeing of UK society (individuals, households, businesses) and the environment**.

Sections 2.4.3.1 to 2.4.3.2 expand on each of these two concepts. Later in this report, in Sections 4.3.1 and 4.3.2, we summarise the existing evidence available on this wider value and highlight the current gaps in this literature, which this study has sought to address through the bottom-up analysis of case studies (Section 6) and top-down economic impact modelling (Section 7).

Notes: (33) HMT 2021, Build Back Better: our plan for growth, link.

(34) Capital stock is a measurement of physical capital within the economy at a point in time. It includes any non-financial assets that are used by firms in the production of goods and services with a lifespan of greater than a year (for example, buildings and machinery).

2.4.3.1 Driving growth in the wider economy

The sector's upstream linkages with the supply chain

Figure 3 presents the scale and breadth of the sector's upstream and downstream linkages with other parts of the economy and highlights the significance of the upstream sectors which provide inputs to the construction sector's production process.

The existing statistical definition of the sector[35] accurately describes **what happens 'at the site of construction'**[36], however, does not account for the **value added in construction related services** (e.g. quantity surveying, structural engineering, architecture and technology providers that enable the digital transformation of the industry) or **product manufacturing** (e.g. cement, bricks, glass, as well as plumbing and heating equipment and electrical fittings).

The CLC has sought to address this issue, advocating for a broader definition of the sector[37] which covers the (i) **construction contracting industry;** (ii) **provision of construction related professional services**; and (iii) **manufacture of construction related products and materials**. The latter two categories cover what might be described as the dedicated 'supply chain' of the construction industry, distinguishing it from more broadly-based supply sectors like financial services.

Given the size of the construction sector's upstream linkages with this dedicated supply chain (e.g. over £11 billion is traded in cement, lime and plaster alone), the supply of goods and services from these sectors is likely to be highly sensitive to any changes in the output of the construction sector (such as those enabled by improving the sector's productivity). **This means any IM-enabled productivity gains in the sector could potentially have positive economic consequences for firms that it trades with, even if those other firms are not directly involved in the use of IM.**

Notes: (35) The international definition of construction in the Standard Industrial Classification (SIC) codes (2007) used to define the sector is 41, 42 & 43, covering the construction of buildings, civil engineering and specialised construction activities.
(36) The Chartered Institute of Building (CIOB) 2020, The Real Face of Construction 2020, Socio-Economic Analysis of the True Value of the Built Environment, link.
(37) Note that this definition is based on analysis of the UK construction sector conducted by BIS 2013, p.1, link. The purpose of this definition was to help illustrate the economic importance of the broader sector where data was available. As such, in some instances some services and products were excluded (e.g. the manufacture of steel, the provision technology enabling services etc.) where it was not possible to determine that a significantly high proportion of the service or product was used by the construction sector. These sectors would be considered important inputs (upstream providers) to the construction sector, but typically not part of the wider construction sector itself.

The sector's downstream linkages with the economy and role in driving UK capital stock

The construction sector also has important downstream linkages with the rest of the economy, including the housing sector, which represents the single largest user of the construction sector's outputs. Other sectors and households use the outputs of the construction sector as either:

1. **'Intermediate users',** wherein other sectors use the outputs of construction for their own production (with 44% (£147 billion) of total construction output reflecting maintenance, refurbishing and service installation services to other sectors); or
2. **'Capital creation',** wherein firms and households use the capital created by the construction sector (e.g. property, infrastructure, plants and equipment) for their production and consumption (with 55% (£182 billion) of total construction output reflecting the design and build of assets reused by other sectors overtime).

This means that any change in the price of outputs produced by construction sector (such as a reduction enabled by productivity gains from the use of IM), could potentially benefit firms and households who use those outputs.

The capital created by the sector in particular plays a critical role in driving long-term economic growth through its role in growing the UK's capital stock. Indeed there is evidence in the literature to suggest that a 10% increase in the public capital stock could lead to a 1-2% increase in GDP[38].

Roughly 55% of the sector's output is investment in capital and just over 50% of all the capital created in the economy annually (i.e. annual national investment) comes from the construction sector[39]. It produces the buildings we live and work in, the factories where we manufacture goods, and the infrastructure we use to generate energy and travel across the country. Consequently, any productivity gains in how capital is created by the sector, such as those enabled by IM, is likely to have significant downstream implications for the rest of the economy.

In Section 7, our top-down economic impact analysis investigates the potential scale of the benefits to the UK economy from widespread IM adoption through the sector's upstream and downstream economic linkages.

Notes: (38) Bom & Lighart 2014, OBR Economic and Fiscal Outlook March 2020, link.
(39) KPMG 2021, Analysis of ONS (1997 – 2018) Input-Output Supply and Use Tables, link.

Figure 3: The construction sector's economic linkages with the wider economy

Upstream inputs

Inputs

£203.5bn
Total

£11.9bn **6%**	Cement, lime and plaster
£10.7bn **5%**	Fabricated metal products
£7.0bn **3%**	Carpentry, joinery and other wood products
6.6bn **3%**	Electrical equipment
£5.5bn **3%**	Rental and leasing services
£4.5bn **2%**	Architectural and engineering services
£4.1bn **2%**	Carpentry, joinery and other wood products
£10.7bn **5%**	Financial services *(except insurance and pension funding)*
£17.9bn **9%**	Other merchandise goods *(such as bricks, stone, and machinery)*
£135.3bn **67%**	Other services *(such as installation, real estate, employment and legal services)*

Construction sector

£333.7bn
Total output

£203.5bn	Intermediate inputs

\+

£130.3bn	Gross Value Added
£57.3bn	Wages paid to labour
£73.0bn	Rents paid to capital (net taxes)

Outputs

Construction of Buildings
(Dwellings, offices, retail stores and other public / utility buildings etc.)

Civil Engineering
(Motorways, streets, bridges, tunnels, railways, sewerage systems, industrial facilities, pipelines, electric lines etc.)

Specialised Construction Activities
(Demolition, site preparation, electrical installation, plumbing installation, plastering, joinery, scaffolding etc.)

Downstream outputs

Intermediate Users

£146.9bn
Total

£17.8bn **12%**	Housing *(Repairs and renovations by households)*
£5.9bn **4%**	Professional Services *(Financial activities, insurance and management consultancy)*
£5.3bn **4%**	Public Administration *(Economic and social infrastructure, including defence and justice) activities*
£4.6bn **3%**	Retail industry *(Department or specialised stores)*
£2.7bn **2%**	Electric power infrastructure *(Power stations, electricity pylons and sub-stations)*
£110.7bn **75%**	**Other domestic users** *(Industrial manufacturing, healthcare, recreation etc)*

Capital Creation

£181.8bn
Total

£77.0bn **42%**	Housing *(Owner-occupied and rented dwellings)*
£15.8bn **9%**	Education *(Primary, secondary and tertiary Education)*
£10.6bn **6%**	Transportation and Storage *(Warehousing and support activities for transportation)*
£8.8bn **5%**	Electric power infrastructure *(Power stations, electricity pylons and sub-stations)*
£6.3bn **3%**	Retail industry *(Department or specialised stores)*
£4.5bn **2%**	Water Infrastructure *(Water collection and treatment, sewerage etc)*
£58.7bn **32%**	Other sectors *(Industrial manufacturing, healthcare, recreation etc)*

44%	Intermediate Use
55%	Capital creation
<1%	Households
<1%	Exports

£203.5bn total intermediate inputs + £57.3bn wages + £71.7bn rents + £1.3bn taxes = £333.7bn output sold

Source: KPMG analysis of ONS (1997 – 2018) Input-Output Supply and Use Tables indexed to 2021, all values converted to basic prices.

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2.4.3.2 Driving social value for customers, wider society and the environment

Beyond the 'hard' economic value that could be enabled by IM in the real economy (through changes in economic output / GDP), the outputs of the construction and infrastructure sector have important implications for the economic wellbeing of the UK population. This is recognised in national policy, with Government highlighting infrastructure investment as being "central to meeting our net-zero objectives" by 2050[40] and "improving everyday life" through the levelling up agenda[41]. This is also reflected in CDBB's Vision for the Built Environment, which highlights the complex interactions between the built and natural environment as essential for our future health, well-being, and resilience[42].

As highlighted previously in Figure 3, some of the downstream sectors or 'users' of the construction sector's outputs include: **economic infrastructure**[44] (e.g. energy, transport, water and waste) and **social infrastructure** (e.g. schools and hospitals) and **housing.** Moreover, most sectors across the economy require **non-domestic buildings** which are produced by the construction sector.

These built assets provide important economic and social functions for customers and wider society which generates public value or 'social value', even if these effects do not have a market price that allows them to be traded in the economy. It is also important to recognise that the environmental impacts of construction permeate across all sectors in the economy (although some more than others), from impacts in the construction, maintenance, renewal and eventual decommissioning of built assets (including embodied carbon of building materials, the carbon sequestration impacts of natural capital degradation and other GHG emissions) through to their operation (including other GHG emissions and noise pollution). These environmental impacts also affect social value.

This social value is influenced by the availability, quality and sustainability of the assets and services produced by the sector. The use of IM has the potential to affect all of these factors through its role in improving the way in which built assets are designed, constructed and operated. Indeed, the role of IM in driving social value through its ability to enable more effective and efficient built assets was highlighted in the National Infrastructure Commission's 2017 report, Data for the Public Good[43]. In this study we provide new evidence of the role of IM in driving social value through the analysis of real-world case studies – see Section 6, as well as the separate Case Study Annex published alongside this report.

The examples below illustrate the type of social value provided by the built assets produced by the constriction sector.

Improved transport connectivity (e.g. better roads, railway connections, airports and seaports) can support improvements in quality of life for transport users and social cohesion, as well as additional economic productivity by allowing firms and labour greater accessibility to new and existing markets, both domestically and internationally[45,46]. The design of transport infrastructure can also have significant implications for the environment – since 2016, transport has been the largest emitting sector of Greenhouse Gas (GHG) emissions, contributing 28% of the UK's total domestic GHG emissions in 2018[47];

Better quality schools and further/ higher education facilities can improve educational outcomes which in-turn generates significant knock-on benefits for society, including increased life expectancy, civic engagement and well-being[48], and supporting growth and competitiveness in the economy (from a higher-skilled future workforce)[49];

Access to high quality and affordable housing provides wellbeing benefits to homeowners and tenants, whilst reducing homelessness and overcrowding can provide a safeguard against poverty[50] and improved access to educational opportunities, increased labour mobility and health improvements[51]. Meanwhile converting underutilised or low value land into residential uses can provide benefits to landowners[52];

High quality health facilities, such as hospitals, are essential for patient welfare, with better designed hospitals associated with improved health outcomes for patients, including faster discharge rates and better symptom management[53];

Notes:
(40) HMT 2021, Build Back Better: our plan for growth, link.
(41) HMT 2021, Levelling Up Fund: Prospectus, link.
(42) CDBB 2021, Our Vision for the Built Environment, p. 11, link.
(43) NIC 2017, Data for Public Good, link.
(44) See National Infrastructure Commission's (NIC) definition of economic infrastructure, link.
(45) DfT 2021, Union Connectivity Review Interim Report, link.
(46) DfT 2016, TAG UNIT A2.4 Appraisal of Productivity Impacts, link.
(47) DfT 2020, Decarbonising Transport: Setting the Challenge, link.
(48) OECD 2013, Education Indicators in Focus, link.
(49) OECD 2006, The Returns to Education: Links between Education, Economic Growth and Social Outcomes, link.
(50) Joseph Rowntree Foundation 2013, The links between housing and poverty, link
(51) MHCLG 2016, DCLG Appraisal Guide, link
(52) Ibid.
(53) University of Sheffield, School of Architecture 1999, Patients in a new-build compared to older buildings had 21% faster rates of discharge. Additional psychiatric patients had 14% shorter stays and displayed reductions in verbal outbursts (24%) and threatening behaviour (42%).

Access to clean water and sanitation is considered a UN human right, reflecting the fundamental nature of these basic services in every person's life[54]. Built infrastructure plays a major role in being able to deliver affordable access to water, and new infrastructure (e.g. a new reservoir) can increase water resilience and reliability in times of drought, protections in times of flood, and generate substantial public health and amenity benefits[55]. Again, the design and type of infrastructure can also have significant implications for the environment (e.g. waterway extraction, desalination plants and recyclable water facilities have substantially different implications for biodiversity and CO_2[56]); and finally

The energy sector is sometimes considered a 'secondary factor' of production, given its critical importance and use by all other sectors in the economy. Efficient production (e.g. power stations) and transmission (e.g. power lines) of electricity relies heavily on built infrastructure, and its efficiency and availability has impacts throughout the economy. **Access to affordable and clean** energy is a key UN sustainability objective[57], while the UK has committed to "ensuring that the cost of the transition to net zero is fair and affordable"[58]. Increasing the provision of renewable energy sources[59] (e.g. new offshore wind turbines and the associated infrastructure) to meet the Government's net zero objectives by 2050 will require a step change in new infrastructure investment[60], driven by the construction sector.

Notes:
(54) United Nations, Human Rights to Water and Sanitation, link.
(55) Ofwat 2020, Draft Water Resource Planning Guideline, link.
(56) DEFRA 2020, Enabling a Natural Capital Approach, link
(57) UN, Sustainability goals, link.
(58) BEIS 2020, The Energy White Paper: Powering our Net Zero Future, link.
(59) Reducing the market share of carbon-intensive fossil fuel energy sources.
(60) HMT 2021, Build Back Better: our plan for growth, link.

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03 Defining Information Management

3.1 Introduction

Over the past decade there has been a step-change in the adoption of IM and, as demonstrated in the existing literature (Section 4) and in our own case study analysis (Section 6), this can have notable productivity benefits for organisations and broader benefits to customers, wider society, the environment and the economy. However, the definition of the construction sector's use of IM is not a clear-cut issue. With a range of definitions, many misunderstandings lead to the direct attribution of IM to Building Information Modelling (BIM), which represents the effective use of IM principles at the capital project-level, but fails to recognise its role across organisational functions and in enabling broader digital transformation activities.

Therefore, this section serves to clarify the use of the term IM within this study and its relationship to BIM. We start by setting out our working definition of IM in the sector and the key principles and activities of IM which underpin this definition (Section 3.2). We conclude by explaining how our definition relates to the UK BIM Framework and the future relationship with CDBB's Information Management Framework and National Digital Twin Programme (Section 3.3). In Appendix A2, we also provide a brief history of the evolution of BIM, from the extant focus on 3D models and graphical information through to the development of the UK BIM Framework.

3.2 Definition of Information Management for this study

3.2.1 The need for a bespoke definition of Information Management

We use the term 'information' throughout our study to represent a grouping of data which collectively carries a logical meaning. Information is an asset which is fundamental to the efficient and effective delivery of goods and services across all sectors of the economy. With the rate of digital technology adoption across the UK and global economies, there is an ever-increasing need for organisations to understand the use and value of information in business terms[61].

In the construction and infrastructure sector, a vast amount of information is created, managed and used throughout the asset lifecycle, as outlined by the National Infrastructure Commission in its 2017 Data for the Public Good report (see Figure 4), and a wide range of organisations play a part in this process. *How* this data is created, managed and used will affect the quality and timeliness of the information available to organisations (discussed further in Section 3.2.2 below) and in turn their ability to undertake effective and efficient decisions at each stage of the asset lifecycle.

Notes: (61) HMG 2011, UK Government Information Principles Version 1.0, link.

Figure 4: The range of data that is managed in the construction and infrastructure sector

Personal data	Non-personal data		
	Network data	Asset data	Organisational data
Consumption Geospatial location Payment information Socio-demographics	Operational System resilience Schedules Traffic flows Emissions	Condition Licences Housing Road Location	Financial Performance Internal Processes

Source: Atkins illustration drawing on NIC 2017, Data for Public Good, link

Across the sector, the roots of IM have been in the effective management of information on capital projects (BIM), with emerging use-cases in capital programme management, asset portfolio/investment planning and wider organisation-level initiatives. However, there is no standard definition of IM within the construction and infrastructure sector which looks beyond the capital and asset phases of project delivery to these wider use cases. Therefore, we have reflected on the broad principles of IM and the range of different definitions employed across industry and Government (see Appendix A1) to develop a working definition for the purposes of this study (discussed below).

3.2.2 Our definition for this study

Our definition of IM in the sector for this study serves to bridge the gap from BIM (as described by the UK BIM Framework and typically applied at the project-level), to the role of effective information in enabling wider organisational change through the principles of digital transformation. This definition has guided our review of the existing literature on the value of IM (Section 4), the development of our Information Management Benefits Framework (Section 5) and our analysis of real-world case studies of the use and benefits of IM (Section 6).

At the project-level, IM embeds quality processes (BIM), governance and wider digital approaches to enable the collection of disparate sources of information and conversion into accurate, consistent, secure and timely information that can support robust and evidence-based decision-making across the asset lifecycle[62].

The use of IM at the project-level can also provide the catalyst for wider adoption of IM at the organisation-level through the aggregation and re-use of information (such as financial data or staffing/ resourcing data) 'upwards' to organisational functions that sit outside of capital and asset delivery.

At the national scale, development and adoption of common approaches to IM across organisations in the sector will support the interoperability of asset data and in turn support the Government's future development of a National Digital Twin[63].

Definition of Information Management in the construction and infrastructure sector

Information Management (IM) is the process by which an organisation collects, structures, stores, uses and shares its data to perform its core business across asset lifecycle activities. In the construction and infrastructure sector, IM is enabled by the application of the UK BIM Framework and supports wider digital transformation approaches (data analytics, data science, Internet of Things, Artificial Intelligence/ Machine Learning applications). Together, these approaches improve the quality, availability and timeliness of the information available to organisations – facilitating more efficient and effective decisions and investments across the asset lifecycle.

Notes: (62) BS EN ISO 19650 1:2018.
(63) CDBB 2018, The Gemini Principles, link.

3.2.3 The key principles of IM

3.2.3.1 The typical qualities of information that are enabled by the effective use of IM

The process of IM affects the quality of the information available to organisations (see Figure 5) and in turn enables them to draw more insight and value from their information. This creates direct benefits for the organisations using IM, as well as benefits for the wider economy, society and the environment, as set out throughout the remainder of this report.

Figure 5: The quality of information enabled by effective Information Management

Accuracy: data is correct in all details and is a true record of the entity it represents.	**Completeness:** data has all or the necessary attribute values relative to its intended purpose.	**Validity:** data conforms to all standards expected.
Timeliness: data is easily accessed or available when required and is up to date.	**Uniqueness:** a single representation exists for each entity or activity.	**Consistency:** an entity that is represented in more than one data store can be easily matched.

Source: Atkins illustration drawing on Institute of Asset Management 2015, SSG 22, 23 & 25 Asset Info, Strategy, Standards & Data Management, link

3.2.3.2 The activities involved in the use of IM

There are a range of activities which constitute IM and result in the quality of information outlined above. These include:

- **Specification of data:** the act of defining an organisation's data requirements and allied processes to fulfil different organisational purposes during the respective stages of the asset lifecycle.
- **Data production or acquisition:** the act of data creation which is an output from any of the processes involved in designing, building, operating, maintaining and disposing of a built asset.
- **Data storage and curation:** the act of collecting the data, associating it with existing data and storing it to enable access.
- **Data assurance:** the act of quality assuring the data against specified requirements.
- **Data distribution:** the act of enabling appropriate access (often role based) to relevant data for users – both internal and external to the organisation.
- **Data maintenance:** the act of ensuring that the data is maintained to specified standards while in use and continues to satisfy the organisation's purposes.
- **Data Archiving or disposal:** the act of managing data that is not in active use or deemed no longer required by archiving it or disposing of it respectively as per the business policies.
- **Managing data security:** the act of securing data at all steps of the above processes in compliance with organisational information security policies and other standards to restrict access to authorised users and purposes only.

Source: Atkins illustration 2021, drawing on multiple sources see Appendix A1.

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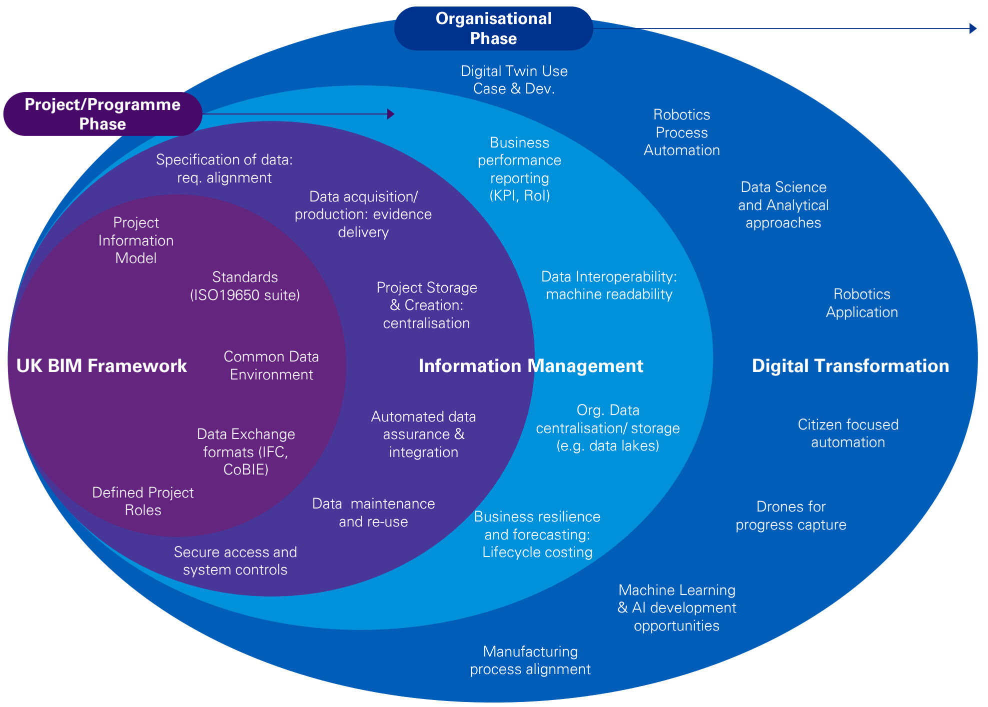
3.3 The relationship between our definition of Information Management, the UK BIM Framework and Digital Transformation

Our definition of IM captures both the use of BIM across the asset lifecycle, as defined by the UK BIM Framework, and the role of IM principles more broadly in enabling wider digital transformation activity within and across organisations. This is summarised in Figure 6 with further explanation provided in the rest of this section.

Figure 6: The relationship between IM, the UK BIM Framework and Digital Transformation



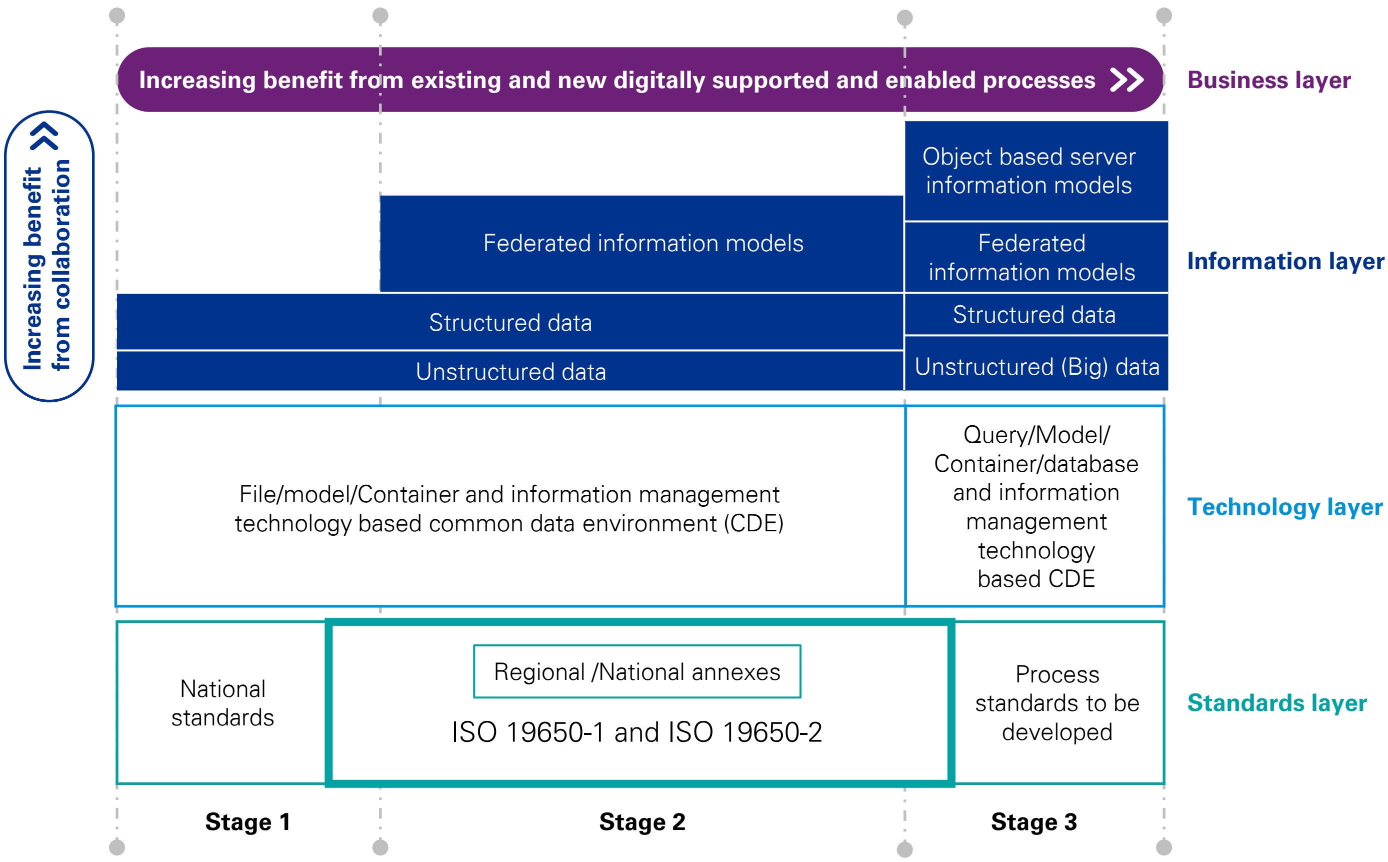
Source: Atkins illustration 2021, drawing on multiple sources see Appendix A1.

BIM in the context of this study focuses on the **UK BIM Framework** which sets out the approach for implementing BIM in the UK using the framework for managing information provided by the ISO 19650 series. BIM is about securing benefits through specification and delivery of the right amount of information concerning the design, construction, operation and maintenance of buildings and infrastructure, using appropriate technologies. The standard develops best practice throughout the whole project and asset management delivery cycle. It applies across the life cycle of an asset and to all types of asset in the built environment – including buildings, infrastructure and the systems and components within them[64].

This study elevates activities from BIM, which are commonly only represented in practice at the project-level (in construction and/ or operations), and places emphasis on the wider use of IM principles (set out previously in Section 3.2.3) by organisational functions which sit outside capital delivery and asset management. This approach establishes greater clarity in understanding the 'business layer' activities set out in ISO19650 guidance[65] (Figure 7 below).

Notes: (64) UK BIM Alliance, Information Management according to BS EN ISO19650, Guidance Part 1.
(65) BS EN ISO 19650 1:2018, Figure 1, a perspective on stages of maturity of analogue and digital information.

Figure 7: Development stages of maturity of digital IM aligned to enterprise architectural layers



Source: BS EN ISO 19650-1 2018.

The process of **IM** (as we have defined in Section 3.2) can occur without strict adherence to BIM, but greatly benefits from its structure and process as set in the ISO19650 suite of standards. Indeed, many of the case studies analysed in this study (see Section 6 and the separate Case Studies Annex published alongside this report) show how BIM has provided a strong foundation for organisations to roll-out wider IM approaches across their organisation.

Effective IM can also be used to drive continuous improvement or change within and across organisations through successful digital transformation. **Digital transformation** involves two types of change: **business-model innovation**, whereby companies introduce digitally-enabled products and services, and **operational improvement**, whereby companies apply advanced technologies and ways of working to enhance the development and delivery of projects[66]. The IM use cases evidenced in this study support both types of change, but generally are most established in the latter, whereby IM provides structured and accurate data to support the adoption of new and innovative technologies.

In our analysis of real-world case studies, we have attempted to distinguish between the activities relating to BIM (activities directly associated with the standards outlined by the UK BIM Framework[67]) and those relating to wider organisational IM approaches or digital transformation. However, whilst it is usually possible to distinguish between these different activities, their interdependencies make it far more difficult (indeed often impossible) to separate out their resulting benefits. Therefore, in our case study analysis, the direct and wider benefits presented (both qualitatively and quantitatively) typically capture the collective impact of these activities.

Notes: (66) McKinsey & Company 2019, Decoding digital transformation in construction, link.

(67) This means where an organisation or project team states/cites the use of Organisational Information Requirements (OIR), Asset Information Requirements (AIR), Exchange Information Requirements (EIR), Project Information Requirements (PIR) or equivalent, in the delivery of a project within the context of a Project Information Model or Common Data Environment. This can happen at multiple points in a project lifecycle, as proposed by the Asset Owner (buying organisation) or by the successful appointed parties.

Illustrative examples of IM in application

Across organisations and within projects, BIM is often represented by a single function or capability which addresses the specific needs of the UK BIM Framework and associated standards in capital or asset data delivery. By contrast, IM and its role in enabling digital transformation activities across organisational functions can drive value at the organisational-level. This is not prescriptive to national standards, guidance or policies.

Example 1: The use of BIM and IM in supporting Modern Methods of Construction (MMC)

A housing developer wants to explore the value from MMC in a project. Although the client does not set BIM requirements in the procurement of outcomes, the developer chooses to apply the UK BIM Framework to enable effective collaboration in the design phase of the housing solution. The project benefits from clarity in the process of data federation and common collaboration in the Project Information Model (PIM). This is a direct use of BIM.

The PIM is used to further address the opportunity for off-site construction and the principles of Design for Manufacture and Assembly (DfMA). This process could occur without the use of the PIM, but the model allows the developer to work with their supplier to break down housing design elements, align their manufacturing requirements and establish an integrated supply chain. This is a direct use of IM, as the processes developed to support DfMA are not prescribed in any BIM artefact or supporting standard. However, DfMA is greatly enabled by the original use of BIM.

Example 2: The use of BIM and IM in enabling the automation of site records

A contractor wants to manage risk and improve efficiencies in the delivery of concrete pour activities on-site. The client does not state a requirement for BIM, but the contractor chooses to develop an Appointed Party Exchange Information Requirement (EIR) across their supply chain to establish a process for managing the breakdown of works activities. The contractor's BIM manager works to develop clear work breakdown activities in the PIM. This model allows concrete specialists to determine their bill of quantities and schedule for works. This is a direct use of BIM. The contractor has also established common tools within their organisation that supports automation of activities. The contractor's site agents choose to leverage simple PowerApps to track the real-time pour activities and map these to the work breakdown, which are detailed in the PIM. This allows the contractor to better manage their suppliers' outcomes and creates an accurate record of site activities. This is a direct use of IM where the end benefit comes from automation of site records. However, the automation is enabled by BIM and the structure offered in the work breakdown for pour activities, which will allow the contractor to baseline future activities for this type of project or asset.

Example 3: The use of BIM and IM in forward maintenance planning for a new build project

A client is keen to better understand and set maintenance budgets for a new build project. The client's operations and maintenance team outline their information requirements to establish the maintenance profile for the project. These information requirements are incorporated into the Appointing Party EIR and Asset Information Requirements (AIR) to ensure the project team delivers the necessary information at the appropriate time to inform a specific purpose, in this instance determining forward maintenance planning for the project. The direct benefit of structured data in response to a purpose helps the client to have early sight of the maintenance budgets required for the new project. This is a direct use of BIM.

Having sight of 3D models and associated asset information not only helps with forward maintenance planning, but also lays the foundation for integration with sensor technology, which helps the client to gain insight into asset performance and utilisation, and in turn make decisions which optimise the use and operation of the asset. The ability to connect technology securely opens up the opportunity to harness data, analyse performance and drive informed decision. This is a direct use of IM.

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04 Existing literature on the value of Information Management

4.1 Introduction

In Section 2.4 we summarised the economic case for investing in IM in the construction and infrastructure sector against the background of the Government and industry's shared ambitions for the sector. This identified the potential for IM to help address national objectives for raising the productivity of the sector and bring down the cost of investment in the country's built assets, as well as drive growth in the wider economy and social value for the UK population.

In this section, we build on that 'case for change' by **summarising the existing literature which evidences:**

- **The direct productivity benefits of IM** for projects and organisations, and how these come about (Section 4.2);
- **The wider benefits to the UK economy** from these productivity gains (Section 4.3.1); and
- **The benefits to society** from higher quality and more sustainable built assets enabled by IM (Section 4.3.2).

We have sought to address gaps in this existing literature through the analysis of real-world case studies on the use and benefits derived from IM (Section 6) and through economic modelling of the potential wider economic impacts of widespread IM adoption across the sector (Section 7). This new evidence on the benefits of IM, as well as the existing literature, has informed the development of our Information Management Benefits Framework presented in Section 5.

4.2 Existing evidence on the productivity gains enabled by Information Management

In the construction sector, organisations that use IM are typically asset owners and/ or the contracting parties appointed to carry out some construction-related service on behalf of a private or public-sector asset owner (see Appendix A3 for a definition of the scope of the sector and its various actors). Based on the existing literature (summarised in this section), the direct benefits from adopting IM typically fall into one of three categories:

1. **Cost savings or costs avoided** over the asset lifecycle at the project-level (i.e. a reduction in unit costs of building or operating an asset) or costs saved/ avoided at the organisation level (i.e. a reduction in unit costs of producing the same level of output);

2. **Output or revenue increases** (from increased demand for an organisation's goods or services), which typically arise at the project-level from optimising the availability and use of built assets through the use of IM, or at the organisation-level from the development of new products and services which are enabled by IM; and

3. **Intangible benefits** associated with an improved reputation or better workplace health and safety practices or culture. These benefits are more difficult to directly monetise (compared to 1 and 2), but do provide intrinsic value to organisations and in the long-term, could be expected to impact an organisation's costs or revenues (e.g. helping to attract more customers or a highly skilled workforce).

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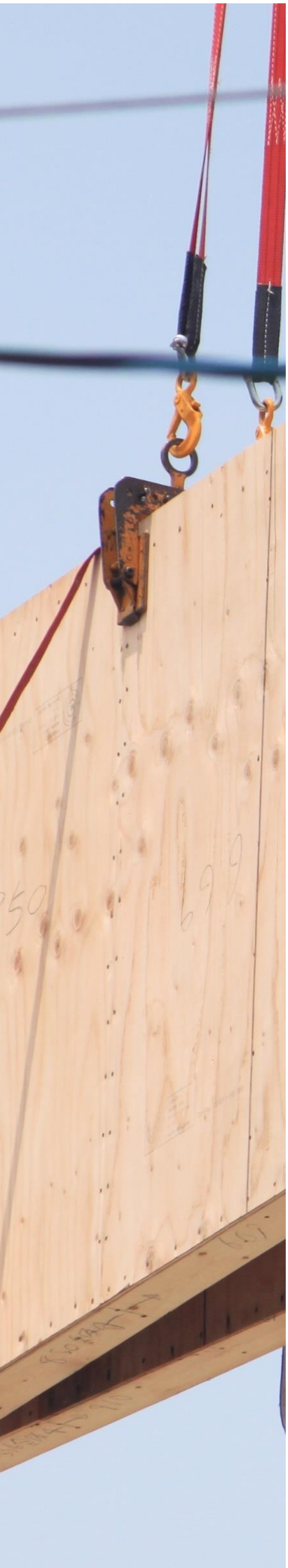


In the medium- to long-term, all three of these categories of benefit can be expected to affect the productivity and competitiveness of construction organisations. At its crux, IM provides organisations with better quality information from which to make decisions. Assuming an organisation is rational and profit-motivated, they are likely to use this information to become more productive – either increasing the amount of output they generate for a given amount of inputs/ resources (e.g. time, labour, materials etc), or delivering the same amount of output for less cost/ inputs.

