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Development of a Framework to Support the Effective Adoption of BIM in the Public Sector: Lessons for Ireland

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Abstract

Building Information Modelling (BIM) has been formally adopted by many countries with the promise of creating greater economic, social and sustainability benefits. Several authors and institutions have presented alternative BIM policies and tactics which have been adopted by developed countries. However, there is evidence to indicate that BIM adoption theories are not well established and, in particular, the linkage between BIM public sector adoption strategy outcomes and their contribution to achieving Government policy objectives are underdeveloped. This paper will present the outcome of the first phase of a systematic literature review of published studies (including journal papers and noteworthy international reports) on global government BIM adoption. It will focus primarily on what are the key drivers affecting the decision to adopt BIM at government level, together with the theories, frameworks, and models adopted by governments or public sector bodies to assist in realising the economic, social and sustainability benefits of BIM adoption. The authors reveal a consistency in the drivers associated with the use of BIM in the delivery of public sector construction projects and how these contributed to the establishment of a National BIM Roadmap for Ireland. The methodology focuses on identifying a list of high quality published information of public sector BIM adoption through a rigorous retrieval and filtering system, presenting and critically reviewing alternative government BIM adoption strategies and finally discusses current perceived conclusions and actual implementation frameworks that serve to inform Ireland's digital transition programme in construction. This paper seeks to inform an early phase in the development of a framework to support the deployment and evaluation of government policy objectives in Ireland and would be applicable to other countries which are an early stage of their digital construction transformation.

Keywords: BIM, Drivers, Public Sector, Frameworks

1. Introduction

The ongoing debate about digital transformation is transcending across all sectors and construction is no exception. In 2016 Finland, Switzerland, Sweden, Israel, Singapore, the Netherlands and the United States were leading the world when it comes to generating economic impact from investments in Information and Communications Technologies (ICT), according to the World Economic Forum (WEF, 2016a). In that same year the WEF also published their report on Shaping the Future of Construction (WEF, 2016b) where the authors identified the challenges and megatrends facing the construction sector and the almost moral obligation to transform the sector.

The construction industry is one of the last large industries to significantly embrace technology and leverage the opportunities that this transformation change can bring (McKinsey, 2017). The principal reason for the slow pace of change is the various internal and external challenges, such as the fragmentation of industry, poor collaboration within the supply chain, outdated regulatory practice and monitoring and the difficulty of recruiting and retaining diverse talent in the sector (Framer, 2016).

Over the years various US published Smart Market reports for BIM indicated that the adoption of BIM in construction projects helps to enhance stakeholder collaboration, leads to reducing errors, omissions and project durations (Bernstein et al., 2010; Jones and Bernstein and 2012a, 2012b, 2014a, 2014b, 2014c, 2015; Jones and Laquidara-Carr ,2017; Lee at al., 2012 and Young Jr. et al. 2009).

Some governments have been particularly proactive and innovative by instigating transformational construction programmes that seek to effect a positive change in the construction industry. The WEF reported that industry is beginning to change thanks to digitalisation, innovative technologies and new construction techniques, such as BIM (WEF, 2017). BIM adoption has been slow, despite its many advantages, as WEF (2018) observes:

Successful BIM adoption requires a high level of collaboration among stakeholders. Steps toward that include increased use of integrated contracts and open standards for data sharing. Adoption also requires a coordinated effort to attract new talent with digital and BIM skills, upskill existing workers, and changing corporate cultures to support new processes. As major owners of built assets, governments must make a long-term commitment to the technology by piloting it in public works projects and creating regulations conducive to its acceptance, including backing innovative forms of financing.

(WEF, 2018 pp. 4)

It can be concluded thus that the public sector plays a key role in supporting and encouraging the adoption of BIM in the industry. Public sector bodies and governments around the world have recommended or mandated the use of BIM as a strategy to address their existing problems. These problems include declining productivity, increasing project costs and accommodation shortage. There is an increasing tendency to connect the adoption of BIM to the Smart City agenda throughout the world (Andrisano et al., 2018).

Additional noteworthy publications that have informed the authors in preparing this paper include the EU BIM Task Handbook (Group 2017) which provided a strategic framework as a common approach for BIM introduction into the European public sector and the Construction IT Alliance (CitA) Global BIM Report (Hore et al., 2017a) which focused on BIM adoption in international regions, with particular focus on the enablers to support Ireland's Digital Transition programme for their construction sector.

It is intended that by identifying what the key drivers are that affect the decision to adopt BIM at the government level, together with the theories, frameworks, and models adopted by public sector bodies, this will assist in the development of a framework to support the deployment and evaluation of Government policy objectives in Ireland or other countries.

