European Commission

European Construction Sector Observatory

Building Information Modelling in the EU construction sector

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1. Digitalisation in the European construction sector

The construction sector and its activities strongly affect the economic, environmental and social development as a whole[1]. In the European Union (hereafter EU) in 2016, the construction sector provided for 18 million jobs, and contributed to almost 9% of GDP[2]. Construction is also a horizontal sector, serving many industries – the sector is, for instance, a major consumer of intermediate products[3] (raw materials, chemicals, and electric equipment, etc.) and services (including banking)[4].

While the construction sector is a key driver of the overall economy, it faces numerous challenges relating to inter alia competitiveness, labour shortage, resource efficiency and especially productivity. In fact, over the past two decades, the labour productivity has grown at around a quarter of the rate in manufacturing (1.0% vs. 3.6% respectively) making the construction sector the poorest performer in terms of productivity[5][6]. This is partly explained by the difficulties of the construction sector to embrace digital innovations that could help improve both productivity and profitability[7].

Digitalisation of the construction sector is increasingly recognised as a potential game changer for the sector, which could contribute significantly to sustainable development and the EU 2020 Strategy[8]. For instance, it is estimated that full-scale digitalisation in non-residential construction would lead to annual global cost savings of EUR 0.6 trillion to EUR 1.0 trillion (13% to 21%) in the engineering and construction phases and EUR 0.3 trillion to EUR 0.4 trillion (10% to 17%) in the operations phase[9].

The European Commission (hereafter EC) has thus supported, promoted and developed several policies and initiatives aiming to foster the digitalisation in the construction sector. These include inter alia the Strategy for the sustainable competitiveness of the construction sector and its enterprises (2012)[10], the EU BIM Task Group[11] and the upcoming EU Digital Construction platform[12]. The digitalisation of the construction sector is also integrated in other policy areas such as the EU directive on Public Procurement (2014), which promotes the use of Building Information Modelling (hereafter BIM) in construction project; or the Digital Entrepreneurship Monitor[13].

As a result, the construction industry in EU Member States (MS hereafter), has gradually adopted digital innovations, with BIM being a frontrunner. However, progress in the EU28 has been heterogeneous, with some countries advancing in digitalisation process faster than others. Northern European countries have led the way in terms of BIM implementation, and are now slowly caught up by Western European countries, finally

1 WEF (2016). Shaping the Future of Construction A Breakthrough in Mindset and Technology http://www3.weforum.org/docs/WEF_Shaping_the_Future_of_Construction_full_report__.pdf

2 EC (2018). Construction. https://ec.europa.eu/growth/sectors/construction_en

3 The OECD defines intermediate products as goods and services consumed as inputs by a process of production, excluding fixed assets. https://stats.oecd.org/glossary/detail.asp?ID=1431

4 WEF (2016). Shaping the Future of Construction A Breakthrough in Mindset and Technology http://www3.weforum.org/docs/WEF_Shaping_the_Future_of_Construction_full_report__.pdf

5 The Economist (2017). The construction industry's productivity problem https://www.economist.com/leaders/2017/08/17/the-construction-industrys-productivity-problem

6 McKinsey (2017). Reinventing construction https://www.mckinsey.com/~/media/McKinsey/Industries/Capital%20Projects%20and%20Infrastructure/Our%20Insights/Reinventing%20construction%20through%20a%20productivity%20revolution/MGI-Reinventing-Construction-Executive-summary.ashx

7 McKinsey (2016). The digital future of construction http://www.globalinfrastructureinitiative.com/sites/default/files/pdf/The-digital-future-of-construction-Oct-2016.pdf

8 EC (2012). Strategy for the sustainable competitiveness of the construction sector and its enterprises https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:52012DC0433

9 BCG (2016). Digital in Engineering and Construction https://www.bcg.com/industries/engineered-products-infrastructure/digital-engineering-construction.aspx

10 EC (2012). Strategy for the sustainable competitiveness of the construction sector and its enterprises. https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2012:0433:FIN:EN:PDF

11 See more information at : http://www.eubim.eu/

12 The European digital platform for construction is intended to serve the purpose of facing the main challenges related to the uptake of digital tools in support of the digital evolution of the sector.