To date, there has been limited research aimed at quantifying or valuing the cost savings or increased revenues associated with IM at the organisational-level[68]. Much of the existing evidence either focuses on: (1) the benefits associated specifically with the use of BIM; and/ or (2) project-level benefits, and most commonly on the capital delivery phase of built assets (with limited evidence on the benefits of IM or BIM in operations). There have, however, been market studies with IT leaders[69] and construction firm leaders[70] which identify key benefits from organisations' digital transformation activities, including commercial advantage and operational efficiency.

From the perspective of BIM, there is widespread evidence of a positive relationship between BIM and productivity resulting from savings in labour, materials and time at the project-level. The **NBS's recent 10th National Annual Survey**[71] of the sector found that some 73% of organisations are now using BIM (up from 13% in 2011), with **a majority strongly agreeing that adopting BIM has or will make them more productive** (71%); **will reduce the risks of problems arising on projects** (72%); and **will increase coordination** of construction documents (85%).

Moreover, an early study on the benefits of BIM by Stanford University's Center for Integrated Facilities Engineering (CIFE), which analysed data gathered from 32 major projects, found that the use of BIM generated[72]:

- **A reduction in unbudgeted change by up to 40%;**
- **Up to an 80% reduction in time taken to generate a cost estimate;**
- **Contract value savings of up to 10% through reduced clash detection; and**
- **Up to a 7% reduction in overall project delivery time.**

These findings align with widespread evidence that BIM helps contractors **avoid the extra costs associated with re-works during the construction of an asset[73]**. Alongside time and material savings, this certainty over information **reduces risk** in the design[74] and capital delivery phases[75], leading to savings through **lower contingency costs**. An early study by the US's National Institute of Building Sciences (NIBS) indicated that BIM (in the context of information management, its flows and reuse between businesses) contributed to a **5% net saving (i.e. accounting for set-up costs) on the construction of new-build projects and a 1.5% net saving in refurbishments costs**[76].

There has also been analysis of the impact of BIM on **improving labour productivity**. Action-based research undertaken with a small, speciality mechanical contracting enterprise in Vancouver found a clear positive impact of BIM on labour productivity. The research team were able to track and benchmark employee performance on BIM projects over time. They found that employees working in areas that were modelled and prefabricated using BIM principles showed an **increase in productivity ranging from 75% to 240%** over the employees working in areas that were not modelled[77]. Meanwhile Khanzode et al[78] found similar evidence of labour productivity savings from the use of BIM in the coordination of Mechanical, Electrical and Plumbing systems on a major healthcare project in Northern California.

Notes:
(68) This in part reflects a lack of consistent reporting from organisations about how they use and benefit from IM.
(69) Zen 2020, Bricks, Mortar and digital transformation, link.
(70) Causeway 2020, Construction's digital front line, link.
(71) NBS 2020, 10th National BIM Report, link.
(72) Azhar. S 2011, Building Information Modelling (BIM): Trends, Benefits, Risks, and Challenges for the AEC Industry. Leadership and Management in Engineering, 11(3), p. 241-252, a review of 32 case studies, link.
(73) Chelson, D., 2010, The Effects of Building Information Modelling on Construction Site Productivity, PhD Thesis, University of Maryland, link.
(74) Gil, N. and Tether, B 2011, Project risk management and design Flexibility: Analysing a case and conditions of complementarity, link.
(75) Ghaffarianhoseini et al., 2015, Building Information Modelling (BIM) uptake: Clear benefits, understanding its implementation, risks and challenges, link.
(76) As referenced in the Building Information Modelling (BIM) Working Party Strategy Paper 2011, A report for the Government Construction Client Group, p. 88, link.
(77) Poirer et al., 2015, Measuring the impact of BIM on labour productivity in a small specialty contracting enterprise through action-research, link.
(78) Khanzode, A. et al. 2008, Benefits and Lessons Learned of Implementing Building Virtual Design and Construction (VDC) Technologies for Coordination of Mechanical, Electrical, and Plumbing Systems on a Large Healthcare Project, link.

In the UK, a **major UK study by PwC in 2018 for CDBB**[79] codified how the application of the then BIM Level 2 standards (now BIM as per the UK BIM Framework) could generate cost savings (and thus productivity gains) across the project life cycle for Government construction clients and asset owners. The study's "Benefits Measurement Methodology" (BMM) provides practitioners with a guide for quantifying the 'end benefits' related to the use of BIM at the project-level, with these cost savings typically arising from:

- **Time savings** (e.g. quicker incident response, more efficient handover processes, fewer requests for information, etc);
- **Material savings** (e.g. less wastage);
- **Other cost savings** (combining both time and materials savings, e.g. better clash detection, fewer design changes, smarter asset maintenance and disposal etc); and/or
- **Reduced risk contingency costs** (from more accurate asset information and accuracy in the costs, delivery timeframes and risks associated with projects).

The BMM also highlighted how using BIM could result in other end-benefits for organisations – including **improved health and safety conditions** throughout the asset lifecycle and an **improved reputation** for Government construction clients by improving the experience for end-users of assets and the wider public (e.g. the use of BIM could result in better site layout and reduce disruption for residents and businesses located near a construction site).

The study also demonstrated an application of the BIM Level 2 BMM through two deep-dive case studies relating to publicly procured capital projects. These case studies estimated the use of BIM Level 2 (now BIM) could generate a reduction in total project costs (in present value terms) of between 1.5% and 3%[80]. The estimates relate to a range of savings across the design, construction and operational phases, including cost savings (both realised and anticipated) in asset maintenance and from better clash detection between project stakeholders, as well as time savings in the design, build and commission and handover stages of the assets' lifecycle.

The **Scottish Futures Trust** (SFT) have developed similar guidance for assessing the benefits of BIM at the project-level, which includes **an interactive tool for estimating the Return on Investment from BIM**. The tool provides practitioners with a method of combining both qualitative and quantitative assessments on the impact of BIM using an array of metrics. The quantitative metrics covered by the tool align with the principle project-level benefits highlighted in PwC's BMM – namely cost reductions related to either time or material savings (including savings related to reduced risk contingencies).

Overall, the micro-level transmission mechanisms of the benefits of BIM have been well established (PwC's BMM, for example, includes 117 different impact pathways) – demonstrating that IM can generate productivity gains through reducing costs or increasing revenue at the project-level.

However, there remain gaps or limitations in the literature when it comes to quantitative evidence of the direct productivity gains of IM in terms of:

The benefits of using IM (and within this BIM) across the lifecycle of assets i.e. beyond the design/construction phase into operations; and

The benefits of IM at the organisational-level and from its role in enabling digital transformation activities (see Section 3 for details of our definition of IM for this study).

Notes: (79) PwC 2018, BIM Benefits Methodology and Report, link.
(80) PwC 2018, BIM Level 2 Benefits Measurement: Application of PwC's BIM Level 2 Benefits Measurement Methodology to Public Sector Capital Assets, link. Note these savings are at the project-level rather than organisational-level.

4.3 Existing evidence on the wider benefits of Information Management

4.3.1 The role of Information Management in helping to drive wider growth in the economy

Section 2.4.3 highlighted that the productivity gains in the construction sector that are enabled by IM could have positive knock-on impacts for UK GDP given the strength of the sector's upstream and downstream linkages with the wider economy. The sector comprises large-scale firms which routinely sub-contract to smaller, specialised firms and draw significant inputs from upstream suppliers (e.g. for raw materials) to build and maintain the country's built assets. The sector's outputs also provide critical inputs to other sectors which rely on capital and built assets in their own production. Thus any productivity gains enabled by IM could generate benefits upstream (in the form of increased demand for goods and services from the supply chain) and downstream (in the form of lower costs and, through dynamic effects in the economy, ultimately increased output / GDP).

The literature generally supports the notion that digitally enabled productivity growth at the firm-level can increase overall output in the real economy. For example, in a UK context, the strategic case for the Digital Built Britain programme produced by EY for BEIS in 2019 investigated the potential net positive impact on the real economy from investing in digital capabilities within the built environment81. The study analysed scenarios with different adoption rates across sectors and geographies and across stages of the asset lifecycle, including a scenario with full integration within the built environment and city services. While impacts were estimated at a national level, the modelling approach focused on the direct GDP impacts within the construction and infrastructure sector, rather than explicitly estimating the knock-on impacts to the wider economy.

In the UK there has not been a specific analysis of the nature and scale of the wider growth in the national economy that could be unlocked by widespread IM adoption within the construction sector. This is because such an analysis would require robust input data on the extent of construction organisations' adoption of IM over time, the nature and scale of the direct productivity gains this has generated, and a way of isolating or modelling the knock-on effects of these direct impacts. This evidence would need to be comparable across organisations, taking account of the different type of organisations using IM, the different uses of IM that have been employed, and use consistent approaches to estimating the direct productivity gains realised at the organisation-level (considering the type of productivity impact, when these gains materialise, etc).

However, internationally, the wider economic impacts of widespread BIM adoption have been analysed using national survey data. In a 2010 study, Australia's Built Environment Innovation and Industry Council (BEICC) used national survey data on the take-up of BIM and a Computable General Equilibrium (CGE) economic modelling framework[82] to conduct a detailed, economy-wide analysis of the impacts of accelerated, widespread BIM adoption on the Australian economy between 2011 and 2025, relative to a 'business-as-usual' adoption scenario[83,84]. This Australian study found direct benefits of increased BIM adoption in the form of cost savings to four main user groups: Architects (6.5% to 11.8%), Engineers (2.7% to 9.4%), Contractors (0.8% to 9.2%) and Asset Owners (0% to 9.2%). **The study estimated these direct cost savings (productivity gains) in the construction sector could in turn boost Australia's overall economic output (GDP) by 0.2 basis points annually, with a net additional boost in private consumption worth some $1.4 billion (in 2010)[85].**

In the UK, there has been some application of CGE-based economic modelling to assess the potential GDP impacts of other types of Government policies and interventions. HM Treasury in particular uses CGE modelling to assess the impacts of tax and trade policies on the UK's economic performance on the basis of the robust economic disciplines underpinning CGE models.

In our wider economic impact analysis reported in Section 7, we use KPMG's own CGE model to illustrate the potential whole economy impacts of initial productivity gains in the construction sector enabled by widespread adoption of IM[86]. In the absence of UK-level, sector-wide data on the productivity gains enabled by IM adoption (to the level and quality discussed previously), we have used hypothetical 'what if' scenarios to investigate the potential ratio between total UK GDP impacts and any initial IM-enabled productivity gain in the sector. The results of the analysis suggest that the returns to the whole economy from widespread IM adoption could potentially be a multiple of the direct gains to the sector.

Notes:
(81) EY 2019, Strategic Outline Business Case for the delivery of Digital Built Britain Programme Level 3, link.
(82) See Section 7.4 later in this report for an explanation of CGE modelling.
(83) BEIIC 2010, Productivity in the Buildings Network: Assessing the Impacts of Building Information Models, link.
(84) The two scenarios were constructed using national survey data and consultation with industry stakeholders and experts to form a view of expected BIM adoption across Australia from 2011 to 2025 (BAU scenario) and assumed higher adoption rate over the same period (widespread scenario). Note there were limitations to the data collection approach. The national survey was undertaken via email correspondence to industry participants who self-reported the extent they had adopted BIM, and the benefits they had received from implementing BIM principles in their organisation, without reference to an agreed counterfactual or consistent cost base.
(85) Note that this analysis is evaluating the difference between two specific adoption policy scenarios in Australia (with one adoption slightly faster than the other) and so the resulting estimates are not directly. comparable to our wider impacts analysis in Section 7.
(86) KPMG's CGE model uses GEMPACK software; Horridge, Jerie, Mustakinov & Schiffmann 2018, GEMPACK manual, GEMPACK Software, ISBN 978-1-921654-34-3.

4.3.2 The role of Information Management in helping to drive social value

As well as supporting productivity gains in the sector and in turn growth in the real economy, there is a range of existing literature which highlights how the use of IM can support improvements in the quality and sustainability of built assets during both construction and operations. These outcomes can provide important and potentially significant benefits in the form of **social value (or public value) to customers, wider society and the environment.** However, the literature is more limited in providing *quantified* evidence of the social value unlocked by the use of IM specifically.

The concept of social value is reflected in the way that UK Government appraises and prioritises public investment in infrastructure and built assets, and to an extent the procurement of those assets – where the aim is to maximise economic welfare. Government guidance requires an assessment of all possible costs and benefits of an intervention in social value terms, and where possible and proportionate to do so, valuing these impacts so that they can be directly compared with the financial costs of intervention. There are also recent proposals to strengthen these principles in public procurement, beyond their current consideration, through the Cabinet Office's 2020 Green Paper: 'Transforming Public Procurement'.

There are broadly two different types of social value defined in the Government's economic appraisal literature (HM Treasury's Green Book and individual Government departments' guidance[87]):

- **Private benefits for users** from the direct consumption of an asset once it is operational (e.g. commuters on a train, patients occupying a hospital ward, students occupying a school or households/tenants occupying housing); and
- **Externalities[88]** which can represent a cost or benefit to society and the environment beyond any private costs/ benefits to asset users, which can arise during the construction or operation of built assets (e.g. noise pollution for local residents from a nearby construction site, or changes in air quality from reduced road traffic congestion from more effective management of highways infrastructure).

There is also an increasing drive across industry to better understand and evaluate the social and environmental impacts of investments in infrastructure (even if not directly linked to those impacts specifically enabled by IM). This includes increasing attention on the Environmental, Social and Corporate Governance agenda at a board-level, as well as the industry's wider socio-economic ambitions outlined in the Construction Sector Deal. The specific link between IM and social and environmental benefits has been made in other studies, although there is limited literature which sets out how to measure and value such impacts. For example, the role of BIM in facilitating **more sustainable designs for buildings[89,90], a better quality built asset[91,92]**, and **improvements in employee health and safety[93]** is well documented. Moreover, the application of IM is seen as critical to helping demonstrate the value of the **Golden Thread of Information** passed between future building owners, and thereby supporting **more effective safety management throughout the building life cycle**[94].

PwC's BMM (explained in Section 4.2) identifies several categories of BIM impacts at the project-level that relate to wider social value, including **material savings and increased energy efficiency leading to reduced GHG emissions and improved asset quality leading to better outcomes for the end-users of assets** (e.g. improved patient experience from a better designed hospital). The BMM also identifies that **improved workforce health and safety,** as well as providing a direct benefit to the organisations using IM, can provide benefits to society (reducing the individual and social costs of accidents and fatalities). Their deep-dive analysis of two project-specific case studies also set out an approach for quantifying and valuing some of these benefits using relevant elements of the Government's economic appraisal guidance (referred to previously). For example, they present a method of calculating the environmental impact of BIM using the embodied carbon value of material savings as a proxy for total impact.

The **Construction Innovation Hub's Value Toolkit** also highlights an approach to defining, measuring, evaluating and then optimising the social value of investments in the built environment which could be transferable to considering the benefits of IM. The Value Toolkit provides "a way of defining and measuring value – as opposed to cost – which can be applied consistently throughout a project or programme lifecycle, from early business cases through to use of an asset"[95]. It allows policy makers to make meaningful value choices and trade-offs, looking beyond the financial costs of delivery when measuring the performance of built assets to consider increased productivity and quality, and to bring forward the importance of wider societal issues such as Net Zero requirements. The Toolkit's 'four capitals' approach is summarised in Figure 8.

Notes:
(87) HMT 2020, The Green Book: Central Government Guidance on Appraisal and Evaluation, link.
(88) HMT Greenbook defines an externality as "an activity imposes costs or produces benefits for economic agents not directly involved in the deal". see p. 29, link.
(89) Lesniewski et al., 'Roadmap for Integration' in American Institute of Architects.
(90) Preece et al. 2016, Toward BIM enabled Sustainable Urban Developments in the UAE, link.
(91) BEIIC 2010, Productivity in the Buildings Network: Assessing the Impacts of Building Information Models, link.
(92) CDBB 2019, Toward a Digitally Enabled Estate: Project Capella, link.
(93) Health and Safety Executive 2020, Improving Health and Safety Outcomes in Construction, Making the Case for Building Information Modelling (BIM), link.
(94) Secretary of State for Housing, Communities and Local Government 2018, Building a Safer Future: Independent Review of Building Regulations and Fire Safety: Final Report, link.
(95) Construction Innovation Hub 2021, Value Toolkit, link.

Figure 8: The Construction Innovation Hub's Value Toolkit 'Four Capitals' approach

Natural Capital	Natural Capital is defined as the stock of renewable and non-renewable resources (e.g. plants, animals, air, water, soils, minerals) that combine to yield a flow of benefits to people. In the context of the built environment, Natural Capital values the natural environment, addresses solutions to climate impacts and provides benefits to society throughout the full life cycle of built assets.	**Social Capital**	Social Capital is defined as the networks together with the shared norms, values and understanding that facilitate cooperation among groups. In the context of the built environment, Social Capital refers to influence and consultation, equality and diversity, networks and connections, as well as the changes people experience in these areas as a result of built assets.
Human Capital	Human Capital is defined as the knowledge, skills, competencies and attributes embodied in individuals that contribute to improved performance and wellbeing. In the context of the built environment, Human Capital encompasses employment opportunities, skills development, and individual health and wellbeing in the construction and operation of built assets, as well as the ability of an asset to influence these factors.	**Produced Capital**	Produced Capital is defined as the man-made goods as well as all financial assets that are used to produce goods and services consumed by society. In the context of the built environment, Produced Capital encompasses a combination of capital cost, operational cost and revenue, thereby covering the whole of direct monetary spend on a project over its whole life. The man-made elements include indicators of the efficiency and quality of design, construction and operational processes.

Source: Construction Innovation Hub – Four Capitals Model.

IM is critical to the successful implementation of the Value Toolkit. Some illustrative examples include:

— **Produced Capital:** where the scaled adoption of the UK BIM Framework and wider digital transformation supports improvement in capital delivery and management of buildings, cities, and assets[96]. IM provides a clear process in establishing information quality, availability, alignment and interoperability of sector datasets. This acts as a catalyst for innovation and further business value in financial and commercial aspects, and organisational planning and response through principles of lifecycle costing, resilience and increased production rates. The use of IM is also a critical enabler of more efficient (and thus less costly) construction approaches such as MMC and the value to be had in off-site assembly approaches[97];

— **Natural Capital:** where IM supports the process of resilience planning in the delivery of built assets within the natural environment. The structuring of clear environmental requirements provides the ability to further align, request and measure information on carbon and GHG performance aligned to an organisation's Net Zero targets and/ or climate resilience planning;

— **Social Capital:** where IM, through visual experiences and immersive approaches, enables a wide range of stakeholder consultation and engagement in the development of schemes – better establishing the principles of Equality, Diversity and Inclusion in design and enabling the delivery of more inclusive infrastructure. Social value metrics can also be made contractually binding through the use IM, with an ability to manage requirements and monitor and measure their outcomes across the lifecycle of assets; and

— **Human Capital:** where the use of IM through the management and creation of a Project Information Model is pivotal in supporting the management of sustainable supply chains across distributed global suppliers. The use of IM also has the potential to upskill and increase the productivity of the workforce through enabling more collaborative, cross-discipline approaches to the design, construction and operation of built assets and the reallocation of staff time from administrative/ repetitive tasks to more productive business activity. As outlined above, IM also plays an important role in achieving a safer working environment and thus the wellbeing of the sector's workforce.

Across the existing evidence discussed in this section, the key implication is that **the nature of the social value derived from built assets and enabled specifically by the use of IM is highly context specific and requires case-by-case analysis.** This presents a key challenge for policymakers, business leaders and IM practitioners in trying to routinely establish a robust evidence base on the wider social value unlocked by the use of IM.

The established valuation methods outlined in Government appraisal guidance are relatively complex and, whilst commonly applied by public sector organisations to understand the impact of potential investment in built assets, they are rarely applied by organisations (both public and private) to understand the specific impacts of investing in IM as part of the process of constructing or operating assets. These valuation methods also require robust input information on the changes in the customer, social and environmental outcomes specifically enabled by IM, which can be difficult to isolate from other aspects of intervention. In our analysis of case studies for this study (Section 6), we have sought to qualitatively identify the social value impacts of using IM and where possible value these impacts using available data and assumptions provided by stakeholders.

Notes: (96) NBS 2020, The Tenth Annual NBS BIM Report 2020, link
(97) HMG 2020, The Construction Playbook, link.

05 Information Management Benefits Framework

5.1 Introduction

This section presents the Information Management Benefits Framework we have developed through this study, which aims to provide a logic flow for how the use of IM can result in direct productivity gains for organisations involved in its adoption, as well as wider value for customers, society, the environment and the economy. We have developed the Framework reflecting on the existing literature on the use and benefits of IM (Section 4), our bottom-up analysis of case studies (Section 6), engagement with CDBB and the Construction Innovation Hub, and KPMG and Atkins' combined experience as advisors to the construction and infrastructure sector.

In this section we provide an **overview of the Benefits Framework, its intended purpose and key considerations for its application** (Section 5.2) followed by **examples of the different use cases for IM** across organisational functions (Section 5.3) and a **summary of the types of direct and wider impacts this can generate** (Sections 5.4 and 5.5).

5.2 Purpose and overview of the Benefits Framework

5.2.1 Purpose of the Framework

The Information Management Benefits Framework serves to provide a summary of how the inputs and activities associated with the use of IM at the project- and organisation-levels could ultimately lead to end impacts for organisations (increased productivity and intangible benefits) and broader impacts for customers, society, the environment and the wider economy.

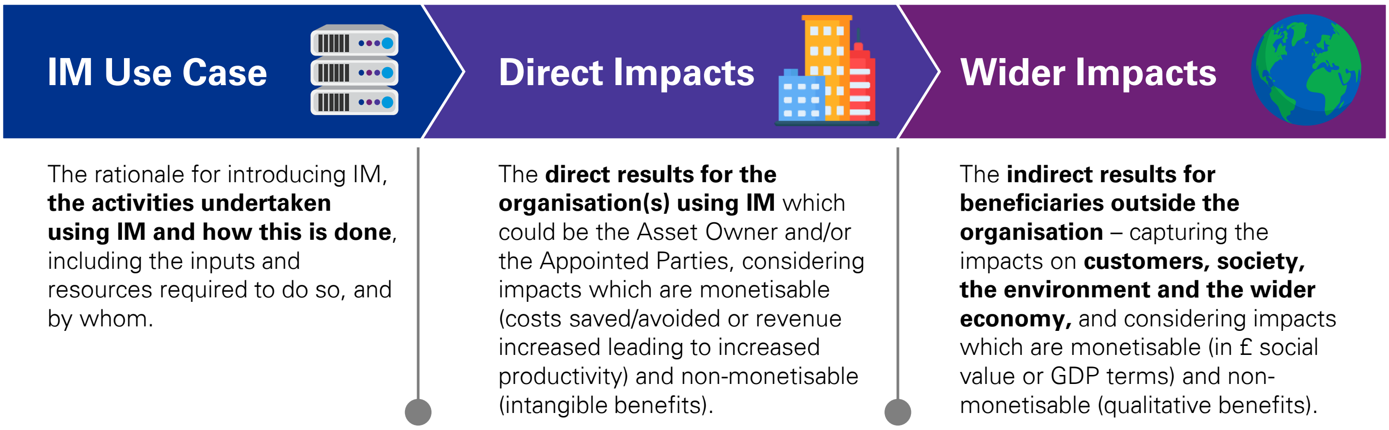
The individual pathways for how these impacts arise is highly context specific, as highlighted throughout this report and in the existing literature on the benefits of IM. The use of IM has a broad range of applications across the construction and infrastructure sector, involving the use of standards and processes in different ways, which in turn results in a wide range of possible outcomes for projects, organisations and external parties. Therefore, **the Framework is not intended to provide a detailed or prescriptive methodology for measuring and quantifying individual impact pathways, but rather to provide a strategic overview of the range of uses and benefits of IM to provide decision-makers with a consistent and integrated basis for considering the value of investing in IM.**

Use of this Report is limited – see Important Notice on page 1.

5.2.2 Overview of the Framework

The Framework uses the following definitions:

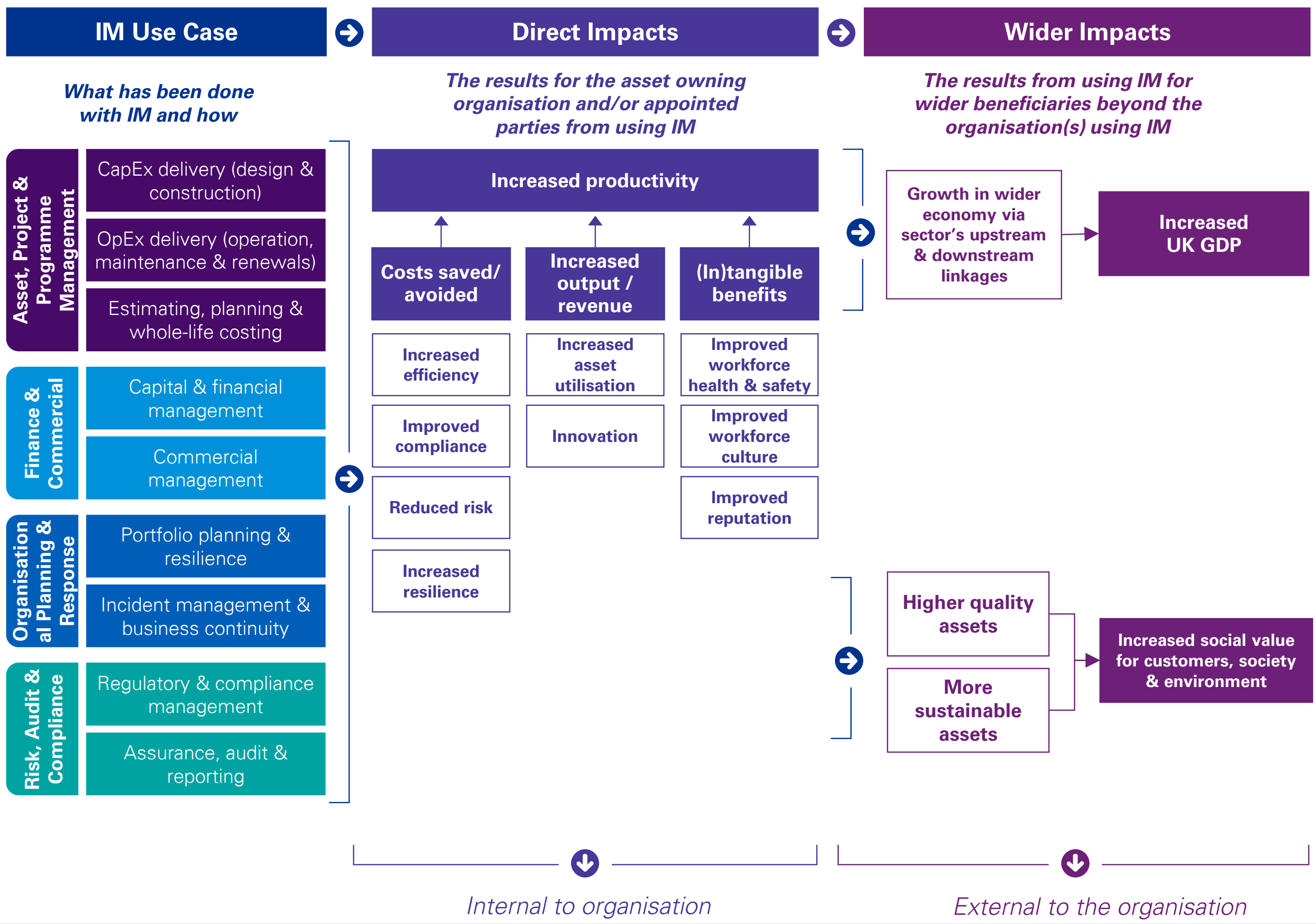
Figure 9: Definitions used in the Information Management Benefits Framework



Source: KPMG and Atkins analysis 2021.

Figure 10 provides an overview of the Information Management Benefits Framework and the remainder of this section outlines some key considerations for organisations in interpreting and applying it. In Section 5.3 we go on to provide examples of the range of potential use cases for IM across an organisation (unpacking the first stage of the Framework), and in Sections 5.4 and 5.5 we explain the range of potential direct and wider impacts (benefits) that can result from the use IM (the second and third stages).

Figure 10: Information Management Benefits Framework



Source: KPMG and Atkins analysis 2021.

5.2.3 Key considerations within the Framework

5.2.3.1 Understanding the use case

For the purposes of this study, the use of IM involves stakeholders from across the breadth and depth of the value chain responsible for designing, building, operating and integrating built assets. This is represented in Figure 24 in Appendix A3 and incudes asset owners, operators, maintainers, designers, constructors, installers, product manufacturers and technology providers. Most of these parties can serve as both actors involved in the process of using IM and direct beneficiaries enjoying the productivity gains from the process (the latter is described as 'Direct Impacts' in the Framework). Organisations that are interested parties in the adoption of IM, but do not directly use IM in the construction and operation of built assets (e.g. regulatory authorities, standards organisations, professional institutes, etc) are excluded from the scope of the Framework[98].

As defined in Section 3, the scope of IM encompasses use cases resulting from BIM adoption (in line with the UK BIM Framework) as well as broader digital transformation activities. Under this definition, the use cases for IM vary between projects, programmes (i.e. several related projects) and organisational functions. They also vary between the design, build and operate stages of the lifecycle.

The key questions to consider in establishing the IM use case (which will in turn help to understand the nature of its direct and wider impacts) are:

- What is the rationale for introducing IM (defining the problem-statement/ opportunity)?
- Who are the key parties (different organisations) and teams (within organisations) that will be involved in its implementation?
- What are the direct financial resources being invested to implement IM by those parties?
- What other resources are being invested/ used by those parties to support the implementation of IM (e.g. people/skills/culture, equipment, technology, data)?
- What activities will be undertaken using IM, and by whom?
- What data/information will be managed, how will this be done, and by whom?

5.2.3.2 Understanding who benefits and how

Distinguishing between outputs, outcomes and impacts

The value of IM relates to the impacts (or end-benefit) it delivers, or helps to deliver, for different beneficiaries within and beyond the organisations which use it. These impacts should link back to the original rationale for investing in IM, which typically might be aligned to an organisation's strategic objectives, such as a drive towards cost competitiveness, providing higher quality assets/ services to customers or being more environmentally responsible. The direct and wider impacts identified within the Framework focus on the role of IM in contributing towards these objectives. This can be identified by unpacking the causal logic between the use of IM and the results this generates for different beneficiaries, distinguishing between:

- **Outputs** – the resulting quality of information available to organisations using IM to perform their day-to-day activities or make decisions – i.e. IM providing an organisation with more timely, accurate or comprehensive data;
- **Outcomes** – what those outputs enable the organisation(s) to do differently (either more efficiently or more effectively) – e.g. resulting in the need for less time or effort in conducting a given activity, or providing the ability to undertake a given activity more effectively or in a more-timely or responsive manner; and
- **Impacts** – the end benefit of those outcomes for different parties within and beyond the organisation (which may or may not be possible to place a monetary value on). In the Framework, we identify two key categories of direct impact for organisations (productivity gains and intangible benefits) and a range of wider impacts which could provide value to customers, society, the environment and/ or the wider economy. These impacts, and the ways in which they can come about, are explained in Sections 5.4 and 5.5.

Understanding when and where these impacts materialise

As outlined in Section 5.2.3.1, there is typically a strong correlation between the organisations using IM and the organisations that benefit from it. This can span asset owners, contractors and the wider supply chain. How the benefits are realised and shared between parties will in part be influenced by the contractual relationship between the parties, as well as the availability of people/skills and the culture of an organisation in seizing the value on offer from IM.

Notes: (98) Organisations that are interested parties in the adoption of IM, but do not directly use IM in the construction and operation of built assets (e.g. regulatory authorities, standards organisations, professional institutes etc.) are excluded from the scope of the framework.

Identifying the wider beneficiaries beyond the organisation that stand to gain from the use of IM

There are broadly two types of wider impact from an organisation's use of IM which provides economic or social value. These are:

— **"Private benefits" for customers/ end-users of an asset or the service it provides, once it is operational.** The nature of these wider impacts and how they are valued is highly dependent on the type of asset and its users (e.g. road users vs. hospital patients vs. housing tenants) and how the use of IM (in either construction and/or or operations) affects the end quality of the asset or service they receive; and

— **Externalities for wider society and the environment in either construction or operation of an asset.** These impacts relate to the benefits unlocked by IM beyond those for customers/ users, and will again be highly specific to the particular use of IM and how this affects the end quality or sustainability of an asset or service.

Section 5.5 provides some illustrative examples of how IM can lead to different types of wider impacts across these two categories.

5.2.3.3 Understanding the counterfactual scenario

A final but critical consideration for understanding the additional benefits of using IM is determining what would happen in the absence of using it. This requires an assessment of the direct and wider impacts resulting from the use of IM and comparing this to the impacts that would otherwise arise under a 'do nothing' or business-as-usual scenario. In practical terms, determining the impacts under a counterfactual or do-nothing scenario can be achieved by either:

— Benchmarking against a similar project/ business scenario observed in the past that did not use IM, controlling for the effects of other factors as far as possible (e.g. the size, complexity and location of a project); or

— Using practitioners' expert judgement on what would happen in the absence of using IM, where this judgement is based on their first-hand experience of a wide number of projects/ business scenarios in which IM has not been used.

5.3 Use cases for Information Management

The Information Management Benefits Framework establishes a range of use cases for IM across the construction and infrastructure sector, categorised into four broad organisational functions and nine sub-functions, as set out previously in Figure 10. We provide example IM use cases under each of these functions in Table 1 below.

The Asset, Project and Programme Management function represents the highest concentration of established use cases for IM (looking across both existing literature and the new evidence gathered through our bottom-up case study analysis), and within this, most commonly the capital delivery (design and construction) of projects and programmes.

Through increased exposure to the UK BIM Framework and digital transformation activities, IM is being implemented to support wider organisational functions and capabilities.

The Finance and Commercial function often spans multiple programmes and projects within organisations, yet stands to benefit explicitly from implementation of IM at the organisation level.

Similarly, the Risk, Audit and Compliance function is accountable to both internal and external authorities outside the core project/ programme teams – implementation of robust IM processes at a project and programme level influences their ability to achieve their own organisational goals effectively.