2. BIM in Ireland

In Ireland the first formal reference to BIM was included in a Forfás report which focused on Ireland's Construction Sector (Forfás, 2013). Specific mention was made of BIM in the report as an advanced technology that will ensure increased competitiveness and innovation in the sector. The report outlined specific actions for sustainable growth, with an action for Enterprise Ireland, Industry Representative Bodies, Higher Education Institutes (HEIs) and Skillnet Ireland to work together to promote the use of BIM and develop the appropriate technical skills amongst Irish construction firms, so that they can successfully compete in markets where BIM is widely adopted or required.

This was followed in 2014 by the Construction 2020 Strategy which aimed at restoring a properly functioning, sustainable and dynamic construction sector, operating at an appropriate level for the size of the economy. The report outlined two specific actions which included implementing a BIM staged development programme to support companies advancing to level 2 BIM capability, which subsequently led to the development of the *BIM Enable* and *BIM Implement* support programmes for Enterprise Ireland clients (Government Publications, 2014).

In January 2017 the Government launched its *Action Plan for Jobs 2017* (Government Publications, 2017). A particular action flowing from the Action Plan for Jobs 2017 included a requirement for the Office of Government Procurement and Enterprise Ireland to prepare a strategy for the adoption of BIM across the public capital programme and to mandate the manner in which it is to be adopted across the public sector.

Following consultation with public bodies engaged in public works projects, the government Construction Contracts Committee (GCCC) prepared a position paper in 2017 for the purposes of inviting responses from industry. Titled *A Public Sector BIM Adoption Strategy*, it outlined the context and rationale for the adoption of BIM on Irish public works projects and put forward a proposed timeline for adoption, ranging from 12 - 48 months, for projects to adopt BIM. These projects range from Band 1, which are of low complexity, such as low density housing projects, to Band 5, which are complex projects with a specialist operation and maintenance regime, such as acute hospitals (GCCC, 2017).

In December 2017 Ireland's National BIM Council published the Roadmap (Figure 1) to Digital Transition for Ireland's Construction Industry 2018-2021 (NBC, 2017). The Roadmap consists of the four parallel pillars of leadership, standards, education and procurement with particular milestones to be achieved for each of the pillars during the programme period 2018-2021. Unfortunately, at the time of writing this paper, no funding has been secured from the Irish government for the implementation of the first three pillars. The procurement process of introducing on a phased basis a BIM mandate for public works projects is on schedule to commence in Q2 2019.

The increased level of interest in BIM in Ireland has been driven primarily by Construction IT Alliance (CitA) in the delivery of specific monthly BIM events, a CitA BIM Gathering International conference in 2013, 2015 and 2017, and its successful CitA Skillnet training funded programme. In early 2016, CitA secured funding for the BIM Innovation Capability Programme for Ireland to capture the current state of readiness of the Irish construction industry to work with BIM. In late 2017 CITA published a BIM in Ireland report (Hore et al., 2017b) which provided a detailed account of the various initiatives and communities of practice advancing BIM in Ireland.