13 See more information at : https://ec.europa.eu/easme/en/tender/36/digital-entrepreneurship-monitor

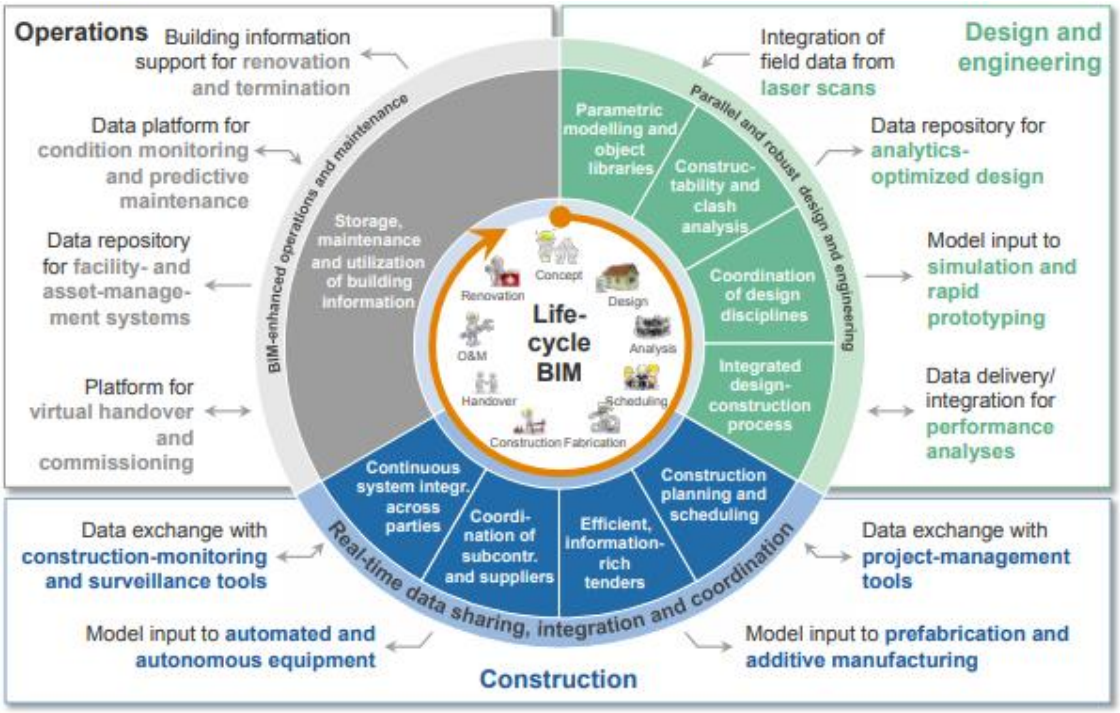
followed by Eastern European countries. However and as importantly, the adoption of BIM by the construction industry remains limited, showing a gap between policy and practice. This may be paradoxical as the industry is in theory the prime beneficiary of digitalisation.

This paper looks at BIM implementation in the EU, analyses the drivers, opportunities, and challenges around its implementation, and draws recommendations for EU policy makers and other relevant actors on how to support and foster the adoption of BIM by the construction industry. For the purpose of this paper, the geographical scope will not cover all EU-28 countries, but rather a representative sample of the groups mentioned above: Denmark will hence represent Northern European countries, France will represent Western European countries, while Poland will represent Eastern European countries.