The Organisational Planning and Response function covers those aspects of an organisation that are responsible for resilience and business continuity – our research shows that the artefacts produced through application of IM are increasingly important to these functions fulfilling their strategic goals.

Table 1: Example Use Cases for IM by organisation function

Organisation's function		Description
Asset, Project & Programme Management	CapEx delivery (design & construction)	Project and programme level IM use for all aspects of delivering capital projects (both greenfield and brownfield), including design, construction, asset acquisition, end of life and associated activities. It excludes activities that are explicitly identified under other categories (e.g. commercial management).
Asset, Project & Programme Management	OpEx delivery (renewals, maintenance & operation)	Project and programme level IM use during the operation, maintenance and renewal of assets, primarily focusing on ongoing and repeated activities.
Asset, Project & Programme Management	Estimating, planning & whole life costing	Project and programme level IM use for estimating, planning and whole life costing activities relating to both the financial and carbon costs of projects/programmes.
Finance & Commercial	Commercial management	Project, programme and organisation level use of IM for contracts, claims and dispute management, change control and other overarching commercial functions.
Finance & Commercial	Capital & financial management	Project, programme and organisation level use of IM for capital management, working capital, cost control, financial management, payments and other commercial/ financial activities.
Organisational Planning & Response	Incident management & business continuity	Project, programme and organisation level use of IM for short-term incident management and response activities.
Organisational Planning & Response	Portfolio planning & resilience	Organisation level use of IM to aid longer-term portfolio planning and resilience strategies.
Risk, Audit & Compliance	Assurance, audit & reporting	Project, programme and organisation level use of IM for assurance and audit activities, including technical, regulatory, data integrity and quality, taking into consideration internal, external, and procedural/ regulatory tasks.
Risk, Audit & Compliance	Regulatory & compliance management	Project, programme and organisation level use of IM for Health and Safety, Regulatory and Environmental compliance, including related Security and Standards requirements.

Source: KPMG and Atkins Analysis 2021.

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Example IM use case

- Communicate detailed information requirements to enable necessary and timely outputs from capital projects delivery.
- Use of standard templates and tools to ensure consistent information delivery by all parties.
- Use of BIM by client teams to ascertain value and soundness of Contractor's proposals.
- Use of CDE solutions to ensure role-based, secure access to right information.
- Standardised information exchange processes.
- Visual and rule-based interrogation of BIM models to aid design, constructability and value engineering discussions.
- Parametric modelling to aid design optimisation.
- Using BIM to drive value engineering decisions.
- Creation and exploitation of digital component libraries.
- Optimising BIM models for use in the DfMA (design for manufacture and assembly) process.

- Use of digital asset registers and asset information to determine operations and maintenance strategy.
- Use of IM processes to enable soft landing (commissioning, testing and familiarisation).
- Use of asset data concerning performance, utilisation and condition to determine proactive maintenance.
- Use of accurate, close to real time data to determine remaining useful life of asset and asset renewal plans.
- Use of asset information model for space utilisation planning.
- Use of intelligent health and safety files in combination with field devices (e.g. tablets, VR goggles etc.) to carry out safe operations and maintenance.

- Using 4D to plan construction sequencing, temporary works and site logistics.
- Automated quantity take off combined with standard rates for more accurate and faster estimating.
- Standardising information requirements across project stages to facilitate the computation and tracking of whole life costs.

- Standardised tender documents and documentation process using necessary templates and tools to enable automated or semi-automated assessment of tender returns.
- Automated reporting of commercial implications of change events and activities.
- Use of accurate up-to-date information to review and validate preceding investment cases.
- Re-use of IM outputs from CapEx delivery for the procurement of operations and maintenance services.

- Integration of 4D scheduling information with ERP to automate payments.
- Use of up-to-date cross-project reporting for resource mobilisation planning.
- Using current and historic CapEx and OpEx information for capital works planning and business case justification.

- Use of 3D/ 4D BIM for virtual walk-throughs and detailed investigations in relation to incident management.
- Carrying out BIM updates to test out temporary logistics and layout/ circulation alterations in response to incidents.
- Use of asset information model as the basis for designing and delivering emergency fit outs and repurposing of facilities in the event of disasters.

- Use of current and historic project data in combination with ERP for standardised workforce planning.
- Employing master data standards at an organisational-level to govern the entire information lifecycle.
- Establishing robust asset data at an organisational-level to facilitate computation of accurate present value of asset portfolio.
- Developing and adopting standardised, scalable models for temporary interventions as part of organisational resilience for disasters.

- Standardised data integrity and assurance criteria and procedures.
- Automated assessment of requirements (e.g. BREEAM, LEED, SEQUAL etc.)
- Introducing quality and compliance controls (e.g. CAT A, CAT B audit and sign-off).
- Use of IM tools to implement data reporting standards and KPI monitoring from Government or Regulator.

- Automated validation of compliance against engineering design standards and guidance.
- Use of 3D and 4D BIM to visualise, review and mitigate health and safety risks to ensure compliance with CDM regulations.
- Use of IM to monitor and report service level targets (e.g. asset failures, outages, customer targets etc.)

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5.4 The direct impacts for organisations

The Information Management Benefits Framework identifies **two key categories of impact** for organisations which use and directly benefit from IM:

Productivity gains arising from a reduction in the unit costs of a project, programme or organisation's activities, or an increase in an organisation's revenue, as a result of using IM. The ways in which these productivity gains can come about are discussed in Section 5.4.1. These productivity gains can be valued as a 'cash-releasing benefit' in £ terms by analysing the reduction in costs to the organisation or the increased revenue earned from goods/ services sold for the same unit cost. In other cases, they can be considered a 'non-cash-releasing benefit' wherein it is possible to place a £ value on the productivity gain, but it does not directly affect an organisation's budget or P&L – for example, the value of labour hours freed up by the use of IM and redirected to more productive activities, or the use of IM increasing the value of an asset; and

Intangible benefits which are not possible to value (as either a cash-releasing or non-cash releasing benefit) but represent important outcomes for an organisation in performing their core business and delivering their strategic objectives. These relate to reputational and cultural factors which have an implicit value to organisations – for example, helping them to attract a talented workforce and customers/ revenue, which in the long-term could be likely to contribute to their productivity and competitiveness. An obvious example is the growing importance of the Environmental, Social and Corporate Governance agenda for organisations, their staff, and their customers. The typical categories of intangible benefit that can be observed in the literature and in our case studies are outlined in Section 5.4.3.

5.4.1 How these productivity gains come about – costs saved/ avoided

The Benefits Framework identifies **four principal ways in which IM can lead to costs saved or avoided for organisations and in turn support productivity gains**. These cover – **increased efficiency, improved compliance, reduced risk and increased resilience** – and are explained in Figure 11.

Figure 11: The four key drivers of IM-enabled productivity gains arising from cost savings / costs avoided

01

Increased efficiency

Delivering the same process, service, or product with a reduced amount of input, thus enabling the organisation to reduce the unit cost of producing the same level of goods or services (or to provide an improved service/ product for the same cost). This could arise from IM removing the need to deploy resource to a process entirely – for example by achieving disintermediation of inputs in the value chain – or from IM enabling an organisation to complete the same process with reduced amount of labour time, materials or combination of the two (e.g. fewer surveys or a shorter delivery timetable).

02

Improved compliance

Enhancing an organisation's ability to meet regulatory standards and sector-specific requirements (for the same level of effort/ cost), thus enabling the organisation to more effectively manage and meet their statutory or contractual obligations, and in turn reduce or avoid the costs of fines or compensation payments for non-compliance. This could arise, for example, at the organisation-level by IM enabling more timely and accurate reporting against a regulator's requirements, or at the project level by providing an organisation with more accurate information to challenge contractual disputes and litigation claims.

03

Reduced risk

Enhancing the accuracy of information about a project, asset or performance of a business function and thus providing greater certainty over the time/costs involved in delivering a process, service or product and a greater ability to reduce the variability of those costs. This could arise at the project level, for example, by IM increasing the certainty of design and delivery timelines which in turn reduces the level of risk contingency costs associated with capital or operating expenditure. At the organisation level, this could arise from IM providing more certainty in the portfolio planning process.

04

Increased resilience

Enhancing an organisation's ability to plan for, and respond to, adverse events in both the short- and long-term (for the same level of effort/ cost), providing increased certainty in the business planning process and reduced downtime of assets in future, which in turn reduces contingency costs held by an organisation for future events. This could arise, for example, by IM providing more accurate and timely asset information when responding to a system failure, or by accurate and comprehensive asset information at the organisation enabling preventative maintenance activity to drive down the whole life costs of the asset.

Source: KPMG and Atkins Analysis 2021.

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5.4.2 How these productivity gains come about – increased revenue

The Information Management Benefits Framework identifies **two principal ways in which IM can lead to an increase in revenue for organisations and in turn support productivity gains** – either via **increased asset utilisation or innovation leading to the creation of new products or services.** These are explained in Figure 12.

Figure 12: The two key drivers of IM-enabled productivity gains arising from increased output / revenue

01

Increased asset utilisation

Optimising and enhancing the utilisation of an organisation's asset(s) (for the same level of effort/ cost), thus enabling the organisation to maximise the value of, and income from, its asset(s) and increase the revenue it receives (either through additional customer demand/revenue or reductions in lost customer demand/revenue). This could arise at the organisation-level, for example, by IM informing investments which in turn reduces the likelihood of faults and unforeseen downtime of the organisation's assets, or the use of IM enabling space utilisation strategies to maximise the occupancy of an organisation's built estate. Or at the project level, by IM enabling the use of design solutions in the capital delivery stage which facilitate better use of the asset in the operations stage.

02

Innovation

The creation of new services or products – over an above an organisation's 'business as usual' offer – enabling entry into new markets and in turn increased revenue for the organisation. This could arise, for example, by IM enabling an organisation's data to be used more effectively for the development of customer Apps which earn additional revenue for the organisation, or by the use of IM reducing the costs of capital delivery such that it becomes possible to build assets which would otherwise be considered unviable (in turn generating new revenue for the organisation).

Source: KPMG and Atkins Analysis 2021.

5.4.3 Intangible benefits

The Information Management Benefits Framework identifies **three key categories of intangible benefit for organisations which use IM – improved workforce health and safety, improved workforce culture, and improved reputation**. These are explained in Figure 13. However, this is not intended to be an exhaustive list, given that each organisation will have specific performance measures against their own corporate objectives.

Figure 13: Three key examples of the intangible benefits for organisations which use IM

01

Workforce health and safety

Enhancing an organisation's ability to provide safe working conditions for their employees and/or their suppliers in both the construction and operation of built assets. This could arise, for example, from the use of IM enabling more effective staff briefing and training on the health and safety risks of their projects (e.g. through the use of a 3D model) or the use of IM enabling improved sequencing of works (e.g. through the use of a 4D model) from a health and safety perspective.

02

Workforce culture

Enhancing an organisation's ability to create a culture of collaboration and a growth-mindset, providing its workforce with more rewarding work and opportunities for upskilling. This could arise as the use of IM enables multiple parties to come together to design, build and operate built assets (e.g. through the use of 3D/4D models and visualisation approaches) and share their knowledge and skills, as well as through the efficiencies enabled by IM which could reduce the need for staff to undertake cumbersome and lower value tasks and instead enable them to spend their time on more strategic and value-add activities.

03

Improved reputation

Enhancing an organisation's reputation with its customers / end users of assets as well as the wider public by either: (i) at the project-level during the construction phase, improving the experience of stakeholders' (e.g. local residents, businesses and existing customers) in the build of projects – such as IM enabling reducing or avoiding disruption through more effective scheduling of works; (ii) at the project-level during the operations phase, improving the experience of stakeholders – such as IM enabling a higher quality asset/ service to end users or reducing/avoiding disruption during adverse events; and (iii) at the organisation-level, improving stakeholders' perception of the organisation as one which delivers/operates high-quality and sustainable built assets which align with the priorities of their customers and the public.

Source: KPMG and Atkins Analysis 2021.

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5.5 Wider impacts beyond the organisation

5.5.1 Social value from higher quality and/or more sustainable built assets

The use of IM can influence the quality and sustainability of built assets during both the construction and operation phases. As outlined previously in Section 5.2.3.2, this can generate benefits for customers/ end-users of an asset or service (e.g. time savings for transport users, improved health outcomes for hospital patients, less crowded or higher amenity housing/ buildings for tenants), as well as generate benefits (externalities) for wider society and the environment.

The externality benefits to society and the environment will typically arise through:

- The construction of an asset (e.g. the use of IM in design and construction helping to reduce the level of materials waste, embodied carbon emissions, noise, accidents and construction blight);
- The operation of an asset by its customers (e.g. the use of IM at either the design or operations stage enabling reductions in the level of operational carbon emissions, air quality, noise and accidents); and/or
- Permanent effects on the local area surrounding an asset once built (e.g. the use of IM enabling the delivery of a better designed asset and in turn providing positive effects on landscape, townscape, heritage and biodiversity – by either helping to mitigate any negative impacts, or potentially enhancing the visual amenity for surrounding land/ property owners).

These benefits have a social value (or public value) even if they do not have a market price that can be traded in the economy. HM Treasury's Green Book guidance and individual Government departments' economic appraisal provides approaches for assessing and in some cases valuing these social value impacts. However, any assessment of these impacts first requires an understanding of how the use of IM delivers, or helps to deliver, higher quality and/ or more sustainable assets and services, which is highly specific to the individual use case of IM. These impacts will also be influenced by the type of asset/ service in question, who uses it, where it is located and how its construction or operation interacts with wider society and the environment.

Table 2 below provides a range of hypothetical examples of how the use of IM could potentially generate social value through enabling higher quality and/ or more sustainable assets and services.

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Table 2: Examples of wider social value impacts from the use of IM

Sector	IM Use Case Example	Construction	Operation	Direct Impacts (internal to the organisation)	Wider Impacts (external to the organisation)
Water	A water company uses IM to enable it to identify changes to its asset standards to improve tap water quality.		✓	— Increased compliance with water quality standards set by regulator, avoiding cost of penalties for the organisation. — Enhanced reputation (fewer customer complaints).	— Improved drinking water improves economic wellbeing of customers.
Transport	An airport minimises the downtime of part of an operational terminal building by using IM to capture and analyse drone survey data.		✓	— Cost saving resulting from avoided lost revenue. — Enhanced reputation (fewer terminal passenger complaints).	— Reduced journey time disruption and improved ambience for airport passengers / customers.
Transport	A transport authority uses IM to better understand what capital works are scheduled within its region to optimise the timing of traffic management systems.		✓	— Costs savings from reduced need for maintenance/ temporary works for traffic management measures.	— Reduced journey times for road users (commuters, business and leisure travellers). — Reduced congestion (less idle traffic) reduces CO2 and improves air quality.
Healthcare	An NHS Trust uses IM to enable it to plan and co-ordinate off-site construction of its hospital expansion.	✓		— Cost savings in construction from reduced delivery timetable (savings in labour, time and materials). — Better designed hospital facilities results in cost savings in operations (better layout reduces ward staffing costs and increases patient throughput). — Better designed hospital facilities results in improved patient outcomes of new facilities and less disruption to existing patients due to less on-site construction, enhancing the reputation of the Trust.	— Reduced construction blight for local residents and businesses during construction. — Improved recovery times and health outcomes for patients.
Education	A building contractor introduces IM through the use of standardised data scheduling to optimise the sequencing and timing of construction works at a school so as to minimise the impact to lessons and extra-curricular activity.	✓		— Cost savings in construction from reduced delivery timetable (savings in labour, time and materials). — Cost savings from reduced need for rewords/ synergies in capital works. — Enhanced reputation (reduced impact on school activities e.g. less construction noise when lessons are in session).	— Reduced construction blight for local residents and businesses during construction. — Better quality experience for users (students and teachers) leading to better educational attainment.
Housing	A social housing provider introduces IM into the design-phase of a residential development enabling it to more accurately simulate energy use (e.g. through airflow / heat simulations) and allow the organisation to construct more energy-efficient homes.	✓		— Increased compliance with current (and increased resilience to future) energy efficiency standards set by Government, avoiding cost of penalties and/or future retrofit projects. — Enhanced reputation (better environmental credentials with customers and the public).	— Reduced CO2 emissions for the environment. — Cost saving for end tenants of housing (lower energy bills).
Non-residential development	An asset owner introduces IM through the implementation of automated data capture for energy usage in their existing building estate, enabling accurate data to be used for modelling and better management of energy consumption.		✓	— Cost saving for asset owner (lower energy bills). — Enhanced reputation (better environmental credentials with customers and the public).	— Reduced CO2 emissions for the environment.

Source: KPMG and Atkins Analysis 2021.

5.5.2 Wider economic impacts from a more productive construction sector

The IM-enabled productivity gains realised by organisations across the sector could have knock-on impacts for other parts of the economy, which could ultimately lead to an increase in total economic output (GDP) nationally.

This wider economic growth comes about if the productivity gains enabled by the widespread use of IM incentivise increased production output in the construction sector. This could provide benefits upstream to other businesses in the supply chain (increasing the output of other sectors) and downstream through lower prices for firms and households who rely on the sector's outputs for their own production and consumption.

These wider economic impacts are likely to be marginal at the project-level. However, as IM is adopted by an entire organisation (particularly those which have a relatively large market share), and between organisations (as envisaged by CDBB's National Digital Twin agenda), any permanent step-change in productivity at the sector-level could potentially drive growth in the wider economy.

Further explanation of how these wider economic impacts come about, and the potential scale of these impacts from widespread adoption of IM across the sector, is provided in Section 7 which presents our economic impact modelling.

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06 Case study analysis

6.1 Introduction

This section presents a **summary of our bottom-up analysis of case studies on the uses and benefits of IM** in the construction and infrastructure sector.

We begin by providing an **overview of the purpose of the analysis and our approach** to selecting a representative sample of case studies and sourcing qualitative and quantitative evidence of their use cases and benefits (Section 6.2).

We then go on to provide a **summary of the eleven case studies analysed** (Section 6.3) and **set out our headline findings** in relation to:

- The rationale for, and approach to, the use of IM (Section 6.4); and
- The benefits unlocked both directly for the organisations using IM and more widely the value for customers, society and the environment (Section 6.5).

The separate Case Studies Annex published alongside this report provides a detailed description and analysis of each of the case studies.

6.2 Our approach

6.2.1 Purpose of the analysis

The purpose of the case study analysis was to test and validate the Information Management Benefits Framework outlined in Section 5 and provide new evidence on the uses and benefits of IM at the project- and organisation- levels (addressing some of the key gaps in the existing literature highlighted in Section 4). Our analysis has used a 'theory of change' approach – considering how the inputs and activities associated with the use of IM ultimately lead to end impacts – considering both direct impacts for the organisation(s) which use it and the wider impacts beyond the organisation for its customers, society and the environment. The analysis was not limited to benefits realised in the past; it also served the purpose of identifying emerging use cases and expected future benefits.

Wherever possible, for each case study we worked with stakeholders to quantify the direct and wider impacts of IM. Where this was not possible, a qualitative assessment of impacts has been provided. In both cases, the benefits identified are based on a comparison of the impacts of using IM with the impacts arising under a comparable situation in which IM is not used – referred to as the 'counterfactual' scenario. In practical terms, this was achieved through one of two means: (i) by asking stakeholders to compare the impacts of the IM use case with a similar project/ business scenario in the past that did not use IM, controlling for the effect of other factors as far as possible; or (ii) by asking stakeholders to use their expert judgement on what would have happened in the absence of using IM. The limited availability of robust data on projects/ situations that were directly comparable to the case studies meant that, in most cases, a judgement-based approach was required.

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6.2.2 Selecting the case studies for analysis

When identifying the case studies for analysis we sought to arrive at a sample which was as representative as possible of the breadth of potential uses of IM across the construction and infrastructure sector. The key sampling criteria used to identify and select case studies for our analysis are listed in Table 3.

Table 3: The main sampling criteria use to identify and select the case studies for analysis

Criteria	Description
Cross Sector	Capturing a mix of economic infrastructure (transport, energy, waste, water, communications, flood defence, defence), social infrastructure (health, education) and buildings (housing and non-residential).
Clients/ Asset Owners	Capturing the perspectives of both public and private sector asset owners.
Appointed/ Lead Appointed Party	Capturing the perspectives of private sector contractors involved in the design, build and operation of built assets, with a primary focus on design consultants, construction contractors and professional services firms involved in construction management activities.
Project-level and Organisational-level	Capturing the uses of IM by organisations in the construction and operation of built assets (project-level) as well as in the course of their wider business functions (organisation-level).
Stages of the Asset Lifecycle	Capturing the use and benefits of IM across both the construction and operation of built assets (recognising that use of IM in an earlier stage of the lifecycle can create benefits that are realised downstream).
Complexity	Capturing the use and benefits of IM in a range of contexts – considering both larger and smaller scale projects using different contractual structures and thus with a varying number of partners involved.
Resilience	Considering a specific assessment of how the use of IM has enabled organisations to anticipate and/or respond to adverse events, particularly given the challenges posed by the COVID-19 pandemic.

Source: KPMG and Atkins analysis 2021.

Through consultation with CDBB, an initial 'long list' of 32 candidate case studies was identified. We then undertook an initial round of engagement with stakeholders to test their willingness and suitability for inclusion in the study. This activity resulted in a final set of 11 case studies, which were shortlisted on the basis of:

— The organisation's willingness to commit the required time and resources to the study (as outlined in the next section, the case study analysis was undertaken through several workshops/ interviews and information requests);

— The availability of a counterfactual scenario (described in the previous section) to compare against the project/ organisation's use of IM and thus isolate the net additional benefits this has generated, or is expected to generate;

— The stage of the project/ organisation's roll-out of IM, recognising that those still in development would be more reliant on expected rather than observed evidence of benefits; and

— The availability of information and evidence on the use case and benefits delivered/expected, considering the commercial sensitivity of information, which could limit the level and quality of information available.

6.2.3 Approach to evidence gathering

Evidence was gathered through in-depth stakeholder engagement over a five-month period. This combined workshops, one-to-one follow-up interviews and data/information requests for input information and supplementary evidence. This bottom-up, 'deep-dive' approach (as opposed to a more wide spread survey of organisations, for example), enabled evidence to be sourced that was specifically tailored to the breadth of impacts covered by our Information Management Benefits Framework. This in turn provided the opportunity to develop a more comprehensive assessment of the benefits of IM within a given case study. Figure 14 illustrates the type of evidence that was gathered for each case study.

Figure 14: Key areas of evidence explored and gathered through the case studies

Strategy

- How IM fits into the organisation's overarching digital transformation and corporate strategies.
- How well IM is embedded within the organisation.
- The original rationale for investing in IM at the project and/or organisation level.

Enablers

- Alignment of procurement processes with IM standards.
- Organisational capability and resourcing.
- Development of IM standards and common BIM artefacts.
- Organisational structures, including teams involved in IM.
- Technologies deployed to support IM.
- Cultural factors, including collaborative working environments and practices.

Use Cases

- The scope of the project(s) / programme(s) in which IM has or is being used.
- The detail of the IM use case(s) (the activities undertaken and how this was done).
- What changed as a result of IM adoption (outputs).
- What these results enabled the organisation to do differently (outcomes).
- Lessons learnt and challenges.

Benefits

- Direct benefits that had or could be realised for the organisation and its delivery partners.
- Wider benefits that had or could be realised beyond the organisation, and how this relates back to the organisation's corporate strategy.

Source: KPMG and Atkins analysis 2021.

A three-step process was employed to gather evidence for the case studies, as set out in Figure 15. This comprised an initial discovery phase, followed by the validation of the uses cases and benefits identified and a final review with stakeholders to confirm the consolidated findings.

Figure 15: Approach to stakeholder engagement and evidence gathering

Steps	1. Discovery	2. Validation	3. Review & Approval
Aims	To establish an initial understanding of how IM has been deployed within the organisation, organisational drivers and known benefits that have been or could be realised.	To identify the details of why and how IM was implemented together with the mapping of benefits (from inputs to outputs, outcomes and impacts) against an agreed counterfactual scenario.	To review and refine the results of the analysis and confirm the qualitative and quantitative impacts identified and estimated.
Activities	1. Sourcing of existing data and information held by stakeholder(s) based on known IM use cases. 2. Analysis of the information received by the organisations ahead of initial meeting and Step 2 workshop(s). 3. Initial meeting(s) with case study organisations to establish current IM use cases and known benefits.	1. Workshop(s) with stakeholder(s) to unpack the details of the IM use cases and benefit pathways, including direct and wider impacts. 2. Issuing of proformas to source data inputs and assumptions to estimate impacts where it was agreed possible to quantify them. 3. Clarification meeting(s) on data provided.	1. Additional meetings and interviews to validate data provided by stakeholders. 2. Final review and approval of case study content by stakeholder organisation.

Source: KPMG and Atkins analysis 2021.

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6.3 Summary of the case studies analysed

The table below contains an overview of the eleven case studies that we have analysed, including details of their sub-sector, IM use cases and the extent to which direct and wider impacts were identified and quantified or valued. The IM use cases and benefit streams are mapped to our Information Management Benefits Framework in Section 5).

Table 4: Summary of the case studies analysed[99]

Sector	Organisation name	Project name	IM Use case(s)[4]: Asset, Project & Programme Management	IM Use case(s)[4]: Finance & Commercial	IM Use case(s)[4]: Organisational Planning & Response	IM Use case(s)[4]: Risk, Audit & Compliance
Defence	**Babcock**	**Devonport Royal Dockyard[3]**	✓			✓
Flood, coastal and waste	**Environment Agency**	**Delivering Asset Data to the Requirements Library[2]**	✓	✓	✓	✓
Transport – Highways operations & maintenance	**Connect Plus Services[1]**	**Road Booking System[2]**	✓	✓		✓
Housing – Design and construction	**EDAROTH[1,100]**	**N/A[2]**	✓	✓	✓	✓
Multiple sectors – Design and construction	**VolkerWessels UK[1]**	**Digital Toolbox[2]**	✓	✓	✓	✓
Non-residential buildings	**Met Office/ Skanska[1]**	**Camborne and Lerwick Balloon Sheds[3]**	✓	✓	✓	✓
Non-residential buildings – Health	**BDP[1]**	**London Nightingale Hospital[3]**	✓		✓	
Non-residential buildings – Commercial office space	**HMRC/ GPA**	**Government Hubs Programme[2]**	✓		✓	
Transport – Highways design & construction and Airports Asset Management	**Heathrow**	**Cargo Tunnel Project[3]**	✓	✓	✓	✓
Transport – Light rail scheme – design & construction	**Transport for Greater Manchester**	**Manchester Metrolink Trafford Park Line extension**	✓		✓	
Water	**BIM4Water / Yorkshire Water**	**Gouthwaite Reservoir Spillway Improvements[3]**	✓			

Keys: Asset, Project & Programme Management; Finance & Commercial; Organisational Planning & Response; Risk, Audit & Compliance

1. Lead Appointed Party or Appointed Party; 2. Organisational use case; 3. Project or Programme use case; 4. Covers both established and emerging use cases

Source: KPMG and Atkins analysis 2021.

Notes: (99) Note that all but the Gouthwaite Reservoir Spillway Improvements case study were produced through primary evidence gathering and analysis, undertaken in line with the approach detailed in Section 6.2.3. The Gouthwaite Reservoir Spillway Improvements case study was instead an existing case study provided by BIM4Water on behalf of Mott MacDonald and Yorkshire Water, based on a published case study already in the public domain.

(100) EDAROTH is wholly owned subsidiary of Atkins Ltd, a member of the SNC-Lavalin Group, providing end-to-end development solutions which focus on delivering social and affordable housing at the point of need.

IM use case description	Direct impacts: Benefit streams	Direct impacts: Quantified / Valued?	Wider Impacts: Identified?	Wider Impacts: Quantified / Valued?
Application of BIM on five live major capital projects at Devonport Royal Dockyard.	Efficiency; Risk; Workforce health and safety			
Supporting use of common asset library, data transfer and BIM delivery methodologies across the whole asset lifecycle.	Efficiency; Risk; Workforce health and safety	✓	✓	
Digital initiative enabling improvements in planning and co-ordination of road works on the M25 motorway network.	Efficiency; Compliance, Reputation	✓	✓	✓
An off-site manufactured approach to building sustainable social housing on publicly-owned brownfield land using IM and MMC.	Efficiency; Risk; Innovation	✓	✓	✓
Roll-out of a "Digital Toolbox" for five pilot projects in the firm's VolkerFitzpatrick business as part of its adoption across VolkerWessels UK.	Efficiency; Risk; Compliance	✓		
Application of BIM and point cloud survey technology for Met Office Balloon Shed projects at Camborne and Lerwick.	Efficiency; Risk, Resilience, Compliance; Innovation; Workforce health and safety	✓	✓	
Rapid, agile design and construction of a temporary hospital at the London Excel Centre as part of Government's emergency response to COVID-19.	Efficiency; Resilience, Workforce health and safety			
Deployment of a "B^2IM" strategy across the Government Hubs Programme, comprising a Functional Model for asset information to enable alignment of BIM information models with facilities management and operational data (at project handover).	Efficiency; Risk; Compliance; Resilience	✓	✓	
Application of BIM and ICE Project 13 Integrator Model to the renewal of Heathrow's Cargo Tunnel – a critical asset for airport operations.	Efficiency; Risk; Workforce health and safety	✓	✓	
Application of BIM for delivery of a major new extension to TfGM's Manchester Metrolink network – the Trafford Park Line.	Efficiency; Risk; Resilience; Reputation	✓	✓	
Application of BIM by Yorkshire Water for its Gouthwaite Reservoir Spillway Improvements project.	Efficiency; Workforce health and safety	✓		

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6.4 Summary findings on the uses of Information Management

6.4.1 The UK Government mandate has promoted investment in Information Management

6.4.1.1 A catalyst for Information Management adoption by both the public and private sectors

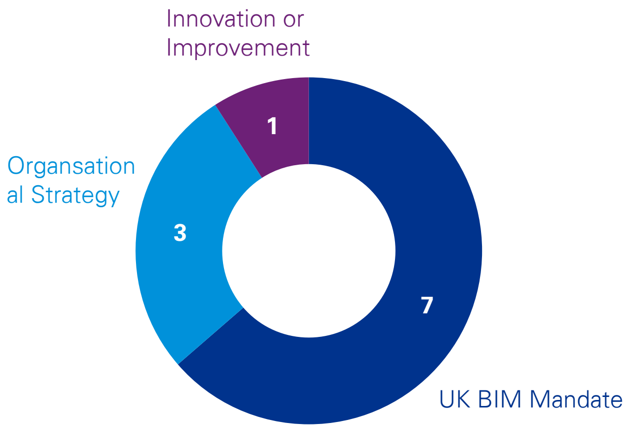
Although the Government mandate does not provide the prescriptive application of formal legislation[101], **for 7 of the 11 case studies[102], the 2016 mandate was either the main driver, or one of the main drivers, for adopting IM**.

The strength of the mandate has also empowered public sector organisations such as the Environment Agency and the Government Property Agency (GPA) to enshrine the principles of IM into their asset management strategy and improve the information required to effectively manage their asset portfolio. A clear link can also be drawn between the Government mandate and the response from the private sector. As illustrated through Connect Plus Services (CPS) serving Highways England (HE), WSP serving Transport for Greater Manchester (TfGM), Babcock serving the needs of the Ministry of Defence (MoD) at the Devonport Royal Dockyard, or BDP serving the requirements of NHS Trusts across the country. These private sector organisations have aimed to fulfil the Government mandate on behalf of the asset owner and collaborate with their clients and their supply chain to expand the client's use of IM, most notably in the capital phases of programmes/ projects in line with the UK BIM Framework.

However, when commissioning IM capability within the lifecycle of programmes there is a mixed picture as to when IM has been introduced. The case studies show a near equal split of: (i) organisations applying IM prior to procurement, facilitated by the asset owner or appointing party; and (2) projects establishing IM post contract award by the appointed parties who have previous experience of application. Those which introduced IM earlier were typically able to maximise the potential of IM in driving value for their projects and programmes. This underlines the principles of the Government's Construction Playbook, which aims to bring forward best practice in programme development prior to procurement in an attempt to maximise the end benefits delivered for public sector asset owners and the end users of built assets.

Notes: (101) Institution of Civil Engineers 2016, BIM Mandate and BIM in legislation: There is a BIM Mandate, how does it work?, link.
(102) Note this statistic does not include Yorkshire Water's Gouthwaite Reservoir Spillway Improvements project, as this case study was provided to the study by BIM4Water, rather than produced via primary analysis undertaken by KPMG and Atkins. Therefore it has not been possible to determine whether the Government mandate was a key catalyst for the adoption of IM on the project.

Figure 16: Drivers for investment in Information Management cited by the case studies



Source: KPMG and Atkins analysis 2021.

6.4.1.2 The growing use case of Information Management in asset management and capital phase handover

The increasing exposure of public sector asset owners to the Government mandate (and UK BIM Framework) has also triggered a growing number of use cases for IM beyond capital delivery into asset management.

Both the GPA and the Environment Agency are leveraging IM to support national transformation programmes which aim to maximise the use of data and information throughout their **business case development activity, project delivery and the operations and maintenance stages of the asset lifecycle** (see Appendix A3 for how the different stages of the asset lifecycle are defined). In the example of GPA, this is supporting the organisation's wider digital transformation in the management of the public estate, such as innovative post-handover survey services (e.g. point cloud surveys) and the use of IoT sensors to monitor and optimise space utilisation. Meanwhile the Environment Agency is introducing the use of IM across its supply chain through innovation funds ('Task and Finish' groups) which aim to establish the ease of use of their asset data requirements and supporting Application Programming Interfaces (APIs) in the open domain[103]. This demonstrates the application of data sharing approaches for a national asset owner using current technologies and simple data sharing arrangements.

Although at a project-level, the MET Office case study further demonstrates value in the asset phases through the use of scan-to-BIM technologies and comprehensive asset information models. The combined richness of data enables a shift to a planned preventative maintenance regime from a traditional, more reactive approach to critical failure responses.

(103) DEFRA 2021, Asset Management, link.

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6.4.2 The UK BIM Framework is being widely adopted

The use of the UK BIM Framework was cited in nearly all of the case studies, with the drive for application mainly coming from capital project teams (rather than wider organisational drivers).

The most commonly cited BIM artefacts were: the Exchange Information Requirements (EIR), as the vehicle for setting asset owners' requirements; BIM Execution Plans (BEP), as the formal response to the EIR; the Project Information Model (PIM), as the central source of federated information; and the Common Data Environment (CDE) in the storage, collaboration and sharing of information. However, the following artefacts of the UK BIM Framework were not evidenced:

— BIM Protocol (or its equivalent CIC Protocol[104]), which can be placed in to contracts to establish the contractual use of the UK BIM Framework on programmes or projects; and

— Established Security Information Requirements, which is likely an outcome of the recent development and issue of guidance.

Prioritised Organisational Information Requirements (OIR) and Asset Information Requirements (AIR) were evident for the GPA only (including the incorporation of policy requirements relating to Net Zero). However, there was an aspiration for these to be developed by other public sector organisations (such as the Environment Agency) and as a basis for enhancements to legacy asset standards/ requirements in the case of Heathrow and TfGM.