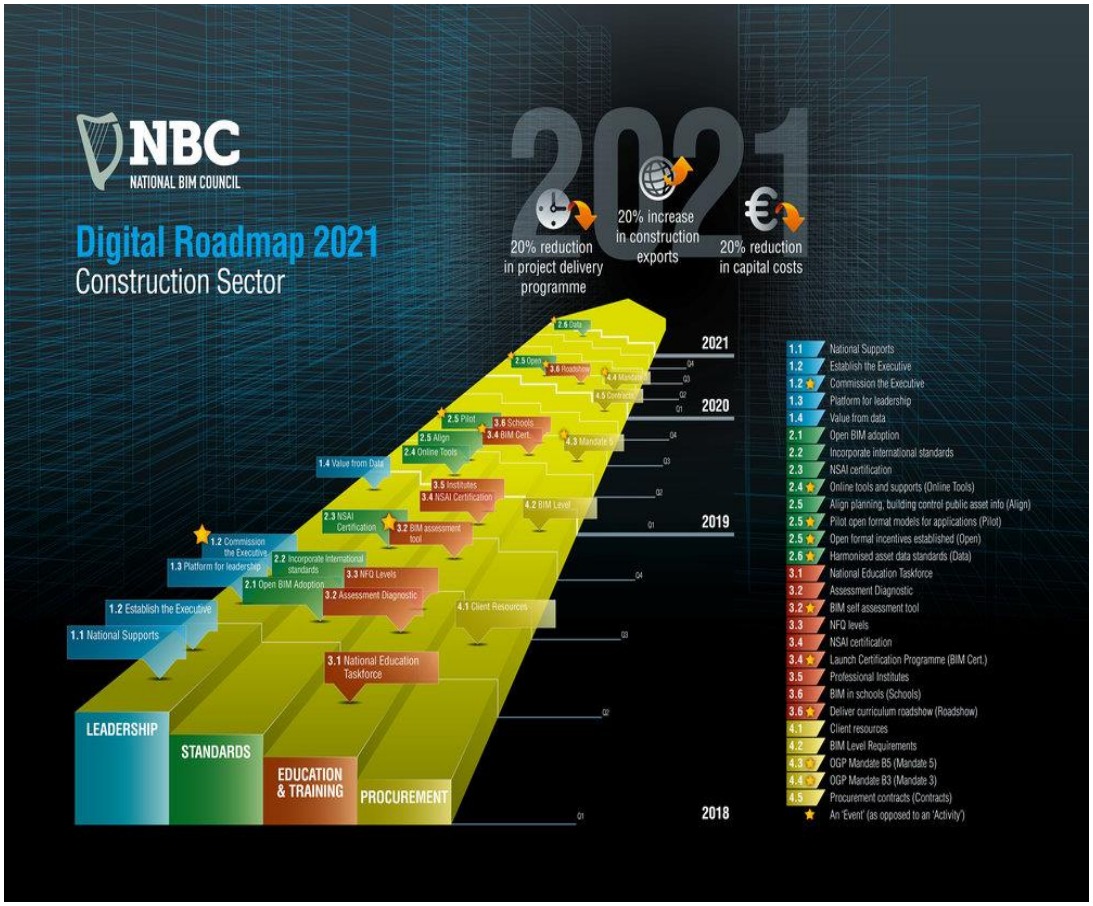

Figure 1. Roadmap to Digital Transition for Ireland's Construction Industry 2018-2021

3. Methodology

This study is undertaken as a Systematic Literature Review (SLR) based on the original guidelines as proposed by Kitchenham (2004) and Budgen and Brereton (2006). In addition, the SLR represents an explicit and reproducible method for collecting and combining existing research knowledge. This literature review can be grouped into three phase: planning, executing and reporting.

3.1 Planning the Review

The first step in the methodology in preparing this paper was to set the primary research questions to be investigated. The fundamental questions that were identified following a review of the contextual literature outlined in the introduction of this paper included:

1. What are the drivers affecting the decision to adopt BIM at government level within the construction industry (RQ1)?

2. What frameworks and models have been adopted by other governments or public sector bodies to support the effective adoption of BIM (RQ2)?

3.2 Executing the Review

This phase aimed to develop a search strategy to identify the relevant studies in support of the two research questions. A range of search terms were chosen from each research questions. A tentative title of 'BIM public sector's drivers and adoption frameworks' was used. Alternative synonyms of search terms and Boolean operators were used to direct the search of database resources. The considered online databases included Scopus, Science Direct, Google Scholar, and Web of Science. The studies utilised inclusion and exclusion criteria to ensure the relevance of both research questions. The first pass search focused on peer-reviewed publications containing these keywords which were published in the past 5 years. A quality checklist (that is, contribution, desktop study, finding, analysis) was devised as part of the quality assessment (QA) process to ensure that the studies selected have adequate methodological rigour. Then the study went through a data collection and data analysis phase in which the data trawling with, information collection cards were used to systematically identify key information from studies, thus ensuring comparability. Finally, the findings of both of the research questions were collated and analysis at data analysis stage.

In the interest of brevity, the processes of filtering, comprising the inclusion and exclusion criteria together with the application of the QA processes, has not been described in this paper.

4. Results

In order to retain the integrity of the findings, the search cross-referenced a number of databases with regards to the two research questions, which initially found 2899 papers. This first set of papers were screened and checked using three stages (as shown in Figure 2). Endnote was used to remove duplicate papers, to check the relevance of titles and abstracts and to check papers with inclusion and exclusion criteria.

The quality score selected 27 papers as being of direct relevance, as listed in Appendix 1. These papers will form the basis of the overall discussion of findings.

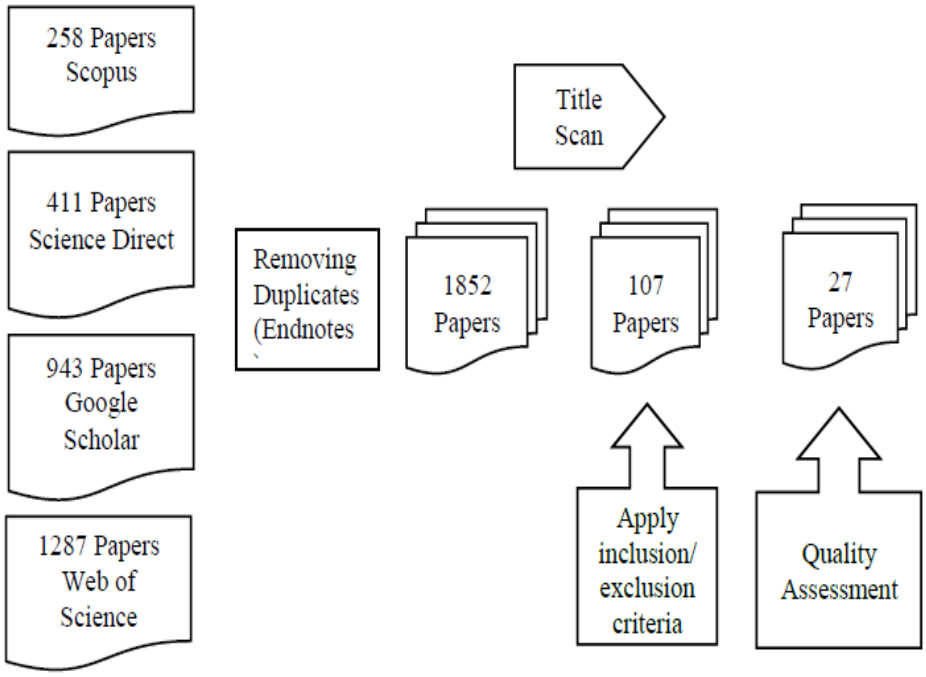

Figure 2. The SLR execution

5 Discussion

5.1 Government Drivers in the Adoption of BIM

Many authors have reported on the beneficial push factors BIM can bring to project stakeholders (Loyola and López, 2018; Bosch-Sijtsema, 2017 and Arunkumar et al., 2018). Some of the push factors include better 3D visualisation, collaboration improvement, reduced time and cost, collision detection, advancement in quality, reduced contingency and conflicts, improved accuracy, reliability of data, energy efficiency, reduced rework during construction, better construction and cost predictability.

Many other authors have reported on the benefits that can be gained by the implementation of BIM by government clients. Over the years there have been many reported pull factors to the use of BIM by governments (Gerges et al., 2017; Memon et al., 2014; Blanco and Chen, 2014; Ghaffarianhoseini et al., 2017). Gerges et al., (2017) focused on the Middle East reporting that their survey found that respondents identified BIM as being a more effective method for designing and managing construction projects by supporting collaboration, improving the quality of the design information and providing a platform, which would facilitate the sharing of information over their entire life cycle.

Nepal et al, (2014) outlined the benefits of and challenges to implementing BIM across different types of projects. They concurred with many other authors that benefits can be realised from BIM implementation across the design, construction, and operational phases of a facility's lifecycle.

Attarzadeh et al., (2015) concluded that successful BIM implementation offers solutions to increase productivity, efficiency and quality and also reduce costs, lead times and rework. The most important benefits of BIM adoption highlighted by the participants of this study were (a) improved coordination between engineering and construction disciplines and (b) the generation of more accurate construction documents in a faster timeframe.

According to a mixture of Iraqi professionals in both the private and public sector, the main benefits of using of BIM in Iraqi construction projects are saving on the cost of the project, providing a high quality and fast data documentation system which minimized change orders (Hatem et al., 2018).

Yang and Chou (2018) carried out a survey focusing on the status of BIM applications within the Taiwan Government to identify the drivers of BIM applications. The results are shown in Figure 3 in which it can be observed that reducing conflicts and changes during construction were the most widely reported benefits. Improved quality and understanding of the design process also featured widely.

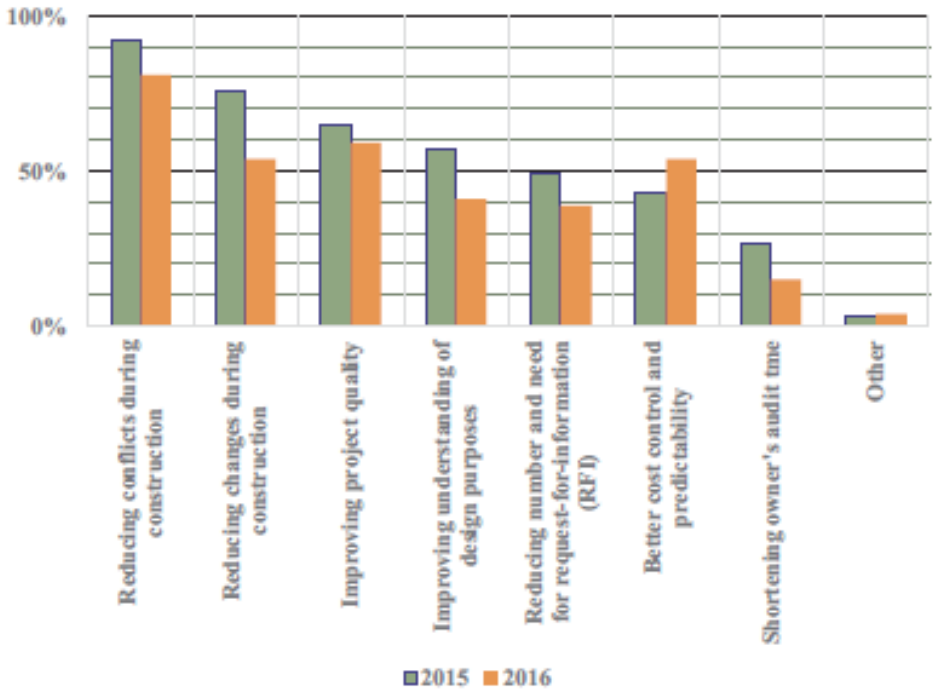

Figure 3. Anticipated BIM implementation benefits (Yang and Chou, 2018, pp. 340)

Government departments are the largest clients of BIM implementation globally and play a major role in supporting and encouraging BIM adoption (Cheng and Lu, 2015). This can be better categorised as pull factors or drivers.