While most case studies represent BIM as a linear, incremental process commencing in project scoping and early design phases, the link into an Asset Information Model in the case of the Met Office and GPA, and BDP's use of BIM for the London Nightingale project, highlight the opportunities to introduce and benefit from IM even in instances where it was not employed in the asset acquisition stage. These experiences stand out as examples of rapid prototyping of a value proposition which would have typically taken longer and required considerably more effort to deliver without IM. A strict adherence to the UK BIM Framework in these instances is not practical, nor would it enable such an agile response.

6.4.3 Information Management is often a strong catalyst for digital transformation within organisations

Many of the case studies demonstrate that their initial use of IM, and the process of standardisation and collaboration it provides, has provided a springboard for wider uses of IM across their organisations and, notably, a catalyst for digital transformation. This includes:

Supporting whole life costing and strategy/ portfolio planning (TfGM, GPA, Met Office, EDAROTH), where the acquisition, management, and reuse of data across capital projects and programmes, mapped to asset groups/types, is seen to enable future investment planning activities;

Supporting the development of new products (EDAROTH, the Environment Agency and VolkerWessels UK) or service lines (Met Office/ Skanska) to drive further productivity gains, which bring together IM and techniques in data science and analytics; and

Supporting the delivery of DfMA approaches and other MMC (Heathrow, EDAROTH, Met Office / Skanska) through the use of IM in product design and the alignment of global supply chains to drive further productivity gains.

Notes: (104) CIC 2018, Second Edition BIM Protocol Published, link.

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6.4.4 An effective organisational strategy maximises the benefits of Information Management

The ability of stakeholders to maximise the value from IM, in terms of both direct productivity gains and value for end customers and wider stakeholders, is most evident in organisations where a digital approach, and within this, the role of IM, is embedded within an organisation's corporate strategy.

Across the private sector, IM has been seen as an enabler to delivering an organisation's corporate strategy in two ways. First, where the private asset owners (e.g. Heathrow) or product owners (e.g. EDAROTH) with oversight of their entire asset lifecycle, recognise the long-term benefits of upfront investment in IM to meet key strategic outcomes. Second, where organisations are seeking cost competitiveness to support their continued strategic plans (e.g. VolkerWessels UK). In both situations, investment in IM was cited by the case studies in helping to:

- Focus on maintaining market position and competitiveness;
- Increase product quality and client satisfaction (and in turn provide value to the client's end customers/ users of the asset);
- Meet evolving client requirements, such as the UK Government Mandate in BIM or the Government's Levelling Up and Net Zero agendas; and
- Provide the foundation for continuous improvement and an ability to rapidly respond to unforeseen external events (such as the COVID-19 pandemic).

However, in the case studies where a grass roots approach to IM adoption has been taken (e.g. through the delivery of a single major project), as opposed to a top-down strategy or significant investment in capability, organisations still experienced notable benefits (as evidenced in Section 6.5).

6.4.5 The capabilities which maximise the benefits of Information Management

The majority of case studies demonstrate that while the primary beneficiary is often the buyer or instigator of the IM capability, benefits can also be realised by others who demonstrate a willingness to engage in the adoption of IM.

Figure 17: Key enablers for the effective use of Information Management

- Technical awareness, skills and culture
- Collaboration and engagement from the supply chain
- Application of IM tools, standards and technologies

Source: KPMG and Atkins analysis 2021.

The case studies highlight three key capabilities which support organisations' effective use of IM and thus have the potential to maximise its potential benefits:

1 Technical skills, effective leadership and culture

All the case studies demonstrate how established skills within both asset owners/operators and their supply chain are key to achieving successful outcomes from IM. The examples from BIM4Water / Yorkshire Water, TfGM and VolkerWessels UK show how supply chain capability has enabled the use of IM to outperform the client's original requirements. Examples from Heathrow, Babcock and VolkerWessels UK highlight successful approaches to embedding IM capability requirements into the supply chain procurement process to ensure corporate standards are met. Meanwhile the case studies of contractors' approaches to IM adoption (VolkerWessels UK and BDP) demonstrate the importance of IM capabilities from C-suite to practitioner level, with the success of the organisations' approaches in part due to early investment in a dedicated Chief Digital Officer (VolkerWessels UK) or Chief Information Officer (BDP) and backing from Exec/ Board level for the roll-out of IM training across the business.

2 Collaboration across the supply chain

Several of the case studies highlighted proactive approaches to incentivise supply chain collaboration in the adoption of IM. This includes: EDAROTH's 'hands on' IM integration across its manufacturing partners to eradicate kinks in a global supply chain; Heathrow's approach to establish and price the benefits of MMC (schedule reduction) with their suppliers to make projects viable; and the Environment Agency's establishment of a digital community of practice to close gaps in capability and identify opportunities for creating further efficiencies.

3 Adoption of IM tools, standards and technologies

The case studies highlight the potential of IM can be maximised as organisations expand their adoption of key IM tools, standards and technologies and establish a standard set of collateral across appointing and appointed parties, such as documenting requirements (e.g. EIRs and requirements libraries), application of technology (CDEs, reality capture, site record capture, MMC, digital rehearsal) and adoption of standards and processes (BS 1192 / ISO 19650). All factors point to the value of common standards (UK BIM Framework), and the importance and willingness for continued collaboration with technology partners as an increasingly pivotal player in the sector.

6.5 Summary findings on the benefits of Information Management

6.5.1 Overview

In this section we summarise our headline findings from the analysis of the qualitative and quantitative evidence provided by the case studies, covering the direct impacts for organisations (productivity gains and intangible benefits) and wider impacts for customers, society and the environment (social value) from the use of IM. In the separate Case Study Annex published alongside this report, we provide a more detailed explanation of the benefits identified under each case study.

Our findings are based on primary data collection and analysis[105] completed through workshops and information requests (in line with the approach outlined in Section 6.2) and have been aligned with the categories of the Information Management Benefits Framework set out in Section 5. The evidence provided by stakeholders came from a combination of their original business cases for investing in IM, internal lessons learned and evaluation exercises, and their own professional judgement.

Our analysis has been limited by the evidence available and, as noted elsewhere in this report, isolating the specific benefits attributable to IM as opposed to other inputs and processes (such as people/ skills, DfMA/ MMC, contractual arrangements/ business models, etc) is inherently difficult. In addition, the different approaches used by stakeholders to measure or estimate the benefits of their IM investments (as well as limitations in what could be shared for commercial sensitivity reasons) makes comparisons across the case studies difficult.

However, these practical challenges are to be expected given that this study represents the first major attempt to comprehensively capture the benefits of IM adoption at both the project and organisation levels. Nevertheless, the findings provide demonstrable evidence of the direct and wider value that can be realised from the sector's use of IM, and provides a strong foundation for future studies to further demonstrate these impacts.

Notes: (105) With the exception of Yorkshire Water's Gouthwaite Reservoir Spillway Improvements Works project, which was provided by BIM4Water based on information originally sourced from Mott MacDonald and Yorkshire Water.

6.5.2 Direct productivity impacts for organisations

Across the case studies we have found significant evidence of IM supporting productivity gains for organisations in the construction and operation of built assets. In line with the Information Management Benefits Framework set out in Section 5, this includes productivity gains arising from costs saved/ avoided and (albeit to a lesser extent) increased revenues from the creation of new products and services. It also covers intangible benefits relating to improved workforce health and safety, culture and reputation. Our headline findings under each of these impacts are outlined below.

It is important to note that the evidence presented is based on information provided by a single organisation or subset of organisations involved in a project or programme. In practice, there are multiple parties which stand to gain from the use of IM (asset owners, contractors, sub-contractors, etc), but the type and scale of those productivity gains could well vary by each party.

6.5.2.1 Productivity gains from costs saved/ avoided

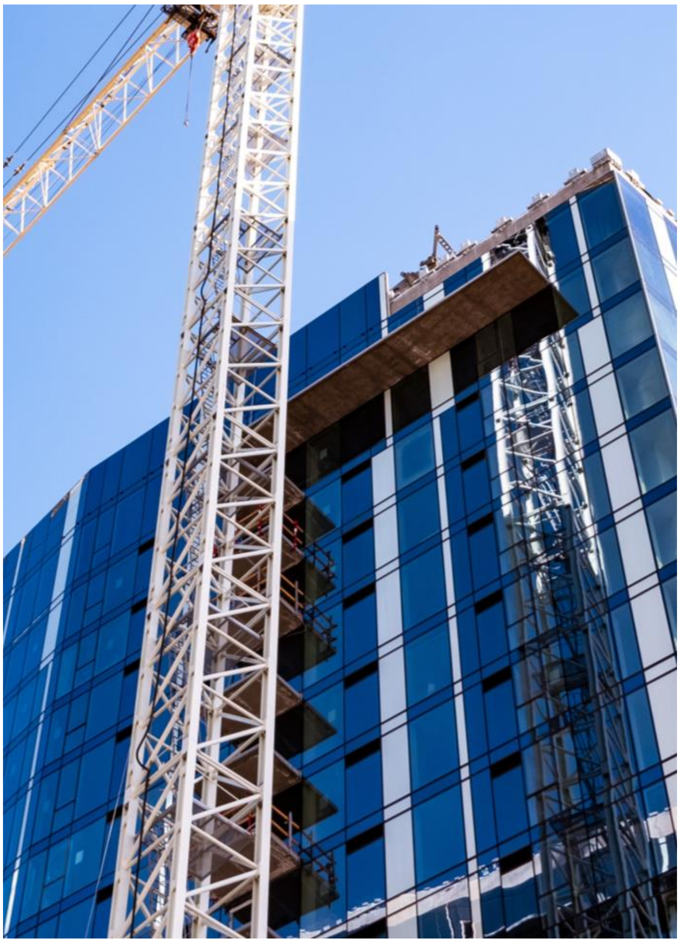
Labour productivity gains (labour cost savings)

At the project-level, labour productivity improvements (and thus labour cost savings) enabled by the efficiencies that IM unlocks was commonly cited across all of the case studies. The case studies demonstrate that effective IM typically results in more consistent data, which is easier to access, analyse and review/ assure, and more easily transferable between parties. This typically reduces the amount of staff time required for specific tasks, with that time being freed up for staff to dedicate to other productive work, or in the medium-term providing organisations with the ability to grow without the need for a commensurate increase in staffing levels.

These labour productivity gains were observed across all stages of the asset lifecycle. For example, TfGM and their contractors experienced significant reductions in staff time through a progressive design assurance process enabled by BIM (halving the timetable of a traditional design approach) and also expect to realise staff time savings in operations when managing the network (enabled by the handover of a complete and fully assured Health and Safety file). BDP's use of IM enabled them to design the London Nightingale Hospital in close to real time, with minimal staff on-site, and enable the construction of the temporary hospital's first 500 beds within 7 days of the original design brief. In operation of the M25, CPS's use of IM in the introduction of a upgraded road space booking system is expected to reduce both in-house and contractor staff time in planning and co-ordinating planned maintenance works.

At a project-level, these labour productivity gains were quantified across three case studies, showing that:

- ✓ **For CPS,** their use of IM is expected to secure **£5.10 of labour productivity gains** for every £1 they have invested in IM[106];
- ✓ **For the Environment Agency,** their use of IM is expected to secure **£6.00 of labour productivity gains** for every £1 they have invested in IM[107]; and
- ✓ **For VolkerWessels UK,** based on 5 pilot construction projects in the VolkerFitzpatrick business, the organisation has experienced a **reduction in site staff time of around 3.7%**, with this time freed up to spend on other tasks which help to secure wider cost savings.



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Total factor productivity gains (time, labour time and material savings)

Across the case studies, total factor productivity gains were also a commonly cited benefit of IM. This represents productivity savings which arise more broadly at different stages of the asset lifecycle from a reduction in the amount of both labour inputs and capital inputs (e.g. equipment) required to complete a project or programme. This typically occurred when the use of IM enabled:

Increased efficiency, leading to a reduced project or programme delivery timetable (i.e. less need for all inputs in the design, construction and/ or operation of built assets). For example, TfGM's use of BIM for construction of the Metrolink Trafford Park Line scheme resulted in a 50% reduction in the overall design phase timetable relative to other Metrolink extensions which did not use BIM. Yorkshire Water and Mott MacDonald achieved a 6 month reduction in the original timetable for their Gouthwaite Reservoir Spillway Improvements Works project and completion 18 months prior to the contract's compliance date[108]. Heathrow is expecting to reduce the overall delivery timetable for their Cargo Tunnel Project from 4 to 3 years using IM (including BIM in design) and DfMA (critically enabled by their use of IM). EDAROTH's use of IM and in particular DfMA is expected to achieve a circa 40% reduction in the delivery timetable for a typical house building programme. Some level of programme delivery time savings are also expected across the Met Office, Environment Agency and GPA.

Costs avoided due to better clash detection, fewer errors/ changes and the reduced need for reworks, enabled by more accurate and thus reliable information communicated effectively across the supply chain. Almost all of the case studies analysed (TfGM, Heathrow, Met Office, EDAROTH, Environment Agency, GPA, Babcock and VolkerWessels UK) have experienced, or expect to realise, some level of cost avoided through reduced errors. Whilst quantifying these savings is difficult on a specific project basis (the average error rates need to be understood and measured against the new error rates), reducing errors is critical in construction costs with industry analysis suggesting the costs of errors can be between 5% (for direct costs) and 21% (when including indirect, waste and latent defects) of total project cost[109]. Technology implementation and, in particular, IM and the use of BIM as part of this, is seen as a critical way of reducing these errors[110].

Increased efficiency, leading to a reduction or elimination of costs for specific elements of the delivery process (e.g. having more comprehensive information available on asset condition reduces the need for, or extent of, onsite surveys and inspections, or more accurate cost estimation activity reducing materials costs). For example, the Met Office, are drawing on a 'digital twin' of their Camborne-based Balloon Shed and repurposing it for the design of their replacement Balloon Shed project at Lerwick. In doing so, they are expecting to reduce the frequency and volume of both onsite surveys and operational/ maintenance inspections, lowering travel costs and onsite costs. Meanwhile in the case of Babcock's major capital projects at Devonport Dockyard, they are seeking to achieve more effective quantity take offs from the use of BIM in combination with cost estimating tools, enabling more accurate estimates of materials and labour requirements and avoiding unnecessary costs during construction.

Reduced risk contingency costs due to increased certainty over the costs and time required for capital delivery or maintenance activities, enabled by more accurate and thus reliable information. Almost all of the case studies analyses cited reduced risk as a key benefit enabled by effective IM. For example, TfGM successfully negotiated a 1.9 percentage point reduction in the contractor's risk allowance for the construction of its Metrolink Trafford Park Line extension (2.9% down from 4.8% on other schemes) owing to a more mature design at the time of procurement through the use of BIM in design and a progressive assurance approach. Meanwhile, GPA's "B^{2}IM" approach across its Government Hubs Programme is expected to reduce the level of maintenance risk contingency during operation of the Government estate, owing to accurate asset information and respective quantities at handover from building fit-out.

Notes: (108) Note this case study was provided to the study by BIM4Water based on existing information provided by Mott MacDonald and Yorkshire Water, rather than produced via primary analysis undertaken by KPMG and Atkins.
(109) Get it Right Initiative 2016, Research Report, Improving value by eliminating error, p 56, link.
(110) Get it Right Initiative, Research Report: Harnessing Technology to Minimise Error, link.

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Total factor productivity gains are often more difficult to quantify and value as they are driven by a combination of savings enabled by IM, as well as other measures delivered alongside IM (e.g. DfMA/ MMC). Indeed it is important to note that in some cases (such as Heathrow and EDAROTH), total factor productivity gains arose from a combination of the use of IM and the delivery of DfMA and other modern construction methods, with these approaches playing a major part in reducing wastage from the construction process and the construction delivery timetable. Nevertheless, stakeholders cited IM's critical role in enabling these innovative construction methods.

Where possible, these total factor productivity gains were quantified across six of the case studies[111]:

- **For EDAROTH, their use of IM is expected to enable a circa 6% saving in the design and construction costs of their housing projects111 (based on the average cost per house) relative to a more traditional build approach.**
- **For the GPA,** their B^{2}IM approach is expected to enable a **circa 3.2% cost saving in capital delivery through improved design integration between office base builds and end-user fit-outs**, in addition to further cost savings in capital delivery and operations from reduced risk and efficiencies.
- **For Heathrow,** their use of IM across their across their capital delivery programme is expected to unlock **cost savings of some £7.40 for every £1 invested in IM.**
- **For the Met office,** their use of IM is expected to enable a **circa 18% saving in the design and procurement costs for their weather Balloon Shed at Lerwick**
- **For TfGM,** their use of IM is estimated to have helped achieve **a circa 1.6% saving in the design and construction costs of their Trafford Park Line Metrolink extension**, through reductions in risk contingency and utility diversion costs.
- **For VolkerWessels UK,** the adoption of their Digital Toolbox approach, underpinned by the use of IM, across the delivery of their VolkerFitzpatrick business's five pilot projects, is expected to unlock **cost savings of some £6.90 for every £1 invested** in the approach.

Notes: (111)

ii) EDAROTH uses a range of non-traditional processes and techniques to reduce costs of house building compared with more a traditional build (e.g. extensive use of DfMA). Savings were built up by examining a range of key processes where IM played a role, with effort then made to apportion the savings in each process to IM versus other unique processes.

iii) Due to information availability, the Met Office savings estimate in design and procurement is measured as a % of total design and procurement costs for the Lerwick shed, rather than total capital costs of the project (which is the basis for the other % savings presented in this box).

iv) GPA expects this estimated cost saving to be the minimum level unlocked by the use of its B^{2}IM approach on its Government Hubs Programme, as the quantified benefits exclude expected cost savings in capital delivery and operations from reduced risk and efficiencies.

6.5.2.2 Increased revenue from innovation

While the case studies analysed provide demonstrable evidence of productivity gains arising from the cost savings enabled by IM, the limited sample size provides less evidence of the role of IM in unlocking new innovations and in turn new revenue/ market opportunities for organisations. However, there are some notable exceptions, specifically in the case of:

- **The Met Office's engagement of Skanska to create a digital twin of the balloon shed at Camborne to reduce the asset's ongoing maintenance costs and re-use in the refurbishment of their balloon shed at Lerwick.** The project has enabled Skanska to rapidly establish a proof of concept for a new, end-to-end 'Digital Estates' service which it plans to offer to other asset owners across the sector. This service builds on the idea of a scan-to-BIM and Asset Information Model developed for existing assets, and uses these techniques to collect and store consistent and accessible information, creating a digital twin for an entire organisation's existing asset portfolio; and
- **The establishment of EDAROTH as a wholly owned subsidiary of Atkins, bringing together IM and digital transformation activities with DfMA to reduce the costs of social housing development and in turn open-up publicly owned brownfield sites that would otherwise be deemed unviable.** Without these elements coming together, arguably EDAROTH would not be able to serve particular clients (local authority land owners) in the market, nor deliver on its corporate aims of providing new housing that is additive to the social housing market.

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6.5.3 Direct intangible impacts for organisations

6.5.3.1 Workforce health and safety

At the project-level, improving workforce health and safety conditions was cited by many of the case studies as a material benefit of IM (Heathrow, Babcock, BIM4Water/ Yorkshire Water). For example, evidence from Yorkshire Water's Gouthwaite Reservoir Spillway Improvements Works (provided by BIM4Water) demonstrates the significance of these benefits, with the reporting of only 2 minor injuries in over 46,000 hours worked on the project over a two year period.

Collectively, the case studies highlighted three key ways in which IM could help to improve workforce safety at the project-level.

Firstly, through IM's ability to surface risks at the design stage and in turn reduce errors and incidents during the construction phase. In the case of Heathrow, for example, the use of IM on its Cargo Tunnel project will provide fire safety officials with accessible information and 3D visual representations to help them conduct their assurance reviews. Meanwhile in the case of Babcock, the 3D representation of risks and 4D sequencing is enabling them to develop visual method statements for mitigating them.

Secondly, through the ability of IM to facilitate virtual briefings and training to staff, avoiding the risks of providing these on-site and increasing staff awareness of risks during the construction and operation phases of projects.

Finally, through IM's role as a key enabler of DfMA and prefabrication methods (in the case of Heathrow, EDAROTH and potentially the Met Office), which can be expected to reduce onsite construction time overall, leading to a lower likelihood of accidents.

6.5.3.2 Improved workforce culture

At both the project-level (TfGM) and organisation-level (VolkerWessels UK, BDP, CPS, Heathrow), the case studies identify the role of IM in promoting a culture of collaboration within and between the organisations using it. TfGM, for example, noted the use of IM on the Trafford Park Line extension (specifically the use of 3D models) provided the ability for a wider range of staff from their in-house engineering team to engage in the design process and opportunities for upskilling of staff through close collaboration with their supply chain. Meanwhile VolkerWessels UK and BDP both cited the benefit of IM in bringing a range of technical disciplines together to deliver better outcomes for their clients.

6.5.3.3 Improved reputation

Across many of the case studies, the use of IM was seen to improve the organisation's reputation with their clients, customers and the wider public in a range of ways, including:

- For contractors, through the delivery of better quality and/or more efficient products and services to their clients (VolkerWessels UK, BDP, EDAROTH);
- For asset owners, through facilitating closer engagement with key external stakeholders in the design of built assets, such as through the use of 3D visualisations (TfGM, GPA), in turn helping to secure public and customer buy-in for projects; and
- For contractors and asset owners, through the delivery of higher quality and/or more sustainable built assets (in construction and/or operations), improving organisations' reputation with end-users of those assets, as well as the wider public (BDP, CPS, Environment Agency, GPA, Met Office, TfGM).

6.5.4 Wider impacts for customers, society and the environment (social value)

Across the case studies, the existing evidence held by organisations on the impacts of IM was largely focused on the internal benefits to their organisations, rather than the wider benefits enabled by IM for customers, society and the environment. As outlined elsewhere in this report, the type of social value unlocked by IM is highly context specific and requires a case-by-case approach to identifying, measuring and valuing these wider impacts. Through our analysis we worked with stakeholders to identify these **wider benefits in qualitative terms (Environment Agency, GPA, Heathrow, Met Office, TfGM)**, and where data allowed, we have **quantified the potential scale of wider benefits in social value terms (CPS and EDAROTH). The separate Case Study Annex published alongside this report provides a detailed explanation of the types of wider social value identified for each case study.** This evidence (even if often qualitative) demonstrates the role of IM in helping to unlock social value in both the construction and operation phases of built assets.

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At the project-level, the social value potential unlocked by IM was estimated for two case studies:

1 CPS – benefits to road users and the environment from reduced delays and congestion on the M25 from the use of IM to more effectively manage road works

CPS's use of IM as part of enhancements to their Road Booking System (used to schedule and co-ordinate planned maintenance on the M25) is expected to provide CPS with the necessary information to introduce new booking policies, which will more effectively manage road space and help them meet their road booking occupancy targets with Highways England. Late booking cancellations and changes regularly lead to unrequired or extended lane closures that otherwise could have been avoided. This can cause traffic disruptions on the M25, by temporarily reducing the capacity of the motorway and/or requiring journeys to re-route, which has knock-on impacts for traffic congestion and extended journey times for road users. Improving road booking occupancy, and in turn reducing overall road bookings, could help to **reduce instances of traffic disruption and congestion** which could generate a range of societal benefits. These include benefits to all road users (both cars and HGVs) from **reduced journey times and vehicle operating costs** (as a result of more free flowing traffic), **reduced traffic emissions, carbon and air pollution** (as a result of less idle traffic) and a **reduced risk of accidents** (from fewer accidents/ causalities for road users associated with disruption to traffic flows and speeds, as well fewer accidents from maintenance workers having to spend less time on site for extended lane closures).

Using a methodology consistent with HM Treasury's Green Book and the Department for Transport's economic appraisal guidance, we have estimated the value of these potential benefits.

Our analysis of the combined benefits to road users and the environment suggests CPS's use of IM, together with the introduction of new booking polices, could potentially unlock social value benefits worth £11m (in present value terms) over the remainder of CPS's contract period (18 years).

2 EDAROTH – benefits to households, wider society and the environment from the use of IM and DfMA in unlocking net additional social housing development

EDAROTH's use of IM as a key enabler of its business model, aims to significantly bring down the costs of social housing development and in turn enable local authorities to develop publicly brownfield land that would otherwise be deemed unviable. This net additional housing development could drive social value in four main ways:

1. **Reducing blight and disruption to surrounding neighbourhoods during the construction phase**, owing to less on-site construction activity.
2. **Regenerating disused and underutilised land** (valued in economic terms as the 'Land Value Uplift benefits' associated with changing the use of land to a more productive use – in this case from disused brownfield land to social housing).
3. **Increasing the availability of high quality social housing to individuals/ households** (resulting from the net additional increase in social housing stock), which in turn should: (i) **improve the economic wellbeing of individuals/ families** occupying the new housing (who would otherwise be in crowded accommodation or homeless); (ii) **reduce the fiscal costs to Government** of other public services (such as healthcare and temporary accommodation); and (iii) provide **distributional benefits** by reallocating resources and housing to lower income groups.
4. **Reducing CO2 emissions through the construction and operation of more sustainable housing development** (relative to traditional build methods). For instance, effective IM has enabled EDAROTH to undertake thermal analysis to adapt their designs in way that is expected to drive down CO2 emissions and heating costs in the 'running' of the homes they build.

Using a methodology consistent with HM Treasury's Green Book and the Ministry for Housing, Communities and Local Government's economic appraisal guidance, we have estimated the value of these potential benefits.

Our analysis suggests that increasing the supply of social housing (in part enabled by IM) could potentially unlock social value benefits (as described above) worth around £61,000 per home (in present value terms).

Ambitions to embed carbon measures into organisations' asset management approaches, enabling more robust monitoring, evaluation and investment decisions against Net Zero targets

Many of the asset owner organisations included in our case study analysis (Environment Agency, GPA, Heathrow, Met Office) are introducing, or have ambitions to include, **CO2 and other Greenhouse Gas emission metrics into their Asset Information Models** to develop a better understanding of the environmental impacts of their built assets. This is expected to enhance organisations' ability to robustly monitor and evaluate their carbon footprint for capital project/programme(s), asset investment portfolio(s) and at the organisation-level to track their performance against their Net Zero and ESG targets. **This will enable organisations to embed sustainability considerations into future investment and replacement planning activity, and in turn might be expected to support their ability to reduce emissions in the future.** This is important when considering the embedded carbon of buildings and infrastructure can make up almost half of some asset intensive organisations carbon footprint (e.g. in the case of the Environment Agency).

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07 Wider economic impact analysis

7.1 Introduction

Throughout the rest of this report we have highlighted that adoption of IM can drive productivity gains directly for the organisations which use it. This section focuses on **the potential wider economic value unlocked by any permanent improvement in the sector's productivity from widespread adoption of IM, measured in terms of total GDP gains to the whole of the UK economy**. This captures the potential role of productivity gains in the construction sector in driving growth in other sectors of the economy, and shows how this could potentially support long-term growth in wages, household incomes, exports, and investment.

Our analysis is based on a range of **hypothetical 'what if' scenarios** which capture the different type of productivity gains typically enabled by IM at different stages of the asset lifecycle (based on the existing literature in Section 4 and new case study evidence in Section 6). The results of the analysis provide a range of **'wider economic impact multipliers' which estimate how much every £1 of direct productivity gain in the sector today, if sustained, could potentially translate into additional annual GDP for the whole UK economy in the longer-term**. The analysis captures relative impacts – i.e. relative to what would otherwise have occurred in a scenario without productivity improvements from widespread IM adoption. It suggests that the long term returns to the UK economy as a whole could potentially be a multiple of any direct IM-enabled productivity gain within the sector.

In the rest of this section we set out the **scope and purpose of the analysis** (Section 7.2), a discussion of the **key limitations and assumptions** used to design our scenarios (Section 7.3), an **overview of our economic modelling approach** (Section 7.4), and finally **details of the modelling results** (Section 7.5) and their **key implications** (Section 7.6). We also provide further technical explanation of certain elements of our modelling approach in Appendix A4.

7.2 The scope and purpose of the analysis

7.2.1 How productivity gains in the sector could potentially drive growth in the wider economy

In Sections 4, 5 and 6 we set out on the different ways in which the use of IM can drive productivity gains for organisations (through reduced costs or increased output) and provide existing and new evidence on the potential scale of these gains at different stages of the asset lifecycle (largely based on project/programme-level evidence). The case study evidence in Section 6.5 in particular highlights that the direct productivity gains realised by an organisation can be a multiple of their original investment in IM. This includes quantitative evidence which suggests the use of IM could potentially secure between £5.10 and £6.00 of direct labour productivity gains for every £1 invested in IM, and between £6.90 and £7.40 in total factor productivity savings (from reductions in delivery time, labour time and materials).

In the medium term, as IM is adopted by an entire organisation (particularly those which have a relatively large market share), and between organisations (as envisaged by CDBB's National Digital Twin agenda), any permanent step-change in productivity at the sector-level could potentially enable the sector to reduce its costs and/or increase production.

This effect could have a knock-on impact on UK GDP because in the real economy, sectors and markets interact with one another; one sector's output is another's input. A change in one sector's productivity (e.g. construction), as long as it is sustained, can flow through to other sectors of the economy through changes in the price and quantity of goods and services in producer, consumer, and factor

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markets. Figure 18 provides a simplistic representation of some of the most important economic linkages through which a direct productivity gain in the construction sector enabled by IM (Step 1 in the figure) could impact on the whole UK economy (Step 2). It shows that wider growth in the economy arises in two key ways; upstream effects and downstream effects.

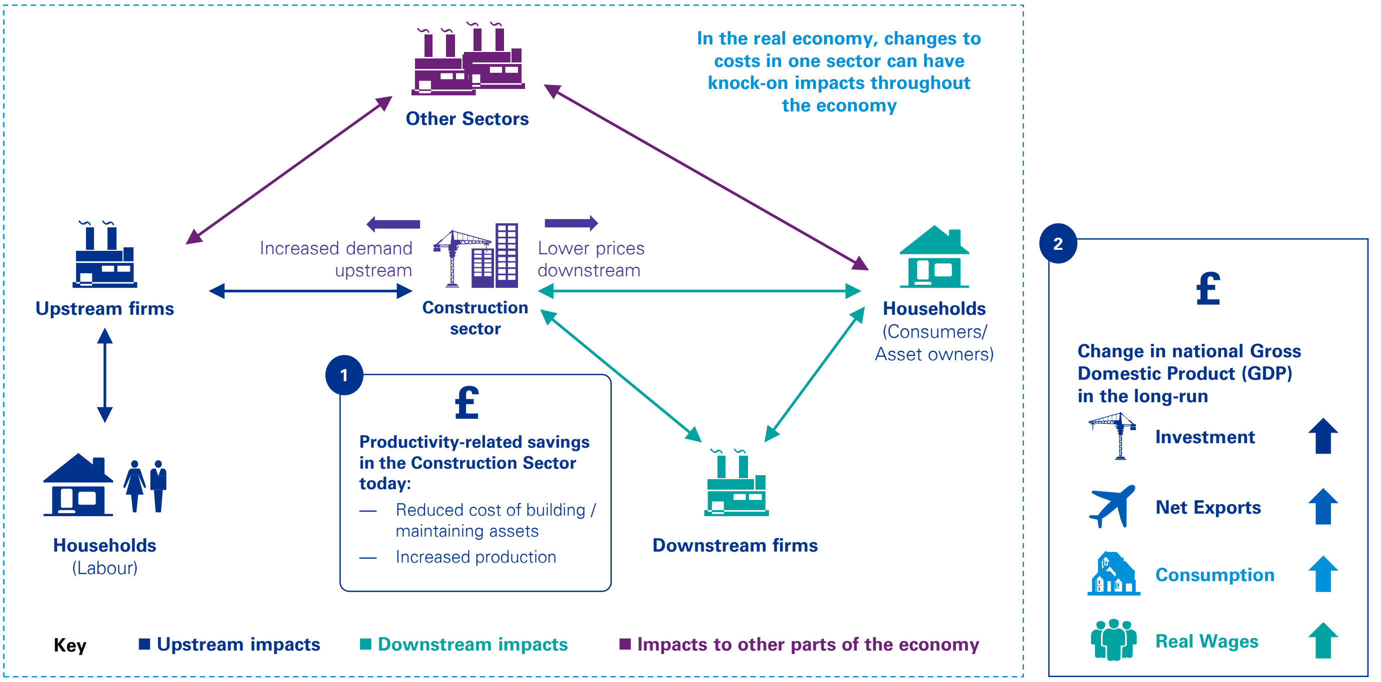
- **Upstream effects:** As the construction sector increases its output, it could demand more inputs from its upstream suppliers (e.g. expanding the construction of buildings requires more raw materials like concrete and timber, as well as electrical equipment and vehicles from manufacturers), potentially enabling them to increase their own production of goods and services, and in turn benefit other firms which provide goods and services to those suppliers (and so on).
- **Downstream effects:** Competition in the construction sector means that much of the productivity gains enabled by IM could lead to lower prices (compared to what they would otherwise have been) for both firms and households (asset owners) who use the outputs of the sector in their own production and consumption. For example, more productive/cheaper construction of houses could lead to lower house prices and rents for households, or the improved design of buildings could lead to lower energy costs for businesses and households. This may result in:
  - Downstream firms and households potentially demanding and consuming more output from the construction sector, given its outputs have become relatively cheaper;
  - Downstream firms potentially competing against one another and producing their own outputs for lower prices; and
  - Households potentially consuming more of other goods and services in the economy, or increasing savings, now that prices are relatively lower.

In turn, this could mean that other sectors of the economy, which interact these downstream sectors, can do the same (and so on).

Under each of these two effects, increased production in other sectors of the economy could potentially lead to those sectors demanding more labour, in turn pushing up wages. It could also increase the returns to private investment for capital owners (i.e. the savers and shareholders in the economy), which would incentivise greater investment in capital and growth in the UK's capital stock.

All of these chain reactions slow down overtime as prices, wages and profits in the economy adjust, and the economy settles at a new "steady state". This new stead state economy would result in a higher level of GDP, wages, investment and consumption (reflected in Step (2) in Figure 18) than would have otherwise been the case without the initial productivity gain in the construction sector as a result of IM.

Figure 18: Transmissions mechanisms through the wider economy from a direct productivity gain in the construction sector



Source: KPMG Analysis 2021.

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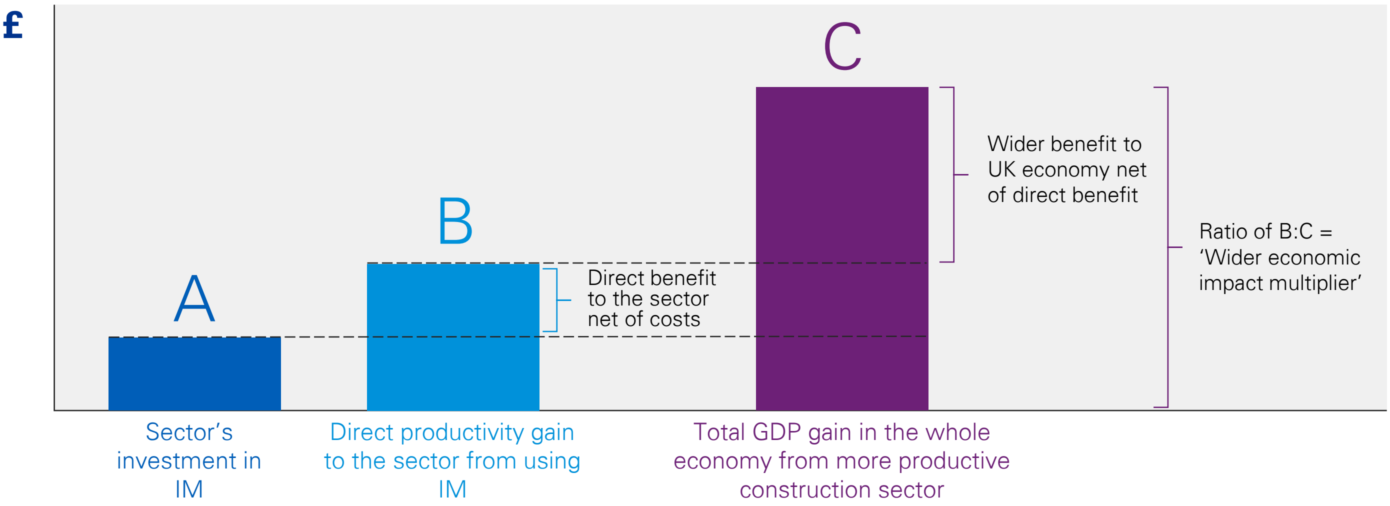
The purpose of our wider economic impact analysis is to estimate the potential scale of the total GDP gains for the UK economy (Step 2 in Figure 18) *relative to* the scale of the construction sector's direct productivity gains from the widespread use of IM (Step 1 in Figure 18). By comparing the direct and wider economic impacts enabled by the use of IM, we can infer **a 'wider economic impact multiplier' which illustrates how every £1 of IM-enabled productivity gain in the sector today could eventually generate '£X' in total GDP gains across the whole economy in the long-term**, once all the chain reactions have fed through. This economic multiplier concept is represented in Figure 19. In the next section (Section 7.2.2), we explain the rationale for estimating the potential wider economic impacts of IM adoption through the use of multipliers, rather than total levels of GDP.

Figure 19: The 'wider economic impact multiplier' effects of IM-enabled productivity gains in the sector



Source: KPMG Analysis 2021.

7.2.2 Establishing the scale and type of productivity gains enabled by widespread IM adoption across the sector

Estimating the potential scale of the wider economic impacts arising from the sector's use of IM requires information on the type and scale of the direct productivity gains that result from its widespread adoption across the sector. However, a limitation of the evidence base is that the direct productivity gains arising from the use of IM (identified in the case studies in Section 6.5) are very context specific and typically based on productivity gains realised at the project/programme level (rather than across an organisation's entire activity). In addition, the sample size of our case studies is small. Similarly, the existing literature on the productivity gains of IM (Section 4) suffers the same limitations.

This means we do not have access to representative data on the typical *scale* of the direct productivity gains enabled by the use of IM across the UK's construction sector which could be used to estimate the *total level* of direct productivity gains unlocked by sector-wide adoption. In turn this means it is not possible to robustly estimate the *total level* of total GDP gains to the UK economy.

Therefore the focus of our analysis is **understanding the *ratio* between the total potential GDP gains to the UK economy and any direct productivity gain in the sector enabled by IM** – referred to as 'wider economic impact multipliers'. These multipliers are derived using a range of hypothetical 'what if' scenarios on the different *types* of productivity gain that could be enabled by IM (informed by our case study evidence and existing literature) **assuming a hypothetical level of improvement in productivity (e.g. 1% across the sector).**

The economic modelling itself, while based on robust economic disciplines and data (as summarised later in Section 7.4), also relies on a range of modelling assumptions and is subject to limitations (as are all economic models). These are detailed in Appendix A4.

One key assumption in our analysis is that in the medium to long term, IM is taken-up by organisations across the sector, and that the gains from IM are not permanently retained as additional profits by these organisations. In other words, innovation and competition amongst firms incentivises them to expand production, subsequently passing on gains upstream (in the form of increased demand for inputs) and downstream (in the form of lower prices) as explained earlier in Section 7.2.1. However, in practice there are existing barriers to the uptake of IM across the sector, and therefore competition amongst organisations to expand production and lower prices could limit the benefits estimated. Conversely, this means polices that increase IM uptake and competition in the sector could result in larger GDP gains to the UK economy than those estimated through our analysis.

7.2.3 Key steps in scoping the analysis

There are **three key steps to our analysis of wider economic impacts**, which are summarised in Table 5. Each step is further explained in the remainder of this section.

Table 5: Key steps in scoping our analysis of the potential wider economic impacts of widespread IM adoption

Designing illustrative 'what if' scenarios on the direct productivity impact within the sector	This step is about **defining the nature of the direct productivity gain** enabled by widespread adoption of IM, requiring **assumptions** on: — What **type** of direct productivity gain has been enabled by the use of IM (i.e. savings in labour inputs, capital inputs or both)? — What is the **scale** of this direct productivity gain across the sector? — At what stage of the asset lifecycle is this productivity gain realised – considering the **design, construction and/or maintenance** of built assets? — **When** do these productivity gains occur? The assumptions used in our modelling across our five 'what if' scenarios are summarised in Section 7.3.
Modelling the potential wider economic impacts of the sector's direct productivity gain	This step involves **the use of an economic modelling framework** (KPMG's Computable General Equilibrium (CGE) model) to **estimate the potential impacts on the wider economy** from the assumed direct productivity gains in the sector enabled by IM (derived in Step 1), and analysing the modelling results to understand the key drivers of these wider economic impacts. The scope of KPMG's CGE model is described in Section 7.4.
Analysing the results of the modelling to infer the long-term multiplier effects for the wider economy	This step involves comparing the estimated level of total GDP gains for the whole economy in Step 2 (the outputs of the modelling) with the assumed level of productivity gains in Step 1 (the inputs to the modelling) to **infer an estimated wider economic impact multiplier**. This allows us to understand, for every £1 of direct productivity gain in the construction sector enabled by IM, how much (£x of GDP) could potentially be gained in the economy as a whole? The results of our analysis are described in Section 5 and their key implications summarised in Section 7.6.

Source: KPMG Analysis 2021.

7.3 Designing our illustrative 'what if' scenarios

IM can provide different types of productivity gains across the various stages of the asset lifecycle (from construction through to operations, including maintenance and renewals) and across different organisations involved in these stages (from design consultants, through to main constructors and sub-contractors). Therefore, in developing our hypothetical 'what if' scenarios for analysis, **we have reflected on the existing literature, evidence from our case studies and engagement with CDBB and the Construction Innovation Hub, with reference to three key design questions:**

1

Which types of organisation typically use and directly benefit from IM in terms of improved productivity at different stages of the asset lifecycle?

2

What are the types of productivity improvement that are typically generated for those organisations through the use of IM?

3

What should be the assumed, hypothetical scale of productivity improvement if we are to assume widespread IM adoption across the sector?

Table 6 provides a summary of the key considerations against each of these questions along with the assumptions used in our analysis. Appendix A4 provides further details of the issues and evidence considered to arrive at our approach.

Table 6: Key considerations in designing our 'what if' scenarios on the assumed productivity impacts gains in the sector

Design question	Key considerations	Modelling input assumptions
1. The type of organisations that typically use and benefit from IM in terms of improved productivity at different stages of the asset lifecycle	The analysis needs to consider all sectors which experience the **initial direct productivity gain** from the direct use of IM. This means considering three core groups: — **The construction sector:** As defined by the ONS, which includes activities related to both building and maintaining built assets (buildings and infrastructure). — **Input sectors (upstream):** Products and services which provide inputs to the construction sector in both building and maintaining built assets. — **Asset owners (downstream):** Sectors that own and operate built assets (and procure services from the construction sector for building and maintaining their assets).	We consider three types of organisations in our 'what if' analysis, on the basis of our case study evidence (see Section 6.5) and existing literature (see Section 4.2): — Direct productivity gains in the **construction of new assets using a narrow view of the construction sector as defined by the ONS**[112]. — Direct productivity gains in the **construction of new assets using a wider definition that includes those sectors involved in the ONS definition of construction, as well as the design stages of constructing new assets**[113]. This is on the basis of IM at the design stage being a well-established use case in the context of IM and its history of application via the UK BIM Framework. — Direct productivity gains in the **maintenance of newly built assets.**
2. The type of productivity improvement generated for those organisations through the use of IM	The analysis needs to consider **which input(s) to the sector's production process are affected by the use of IM**. This could be one or multiple factors of production (labour and capital) or intermediate inputs (goods and services generated by downstream sectors used in production, e.g. cement).	In our 'what if analysis', we investigate the potential wider economic impacts resulting from **two types of direct productivity impact enabled by IM**, on the basis these are most commonly observed in the evidence from our case studies analysis (see Section 6.5) and existing literature (see Section 4.2). These are: — **Labour productivity** – an improvement in employee productivity (e.g. IM reduces the time taken to review and assure a project's design, improving the productivity of staff). — **Total factor productivity** – an improvement in both labour and capital (e.g. IM reduces a project's delivery schedule, improving the productivity off both staff and machinery used as inputs to the construction process).
3. The scale of the productivity improvement	The **scale of the direct productivity gain enabled by IM, and assumed to be realised across the sector**, is a key input to wider economic impact modelling. However, the direct productivity gains observed in our case study analysis (Section 6) and existing literature (Section 4) do not provide a representative sample from which we can extrapolate to sector wide-gains. This is because the scale of the direct impacts realised from IM are: — Very context specific; that is, different types of organisations benefiting in different ways, with different measurement/presentation approaches depending on available information. — Measured at different levels (e.g. either at different stages of a project, at the overall project level, or at the programme-level); and — Based on a sample size which is very small. What is important, therefore, is to the compare the ratio (or multiplier) of an assumed direct productivity impact in the sector, i.e. a % improvement (an input to the modelling), with the estimated wider economic impacts across the economy (outputs of the modelling). At smaller % scales of improvement (i.e. single digit levels of % improvement), this multiplier remains fairly linear, meaning that the multiplier effect for the wider economy remains consistent for different levels of direct productivity gain enabled by IM.	**In our 'what if analysis' we assume that a hypothetical 1% direct productivity gain is experienced across the sector in 2021**. We assume a 1% improvement because: — It makes the presentation and calculation of the relevant multipliers more straight forward; and — This is on the lower range of the scale of % improvements observed in the existing literature and case study evidence[114], conservatively ensuring that the 'linear relationship' at small scales of improvement is observed.

Source: KPMG Analysis 2021.

Notes: (112) The ONS defined construction sector covers general construction and allied construction activities for buildings and civil engineering works. This includes new work, repair, additions and alterations, the erection of prefabricated buildings or structures on the site and also construction of a temporary nature. Specifically, it refers to Section F, and Divisions 41, 42 and 43 of the UK Standard Industrial Classification of Economic Activities 2007 – SIC (2007).

(113) Specifically, Architectural and engineering activities, technical testing, and analysis services. Division 71 of the UK Standard Industrial Classification of Economic Activities 2007 – SIC (2007). The division includes provision of architectural services, engineering services, drafting services, building inspection services and surveying and mapping services and the like link.

(114) While different information availability means that benefit calculation methodologies and presentation of those benefits differ across our case studies (Section 6.5.2), and as well as the benefits highlighted in the literature (Section 4.2), the majority of the % cost savings range from low single digits to low double digit changes.

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7.3.1 Summary of the 'what If' scenarios analysed

Table 7 sets out how we have combined the assumptions detailed above into five 'what if' scenarios which have been analysed through our economic modelling framework. The scenarios broadly split into two types:

- **Scenarios 1-3 analyse the impacts of different types of a 1% direct productivity improvement in the construction of built assets.** We begin with labour improvements only (Scenario 1) and then build in the impact of further productivity gains to capital inputs to the sector's production to consider the 'total factor productivity' gains enabled by IM (Scenario 2), with each of these based on a narrow definition of the construction sector (as per the ONS's statistical definition). We then extend the productivity gains to a wider definition of the sector, incorporating organisations which are involved in design-related activities as well as on-site construction (Scenario 3).
- **Scenarios 4 and 5 analyse the impacts of a 1% productivity improvement in the design, construction and maintenance of newly built assets.** Scenario 4 is a stand-alone scenario which considers productivity gains in the maintenance of new assets only. Meanwhile Scenario 5 considers productivity gains in 'whole life cost'; combining both improvements in design and construction (as considered in Scenario 3) and improvements in the maintenance of newly built assets (as considered in Scenario 4).

Table 7: Description of the five, hypothetical 'what If' scenarios analysed in our wider economic impact analysis

Productivity improvement		Description
IM in design and construction		
Scenario 1	**1% Labour productivity improvement in the *construction* of newly built assets**	— Based on the evidence from the case studies, a significant amount of the improvement from IM is related to **labour time savings.** Typically this will free up labour resources, which could then be reallocated to more productive activities increasing output for the same level of input, or could lead to lower labour requirements for firms to produce the same level of output. — For example, IM can help to reduce the time required from on-site construction workers to complete the same type of activities (relative to the amount of time required had IM not been used), making those workers more productive. — **This scenario provides an understanding of how labour productivity improvements in the construction of newly built assets could potentially flow through to the rest of the economy and support national GDP gains.**
Scenario 2	**1% Total Factor Productivity (TFP) improvement in the *construction* of newly built assets**	— The case studies also show evidence of more general **productivity improvement across 'multiple factors of production' (i.e. capital and labour)** from IM. — For example, by cutting down overall project time, IM allows companies to get more out of their employees (labour), as well as the machines and tools they use (capital), for the same level of input. Alternatively, this can be understood as using less of these factors, to achieve the same amount of output. — **This scenario shows how a total productivity improvement in the construction of newly built assets could potentially flow through to the rest of the economy and support national GDP gains.**
Scenario 3	**1% Productivity improvement in the *design and construction* of newly built assets, consisting of:** — A 1% TFP improvement in the construction sector, and; — A 1% productivity improvement in Design: Architectural and Engineering services, specifically in technical testing and analysis services (SIC code 71).	— The case studies also show that there is evidence of IM-related productivity improvements in key sectors which fall outside the ONS definition of the construction sector, primarily in architectural, engineering and professional services (i.e. those sectors involved in the 'design' of built assets). — This scenario combines the TFP productivity improvement to the construction sector (ONS definition) from **Scenario 2** with an equivalent productivity improvement in the outputs of the 'design' sector that are specifically used by the construction sector. — **This scenario shows how a total productivity improvement in both the design and construction stages of newly built assets could potentially flow through to the rest of the economy and support national GDP gains.**
IM in maintenance and whole life cost (design, construction and maintenance)		
Scenario 4	**1% Productivity improvement in the *maintenance* of new built assets** — 1% improvement only applied to new buildings /infrastructure (stock). — The proportion of new stock is assumed to grow from 2021-2041 (20 years) at 3% per year (depreciation rate), and cap out at 60% of total stock.	— The case studies and literature provide some evidence that **IM can potentially reduce the ongoing cost of maintaining the built assets that the construction sector builds.** These savings can about because asset owners/operators have, for example: – Greater input into the design and construction of assets, so they are built with maintenance and whole life implications in mind. – Better information on the age and integrity of their assets which enables better maintenance scheduling, reduces the need for further information gathering, and also minimises unplanned maintenance costs over the longer term (i.e. a proactive rather that reactive approach to asset maintenance). — **This scenario shows how productivity improvements in the maintenance of newly built assets could potentially flow through to the rest of the economy and support national GDP gains.**
Scenario 5	**1% Productivity improvement in the *design, construction and maintenance* of new built assets**, by combining: — Scenario 3: 1% Productivity improvement in the design and construction of new built assets. — Scenario 4: 1% Productivity improvement in the maintenance of new built assets.	— **This scenario shows how productivity improvements in the whole life cost of newly built assets (covering design, construction and maintenance) could potentially flow through to the rest of the economy and support national GDP gains.**

Source: KPMG Analysis 2021.

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7.4 Modelling the potential wider economic impacts of the sector's direct productivity gains from IM adoption

7.4.1 Overview of KPMG's Computable General Equilibrium (CGE) model

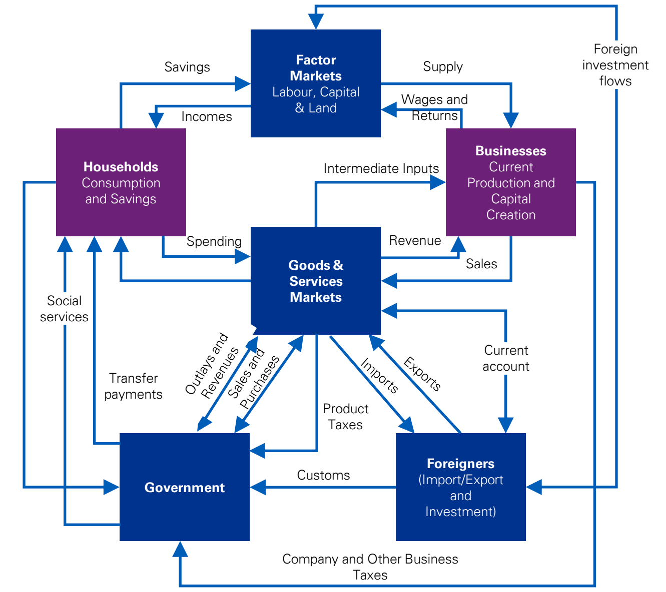
We have used KPMG's CGE model[115] of the UK economy to analyse the potential wider economic impacts of IM-enabled productivity gains in the construction sector. CGE models are a well-established type of economic modelling approach which are used by national governments and policymakers to understand the impacts on the whole economy from a direct intervention by the public or private sectors, or from changes in external economic conditions.

In the UK, HM Treasury use CGE modelling to understand the economic impacts of the Government's tax and trade policies[116] (see Appendix A4 for more details) and CGE modelling is being increasingly used to evaluate other policy changes and investments, including the delivery of the Government's net zero carbon agenda[117].

CGE models combine real economic data with economic theory to simulate the behavioural response and market interactions from a particular economic change or intervention (in this case, a direct productivity gain in the construction sector enabled by widespread adoption of IM), considering inter-sector trade (supply chains), capital markets (investment and saving), international trade (imports and exports), labour markets, household consumption and Government spending and taxes. Figure 20 illustrates how the linkages between different economic agents and markets are reflected in KPMG's CGE model.

Without capturing these impacts, standard economic modelling is limited to estimating impacts for a given sector or limited part of the economy. Appendix A4 provides further details on the economic disciplines of KPMG's CGE model.

Figure 20: Overview of the different economic agents and interactions captured in KPMG's CGE model



Source: KPMG Analysis 2021.

7.4.2 CGE models compared to other forms of wider impact modelling

There are many differences between CGE modelling and other types of static wider economic impact, or 'input-output', modelling approaches. Two key differences are highlighted below, with further detail covered in Appendix A4. These considerations make CGE modelling a robust approach for understanding the potential wider economic impacts resulting from interventions which affect the productivity of a particular sector.

7.4.2.1 CGE models align with HM Treasury Green Book guidance for appraisal

CGE analysis considers the interaction between demand and supply, and robustly accounts for all necessary economic considerations when estimating the potential net additional impacts of an intervention, in line with HM Treasury's Green Book guidance. This includes displacement effects, substitution effects, leakage, and dead weight loss[118]. CGE models also consider changing prices, trade and fiscal policy e.g. Government current expenditure and revenues must balance in the longer term. This approach involves the same disciplines that the UK Government applies in its own CGE modelling of tax and trade policy[119]. This sets a higher bar than the typical alternative form of static wider economic impact modelling, which uses 'demand side' multipliers and does not take account of supply side constraints, additionality effects, balance of payments and fiscal policy when estimating impacts on UK GDP.

Notes:
(115) KPMG's CGE model uses GEMPACK software; Horridge, Jerie, Mustakinov & Schiffmann 2018, GEMPACK manual, GEMPACK Software, ISBN 978-1-921654-34-3.
(116) HMG 2018, EU Exit: Long-Term Economic Analysis Technical Reference Paper, link; HMRC 2013, Analysis of the dynamic effects of Corporation Tax reductions, link; and HMG 2014, Analysis of the dynamic effects of fuel duty, link.
(117) HMT 2020, Net Zero Review: Interim Report, p. 21, link.
(118) HMT 2020, The Green Book, p. 93-94, link.
(119) HMRC 2013, HMRC's CGE model documentation, link HMG 2018, EU Exit: Long-Term Economic Analysis Technical Reference Paper, link; HMRC 2013, Analysis of the dynamic effects of Corporation Tax reductions, link; and HMG 2014, Analysis of the dynamic effects of fuel duty, link.

7.4.2.2 CGE models account for investment in new capital

CGE modelling can capture the long-term impacts that productivity improvements have on investment in the economy. Net increases in capital stock (through investment) is a well-established, critical driver of economic growth[120] and GDP per capita; an area where the UK has historically lagged behind its global competitors[121]. HM Treasury analysis suggests dynamic capital stock effects could account for as much as 50-60% of the GDP impact of a cost improvement[122]. Since the construction sector accounts for around 50% of all UK investment in capital stock[123], it is especially important that investment is robustly considered as part of any analysis of the potential wider economic impacts of productivity-focused interventions in the sector.

Typical (demand-side only) input-output analysis will tend to be pessimistic (or completely ignore) the effects of productivity gains on investment and capital stock. They can also be overly optimistic in their treatment of net employment impacts because of their limitations in dealing with supply side constraints in the economy, as well as the additionality factors described previously.

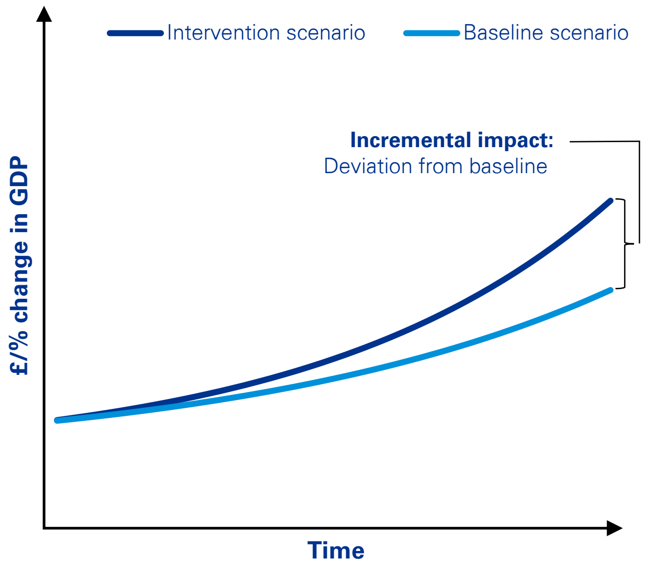
7.4.3 Understanding the 'incremental impact' in the wider economy

To understand the impact on the wider economy from a more productive construction sector, **we use KPMG's CGE model to estimate the difference or 'incremental impact' between two modelled scenarios; a 'With IM' intervention scenario ("Do Something") and 'Without IM' baseline scenario ("Business As Usual").** This is illustrated in Figure 21.

In our analysis, our five 'what if' scenarios (described previously in Section 7.5) represent five different types of hypothetical intervention scenario 'With IM'. We model the performance of the economy under each of these intervention scenarios and compare them against a common 'Without IM' baseline scenario. Results for each intervention scenario are presented as a percentage or pound deviation from the baseline scenario. This is a standard approach in economic impact modelling and aligns with the principles of the HM Treasury's Green Book guidance.

The modelling of the 'With IM' intervention scenario and 'Without IM' baseline scenario is *not* an attempt to predict the future, but instead provide a representation of the potential future growth path of the economy based on today's available information and input assumptions provided by CDBB. While this long-term growth path may differ in both the baseline and intervention scenarios to what occurs in reality, what is most important in understanding the potential wider economic value of IM is the difference (i.e. the incremental impact) between the two scenarios.

Figure 21: Illustration of incremental impact



Source: KPMG Analysis 2021.

Notes:
(120) Smith. A, 1776, The Wealth of Nations Book II, Ch. 1, link.
(121) According to the IMF World Economic Outlook April 2021, link, In GDP per capita PPP for 2021, the UK ranks 27th, behind the likes of France, Germany, Australia, Canada, the United States, Denmark, Norway, Austria Ireland etc. In Total Investment for 2021 as a ratio of Investment/GDP, the UK ranks 139th out of 171 countries with available data, and 33 out of 37 OECD countries.
(122) HMG 2018, EU Exit: Long-Term Economic Analysis Technical Reference Paper, p. 32, link, discusses academic research into the differences between static and dynamic impact analysis as suggesting accounting for dynamic investment impacts (via changes in capital stock) increases estimated long-term GDP impacts by 50-60%.
(123) KPMG 2021 analysis of ONS (1997 – 2018) Input-Output Supply and Use Tables, link.

7.5 Results of the analysis

This section highlights the key results of our economic modelling, setting out:

— The **scale of the estimated 'wider economic impact multipliers' for each of the five 'what if' scenarios** we have analysed (Section 7.5.1);

— The **key drivers of these estimated, whole economy GDP gains** (Section 7.5.2), including the importance of investment/ capital accumulation and exports; and

— The **key implications and considerations for the future efforts of Government and industry** in advancing the widespread adoption of IM across the sector (Section 7.6).

7.5.1 The multiplier effects for the whole economy from direct IM-enabled productivity gains in the sector

Table 8 summarises the estimated wider economic multipliers for each of our 'what if' scenarios (described above in Section 7.3 and Table 7). The results suggest that the estimated impacts across the whole economy (third column of the table) are materially larger than the direct productivity gains in the sector that are assumed to be enabled by widespread IM adoption (second column). The results suggest that **every £1 of direct productivity gain in sector today (2021) could potentially generate between £3.30 and £4.00 in additional annual GDP for the UK economy in 2051** (final column).

The results also highlight the importance of considering the direct productivity gains enabled by IM over the whole lifecycle of assets, as the analysis suggests that **productivity gains in whole life costs (Scenario 5) could potentially have a materially larger impact on *total* GDP compared to productivity gains in design and construction alone (Scenario 3).** Further explanation of the impacts under each scenario is provided below.

Table 8: Estimated 'wider economic impact multipliers' for each hypothetical 'what if' scenario (2021 prices)

What If Scenario	Assumed annual direct productivity gain in the sector, £m, 2021 (rounded to nearest £100m)	Estimated annual GDP gain in UK economy, £m, 2051 (rounded to nearest £100m)	Wider Economic Impact Multiplier, £ (ratio of assumed direct productivity gain in 2021 to the estimated total UK GDP gain in 2051)
Scenario 1: 1% Labour productivity improvement in the construction of newly built assets.	1,100*	4,300	**4.0**
Scenario 2: 1% Total Factor Productivity (TFP) improvement in the construction of newly built assets.	1,300	5,100	**3.9**
Scenario 3: 1% Productivity improvement in the design and construction of newly built assets.	1,400	5,400	**3.9**
Scenario 4: 1% Productivity improvement in the maintenance of newly built assets.	900**	3,100	**3.3**
Scenario 5: 1% Productivity improvement in the design, construction and maintenance of newly built assets.	2,300**	8,400	**3.7**

Source: KPMG Analysis 2021.

Notes: Due to rounding, the ratio of the productivity gains and GDP gains presented in the second and third columns of the table may not calculate to the multipliers shown in the fourth column of the table.

* The standard ONS statistics have payments to labour (wages) reflecting around 45% of GVA, and 55% payments to capital (profits), with the self-employed being treated as capital owners (businesses). The construction sector is unique in that a very large proportion - between 36% (KPMG analysis of ONS 2021, EMP14: Employees and self-employed by industry, link) and 49% (IN-SYNC 2019 Group, Self-employment now makes up 49% of the construction industry according to latest figures, link) - of the labour force are self-employed, due to a range of reasons, including the favourable tax treatments under the Construction Industry Scheme. Tax aside, self-employed persons and very small businesses exhibit behaviours more similar to labour than business (e.g. the nature of services provided, very low levels of investment, mobility and flexibility of work etc. See Savidis and Mills, 1999, Labour productivity in the construction sector, link). Representing the CGE GVA split between labour and capital better reflects this labour intensity within the construction sector than observed in the ONS's statistics.

** The 1% maintenance productivity improvement does not occur immediately in 2021, but is assumed to ramp up overtime by 3% per year from 2021-2040 as the share of newly built assets benefiting from the maintenance saving increases over time (so the first year is equivalent to a 0.03% improvement - see Table 7). To make the multiplier consistent with the others scenarios, the cumulative improvement in annual maintenance costs up until 2040 is presented.

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What are the 'Wider Economic Impact Multipliers' presented here?

The 'Multipliers' presented here show the ratio between:

a) the initial direct productivity improvement in the first modelling year, 2021, which is solely within the construction sector before any wider economic responses; and

b) the final total economic impact (GDP) in 2051 across the whole economy, once the wider benefits of the sector's productivity gain have flown through the economy, and the economy has reached a new steady state equilibrium[124].

The multipliers serve to illustrate the potential size of the whole economy impact that could result from a direct productivity gain in the sector that is assumed to be enabled by widespread IM adoption. In other words, **if IM enables £1 of direct productivity gains in the sector today, one might expect "£X" in additional annual GDP across the whole economy by 2051**. If this productivity gain is sustained, the net additional benefit to the UK economy equates to the "£X" whole economy impact less the original £1 productivity gain in the sector (as illustrated previously in Figure 19 in Section 7.2). Thus, the results highlight what would be missing in an analysis that only looked at the direct productivity saving within the sector itself (i.e. those evidenced in the case studies in Section 6 and existing literature in Section 4).

It should be made clear that since these multipliers are estimated using KPMG's CGE model, they represent a permanent 'supply side improvement', taking into account resource constraints in the economy and the competition between sectors for these resources. They are not 'demand side' multipliers (often used in static, Input-Output style economic impact modelling), which typically presume spare capacity in the economy and do not take into account supply side constraints.

This means the multipliers presented in our analysis adhere to HM Treasury's Green Book guidance, taking account of displacement effects, substitution effects, leakage, and dead weight loss[125]. They also consider changing prices, trade and fiscal policy (with the prudent assumption that Government current expenditure and revenues are required to balance in the longer term).

Notes: (124) The final total economic impact in 2051 refers to the net additional GDP in the economy resulting from a hypothetical 'With IM' scenario, which is estimated by comparing the estimated level of GDP in the economy under this 'With IM' scenario with the estimated level of GDP under a baseline, 'business as usual' scenario without any assumed productivity gains from widespread IM adoption (see Section 7.4.3 for further explanation).

(125) HMT 2020, The Green Book, p. 93-94 link.

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SCENARIO 1 – 1% Labour productivity improvement in the construction of newly built assets

Scenario 1 shows the potential impact of improving labour productivity in the construction of new assets, assuming a 1% improvement in 2021. The analysis estimates that **every £1 of direct labour productivity gain in the construction of newly built assets could potentially translate into a whole economy impact of £4.00 in annual GDP in 2051** (expressed in real terms in 2021 prices). The high return is a function of the sector's importance in UK capital stock[126] (roughly 55% of the sector's output goes into UK capital stock[127]) and the importance of dynamic stock effects to overall GDP (see Section 7.5.2).

This multiplier is the largest of all the scenarios analysed, reflecting the significant labour intensity in construction[128], and the proportion of the construction sector value added (share of own rather than imported costs), which means each £1 of labour cost saving translates into a higher proportionate reduction in the cost of construction[129]. It also reflects the relatively low historical labour productivity gains made in the construction sector compared with others (see Section 2.4.1). In our modelling, this means that labour which might otherwise have been drawn into the construction sector instead finds better paying employment in other sectors of the economy, which are growing as a result of the initial improvement in the construction sectors itself.

SCENARIO 2 – 1% Total Factor Productivity (TFP) improvement in the construction of newly built assets

Scenario 2 shows the potential impact of improving the productivity of both labour and capital inputs in the construction of new assets, reflecting a 1% improvement in 2021 in all factors of production. The estimated total GDP gains to the UK economy of £5,100m is larger when compared to Scenario 1, reflecting the larger initial direct productivity impact in the sector (£1,300m). However, the multiplier is slightly smaller, with the analysis estimating that **every £1 of total factor productivity gain in the construction of newly built assets could potentially translate into a whole economy impact of £3.90 in annual GDP in 2051** (expressed in real terms in 2021 prices). This suggests that productivity improvements in capital inputs have slightly smaller pound-for-pound impact on the wider economy than labour, including via the labour redeployment point above. Capital freed-up by capital productivity gains in the construction sector will also find alternative uses, but there tend to be smaller variations in the returns to capital between sectors than there are in labour.

SCENARIO 3 – 1% Productivity improvement in the design and construction of newly built assets

Scenario 3 uses a slightly wider definition of the construction sector, assuming productivity improvements in both design services and the construction of new built assets[130]. Assuming a 1% improvement in total factor productivity across this wider sector definition has little impact on the multiplier; it is slightly higher but still rounds to the same level as Scenario 2. The analysis estimates that **every £1 of total factor productivity gain in the design and construction of newly built assets could potentially translate into a whole economy impact of £3.90 in annual GDP in 2051** (expressed in real terms in 2021 prices). This minor shift reflects the small relative size of design services used in construction (shown by the fact it adds less than 5% to the £ value of the initial direct improvement). However, a multiplier of £3.90 still reflects the importance of this sector's inputs into the construction sector, and its importance to the whole economy. In addition, **our case study evidence and existing literature highlights that in practice, the use of IM in the design stage is critical to unlocking productivity savings during construction** (i.e. the use case for IM in the design and build of new assets is often inseparable), **which arguably makes this scenario more reflective of widespread IM adoption compared to Scenario 2.**

SCENARIO 4 – 1% Productivity improvement in the maintenance of newly built assets

Scenario 4 shows the potential impact of a 1% productivity improvement in the maintenance of newly built assets as a result of IM. This improvement is only applied to new capital stock available each year (i.e. new buildings and infrastructure)[131], which is assumed to grow by 3 percentage points each year for 20 years. The multiplier for this scenario is lower, with the analysis estimating that **every £1 of productivity gain in the maintenance of newly assets could potentially translate into a whole economy impact of £3.30 in annual GDP in 2051** (expressed in real terms in 2021 prices). This reflects the assumption that the majority of newly built assets in the economy will not be impacted by IM improvements in the early years, until they are replaced by new stock. It also means that not all of the long-term effects of the later improvements in productivity (i.e. those closer to 2040) have fed through by 2051 – thus the multiplier could be understating the wider benefits of more productive maintenance.

More significantly, however, is that the smaller ratio reflects the lower impact on UK capital stock of an improvement in productivity of maintenance only, compared to improving the productivity of construction (i.e. the creation of capital in the economy). The key point is that productivity gains in construction feed directly into the productivity of capital stock, increasing UK investment and leading to long-term growth in UK capital stock. Maintenance on the other hand, generates its effects on UK stock indirectly by improving returns in the economy more generally (similar to many other sectors), which has a smaller but still significant effect on increasing UK investment.

SCENARIO 5 – 1% Productivity improvement in the design, construction and maintenance of newly built assets

Scenario 5 shows the potential impact of productivity improvements in the whole life cost of assets, covering design, construction and maintenance (i.e. combining Scenarios 3 and 4). The analysis estimates that **every £1 of productivity gain in the whole life cost of newly built assets could potentially translate into a whole economy impact of £3.70 in annual GDP in 2051** (expressed in real terms in 2021 prices). The multiplier at £3.70 is in between the two component scenarios (3 and 4), but closer to that for Scenario 3. An important finding of this scenario, beyond the multiplier alone, is the **much larger estimated *level* of total GDP under Scenario 5 (£8,400m), which is nearly 60% greater than Scenario 3 (£5,400m) which looks solely at design and construction. This underlines the importance of considering the value of IM across the asset lifecycle** – both in terms of the use of IM and the direct productivity gains this generates.