Mamter and Aziz (2016) carried out a comprehensive literature review to identify BIM driven factors in Malaysia. The driven factors identified focused on the experiences of seven countries, namely, United Kingdom, South Korea, Taiwan, Singapore, Hong Kong, New Zealand and Australia. The factors focused on the sub themes of policy, engagement, investment, implementation and education. The key policy pull drivers identified included the use of government enforcement and construction regulations, such as mandates, best practice and government published guidelines.

The key challenge in respect to the many reported benefits associated with working with BIM by government agencies is how to measure these benefits. The Key Performance Indicators (KPIs) identified in Ireland's Roadmap for Digital Transition include a 20% saving in project delivery time, 20% saving in construction costs and a 20% increase in construction exports. One of the key features associated with the formation of a framework to support the effective adoption of BIM in the public sector in Ireland will be to ensure that these three KPIs are robustly measured and monitored through the vehicle of pilot projects.

Government Frameworks to Adopt BIM

Smith (2014) reported on the various initiatives and approaches that are being used in various countries around the world to promote effective BIM implementation. Smith concluded that implementation strategies in North America, the United Kingdom and the Scandinavian region were leading the way globally. A key finding was the importance of coordinated government support and leadership as components of BIM implementation. Other important strategies were found to be the development of national and global BIM standards, legal protocols to address liability issues, BIM certification, education and training and articulating the business case for BIM implementation. It was noted earlier that leadership, standards and education were key pillars in Ireland's BIM Roadmap.

Cheng and Lu (2015) reported on the different kinds of the efforts by governments in encouraging BIM adoption, focusing on four regions - the United States, Europe, Asia, and Australasia. The efforts included establishment of BIM programs and committees, organization of BIM activities and seminars, setting up of different BIM goals and preparation of BIM guidelines and standards.

Cheng and Lu identified six major possible roles of the public sector for BIM adoption (Figure 4), including initiators and drivers; regulators; educators; funding agencies; demonstrators and researchers.

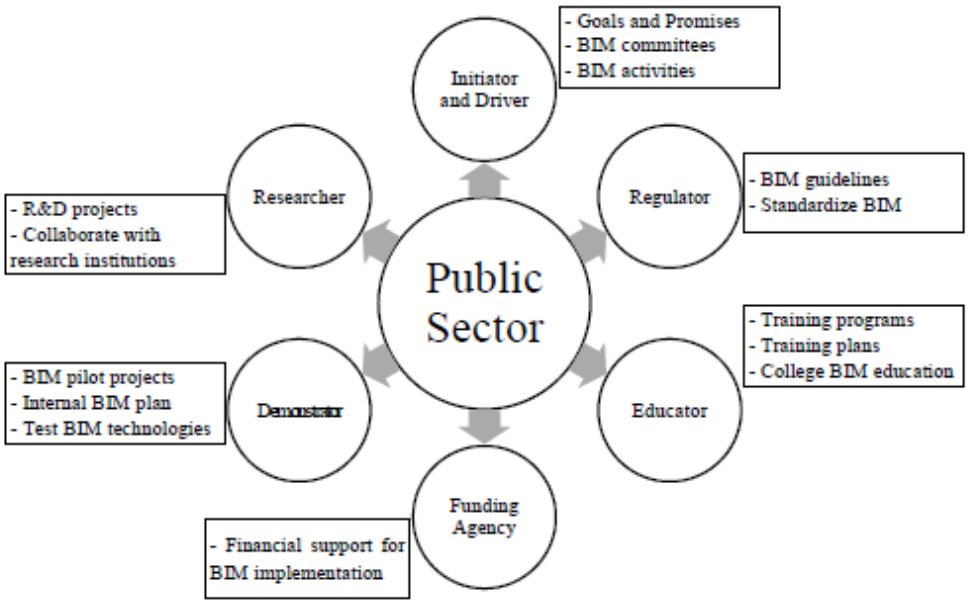

Figure 4. Roles of the public sector for BIM adoption (Cheng and Lu, 2015, pp. 446)

Cheng and Lu reported that the key lessons learned by the Taiwanese Government in respect to the above roles are as follows.

- Initiators and drivers: to mandate BIM implementation.
- Regulators: to publish BIM implementation guides for use.
- Educators: to support universities and institutions in providing BIM training courses and programs.
- Demonstrators: to host BIM conferences to share their experiences.
- Researchers: to conduct research projects to identify obstacles and solutions.