Notes:
(126) Capital stock is the already produced durable (non-financial assets) used as 'tools' in production of goods or services, e.g. Buildings, Computers, etc. It is further described in 7.4.3 and Appendix A4.
(127) KPMG Analysis of ONS 2020, Supply and Use Tables, 1997 – 2018, Table 4 Gross fixed capital formation by industry 2018, link.
(128) McKinsey Global Institute, 2017, Reinventing Construction: A Route to Higher Productivity, link.
(129) The standard ONS statistics have payments to labour (wages) reflecting around 45% of GVA, and 55% payments to capital (profits), with the self-employed being treated as capital owners (businesses). The construction sector is unique in that a very large proportion - between 36% (KPMG analysis of ONS 2021, EMP14: Employees and self-employed by industry, link) and 49% (IN-SYNC 2019 Group, Self-employment now makes up 49% of the construction industry according to latest figures, link) - of the labour force are self-employed, due to a range of reasons, including the favourable tax treatments under the Construction Industry Scheme. Tax aside, self-employed persons and very small businesses exhibit behaviours more similar to labour than business (e.g. the nature of services provided, very low levels of investment, mobility and flexibility of work etc. See Savidis and Mills, 1999, Labour productivity in the construction sector, link). Representing the CGE GVA split between labour and capital better reflects this labour intensity within the construction sector than observed in the ONS's statistics.
(130) Design services relate to: architectural and engineering services, technical testing, and analysis services, SIC Code 71.
(131) The productivity gains resulting from IM in the maintenance of the country's current stock of built assets has not been analysed in our modelling. However it is important to note that there are examples of organisations using IM in the maintenance of current buildings and infrastructure (e.g. the GPA case study). While this scenario has not been conducted, the expected multipliers may be even larger, as it takes less time for the maintenance gains to build up in the economy compared to when the gains are only feeding through from new stock.

Approximating an HMT Green Book-style economic appraisal over time

The results described above provide an indication of the potential scale of the GDP gains to the whole UK economy in the long-term (2051) *relative to* a direct productivity improvement in the sector today (2021). The estimated GDP gains are presented as the potential permanent step-change in GDP in a given year (2051). This provides a direct comparison with the alternative, static demand-side 'multipliers' practitioners are used to seeing when assessing wider economic impacts (the previous sections explain the differences between our multipliers and those used in static, Input-Output style modelling).

However in practice CGE models, including KPMG's model used for this study, are dynamic, meaning that impacts are captured over time. Thus the estimated annual GDP impact of an IM-enabled productivity gain in the sector ramps up over time before reaching a 'steady state' level in 2051. The *total* potential GDP gains to the UK economy is equal to the summation of the estimated permanent change in annual GDP in every year during this future time period. HM Treasury's Green Book guidance for economic appraisal seeks to consider the total net additional economic welfare of an intervention over a given future period (typically 30-100 years when considering the effects of infrastructure projects/ programmes). This is achieved by adding together the estimated net additional economic GDP (with adjustments for differences in GDP and 'economic welfare' – see Appendix A4) each year over a chosen appraisal time period, and discounting these back to a present day value so they can be compared in today's money (a 'present value')[132].

We have analysed the model's estimated annual economic impacts between 2021 and 2051 for Scenarios 3-5 and discounted these estimates in line with HMT Green Book guidelines to arrive at a total present value economic impact for the UK economy, and compared this estimate to the present value of the assumed productivity gains used as an input to the modelling.

This analysis suggests that **a typical public sector economic appraisal which focused solely on the sector's direct productivity gains enabled by IM could potentially be excluding an additional 47-72% of wider economic gains to the UK economy**. Further details of our analysis under this Green Book-style appraisal are provided in Appendix A4.

Notes: (132) This accounts for time value of money and opportunity costs of investment. That is, £1 today in is worth more to someone than £1 in 2051, because it can be spent today instead of later, or invested today to make more money later. This difference in value can be accounted for when considering benefits over time by discounting values further away in time.

7.5.2 Key drivers of the estimated GDP impacts for the whole economy

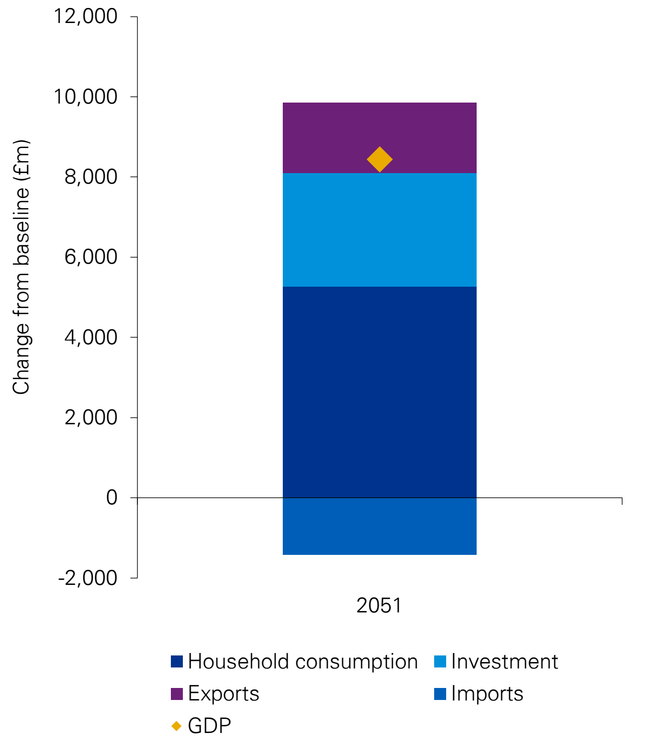
This section outlines the key drivers of the estimated GDP gains to the UK which underpin the wider economic impact multipliers presented previously in Section 7.5.1. This is based on **examining the results of our analysis from both the expenditure-side and income-side of GDP[133]**.

On the expenditure side of GDP, we explain the effects on household consumption, capital investment, and net exports in the economy. We also explain the effects of IM-enabled productivity gains on the growth of the UK's capital stock, which is a key consequence of increased investment, and a key driver of long-term economic growth. On the income side of GDP, we highlight the effects on employment and real wages across different sectors of the economy.

7.5.2.1 The expenditure-side effects of the estimated GDP impacts

A typical breakdown of GDP is through the different types of expenditure in the economy. Using this breakdown helps us understand the main drivers of our estimated GDP impacts. Figure 22 presents the breakdown of the estimated annual GDP impact in 2051 under Scenario 5 of our analysis (considering productivity improvements in the design, construction and maintenance of newly built assets). This covers the expenditure components of household consumption, investment, exports and imports[134]. Note that there is no additional government spending component (national or local) of GDP in the figure. This is because under the scenarios used in this analysis, Government expenditure has been held constant at the level observed in the baseline scenario 'Without IM'[135].

Figure 22: Scenario 5: Expenditure components of the estimated additional GDP gain across the UK economy (2051, £m, 2021 prices)



Source: KPMG Analysis 2021.

There are three key effects which contribute to the estimated GDP gains for the whole economy:

1 Real economy benefits to households

In our modelling, households are estimated to be real world beneficiaries of any productivity gains enabled by IM, as household income is higher, and prices are relatively lower. This is demonstrated through greater consumption and savings[136] in the economy with:

— Real increases in household consumption (dark blue bar in Figure 22), which accounts for more than 60% of the estimated total GDP impacts in our analysis.

— A material ongoing long-term increase in investment, reflecting the potential impact of IM-enabled productivity gains on investment returns across the economy. In practice this means household saving is higher (households savings finance investment, through pension funds, share portfolios, bank accounts etc)[137].

Notes: (133) This reflects the two established methods of measuring GDP – summing up either all the incomes, or all the expenditures, in the economy – with total expenditure and total income in the economy equalling each other (as someone's income is always another's expenditure).
(134) Remembering that additional imports is a leakage and so scores as a negative in GDP terms, which is why total GDP is less than the sum of extra investment, exports and consumption.
(135) This is a standard simplifying assumption in CGE modelling which aids transparency; if Government expenditure were allowed to change in response to changes in GDP it would be necessary to make assumptions about the impact of the additional government spending – or savings if GDP fell – on productivity. The assumption that expenditure is constant when combined with the long-term balanced budget assumptions (the stabilisation of long-term government debt) results in modest reductions in assumed income tax rates as GDP increases in response to the impact of IM. HMG apply the same adjustments in their own CGE modelling, see HMG 2014, Analysis of the dynamic effects of fuel duty, p. 25, link.
(136) Note that in markets which clear, savings are equivalent to investment, and can also be understood as simply consumption delayed to a future point in the pursuit of some type of economic return e.g. the returns from investment in the share market or interest on bank account.
(137) Although some of the investment would be in the form of additional Foreign Direct Investment (FDI), this additional investment has to be repaid, which means the position does tend to net itself out overtime.

2 Increases in investment and its impact on the UK's capital stock

An important feature of our CGE modelling is that it addresses the effects of additional investment on capital stock, and the impact of this additional capital stock on GDP. The role of investment in capital, and subsequent growth in capital stock, is a well-established driver of economic growth[138]. This is because capital (e.g. buildings, machines etc) is a core factor in business production, and one that can be accumulated overtime. The more capital stock an economy has, the more goods and services it can produce, and the more that economic growth can be spread amongst the population. In other words, more capital stock means more capital per worker in the economy, typically leading to higher GDP per worker, and thus higher wages and household incomes. Modelling these effects robustly is critical in the context of the construction sector, given that its output accounts for around 50% of all UK investment in capital[139].

Trying to achieve more investment in capital stock has particular importance to the UK for two reasons. Firstly, due to the country's historic challenges in delivering both investment rates[140] and GDP per capita at levels consistent with the UK's peer economies[141,142]. Secondly, due to the Government's ambitions to "Build Back Better"[143], Level Up the national economy and transition to Net Zero by 2050[144]. Addressing each of these will require very substantial levels of private investment in the economy, sustained for future decades. Our modelling suggests that **productivity gains in the construction sector enabled by IM could potentially significantly increase the level of private investment in the economy by 2051** (light blue bar in Figure 22). This subsequently drives a substantial increase in the UK's capital stock, with a 1% improvement in the productivity of the design, construction and maintenance of newly built assets in 2021 (Scenario 5) estimated to lead to a **capital stock that is potentially some 0.25% (£32bn 2021 prices) larger in 2051** (relative to a baseline scenario 'Without IM').

Notes:
(138) Smith. A, 1776, The Wealth of Nations Book II, Ch 1, link.
(139) KPMG 2021 analysis of ONS (1997 – 2018) Input-Output Supply and Use Tables, link.
(140) According to the IMF World Economic Outlook April 2021, link, In total investment for 2021 as a ratio of Investment/GDP, the UK ranks 139th out of 171 countries with available data, and 33 out of 37 OECD countries.
(141) Financial Times 2017, Four Theories to Explain the UK's productivity woes, link.
(142) According to the IMF World Economic Outlook April 2021, link, In GDP per capita PPP for 2021, the UK ranks 27th, behind the likes of France, Germany, Australia, Canada, the United States, Denmark, Norway, Austria, Ireland and others.
(143) HMT 2021, 'Build Back Better: our plan for growth, link.
(144) Climate Change Committee 2021, Sixth Carbon Budget, Ch 5, link.

3 Increases in exports outside of the construction sector

Export (trade) growth is another important driver of long-term GDP growth, embedded in the idea of comparative advantage, and the gains that come from specialisation and economies of scale. Trade and exports are particularly important for the UK post-Brexit, which requires new ways of boosting productivity and remaining internationally competitive.

Our modelling suggests there could potentially be a significant positive impact on exports from direct productivity gains in the construction sector enabled by IM (purple bar in Figure 22), with most of this export growth estimated to come from sectors outside of construction. This is because **although very little of the output of the UK construction sector itself is exported (<1%[145]), its output (especially the capital stock it generates) is critically important for the production of other sectors which are more export intensive**. This includes sectors such as transport (with the sector producing built assets such as roads, rail, airports, seaports and warehouses that support the trade of goods), service sectors (such as commercial office buildings) and manufacturing (such as warehouses and factories required to produce and store goods), to name a few.

Notes: (145) KPMG analysis of ONS 2020, Supply and Use Tables, 1997 – 2018, Table 4 Gross fixed capital formation by industry 2018, link.

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7.5.2.2 The income-side effects of the estimated GDP impacts

Increases in labour income outside of the construction sector

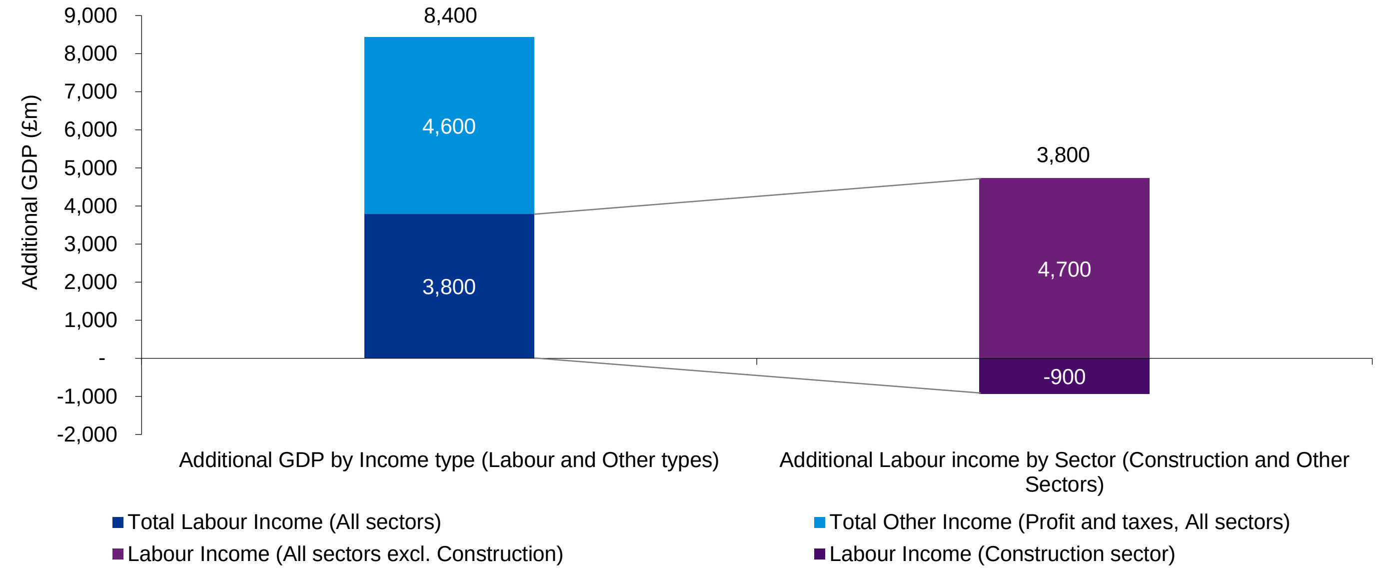
Figure 23 examines the income-side of our estimated GDP impacts for Scenario 5 and shows the extent to which the impacts are driven by additional labour income in the economy (comprising real wages and the quantity of labour) relative to other income (additional profits/ dividends for capital owners [economic rents] and taxes).

This suggests that **increased labour income makes up 45% of the estimated total GDP impacts** in our analysis of Scenario 5 (a 1% improvement in the productivity of the design, construction and maintenance of newly built assets). **The majority of the gains fall outside the construction sector, again underlining the importance of the construction sector in driving the growth of others.**

Our analysis shows, as similar wider economic impact modelling of the construction sector has shown internationally[146], that while productivity gains lead to lower real wages in the construction sector itself, there are higher real wage gains in the economy overall.

This reflects the relatively low historical labour productivity performance of the construction sector compared with others (see section 2.4.1), as well as the importance of the construction sector in driving growth in other sectors. It means that when the productivity gain in construction is felt, labour which might otherwise have been drawn into the construction sector instead finds better paying employment in other sectors of the economy, which are growing (and so are demanding more labour) as a result of the initial improvement in the construction sector.

Figure 23: Scenario 5 employment and wage gains across the wider economy (2051, rounded to nearest £100m, 2021 prices)



Source: KPMG Analysis 2021.

Notes: (146) BEIIC 2010, Productivity in the Buildings Network: Assessing the Impacts of Building Information Models, link.

7.6 Summary findings and key implications

Our analysis suggests that the potential economic value of adopting IM across the construction sector is not restricted to the individual organisations using IM, or the sector alone. Indeed, we find that the benefits outside the sector are potentially greater than within, and that the long-term GDP gains to the whole UK economy could be a multiple of any direct IM-enabled productivity gains experienced by the sector.

Assuming widespread adoption of IM across the sector, the results of our hypothetical 'what if' analysis (compared to a baseline scenario 'Without IM'), suggests:

- **Every £1 of direct productivity gain in the design, construction and maintenance of newly built assets enabled by IM today (2021) could potentially translate into a whole economy impact of £3.70 in annual GDP in 2051** (expressed in real terms in 2021 prices) – demonstrating the economic returns to the UK economy are a multiple of any direct productivity gains in the construction sector that are enabled by IM.
- **A significant driver of this wider impact is the role of the construction sector in supporting growth in the UK's capital stock across all sectors of the economy.** We estimate that a 1% productivity improvement in the design, construction and maintenance of newly built assets in 2021 (£2.3bn) could potentially increase the UK's capital stock by some 0.25% (£32bn) in 2051. This **highlights the important role that IM and other productivity-focused interventions in the construction sector could play in helping to address the Government's ambitions to Build Back Better, Level Up and transition to Net Zero by 2050**, which require very substantial levels of private investment sustained for future decades[147,148].
- **Net increases in household consumption, employee wages and exports, with most of these gains estimated to arise in sectors outside of construction**, driven by the impact of a more productive construction sector on the competitiveness and economic output of other sectors.
- **A greater long-term increase in total additional annual UK GDP when IM-enabled productivity gains are realised in *both* the design/construction *and* maintenance of built assets** – underlining the importance of a continued focus on a whole life cost approach to improving productivity and advancing the emerging use cases for IM in the operation of built assets.

Notes: (147) Climate Change Committee 2021, Sixth Carbon Budget, Ch. 5, link.
(148) HMT 2021, Build Back Better: our plan for growth, link.

08 Conclusions and proposals for future areas of focus

8.1 Introduction

Our original hypothesis for this study proposed that the effective use of IM delivers direct value for organisations through enhanced productivity; wider social value to customers, society and the environment through enhancing the quality and sustainability of built assets; and wider value to the UK economy by supporting long-term GDP growth.

In this section, we return to our original hypothesis and set out our four key headline findings from the evidence gathered through this study, including: our review of existing literature (Section 4); bottom-up analysis of real-world case studies (Section 6); and top-down wider economic impact modelling (Section 7). In doing so, **we highlight that there is demonstrable evidence of the direct and wider value potentially unlocked by IM** and set out the **key implications for the Government and industry's shared ambitions** for the construction and infrastructure sector.

8.2 Evolution and revolution in the sector's use of Information Management

Over the last 10+years, the UK Government has spearheaded a broad range of initiatives to drive the adoption of digital technology across the construction and infrastructure sector, from the introduction of the BIM Mandate in 2011 (the key 'pull' element of Government's strategy), to the creation of the Centre for Digital Built Britain in 2018 and co-investment with industry through the Construction Sector Deal (a joint 'push' strategy). Today, these efforts continue, most notably through the Government's National Digital Twin Programme in the drive to facilitate an ecosystem of connected digital twins via secure, resilient data sharing across the sector.

Our analysis of real-world case studies from across the sector highlights the significant impact of the Government's "Push-Pull" strategy on the uptake of IM across a range of contexts in the sector. However, we have also observed, compared to previous studies on the benefits of BIM in the sector, a notable shift in wider 'pull' factors that are driving the industry to embrace IM. From organisations' shift to value-driven asset management approaches, through to external forces such as regulators stipulating the need for data strategies as part of companies' regulatory settlements.

Relative to previous studies, we have seen a step-change in the volume, complexity, and variety of use cases of IM across both asset owners and contractors through the eleven case studies we have analysed. These organisations are seizing IM as a key enabler to digital transformation and the economic opportunities it unlocks. Our analysis shows how organisations are utilising IM to enable DfMA, MMC and new services in the market which are bringing life into projects that would otherwise be too costly. The clarity provided by centralised information approaches equips organisations to drive closer engagement with global supply chains, streamline the manufacturing process and improve the quality of outcomes for the end customer.

The exposure of asset owners to IM is also promoting the green shoots of technology adoption in ways that transform the construction sector's traditional approaches. At the national scale, this is a valuable catalyst of change from applications of IoT and sensor technology, through to utilisation of drones to replace human surveying, and the reuse of this data and information in systematic ways beyond simple task replacement. The simple availability of quality data provides a solid platform for the development and application of technologies already bringing value elsewhere (such as Machine Learning and Artificial Intelligence).

However, the role of IM and its continued function in wider digital transformation activities is commensurate with the sector's view of its value. In many ways this will be defined by the ability of a once traditional market to realise the value in openness and trust that comes with data re-use and onward application. We have also seen in this study some early examples of how data sharing can create value outside of organisations. This speaks to a broader shift across the sector in promoting the value of Government's open data policy, and in the interdependencies that could deliver value at the scale of a National Digital Twin.

8.3 Information Management can deliver direct value for organisations via enhanced productivity

The adoption of IM across the asset lifecycle could have a critical role helping to achieve the Government and industry's shared ambition to raise the productivity of the construction sector and reduce the whole life costs of assets.

Both the existing literature (Section 4) and our own analysis of case studies across the sector (Section 6) highlight the potential role of IM in enabling cost savings and increased revenues at both the project and (albeit to a lesser extent) the organisation levels. These benefits can lead to **direct and measurable productivity gains for contractors and, through a competitive environment, in turn asset owners.**

Our case study analysis shows the direct productivity gains in design and construction are well established. For example, **we find that in two of the case studies analysed, they expect to secure between £5.10 and £6.00 of labour productivity gains for every £1 they are investing in IM.** Meanwhile we find a range of evidence on the potential of IM to help drive total factor productivity gains (involving savings in delivery time, labour time and materials). **Two of the case studies expect to secure total cost savings between £6.90 and £7.40 for every £1 they are investing in IM, and several case studies identifying costs savings ranging from 1.6% to 18%[149], depending on the lifecycle stage in which these savings are realised.** These savings often come from IM's role in enabling wider digital transformation approaches and DfMA / MMC, rather than the use of IM alone.

Notes: (149) Note that the different approaches used by stakeholders to measure or estimate the benefits of their IM investments (as well as limitations in what could be shared for commercial sensitivity reasons) makes comparisons across the case studies difficult. The cost savings quoted also relate to different stages of the asset lifecycle – e.g. cost savings in design vs. cost savings in total build costs, and therefore should be interpreted with caution. See Section 6.5.2 for details.

However, we have found less quantitative evidence on the productivity gains in operations from the use of IM. This is largely due to the use cases for IM in operations being relatively new (owing to the fact BIM was originally envisaged for the capital phase) and where these use cases have been deployed, they are at an early stage of implementation making it difficult to estimate either realised or expected benefits.

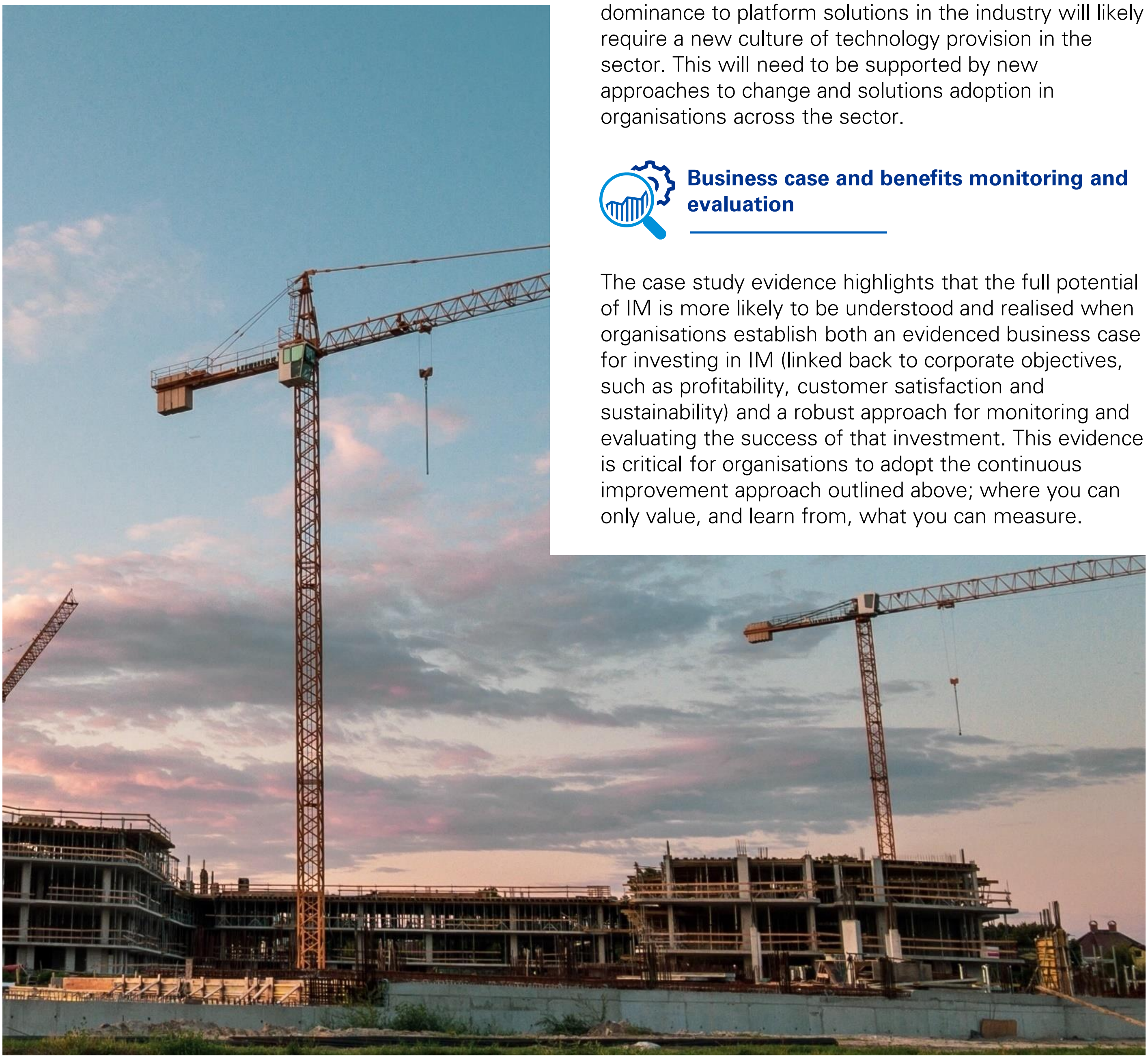
Our analysis also highlights that **advancing the use of IM and maximising its potential to support productivity gains is about more than standards, processes and technology**. The evidence highlights the need for a greater focus on the enterprise value of IM, as opposed to seeing IM as a service bought as part of capital delivery or a stand-alone project. **Embedding IM at the organisation level and using it to its full potential requires a number of important 'enablers'. Below we highlight four key factors highlighted by the case studies we have analysed through this study.**

Leadership

Our case study evidence demonstrates how top-down leadership (CIO/ CDO/ CTO level), aligned to a clear corporate strategy, anchors the use of IM in the delivery of an organisation's core business. Senior accountability improves the outcomes of IM and provides greater visibility at board-level over the value it can create at an organisation-level, as well as for the capital and/or asset programmes in which IM is used.

Investment in skills

Over the past decade, the adoption of IM through the UK BIM Framework has built capability across the sector's workforce. From the hard work of a few individuals and organisations (BIM innovators), the UK is seen as a pioneer in continuing to broaden the use cases for IM and the value it delivers. However, the function of IM is still largely delivered through existing capabilities in the sector, i.e. allocated to an organisation's in-house BIM capability. However the diversification of skills across the sector in areas such as data science, product development and data regulation, is likely to becoming an increasingly important factor in securing the success of widespread IM adoption across the sector.



Culture and embracing change

The discipline of IM is not solely technology-focused (although it is strongly enabled by it). It requires a clear vision for the business needs and the role of IM in achieving this, coupled with an implementation approach which centres on people and culture. The most successful examples of IM adoption in this study are seen in organisations where innovation and continuous improvement is embedded across all levels of the business, and where IM specialists work within, rather than external from, delivery teams.

The absence of the technology vendors in most of the case studies analysed suggests a dominance of traditional methods of technology procurement (i.e. licensing of software). However, the increasing shift of dominance to platform solutions in the industry will likely require a new culture of technology provision in the sector. This will need to be supported by new approaches to change and solutions adoption in organisations across the sector.

Business case and benefits monitoring and evaluation

The case study evidence highlights that the full potential of IM is more likely to be understood and realised when organisations establish both an evidenced business case for investing in IM (linked back to corporate objectives, such as profitability, customer satisfaction and sustainability) and a robust approach for monitoring and evaluating the success of that investment. This evidence is critical for organisations to adopt the continuous improvement approach outlined above; where you can only value, and learn from, what you can measure.

8.4 Productivity gains enabled by the sector's use of Information Management could unlock wider growth in the UK economy

The policy narrative for the construction sector typically focuses on how to address the well-documented challenge of poor productivity performance. Meanwhile the policy narrative for buildings and infrastructure (e.g. Build Back Better) has focused on investing more – recognising this is an area where the UK has underperformed relative to its peers (sitting in the lowest decile of OECD nations for 20 years[150]), or deciding on where or what type of infrastructure to invest in – addressing concerns of inequality across the country[151] and the UK's legal commitment to Net Zero by 2050. What is often overlooked is the important link between the two policies; with **the potential for productivity-focused policies in construction – including advancing the use of IM – to support an increase in private investment in the country's built assets and drive growth across the UK economy.**

This is largely due to **the pivotal and unique role that productivity gains in the construction sector play in driving growth in the UK's capital stock through greater returns to investment[152], and how interlinked the sector is with so many others in the economy**.

Our wider economic impact analysis in Section 7 suggests that the potential economic value of implementing IM in the construction and infrastructure sector is not restricted to the individual organisations using it, or the sector alone. Indeed, **we find that every £1 of direct productivity gains in the design, construction and maintenance of newly built assets enabled by IM today (2021) could potentially translate into a whole economy impact of £3.70 in annual UK GDP in 2051** (expressed in real terms in 2021 prices). These estimated GDP gains imply a higher level of net exports, household consumption, employment and employee wages in the economy – arising largely through the growth unlocked in other sectors outside of construction.

Both the direct productivity gains enabled by IM within the sector and the potential wider impacts of sector-wide IM adoption on the UK economy could together put the UK in a better position to meet the Government's long-term objectives for investment in infrastructure.

For instance, the Government's Levelling Up and Building Back Better agendas rely on multiple reforms, a key one being additional Government investment in transport, housing and other economic and social infrastructure[153] to help drive the economic prosperity of the country's more deprived communities. Making public investment cheaper/ more productive through the use of IM could play an important role in achieving these national objectives. This is evidenced in the case studies, which highlight **the potential of IM to reduce the costs of constructing and (albeit to a lesser extent) operating publicly-funded assets** (e.g. TfGM, GPA, the Environment Agency and EDAROTH via local authorities), and often **whilst also facilitating the delivery of higher quality and more sustainable infrastructure**, which ultimately provides **better value for money to the UK tax payer.**

Similarly, a critical aspect in achieving the Government's commitment to Net Zero by 2050 is the infrastructure investment revolution it will require. The Government's Sixth Carbon Budget estimates that achieving Net Zero by 2050 will require a large sustained increase in investment of around £50 billion annually by 2030 (compared to current economy-wide investment of nearly £400 billion) and that much of this can, and should be, delivered by the private sector. Again, **lowering the costs of private investment through IM-enabled productivity improvements** in building and maintaining the low-carbon infrastructure of the future – from wind and solar farms, to sustainable public transport systems and zero carbon homes, could have an important role in helping to achieve this ambitious target. The potential effects of IM-enabled productivity gains across the construction sector on private investment in the economy is captured within our wider economic impact analysis, which suggests that **a 1% improvement in the productivity of the design, construction and maintenance of newly built assets in 2021 could potentially increase the UK's capital stock by some 0.25% (£32 billion) in 2051** (relative to a baseline scenario 'Without IM').

To help unlock the potential wider economic value identified in our analysis, **Government and industry should remain focused on measures which expand and accelerate the adoption of IM and thus the direct productivity gains this unlocks. Over time, as our economic modelling highlights, market forces should mean that more investment and economic growth across the wider economy will follow.**

Notes:
(150) ONS international comparison of gross fixed capital formation drawing on OECD data, 2017.
(151) The UK is one of the most geographically unequal countries in the developed world; compared with 26 other developed countries, it ranks near the top of the league table on most measures of regional economic inequality, IFS, 2020, Levelling up: where and how?, link.
(152) 50% of investment in the UK's capital stock comes from the construction sector. Based on KPMG 2021 analysis of ONS (1997 – 2018) Input-Output Supply and Use Tables, link.
(153) IFS, 2020, Levelling up: where and how?, link.

In advancing the adoption of IM, our wider economic impact analysis highlights the importance of a continued focus on:

- **Using IM to improve productivity across the asset lifecycle.** Our analysis suggests the total level of additional annual UK GDP gains could be significantly when IM-enabled productivity gains are realised in *both* the design/ construction *and* maintenance of built assets. And yet as outlined elsewhere, the use cases for IM in operations are still emerging – underlining the importance of advancing the use of the UK BIM Framework's latest standards across the asset lifecycle; and

- **Initiatives which support the take-up of IM across the 'long tail' of SMEs in the sector.** Our wider economic impact analysis assumes widespread adoption of IM by all firms in the sector. With more than 94% of total firms employing less than 10 employees[154], it remains critical that both Government and industry maintain a focus on addressing the barriers to IM adoption for these smaller firms, which are well documented in the NBS's 10th Annual BIM Report 2020[155]. Typically, these relate to the perceived suitability of IM for smaller projects relative to the costs associated with developing the necessary capability (including software acquisition) to implement it.

Notes: (154) ONS 2019, UK Business Counts – Enterprises by Industry and Employment Size Band, link.
(155) NBS 2020, 10th Annual BIM Report – Use of BIM across different sized firms: "62% of practices with 15 members of staff or fewer have adopted BIM, compared with 80% of those with over 50 employees", p. 19, link.

8.5 Information Management can enable wider social value for customers, society and the environment

Beyond the 'hard' economic value of IM for both organisations (in the form of productivity gains) and for the UK economy (in terms of overall GDP), when used to its full potential, **IM can play an important role in delivering higher quality and more sustainable built assets. This provides public value to customers/ users of built assets, wider society (individuals, business and households) and the environment.** Not only does this contribute to the Government's policy objectives for Net Zero, Build Back Better and Levelling Up, but also the industry's focus on ESG, which has risen to the top of board-level agendas.