Government frameworks designed to support BIM implementation vary significantly from country to country. Edirisinghe and London (2017) presented international BIM standardization efforts. National standardization efforts and policy initiatives were discussed with the emphasis on pre and post policy BIM adoption. An analysis of countries like the USA, the UK, Singapore, Finland and Norway suggests that the national governance and institutional frameworks influence BIM adoption. The authors recommended that the governments in the countries where BIM is becoming a formal requirement should consider proliferation of national standards and compliance for a wider spread of BIM adoption.

Hadzaman et al. (2015) and Haren et al. (2015) suggested that the strategic analysis elements (that is, capacity, support, and value) should be incorporated in the existing Malaysia's BIM roadmap that contained seven pillars (namely, standards and accreditation, collaboration and incentives; education and awareness, national BIM library, BIM guidelines, special interest groups (SIG); research and development (R&D). Yang and Chou (2018) described how a mixed approach to a government BIM implementation policy was more suited to Taiwan in comparison to a government (for example, as in Singapore) or industry (for example, as in USA) driven approach that is common throughout the world.

The BIM mandate is a clear policy made by a government to be followed by government agencies. BIM mandates are seen as a key component of a macro BIM adoption programme (Succar and Kassem, 2015; Kassem and Succar, 2017).

One of the influential publications in Ireland in respect to the effective adoption of BIM by governments was published by the WEF in 2018. *An Action Plan to Accelerate Building Information Modeling (BIM) Adoption* (WEF, 2018). A BIM Adoption Cycle was presented in this report (Figure 5). The next phase of the author's research work will focus on the application and monitoring of the BIM Adoption Cycle to support Ireland's National BIM roadmap.

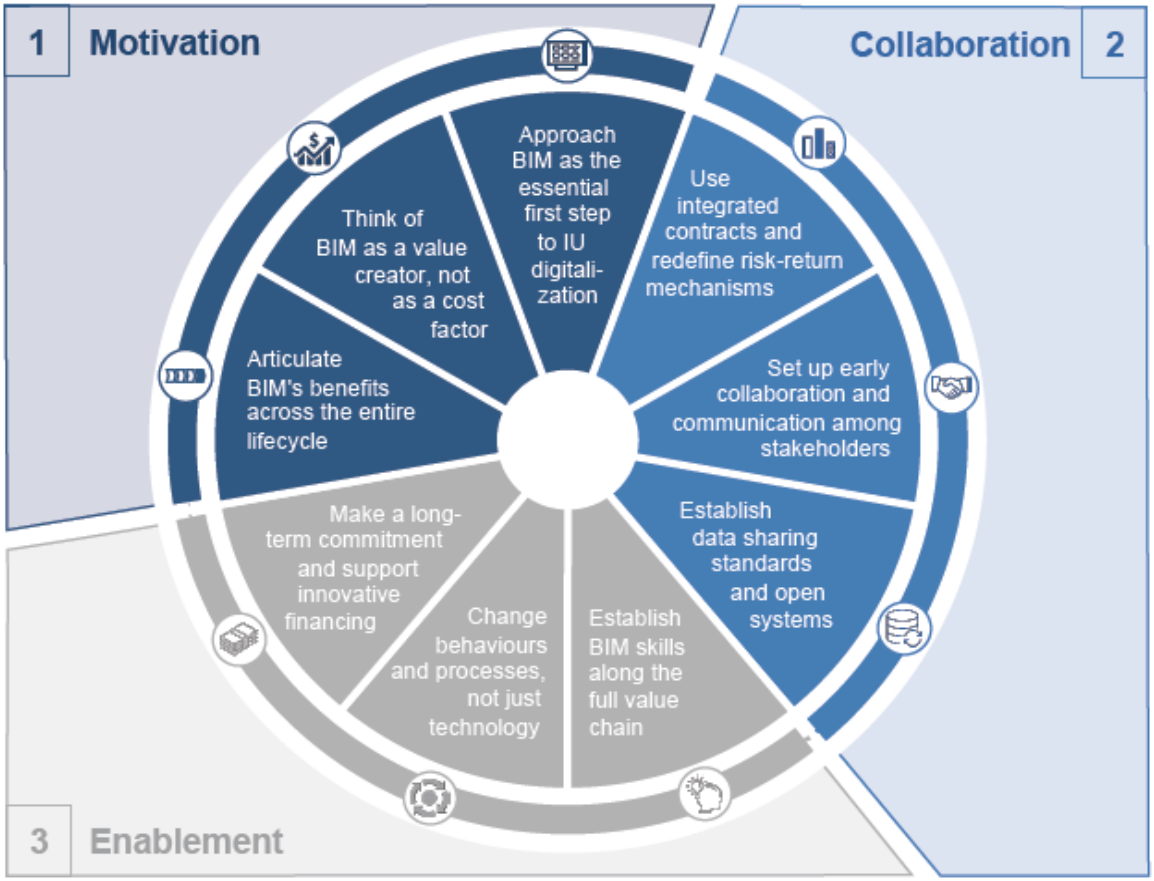

Figure 5. The BIM Adoption Cycle (WEF, 2018 pp. 6)

An additional publication which was very influential in the formulation of the Ireland's BIM Roadmap was the work of the EU BIM Task Group, in which Ireland played an important committee role.