The specific type of social value unlocked by IM's role in delivering higher quality and/or more sustainable built assets is highly context specific. It varies not only according to the way in which IM is used, but also according to the type of asset/ service in question, who uses it, where it is located and how its construction or operation interacts with wider society and the environment.

Our analysis of case studies across the sector (Section 6) highlights the use of IM in driving benefits in the construction of built assets (such as reducing disruption and blight impacts via more effective scheduling of works, or reducing wastage and GHG emissions in the supply chain), and in the operation of built assets (such as reducing the downtime of assets to customers or providing more accessible infrastructure for minority groups via a more inclusive design).

However, on the whole, we find organisations are not fully considering the breadth of social value that could be unlocked by investing in IM, with internal business cases more focused on the direct cost savings and productivity gains it unlocks for the organisation. Organisations are more inclined to value and thus measure social value metrics which yield enterprise value, such as those affecting their reputation or long-term customer demand/ revenue (even if these gains are less explicit than direct cost savings/ productivity gains), compared to those which relate to wider environmental or societal impacts that do not have direct financial implications for the organisation (such as improving air quality or promoting economic inclusion). This is a key area of debate in the more general push to get organisations to report on ESG metrics.

In practice, all dimensions of social value are critical to achieving the Government and industry's shared aims for the sector. **There is therefore a need for more extensive evidence and awareness of the range of use cases for IM in the context of driving social value, as well as more clarity in who holds responsibility for capturing and investing against these impacts.**

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Appendix

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A1. Existing definitions of Information Management in the literature

The table below outlines the different definitions of Information Management (IM) which can be found across reference standards within the construction sector and in other sectors, which has informed our established definition of IM in the construction and infrastructure sector for this study (see Section 3.2.2).

Table 9: Definitions of Information Management found in the existing literature

Description	Source
Business processes across the built environment sector in support of the management and production of information during the life cycle of built assets.	ISO 19650-1:2018 (see Introduction section)
It (IM) provides the basis for informed decision making and the platform upon which performance can be measured.	UK Government Information Principles
IM is the collection, storage, curation, dissemination, archiving and destruction of documents, images, drawings, and other sources of information.	Association for Project Management, What is information management?, link
The data and information held within an organisation's asset information systems and the processes for the management and governance of that data and information.	Institute of Asset Management Asset Management 2015, Definition of Data & Information Management, from the iam an anatomy, version 3, link
IM is the retrieval, analysis, interpretation and presentation of health data and information.	NHS, Definition of IM, Information management staff | Health Careers, link
Management of data from disparate sources and conversion it into accurate, actionable information that can support fact-driven decision-making and generate an insight-driven advantage.	Deloitte UK, Analytics & Information Management, link
The process of collecting, organising, storing, and providing information within a company or organisation.	Cambridge English Dictionary, INFORMATION MANAGEMENT, link
IM is the management of the information resources of an organisation and involves the management of information technology.	Bouthillier and Kathleen Shearer, McGill University, Montreal, Canada., Understanding knowledge management and information management: the need for an empirical perspective link
IM is the means by which an organisation seeks to maximise the efficiency with which it plans, collects, organises, uses, controls, stores, disseminates, and disposes of its Information, and through which it ensures that the value of that information is identified and exploited to the maximum extent possible.	Oracle, Information Management and Big Data: A Reference Architecture, link

Source: Atkins Analysis 2021.

A2. The evolution of BIM to the UK BIM Framework

The recommendations from the Latham report (1994)[156] highlighted teamwork and collaboration as one of the key themes to overcome some of the perceived problems within the construction industry. Together with advancements in both software and hardware technology, organisations increasingly encouraged collaborative working arrangements. Through the Constructing Excellence Avanti initiative (2001-2005), the basis for British Standard (BS1192) was established and released in 2007. This sets out a methodology for "managing the production, distribution and quality of construction information" within a collaborative environment with technology enabled processes[157].

In support of the Government's plan for growth (2011), the UK Government released both the BIS BIM Strategy and the Government Construction Strategy 2011[158] which laid the foundations for BIM and outlined the key opportunities to address some of the inefficiencies prevalent in the UK's construction sector. This strategy conveyed the UK Government mandate requiring fully collaborative 3D BIM (with all project and asset information, documentation and data being electronic) as a minimum by 2016 for all centrally-funded projects. The concept of BIM Level 2[159] was developed to articulate the BIM mandate requirements and BIM implementation journey. Since then, the UK has been on an accelerated path of BIM adoption enabled by the efforts of the **BIM Task Group** (subsequently brought under the stewardship of CDBB in 2018), the BSI and various industry bodies.

Accordingly, the equivalent British Standards which informed the ISO are being progressively withdrawn and the UK BIM Framework has been established as a common approach for implementing BIM in the UK using the ISO 19650 series of standards.

The UK BIM Framework is managed by a consortium comprising: CDBB with representation from UK Government (BEIS), the BSI as the UK standards authority, and the UK BIM Alliance which brings practical experience from the industry. The consortium has taken a progressive role in establishing BIM guidance material through the UK BIM Framework website[160].

One of the principal objectives of the Government's latest Construction Strategy (2016-20[161]) is to embed BIM Level 2 and exploit the use of digital technology. This strategy continues to emphasise the importance of the BIM Level 2 mandate on all centrally funded government construction projects and recognises the experience and learnings.

The adoption of BSI's publicly available specifications PAS 1192-2:2013 and PAS 1192-3 as BIM standards for the capital and operational asset phases, respectively, both in the UK and overseas, inspired the UK to encourage the International organisation for Standardisation (ISO) and develop an ISO BIM standard series based on the existing and emerging UK BIM methodology[162]. As a result, in 2016, ISO and the UK's B555 Committee collaborated to develop the ISO 19650 series of standards. Publication of the ISOs proceeded in 2018 with regular updates and guidance to support the UK's commitment to its adoption, with the **UK BIM Framework** launched at Digital Construction Week in 2019 by CDBB, BEIS, and the UK BIM Alliance. The UK BIM Framework replaced 'BIM Level 2' as the requirement. The rollout of the various series of the ISO standards has replaced the equivalent BS/PAS1192 standards and has been accompanied by updated companion UK contractual protocols, reinforcing sector-wide adoption.

Table 10: Current list of ISO standards supported by the UK BIM Framework

ISO Ref	Date of Issue	Description
BS EN ISO 19650-1	2018	Organisation and digitisation of information about buildings and civil engineering works, including building information modelling — Information management using building information modelling: Concepts and principles.
BS EN ISO 19650-2	2018	Organisation and digitisation of information about buildings and civil engineering works, including building information modelling — Information management using building information modelling: Delivery phase of the asset.
BS EN ISO 19650- 3	2020	Specification for information management for the operational phase of assets using building information modelling (BIM).
BS EN ISO 19650 – 5	2020	Organisation and digitisation of information about buildings and civil engineering works, including building information modelling (BIM). Information management using building information modelling. Security-minded approach to information management.

Source: Atkins Analysis 2021.

Notes: (156) Latham, M.,1994., Constructing the team: Joint Review of Procurement and Contractual Arrangements in the UK Construction Industry., HMSO.
(157) BS1192:2007. Collaborative production of architectural, engineering and construction information – code of practice.
(158) HMG 2011, Government Construction Strategy 2011, link.
(159) First defined by Mark Bew and Mervyn Richards, 2018.
(160) UK BIM Framework, link.
(161) HMG 2020, Government Construction Strategy 2016-2020, link.
(162) UK BIM Framework, link.

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A3. Definitions and boundaries which apply to this study

Throughout the study and in this report we have employed several definitions to guide our analysis. The scope of the study has also been bound by a number of parameters that were agreed with CDBB at the outset and throughout the course of our work. It is important to consider these definitions and boundaries when interpreting the evidence and findings that are set out in this report.

Definitions used in this study

Defining the construction and infrastructure sector

In order to understand the use and benefits of IM, we have established a working definition of the construction and infrastructure sector for this study which captures: (i) at the project-level, the range of organisations involved in the use of IM for the construction and/or operation of a built asset; and (ii) at the organisation-level, the different types of client and supplier organisations that make up the sector and use IM to carry out their core functions.

The construction and infrastructure sector operates a significant number of organisational and contractual structures, meaning a wide range of parties can be involved in the use of IM and thus stand to directly benefit from the value it creates. The key parties include:

- **Asset owners,** who own the built asset and are often responsible for procuring it and ultimately accountable for operating and maintaining it (either directly or through other contracted parties) in the delivery of an end service to customers. Asset owners are often responsible for undertaking or procuring resilience planning and onward procurement of new assets as part of replacement, renewal or decommissioning works;
- **Design consultants,** responsible for delivering the design of the asset to a level of detail fit for the stage that they are contracted for;
- **Construction contractors,** responsible for building the asset, often through multiple sub-contracts, and the handover of key datasets from the capital works phase to asset owners in accordance with their operational, maintenance and wider facilities management requirements;
- **Professional services firms,** advising (or acting on behalf of) the asset owner, design consultants or construction contractors on one or more construction management aspects e.g. project and programme management, cost consultancy, legal etc;
- **Specialist suppliers,** responsible for delivering specialist activities as part of construction work packages or products, often responsible for design and engineering for their portion of works. For example, mechanical or electrical equipment providers, logistics partners, and/ or DfMA specialists; and
- **Technology suppliers,** who provide technology products including hardware, software and infrastructure (e.g. cloud storage), and related services to enable various processes during the asset lifecycle. This includes provision of core capabilities to support interoperability in the delivery of IM outcomes in alignment with UK BIM Framework[163].

Beyond the six types of organisation listed above, there are other parties which play a role in the construction and operation of built assets – such as funders, insurers and regulators. However, these parties have not formed part of our analysis on the basis that existing literature on the use of IM by these organisations specifically in the context of constructing and operating built assets is relatively limited.

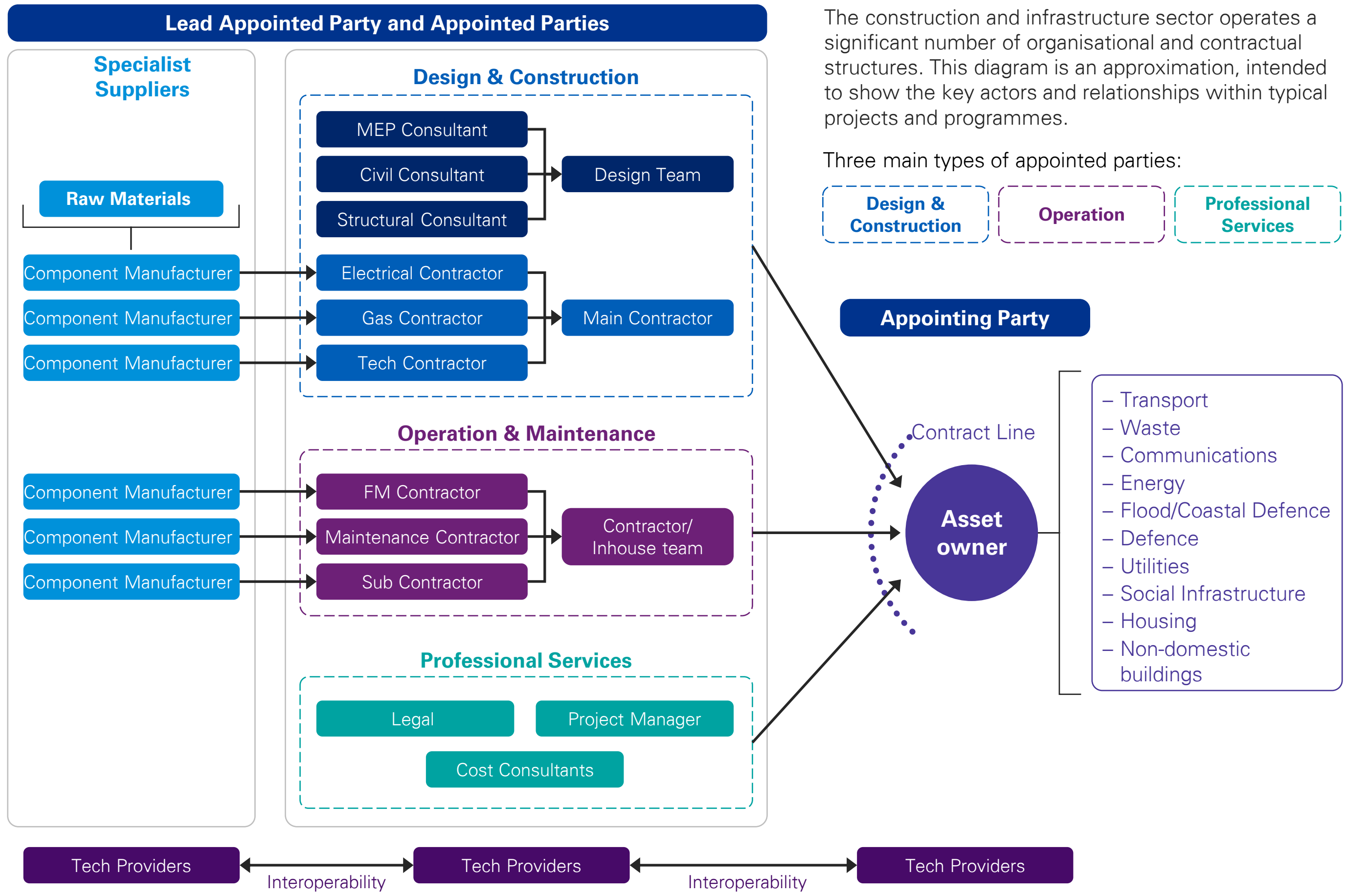
Figure 24 below approximates how a typical project or programme is structured and is intended to broadly illustrate the key parties (organisations) that could be involved in the use of IM.

In our bottom-up analysis of case studies, which are typically focused on the project-level use of IM, we have provided an approximation of the contractual and supply chain relationships that exist based on the information provided by stakeholders (see the separate Case Studies Annex published alongside this report). This case study analysis also highlights the application of novel procurement approaches, such as Project13's Integrator Model, which reconfigures the components of the infrastructure and construction delivery supply chain shown in Figure 24. The Project13 Integrator Model embeds digital transformation, and by association BIM, through enterprise strategies to enable an integrated digital approach to asset management and delivery, and an overall aim to deliver intelligent outcome-based solutions[164].

In our top-down economic impact analysis, we have used data from the Office for National Statistics (ONS) on Standard Industrial Classification (SIC)[165] to employ a definition of the sector which reflects the contractor organisations involved in the construction and operation of built assets. This definition is broader than the international definition of construction in SIC, which only covers the non-design aspects of construction and the operation and maintenance of assets (see discussion in section 2.4.3.1, as well as Table 6 in Section 7 of this report).

Notes: (163) CIH 2020, BIM Interoperability Expert Group Report, link.
(164) Institution of Civil Engineers 2019, Exploring Project 13 Principles, link.
(165) HMG 2008, Standard industrial classification of economic activities (SIC), link.

Figure 24: Construction and infrastructure organisations which use IM



Source: KPMG and Atkins analysis of Department for Business, Innovation & Skills 2013, UK Construction: An Economic Analysis of the Sector, Figure 3.6, p. 27 [166]

Notes: (166) Department for Business, Innovation & Skills 2013, UK Construction: An Economic Analysis of the Sector, Figure 3.6, p. 27, link.

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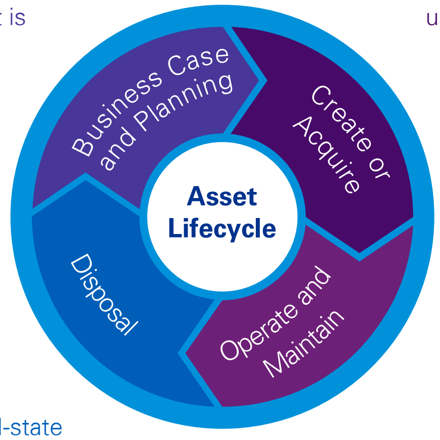
Defining the key stages in the asset lifecycle

This study investigates the use and benefits of IM across the lifecycle of assets. In the context of this study, the lifecycle approach as set in ISO 55000 series is used to define four primary lifecycle phases[167]. The application of which is applied in both the public and private sectors:

Business Case/ Planning, which represents the first stage of the asset life cycle that establishes and verifies asset requirements. Requirements are based on evaluation of the existing assets and their potential to meet service delivery needs. Resultant management strategies include analysis of the need for an asset. Throughout all stages of planning, it is crucial to make sure that the ongoing. development adds value to the organisation;

Create or Acquire, which includes activities involved in purchasing an asset with the aim of ensuring cost effective acquisition. This covers activities such as designing and procuring the construction of an asset. Appropriate application of these activities guarantees that the asset is fit for use. Throughout this report this largely represents the capital investment commonly termed as 'design and build of an asset' or the 'construction phase'.



Disposal, wherein an asset reaches the end of its useful life and can be treated as a surplus, or otherwise is considered as an underperforming asset. Disposal should be treated in the perspective of the effects of the decision on service delivery and any responsibilities. A special focus should be placed on cultural heritage with detailed requirements aiming to capture the of end-state of assets of cultural significance (industrial legacy, social/historic buildings etc) prior to subsequent disposal.

Operate and Maintain, which defines the management of an asset, including maintenance, with the aim of delivering services. Asset management focuses on asset maintenance issues. Long lived assets especially roads and buildings, require particular maintenance during their life cycle. Throughout this report this is commonly termed as the 'operations phase' of an asset.

It is important to note that often the effective use of IM in one asset phase can derive benefits in other phases of the asset lifecycle, as is evidenced by our case study analysis (and previous studies on the benefits of BIM at the project-level). **In the context of the UK BIM Framework, uses of IM are most common in the Create or Acquire phase, but with increasing use cases in the Operate and Maintain phase** (ISO19650 Part 3:2020[168]) **and in supporting the Business Case/ Planning Phase** creation for assets.

Notes: (167) ISO 55000:2014 provides an overview of asset management, its principles and terminology, and the expected benefits from adopting asset management.
(168) BS EN ISO 19650-3:2020: organisation and digitisation of information about buildings and civil engineering works, including building information modelling (BIM). Information management using building information modelling. Operational phase of the asset.

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Boundaries of the study

Measuring and analysing Information Management maturity

In the context of this study, a reasonable hypothesis is that the higher the IM maturity of an organisation, the higher the level of benefits that will be realised from its use. However, there is currently no standard approach for measuring IM maturity in the construction and infrastructure sector in a way that could be directly translated to this study (noting this study employs a bespoke definition of IM and covers its use at both the project- and organisation-levels). Therefore, in the development of our Information Management Benefits Framework and across the analysis of benefits (through both the case studies and wider economic impact modelling), we have not attempted to measure maturity or link this to an assessment of benefits.

It should be noted that for the use of the UK BIM Framework at the project-level, several methodologies exist for assessing maturity. These vary in scope from assessing organisational readiness, capability assessment and capability maturity through to capability benchmarking and compliance benchmarking[169]. However, a recent review by CDBB of existing BIM maturity methodologies identified notable limitations, including: the complexity in benefits measurement, the lack of benchmarking data, and the reliance on estimates of the knowledge of users inputting the data and the subjectivity this involves[170]. Concern around the representation of organisational maturity was also noted, where capability in BIM does not map directly to a maturity between organisational teams or respective projects[171]. At an organisation level, methodologies such as the Carnegie-Mellon 5 layer Maturity Model[172] have been proposed to expand upon the measure of BIM maturity to further assess maturity in aspects of digital transformation[173], and a report by the IET and Atkins posited a digital twin maturity spectrum[174]. However, application in the UK construction and infrastructure sector as evidenced in this study is limited[175] and as already outlined above, such approaches would not directly translate to the scope of this study.

Notes:
(169) Building Information Modelling: Evaluating Tools for Maturity and Benefits Measurement. CDBB in partnership with UK BIM Alliance.
(170) Ibid.
(171) Bilal Succar 2010, Building Information Modelling Maturity Matrix, DOI:10.4018/978-1-60566-928-1.ch004, link.
(172) Software Engineering Institute. 2011, "CMMI Version 1.3 Information Center", link.
(173) Bilal Succar 2010, Building Information Modelling Maturity Matrix, DOI:10.4018/978-1-60566-928-1.ch004, link.
(174) ATKINS, Digital twins for the built environment, link.
(175) Bilal Succar 2010, Building Information Modelling Maturity Matrix, DOI:10.4018/978-1-60566-928-1.ch004, link.

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A4. Supporting information on our wider economic impact analysis

This appendix provides supplementary information on our approach to the wider economic impact analysis described in Section 7 of this report, which has been undertaken using KPMG's Computable General Equilibrium (CGE) Model of the UK economy. This comprises:

— Further details on the differences between dynamic CGE modelling and alternative forms of static economic impact modelling;

— A description of the key limitations of the CGE modelling approach used;

— A detailed explanation of the approach taken to design our hypothetical, 'what if' scenarios of widespread IM adoption across the construction sector; and

— Further explanation of the estimated GDP impacts over time for some of our key 'what if' scenarios.

CGE models compared with static Input-Output models

A robust feature of CGE models is that when analysing a change or 'shock' in one part of the economy, growth in the whole economy is constrained by available resources, meaning over time the economy must converge to a new "general equilibrium" or "steady-state" (after adjusting for changes in prices and a new allocation of resources). This contrasts with static input-output modelling, which is a partial equilibrium approach to measuring wider economic impacts that does not capture budget and resource constraints and the interactions/ competition between different economic agents for those resources. The key methodological differences between the two modelling approaches are summarised in the table below.

Table 11: Key features of dynamic CGE modelling and static Input-Output modelling

	Input-output analysis	CGE (national)
Supply side constraints	✗ None	✓ National level constraints
Endogenous prices	✗ None (assumes prices are fixed)	✓ National level
Different ratios for intermediate inputs and production	✗ None (assume fixed ratio)	✓ Substitution across factors and products (domestic and international) ✓ Diminishing marginal returns
Budget constraints	✗ None	✓ Households and government have budget constraints
Allowance for purchases marginal response to change	✗ None	✓ Households and firms budget shares can change
Applicable for small regions	✗ Not applicable (interlinkages are shallower than regional level)	✗ Not applicable (interlinkages are shallower than regional level)

Source: KPMG 2021, based on information from the ABS 2020, link.

Key limitations of the CGE modelling used in this study

All models, including CGE models, are subject to some uncertainty. These uncertainties relate both to the underlying data, estimated parameters and assumed formulae used to reflect the way markets operate in the model (e.g. the steepness of the relevant supply and demand curves), and (perhaps more fundamentally) about the scenario specific inputs to the model. If the direct productivity improvement scenario being tested generates a different scale or distribution of improvement than that which is assumed, this would be reflected in a different estimated impact in the CGE model.

It should also be noted that CGE models are not designed for short-term forecasting. Their strength lies in their internally consistent and disciplined approach to modelling the long-term economic effects of policies when compared to a baseline scenario, rather than short-term economic fluctuations relative to GDP today. The cyclical nature of the construction sector (see Section 2.4.1.2), is captured in the underlying model data in so far as the peaks and troughs experienced over time are incorporated into a long-run sector average growth rate. Cyclical and other short-term uncertainties are not, however, simulated in the model, and so using the outputs of the modelling to inform any assessment of short-term outcomes, should be done so with caution. Further, while cyclical effects would principally affect both the 'baseline' and 'with intervention' scenario, and therefore net out in the long-term once the dynamic effects in the modelling have stabilised and the economy is back in a 'steady state equilibrium', we cannot discount the possibility of short-term effects that disproportionately affect either scenario, which would affect the incremental GDP impacts estimated through the modelling.

The nature of the construction sector as having a 'long tail', with many SME's (see Section 2.4.1.2), is not explicitly simulated in the CGE. The underlying sector specific model data and elasticities reflect an average of the sector. In this way the overall nature of the construction sector is captured when compared to other sectors (e.g. sectors with higher than average SMEs tend to have lower than average productivity from 'economies of scale', and this average would be captured across all sectors).

The CGE modelling in this study is underpinned by ONS data, specially the UK National Accounts 2016 Blue Book. This means that while the modelling assumes growth across the economy over time in the baseline, it does not consider any realised trends (e.g. increased investment in green sectors) beyond 2016 or any projected/ potential future trends not already reflected in this data. For instance, it will not incorporate long-term impacts of COVID-19 on the makeup of the economy.

In addition, CGE modelling does consider the positive or negative externalities associated with improving the construction sector's productivity (or the wider social value generated by the use of effective IM); instead it only values marketable transactions. The direct productivity improvements, as well as the social value impacts of IM from higher quality and more sustainable built assets, have been addressed separately as part of the case study analysis (see Section 6). However, this case study analysis does not consider any additional externalities from wider economy effects. For example, if the CGE model estimated an increase in the output of the automotive sector (as a result of improving the construction sector's productivity) and thus imply an increase in car production, it would not include the effects of this on carbon, air quality and road congestion.

Designing our illustrative 'what if' scenarios

IM can provide different types of productivity gains across the various stages of the asset lifecycle (from construction through to operations, including maintenance and renewals) and across different organisations involved in these stages (from design consultants, through to main constructors and sub-contractors). Therefore, in developing our 'what if' scenarios for analysis, we have reflected on the existing literature, evidence from our case studies and engagement with CDBB and the Construction Innovation Hub, with reference to three key design questions:

01 Which types of organisation typically use and directly benefit from IM in terms of improved productivity at different stages of the asset lifecycle?

02 What are the types of productivity improvement that are typically generated for those organisations through the use of IM?

03 What should be the assumed scale of this productivity improvement if we are to assume widespread IM adoption across the sector?

The rest of this section explains how we have addressed each of these in the design of our scenarios for analysis through the CGE model.

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01 Which types of organisation typically use and directly benefit from IM in terms of improved productivity at different stages of the asset lifecycle?

The analysis of wider economic impacts needs to consider all parts of the construction and infrastructure sector that use IM and directly benefit in terms of experiencing productivity gains. As outlined elsewhere in this report and evidenced by our case study analysis (see Section 6), the range of organisations involved in the use of IM is broader than the statistical definition of construction. As such, the analysis needs to consider all the sectors **where the initial productivity benefit from IM is felt**. The different actors can be broadly split into three categories (see Table 12 below for more detail, as well as Appendix A3 which sets out the different types of organisations which are typically involved in the construction and operation of built assets):

— **The ONS defined construction sector**, covering general construction and allied construction activities for buildings and civil engineering works[176]. This includes new work, repair, additions and alterations, the erection of prefabricated buildings or structures on the site and also construction of a temporary nature.

— **The key sectors providing inputs into the construction sector**, as illustrated in Figure 3 in Section 2.4.3.1. These key sectors include:

  - Professional services, including 'Design' services (Architectural and engineering activities, technical testing, and analysis services)[177] which is of significance in context of IM and its history of application via the UK BIM Framework;
  - Raw materials from mining and querying sector;
  - Key products and equipment from the manufacturing sector;
  - Wholesale trade;
  - Administrative support services; and
  - Many others[178].

— **Asset owners** i.e. the organisations that typically use the outputs of the construction sector, in that they own and operate the buildings and infrastructure built by the construction sector. Key sectors include the construction sector itself, housing, transport, energy, water and waste, public administration and defence, primary industries (agriculture, mining, and extraction) and many more (see Figure 3 from Section 2.4.3.1)[179].

Table 12: Sectors of interest

Construction and its subsectors	Inputs - products and services	Asset owners – operation and use of the asset
Construction sector as defined by the ONS includes three subsectors: — Construction of buildings. — Construction of civil engineering works. — Allied construction and trades. While construction sector is the key sector where direct benefits of IM are realised in the capex phase, the sector also includes the key maintenance activities.	**The key services sectors connected to construction of buildings and infrastructure as well as IM are:** — Design: Architectural and engineering services; technical testing and analysis services (SIC Code 71). The majority of the products used as inputs into construction come from the manufacturing sector and raw goods sector. From our case studies, these are sectors more likely to be indirectly effected by improvements in IM through improvements in the construction sector itself.	**Buildings and large infrastructure assets are used by many sectors (asset owners) in the economy.** They receive the downstream benefit from productivity in the construction sectors (lower asset prices), as well as maintenance and operational efficiencies that come from having better designed and constructed buildings and infrastructure (higher asset quality).

Source: KPMG Analysis 2021.

Notes:
(176) Refers to Section F, and Divisions 41, 42 and 43 of the UK Standard Industrial Classification of Economic Activities 2007 – SIC (2007).
(177) The group includes provision of architectural services, engineering services, drafting services, building inspection services and surveying and mapping services and the like link.
(178) In order or reference, Section M, B, C, G, N of the UK Standard Industrial Classification of Economic Activities 2007 – SIC (2007).
(179) In order reference, Section F, A, B, D E, H, L, O of the UK Standard Industrial Classification of Economic Activities 2007 – SIC (2007).

The following diagram visually aligns the key sectors of interest with their corresponding SIC codes.

Figure 25: Construction and infrastructure organisations which are potentially involved in the use of IM

Products

Mining and Quarrying (B)

- Other mining & quarrying i.e. Quarrying of stone, sand and clay **(08)**
- Mining support services **(09).**

Manufacturing (C)

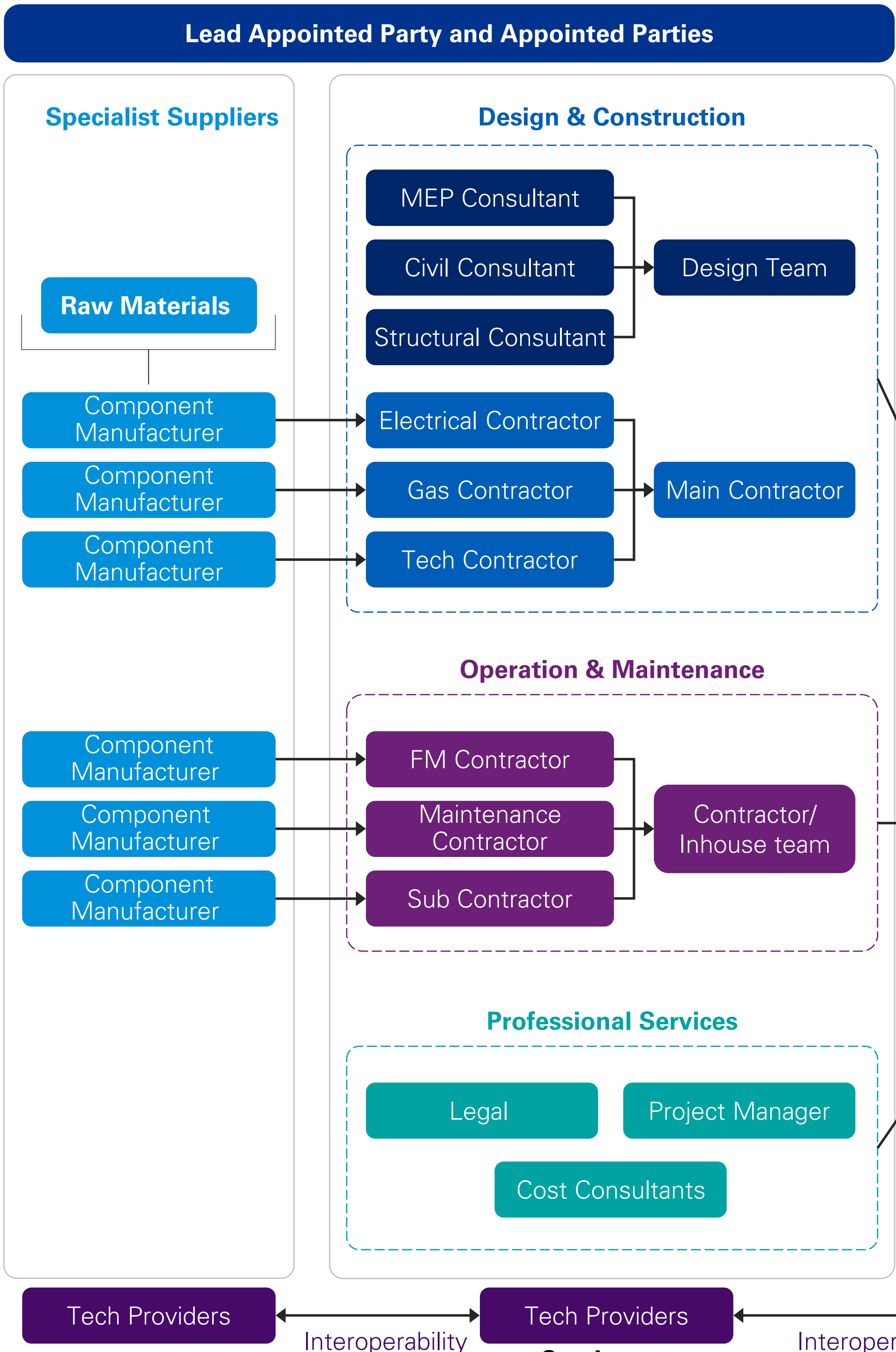
- Manufacture of wood and products of wood and cork **(16)**
- Manufacture of rubber and plastic products **(22).**
- Manufacture of other non-metallic mineral products **(23)**
- Manufacture of fabricated metal products, except machinery and equipment **(25)**
- Manufacture of electrical equipment **(27)**
- Manufacture of machinery and equipment n.e.c. **(28)**
- Repair and installation of machinery and equipment **(33).**

Wholesale and Retail Trade (G)

- Wholesale trade, except of motor vehicles and motorcycles **(46).**

Administrative and Support Service Activities (N)

- Renting and leasing activities (i.e. construction and civil engineering machinery and equipment) **(77).**



Services

Professional, Scientific and Technical Activities (M)

- Architectural and engineering activities; technical testing and analysis **(71)**
- Other professional, scientific and technical activities (i.e. quantity surveying) **(74).**

Source: KPMG and Atkins analysis of Department for Business, Innovation & Skills 2013, UK Construction: An Economic Analysis of the Sector, Figure 3.6, p. 27 [154]

Contracting

Construction (F)
- Construction of Buildings **(41)**
- Construction of Civil Engineering Works **(42)**
- Allied Construction Activities, or Allied Trades **(43).**

Three main types of appointed parties

- Design & Construction
- Operation
- Professional Services

Appointing Party

Contract Line

Asset owner

- Transport
- Waste
- Communications
- Energy
- Flood/Coastal Defence
- Defence
- Utilities
- Social Infrastructure
- Housing
- Non-domestic buildings

Tech Providers

ability

Destination of Construction-related Capital

- **Agriculture, Forestry and Fishing (A)**
- **Mining and Quarrying (B)**
  - Extraction of crude petroleum, natural gas & mining of metal ores **(06 / 07)**
  - Other mining & quarrying **(08)**
  - Mining support services **(09).**
- **Electricity, Gas, Steam and Air Conditioning Supply (D)**
- **Water Supply, Sewerage, Waste Management and Remediation Activities (E)**
  - Water collection, treatment and supply **(36)**
  - Sewerage **(37)**
  - Remediation activities **(39).**
- **Construction (F)**
- **Transportation and Storage (H)**
  - Warehousing and support activities for transportation **(52).**
- **Real Estate Activities (L)**
- **Public Administration and Defence (O)**
- **Education (P)**
- **Art, Entertainment and Recreation (R)**
  - Libraries, archives, museums & other cultural activities **(91)**
  - Sports activities, amusement & recreation activities **(93).**

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In our ‘what if’ scenario analysis, we have analysed two definitions of the sector directly benefiting from IM (in the form of productivity gains). First, we have assessed the direct productivity impacts in the construction of new assets using a narrow view of the construction sector as defined by the ONS[180]. Secondly, we have assessed the direct productivity impacts in the construction of new assets using a wider definition that includes those sectors involved in the ONS definition of construction, as well as the design[181] stages of constructing new assets. This is on the basis of IM at the design stage being a well-established use case in context of IM and its history of application via the UK BIM Framework.

We have also considered the wider impacts of using IM in the maintenance of buildings and infrastructure, in addition to its role in the design, planning and construction of these new assets (i.e. the investment in new capital). Further, we have considered a combined scenario that evaluates the wider impacts of using IM to generate Whole Life Cost savings (i.e. across design, construction and maintenance) of newly built assets.

Through our modelling, we have not applied the direct IM improvement to any other specific asset owner (e.g. transport, energy, housing etc.) or input sector (e.g. manufacturing). Instead by applying the direct improvements of IM in the construction sector, we have then evaluated the knock-on impact of improved productivity in design, construction and/or maintenance on these asset owning sectors and the wider economy.

02 What are the types of productivity improvement that are typically generated for those organisations through the use of IM?

The wider economic impacts of using IM will vary depending on which aspects of an organisation’s productive activity it affects. To produce one unit of output, a typical firm can draw on factors of production (labour and capital) and intermediate inputs (goods and services generated by other firms, including in other sectors). If the use of IM makes any of these inputs more productive (greater output for the same level of input, or less input for the same level of output), it makes the firm/ organisation more productive and more profitable. See Table 13 for a more detailed description.

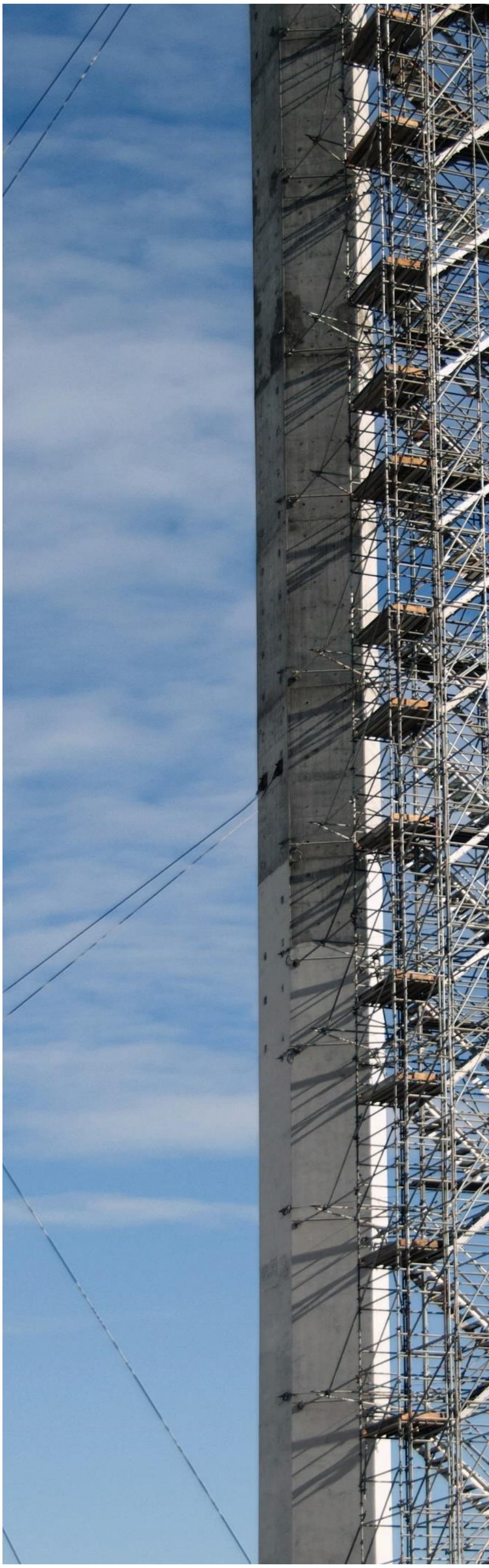
Table 13: The different types of productivity improvement potentially enabled by the use of IM

Type of productivity improvements	Description
Labour productivity improvement	Labour productivity is defined as output per unit of labour. An improvement in labour productivity occurs when a businesses employees are able to do more and/or different (work) over a given time period than before, or do the same amount of work in less time. For example, IM can reduced the amount of time it takes to review and handover information between contractors and asset owners, freeing up labour time and potentially cost.
Capital productivity improvement	Capital refers to non-financial assets (i.e. durable) used as ‘tools’ in the production of goods and services (e.g. buildings, computers, machines etc). Capital is produced by distinct sectors of the economy (e.g. the construction sector) and accumulated by business overtime. It also depreciates with age and must be replaced if output levels are to be sustained. Hence, a capital productivity improvement refers to an increase in output per unit of capital employed. For example, IM can change the capital required from traditional physical assets (design models, paper etc) to more productivity digital assets (computer databases etc.)
Total Factor Productivity (TFP) improvement	TFP reflects the overall efficiency with which labour and capital inputs are used together in the production process. A TFP improvement refers to an increase in output that is not accounted for by changes in the amount of labour or capital input. For example, IM can lead to a reduction in overall programme time in both design and construction, leading to less labour and capital required to produce the same asset.
Intermediate input improvement	Intermediate inputs are the goods and services (including energy, raw materials, semi-finished goods, and services that are purchased from all sources) that are used in the production process to produce other goods or services rather than for final consumption. An intermediate input improvement refers to a productivity increase in the production process that produces the goods and services which are used as intermediate inputs. For example, IM could enable more efficient design and/or maintenance, allowing for less material wastes.

Source: KPMG Analysis 2021.

Notes: (180) ONS defined construction sector covers general construction and allied construction activities for buildings and civil engineering works. This includes new work, repair, additions and alterations, the erection of prefabricated buildings or structures on the site and also construction of a temporary nature. Specifically, it refers to Section F, and Divisions 41, 42 and 43 of the UK Standard Industrial Classification of Economic Activities 2007 – SIC (2007).

(181) Specifically, Architectural and engineering activities, technical testing, and analysis services. Division 71 of the UK Standard Industrial Classification of Economic Activities 2007 – SIC (2007). The division includes provision of architectural services, engineering services, drafting services, building inspection services and surveying and mapping services and the like link.



Our review of existing literature and analysis of case studies has shown that using IM can support different types of productivity improvement – from savings in labour hours/ costs, through to cost savings in capital (e.g. equipment) and materials, as well as combined cost savings.

In our 'what if' scenario analysis, we investigate the wider economic impacts of both direct improvements in labour productivity and in total factor productivity as a result of IM, on the basis these are most commonly observed in the evidence from the sector, with the use of IM that *only* affects capital being less common.

Instances of *direct* improvements in the productivity of the 'intermediate inputs' of construction (e.g. raw materials, manufactured products etc) were also found to be less common in the evidence available. Most often, these inputs were more likely to be *indirectly* affected by improvements in IM, via improvements in the labour and capital involved in construction. The exception being direct improvements in design services (covering architectural and engineering services, technical testing, and analysis services sector), which is included in the analysis by incorporating it into the wider definition of construction, as outlined in above.

03 What should be the assumed scale of this productivity improvement if we are to assume widespread IM adoption across the sector?

As outlined in Table 6, the scale of the direct benefit is a key consideration for wider economic impact modelling. However, the direct productivity gains observed in our case study analysis (Section 6) and existing literature (Section 4) do not provide a representative sample from which we can extrapolate to sector wide-gains. This is because the scale of the direct impacts realised from IM are:

— Very context specific; that is, different types of organisations benefit from IM in different ways, with different measurement/ presentation approaches depending on available information.

— Measured at different levels (e.g. either at different stages of a project, at the overall project level, or at the programme-level); and

— Based on a sample size which is very small.

What is important is to the compare the ratio (or multiplier) of an assumed direct productivity impact in the sector, i.e. a % improvement (an input to the modelling), with the estimated wider economic impacts across the economy (an output of the modelling).

At smaller % scales of improvement (i.e. single digit levels of % improvement), this multiplier remains fairly linear, meaning that the multiplier effect for the wider economy remains consistent for different levels of direct productivity gain enabled by IM.

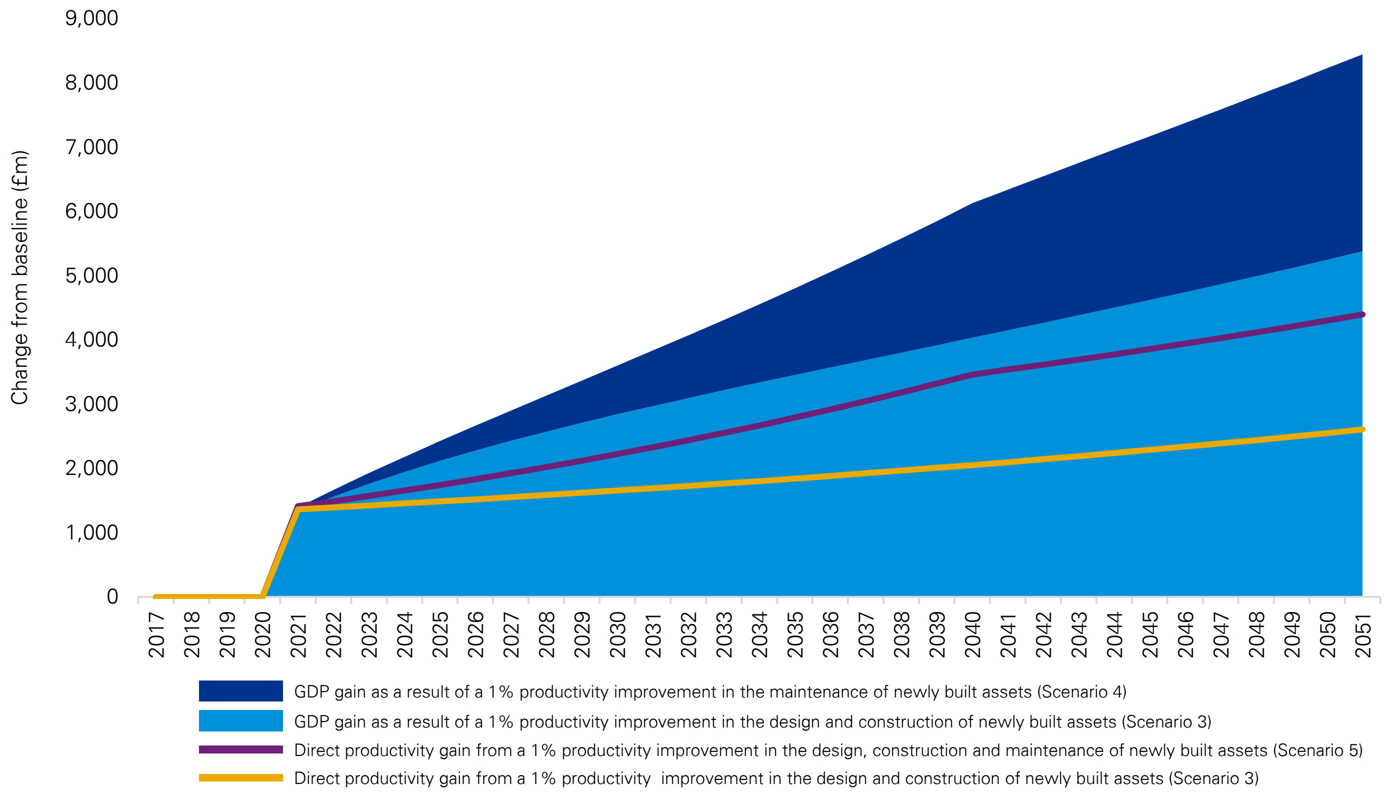
Estimated GDP impacts over time

The results in Table 8 illustrate the potential overall gains to the wider economy in the long-term (2051) relative to an assumed direct productivity gain in the sector today (2021). Figure 26 provides a more detailed picture of what these estimated impacts look like over time.

These results show the assumed size of the initial productivity improvement in the construction sector from IM under Scenario 3 (orange line) in 2021. This direct productivity impact is assumed to grow over time, reflecting underlying background growth in the economy (i.e. this is growth not driven by any assumed additional improvements from IM beyond the initial direct gain), which means a larger construction sector and thus a bigger £ gain from a given % improvement in its productivity[182]. The GDP gain from construction (light blue area) begins at the same level[183], but as prices and outputs change, and gains flow through the rest of the economy to households and firms (downstream and upstream) increasing capital investment and demand for labour across the economy, this leads to a much larger estimated impact over the 30 year period.

The purple line reflects the assumed 'whole life cost' productivity gain (Scenario 5), by adding the initial productivity improvements in maintenance (Scenario 4) to the direct productivity gain in design/construction under Scenario 3 (orange line). Note that the initial 'whole life' shock here grows faster over the first 20 years, as the share of the building stock that benefits from the maintenance productivity gain increases as well as background growth in the economy adding to that stock. In 2040 (after 20 years), the share of building/infrastructure stock benefiting is assumed to stop growing, and the shock grows by a smaller amount, reflecting underlying background growth in the economy only[184]. The estimated, whole-economy UK GDP gains from the inclusion of productivity gains in the maintenance of built assets is shown by the dark blue area, with the sum of the light blue and dark blue areas illustrating the total impacts of Scenario 5 – productivity gains across the design, construction and maintenance of newly built assets.

Figure 26: Direct productivity improvement and incremental whole economy GDP impacts overtime (2021-2051, £m, 2021 prices)



Source: KPMG Analysis 2021.

Notes: (182) Its important to remember that what we are examining here is still the incremental difference between the baseline (With-out IM) and the 'With IM' scenario. The reason that we see improvements growing due to baseline growth, is because we are presenting the £ improvements, not % improvement which instead level out over time (see Figures 27, 28 and 29 to see this presented). The concept is the same as the 'real escalation' of benefits applied in all UK Green Book economic appraisals.

(183) Before any responses in terms of output and in other sectors, a given reduction in costs amounts to the same improvement in real GDP because even if output has not changed (so nominal GDP is the same) inputs are lower which means real GDP has increased.

(184) It is important to remember that what we are examining here is still the incremental difference between the baseline (With-out IM) and the 'With IM' scenario. The reason that we see improvements growing due to baseline growth, is because we are presenting the £ improvements, not % improvement which instead level out over time (see Figures 27, 28 and 29 to see this presented). The concept is the same as the 'real escalation' of benefits applied in all UK Green Book economic appraisals.

Approximating an HMT Green Book economic benefits assessment over time

The results described in Section 7.5.1 estimate the potential overall gains to the wider economy in the long-term (2051) *relative to* a direct productivity improvement in the sector today (2021). The estimated GDP gains are presented as the potential permanent step-change in GDP in a given year, in line with the typical presentation of GDP as a broad measure of national economic progress (i.e. annual GDP for the UK). It also provides a direct comparison with the alternative, static demand-side 'multipliers' practitioners are used to seeing when assessing wider economic impacts using Input-Output style modelling (see Section 7 and Appendix 4 for an explanation of the key differences between dynamic CGE modelling and static, Input-Output style modelling, and thus the multipliers they produce).

However, in practice CGE models, including KPMG's model used for this study, are dynamic meaning that impacts are captured over time. Thus, the estimated annual GDP impact of an IM-enabled productivity gain in the sector ramps up over time before reaching a 'steady state' level in 2051. The *total* potential GDP gains to the UK economy is equal to the summation of the estimated permanent change in annual GDP in every year during this future time period. HM Treasury's Green Book guidance for economic appraisal seeks to consider the total net additional economic welfare of an intervention over a given future period (typically 30-100 years when considering the effects of infrastructure projects/ programmes). 'Economic welfare' here is a wider term than GDP, which includes impacts that are traded in the economy (and therefore count towards GDP) and things that are not traded, such as the value of individuals' leisure time (which does not count towards GDP). An estimate of economic welfare is achieved by adding together the estimated net additional economic benefit each year over a chosen appraisal time period (adjusting for additional hours worked and thus leisure time foregone)[185] and discounting these impacts back to a present day value so they can be compared in today's money ('present value')[186].

We have therefore analysed the model's estimated annual wider economic impacts between 2021 and 2051 for Scenarios 3-5 and discounted these estimates in line with HMT Green Book guidelines to arrive at a total present value GDP impact, and compared this to the present value of the assumed productivity gains. This analysis suggests that **a typical public sector economic appraisal which focused solely on the sector's direct productivity gains enabled by IM could be excluding an additional 47-72% of wider economic gains to the UK economy**.

This is a different way of understanding the results to those presented in Section 7.5.1. A key difference being driven by the time it takes for wider impacts to flow through the economy as modelled within the CGE. This is because the estimated wider economic impacts in future years are discounted more heavily than the direct impacts that occur earlier on in the appraisal period[187]. Another is the adjustments made to net out additional hours worked (i.e. the leisure time lost), which has a very marginal effect on the overall measure since additional hours worked makes up a very small fraction of the overall GDP gain, with most impacts being felt through higher real wages.

Table 14: Assumed direct productivity gains, estimated incremental UK GDP impacts (net of additional labour hours), and estimated multipliers based on impacts over time (2021-2051, Present Value expressed in 2021 prices and assuming a 3.5% discount rate, rounded to nearest £100m)

'What if' scenario	Present Value of direct productivity gain in the sector, £m	Present Value of wider economic gain in UK economy, £m	PV Wider Economic Impact Multiplier: ratio of £PV of direct productivity gain to £PV 2051 of whole economy gain
Scenario 3: 1% Productivity improvement in the design and construction of newly built assets	35,100	60,300	1.72
Scenario 4: 1% Productivity improvement in the maintenance of newly built assets	15,800	23,300	1.47
Scenario 5: 1% Productivity improvement in the design, construction and maintenance of newly built assets	50,900	83,700	1.64

Source: KPMG Analysis 2021.

Notes:
(185) In the context of this analysis, there are two key considerations included in economic welfare, but not GDP. These are (i) the lost leisure time as a result of additional hours worked (as a result of increased employment, see footnote 188 for context) and (ii) negative externalities which occur as a result of greater economic activity (such as increased CO2 emissions and transport congestion). We make adjustments to our GDP estimate to account for additional hours worked and the resulting loss in leisure time, using recognised 'willingness to pay estimates' from DfT (TAG 2021, link), however our modelling does not account for wider externalities that may be explicitly caused by increased economic activity. Modelling these effects requires further sophisticated techniques outside the scope of this study, such as understanding (i) the full breadth of externalities that could arise from additional GDP growth; (i) the nature of those relationships (e.g. they could be linear or non-linear); and (iii) whether such externalities are negative or positive. For instance, traffic congestion is more closely linked to population growth and density (held constant in the modelling between the baseline and 'what if' scenarios) than productivity-driven GDP growth, and while additional economic activity could indicate more trade and therefore more traffic, the additional economic activity itself is partly enabled by greater capital investment, which would include an expansion in transport infrastructure and further network capacity that would relieve congestion. Similarly in the case of additional CO2, the UK has experienced a de-coupling in the relationship between GDP/per capita and CO2 overtime (ONS 2019, The decoupling of economic growth from carbon emissions: UK evidence, link) and this decoupling is expected to accelerate as the country transitions towards a Net Zero 2050 economy. Again, the additional capital investment that enables additional GDP in our scenarios could drive that acceleration, and instead of increasing CO2, it could help the UK meet its Net Zero agenda sooner than under a baseline scenario.
(186) This accounts for time value of money and opportunity costs of investment. That is, £1 today in is worth more to someone than £1 in 2051, because it can be spent today instead of later, or invested today to make more money later. This difference in value can be accounted for when considering benefits over time by discounting values further away in time.
(187) This reflects another limitation of input output or static wider impact analysis, in how it considers the time it takes for wider impacts to flow through the economy and the gains to eventuate, if it does consider it at all.

Understanding the estimated GDP impacts in terms of percentage changes relative to the baseline over time for key scenarios

Figures 27, 28 and 29 show how GDP, along with a range of different other measures, are estimated to grow over time for three of our key 'what if' scenarios. These changes are presented as % deviations from the 'Without IM' baseline scenario (in real terms), rather than the absolute £ figures presented in Section 7.5.

These results show:

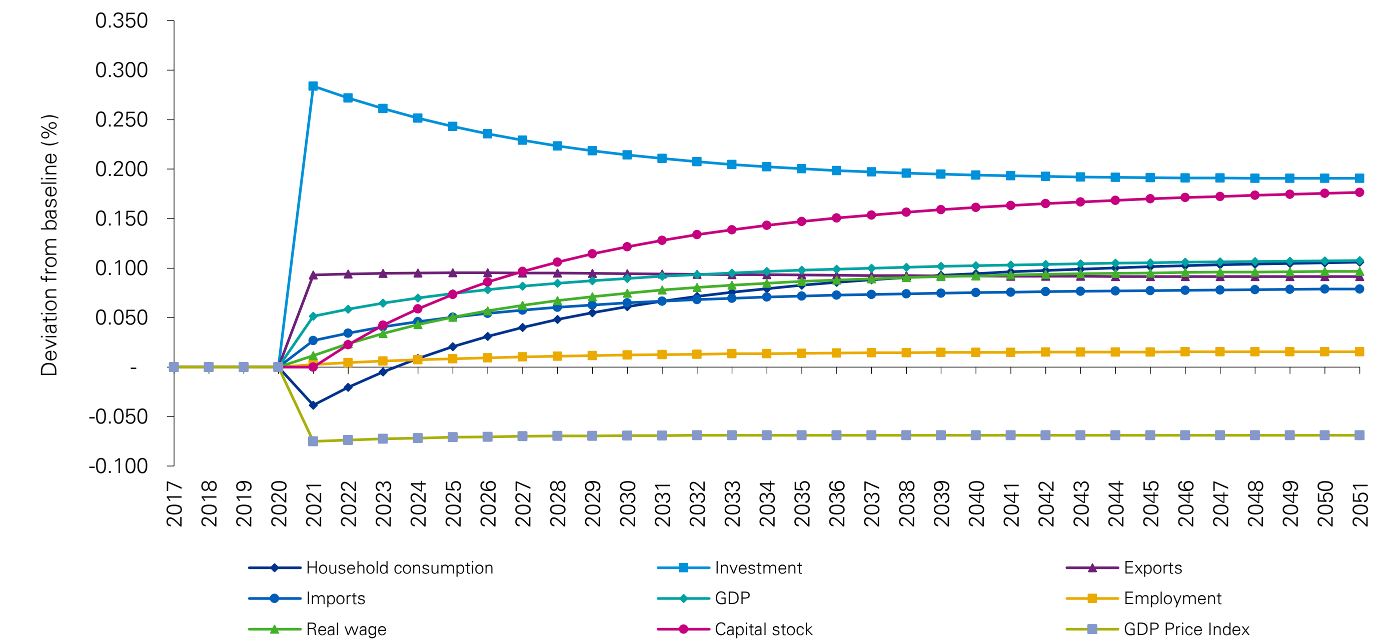
— The relationship between investment and capital stock, with the long-term % change in investment ultimately translating into a comparable % change in capital stock;

— The consumption/ investment trade-off under higher levels of investment impact under our scenarios, where there is a direct impact on investment incentives by reducing capital costs (Scenarios 3 and 5). In both of these, the initial boost in investment is such that even though the investment is adding to household incomes, consumption initially falls. This is because additional investment requires additional saving and therefore a reduction in consumption at least in the very short-term. In the medium-term, the impact of the additional stock on output and therefore incomes takes over and net consumption rises compared to the baseline scenario. It also rises by more than in Scenario 4, which avoids the initial consumption reduction, but delivers less in the longer term because it delivers a lower impact on capital stock. This is a further illustration of the disciplines inherent in the CGE approach which highlights real world trade-offs.

— The relatively modest role of net increases in employment. In all three scenarios, these increases reflect the impact of increases in real wages in the economy as a whole, as those sectors seeking to expand bid up wages in order to attract additional labour[188]. The relativities between the % change in investment and % increase in employment highlight the greater importance of dynamic capital effects in the overall change in GDP in all three scenarios.

— All three scenarios also highlight the importance of changing prices. As noted elsewhere, one of the strengths of the CGE approach is that prices are endogenous, rather than imposed externally and fixed. This endogeneity is necessary to allow markets to clear. All three scenarios show aggregate prices (the GDP price index) in the economy falling relative to the baseline scenario. This does not mean absolute price reductions, but rather lower inflation relative to the baseline scenario. The reductions are greatest in our two higher GDP impact scenarios, underlining the point that this analysis is focused on real GDP – i.e. after allowing for changes in price. It is also worth noting that some of the price change will reflect the impact of higher exports on exchange rates, which will be reducing input costs.

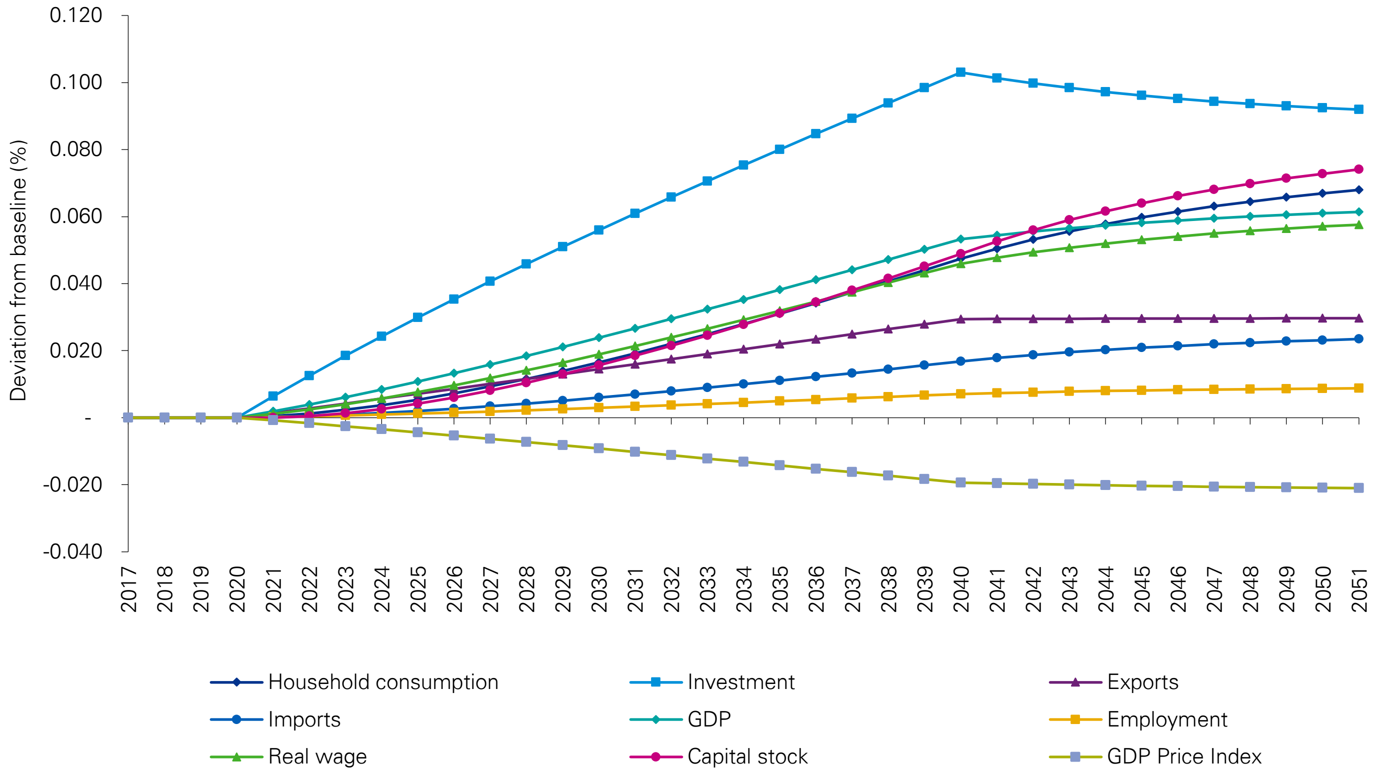
Figure 27: Scenario 3, Key economic metrics, % deviation from baseline over time (2021-2051)



Source: KPMG Analysis 2021.

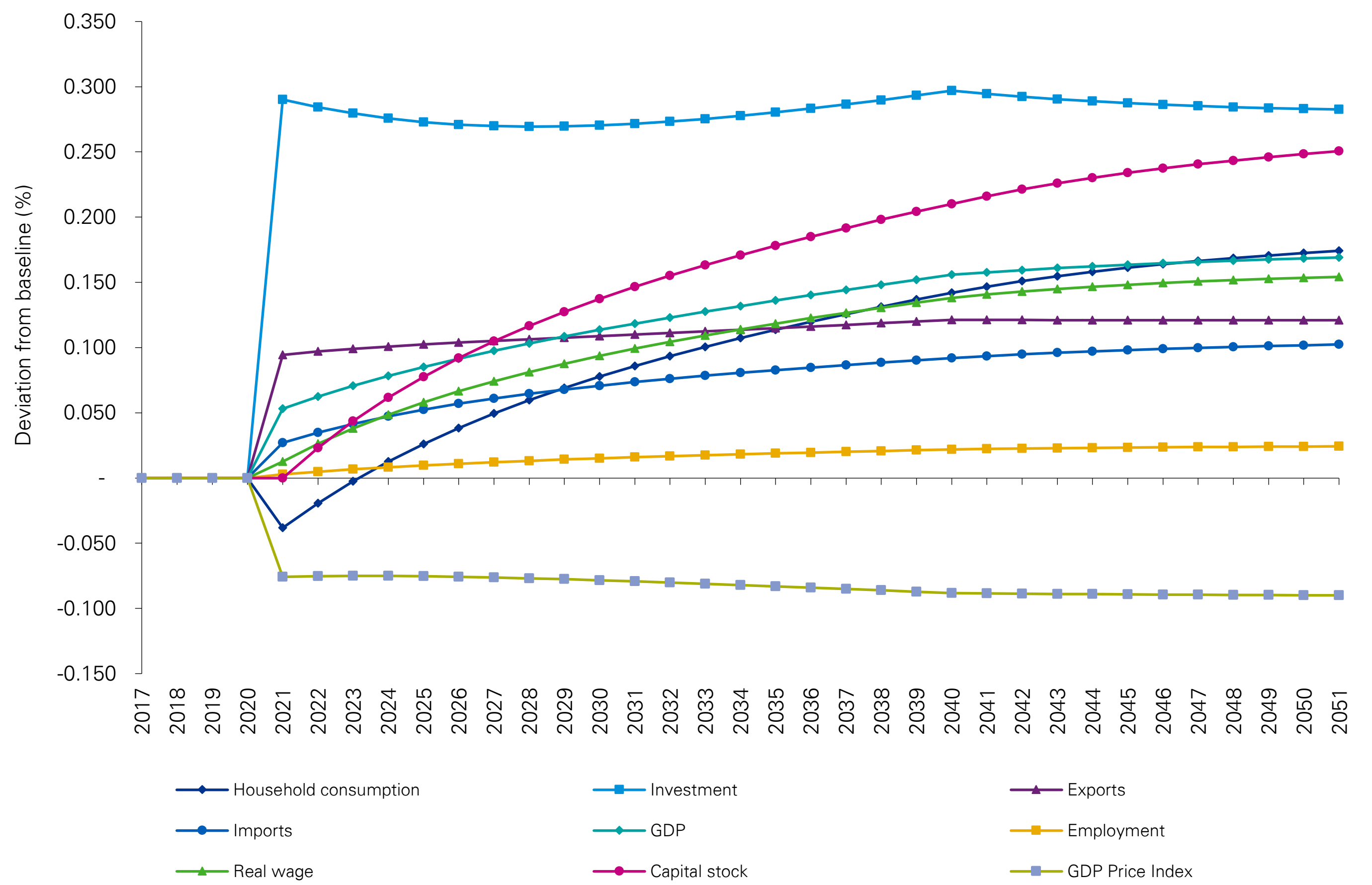
Notes: (188) Under both the baseline and the various 'With IM' hypothetical scenarios, we assume 'full employment' from a structural and cyclical point of view. Therefore, the vast majority of employment changes in certain sectors/regions reflect displacement in others. However, while labour supply at an aggregate level is inelastic, it is not assumed to be perfectly inelastic. This is because even in an economy at Full Employment in equilibrium, a work/leisure trade off exists and needs to be accounted for. As real wages improve in the economy, households will substitute towards work, and this leads to small increases in hours worked (employment) at the economy wide level.

Figure 28: Scenario 4, Key economic metrics, % deviation from baseline over time (2021-2051)



Source: KPMG Analysis 2021.

Figure 29: Scenario 5, Key economic metrics, % deviation from baseline over time (2021-2051)



Source: KPMG Analysis 2021.

A5. List of contributors

— Atkins and Faithful+Gould (SNC-Lavalin)
— Babcock
— Balfour Beatty plc
— BDP
— BIM4Water
— The Cabinet Office
— Connect Plus Services
— EDAROTH Ltd (a wholly owned subsidiary of Atkins - part of the SNC-Lavalin Group)
— Environment Agency
— Government Property Agency (GPA)
— Heathrow Airport Ltd (Heathrow)
— Her Majesty's Revenue and Customs (HMRC)
— Mott MacDonald
— The Met Office
— Skanska UK plc
— Transport for Greater Manchester (TfGM)
— UK BIM Alliance Wales
— VolkerWessels UK
— Yorkshire Water

A6. Scope of work from CDBB

Background

The implementation of BIM across the built environment has been designed to increase efficiency and reduce cost in the construction of new assets. There is increasing awareness that the principles of BIM can be applied across the entire lifecycle of an asset to increase efficiency and reduce cost across the entire lifecycle of the built environment – both existing and new. Research undertaken to date, including that commissioned by CDBB, indicates that managing information about the built environment can enable us to get more out of existing and new assets. Whilst this concept is becoming increasingly understood, the quantification of benefits from information management in the built environment is not yet well developed. The recent and ongoing Covid-19 pandemic has suggested that organisations with a higher degree of information management experience a higher level of organisational resilience, however this link has not yet been empirically demonstrated.

CDBB has engaged KPMG to undertake a further study to better understand and quantify the benefits of Information Management in the construction and infrastructure sector.

Purpose and scope of the study

The purpose of the study is to:

— Identify the broad range of potential benefits of investing in Information Management throughout the lifecycle of assets in the built environment and how that investment can potentially support economic recovery and increased economic resilience in the future, considering: (i) the benefits of BIM adoption between 2011 and 2020; and (ii) the benefits of wider Information Management practices at the organisation-level.

— Provide economic analysis of the potential scale of these benefits, where possible, to add to the existing empirical evidence on the effectiveness of BIM and Information Management in providing benefits to construction organisations and asset owners, the multiplier effects for the whole UK economy, and wider society.

— Understand to what extent the BIM mandate has contributed to the benefits that have been realised in the sector.

Deliverables

The deliverables from the study will comprise:

— A full report outlining the context for the study, the analytical approach employed and the results of the analysis;

— An Executive Summary of the full report; and

— A 1-page summary of the key messages from the report.

Contact us

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