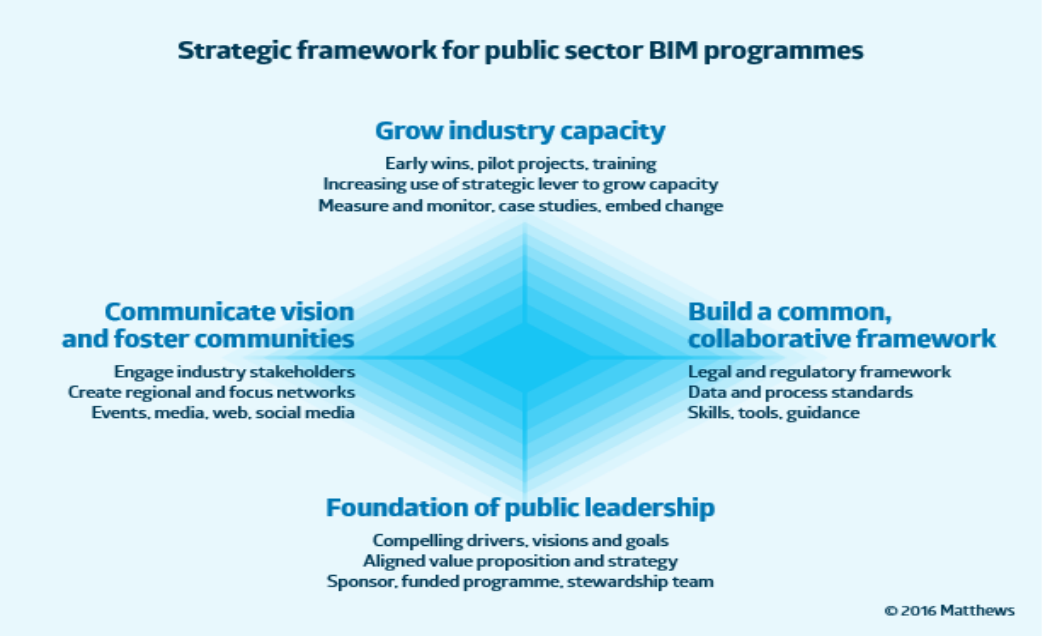

Figure 6. Strategic framework (EU BIM Group 2018, pp. 24)

It can be clearly seen that the established pillars of leadership, standards, education and procurement largely emendated from the strategic framework illustrated in Figure 6.

Other framework themes that currently have synergies with international BIM programmes include:

1. Smart Cities Agenda
2. Sustainable Strategic Development
3. Facilities Management and soft landings.

With the population of urban cities set to double by 2050, the smart city paradigm is increasingly emerging as a revolutionary approach to tackling the challenges posed by modern urbanisation (Andrisano, 2018). Rapid urbanization, aging buildings, increasing heavy vehicular traffic, energy usage, personal safety, and data security are just some of the issues that place serious strains on citizens' quality of life and health as well as on the economical and environmental sustainability of urban cities (Cassandras, 2015; Batty, 2014).

An increasing number of authors in recent years have documented the linkage of BIM to Operations and Maintenance (O & M) (Lu et al., 2018; Gerrish et al., 2017; Gheisari and Irizarry, 2016; Ma et al., 2018; Handayaniputri and Latief, 2018). Lu et al. (2018) concluded that there is still a lack of practical and comprehensive rules when it comes to considering BIM implementation and it relevance at the O&M phase of a project. They suggested that an evaluation framework is needed to assess overall performance of these developed systems, from cost, practical possibilities and convenience aspects. Government building portfolios are significant state assets that require effective and efficient maintenance management, to extend the maintenance life of the building and to optimize its utilization or function. Poor government building maintenance strategies not only cause losses to the state but also harm building users (Handayaniputri and Latief, 2018). Lu et al. (2018) sought to develop a BIM roadmap of the project lifecycle which is designed to enhance the multidisciplinary collaboration.

Governments across the globe are setting ambitious but necessary plans for all new domestic and commercial buildings to be zero carbon rated to combat climate change pressures. There are also sustainability principles that need to be addressed, such as waste and pollution. Alwan (2017) suggests

that these negative impacts result from a variety of causes, including ineffective leadership, ingrained cultures, outdated technologies and poor logistics.
It is important that these three compatible themes remain in focus when developing a framework to support the effective adoption of BIM in the public sector.

6. Conclusion

This paper set out to outline Ireland's journey with BIM in recent years and to showcase the Roadmap to Digital Transition for Ireland's Construction Industry 2018-2021 and how it was influenced by a multitude of international authors and publications. The big leap towards digitization is not yet realised in the Irish construction industry, but there appears to be steady acceptance of the increased use of BIM in Ireland in which progress is mainly confined to larger projects and first tier companies.

The authors presented the outcome of the first phase of a systematic literature review identifying 27 publications that specifically addressed particular research questions. Both push and pull drivers were presented, however, the most difficult challenge facing policy makers is that of measuring the impact of these factors. Governments across the globe are encouraging industry to adopt BIM by use of a variety of frameworks, many of which contain formal mandates. Ireland has been clearly influenced by the introduction of a BIM mandate in the UK Government in 2016 including the formation of the Centre for Digital Built Britain and the funding of their Level 3 BIM initiative. The pillars contained in the Roadmap for Digital Transition of Ireland's Construction industry 2018-2021 reflect a consistency of approach in comparison to other countries investigated.

This paper sought to be an early phase in the development of a framework to support the deployment and evaluation of government policy objectives in Ireland or other countries who are at an early stage of their digital construction transformation programme. The focus of this implementation framework will form the next phase of the author's research.

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Appendix

ID	Authors	RQ1	RQ2	Title
S1	Yang and Chou (2018)	0.50	0.50	Mixed approach to government BIM implementation policy: An empirical study of Taiwan
S2	Kassem and Succar (2017)	0	1.00	Macro BIM adoption: Comparative market analysis
S3	Mamter et al. (2017)	0	0	Stimulating a Sustainable Construction through Holistic BIM Adoption: The Root Causes of Recurring Low BIM Adoption in Malaysia
S4	Ahmed and Kassem (2017)	0	0	A Conceptual Model for Investigating BIM Adoption by Organisations
S5	Mamter and Aziz (2016)	0.50	0	Holistic BIM Adoption and Diffusion in Malaysia
S6	Attarzadeh et al. (2015)	1.00	0	Identifying key factors for building information modelling adoption in Singapore
S7	Succar and Kassem (2015)	0	1.00	Macro-BIM adoption: Conceptual structures
S8	Haron et al. (2015)	0	0.50	An Industrial Report on the Malaysian Building Information Modelling (BIM) Taskforce: Issues and Recommendations
S9	Hadzaman et al. (2015)	0	1.00	BIM roadmap strategic implementation plan: Lesson learnt from Australia, Singapore and Hong Kong
S10	Hatem et al. (2018)	1.00	0	Analysis of the Benefits for Adopting Building Information Modelling (BIM) in Iraq
S11	Enegbuma et al., (2018)	0	0	Preliminary building information modelling adoption model in Malaysia A strategic information technology perspective
S12	Memon et al. (2014)	0.50	0	BIM in Malaysian construction industry: Status, advantages, barriers and strategies to enhance the implementation level
S13	Smith (2014)	0	1.0	BIM Implementation – Global Strategies
S14	McAuley et al. (2014)	0	0	Aligning BIM and Lean Methodologies within Capital Works Management Framework in Ireland
S15	Atkinson et al. (2014)	0	0.50	Government's influence on the implementation of BIM
S16	Nepal et al. (2014)	0.50	0	Evaluations of BIM: Frameworks and Perspectives
S17	Cheng and Lu (2015)	0	0.50	A review of the efforts and roles of the public sector for BIM adoption worldwide
S18	Edirisinghe and London (2015)	0	1.0	Comparative Analysis of International and National Level BIM Standardization Efforts and BIM adoption
S19	Blanco and Chen (2014)	0.50	0	The Implementation of Building Information Modelling in the United Kingdom by the Transport Industry
S20	Wang and Song (2017)	0	0	The relation of perceived benefits and organizational supports to user satisfaction with building information model (BIM)
S21	Ghaffarianhoseini et al. (2017)	0.50	0	Building Information Modelling (BIM) uptake: Clear benefits, understanding its implementation, risks and challenges
S22	Liao and Teo (2017)	0	0	Critical Success Factors for enhancing the Building Information Modelling implementation in building projects in Singapore
S23	Liu et al. (2017)	0	0.50	Review and Prospect of BIM Policy in China
S24	Hore et al. (2017a)	0	1.0	Establishing Lessons for Ireland's BIM Policy Through a Systematic Review of International BIM Programmes
S25	Hore et al. (2017b)	0	1.0	BICP Global BIM Study-Lessons for Ireland's BIM Programme
S26	Ahmed et al. (2017)	0	0	A comprehensive identification and categorisation of drivers, factors, and determinants for BIM adoption: A systematic literature review
S27	Davies et al. (2015)	0	0.50	BIM in Europe: innovation networks in the construction sectors of Sweden, France and the UK