2. State of play of implementation of BIM in EU Member States

Building information modelling is taking a centre stage in the digital transformation of the construction industry[14][15][16]. It serves as the focal software platform for integrated design, modelling, planning, and collaboration, thereby "*providing all stakeholders with a digital representation of a building's characteristics in its whole lifecycle*"[17]. By supporting a transparent and seamless flow of information between all stakeholders (thus cutting information loss), BIM facilitates their collaboration throughout the different project phases (See Figure 1). In turn, this translates into large efficiency gains, with lower costs, faster delivery with less miscommunications, inaccuracies and delays, growing business opportunities and lower emissions and waste. In fact, 75% of companies adopting BIM reported positive returns on their investment with shorter project life cycles and savings on paperwork and material costs[18]. BIM is of most relevance for large, complex and integrated infrastructure projects, involving a wide range of activities and stakeholders.

Figure 1 Application of BIM along the construction value chain



Source: WEF, 2016.

Today the level of sophistication of BIM also varies from 2D BIM (drawing) to 3D BIM (includes information sharing and the creation of graphical and non-graphical information), 4D BIM (includes time management); 5D BIM (includes cost analysis), 6D BIM (includes sustainability assessment) and finally 7D BIM (management

14 BCG (2016). Digital in Engineering and Construction https://www.bcg.com/industries/engineered-products-infrastructure/digital-engineering-construction.aspx

15 Branthonne (2017). Can the Construction Industry Catch Up on Digitization? http://www.novade.net/construction-industry-digitization/

16 WEF (2016). Shaping the Future of Construction A Breakthrough in Mindset and Technology http://www3.weforum.org/docs/WEF_Shaping_the_Future_of_Construction_full_report__.pdf

17 JRC, (2017). Building Information Modelling (BIM) standardization http://publications.jrc.ec.europa.eu/repository/bitstream/JRC109656/jrc109656_bim.standardization.pdf

18 McKinsey (2016). The digital future of construction http://www.globalinfrastructureinitiative.com/sites/default/files/pdf/The-digital-future-of-construction-Oct-2016.pdf

phase of what has been achieved)[19]. BIM also has different levels of maturity, ranging from one to three, referring essentially to the supply chain's ability to exchange information digitally.

In addition, CEN has adopted officially BIM standards (CEN/TC 442: IFD (ISO 12006-3:2007), IFC (ISO 16739:2013) and IDM (ISO 29481-2:2012), to create a common language when sharing information and an agreed understanding of the information required at the various stages of a project[20][21]. The standardisation process, which is still ongoing, is nevertheless of prime importance in an industry that is fragmented (whether by profession – engineers, architects to manufacturers; or by firms' size with MSMEs representing the highest portion of the sector).

While most stakeholders seem to agree on the importance and relevance of BIM in the construction sector, its adoption by the industry is often limited. The main barriers associated with BIM implementation often relate to interoperability, matching the user's requirements, changing work processes, legal issues and training and creation of new roles and responsibilities[22].

2.1. European BIM Market

The European BIM market was valued at EUR 1.8 billion in 2016[23], and is predicted to grow by 13% to reach EUR 2.1 billion in 2023. This growth is driven by a set of factors:

- **Integrated urban development trends**: the recent increase in the public infrastructure and other renovation projects in Europe, often implying large, complex projects involving a wide range of stakeholders, drives the European BIM market. In addition, recent concepts such as 'Smart Cities' and 'Green Building' emphasise the need for the construction actors to foster resource efficiency and exploit opportunities related to digital transformation.
- **Government policies and initiatives**: An increasing number of EU Member States are implementing (binding and non-binding) policies and initiatives aiming to foster the adoption of BIM in public procurement (see figure 2). These include, inter alia Denmark, Finland, Germany, Lithuania, the Netherlands, United Kingdom (UK hereafter), France and more recently Italy, while other MS are expected to put similar policies in place by 2019[24][25]. The growing pressure on public spending to avoid resource waste is expected to further reinforce this trend.

19 Biblus (2018). BIM dimensions – 3D, 4D, 5D, 6D, 7D BIM explained http://biblus.accasoftware.com/en/bim-dimensions-3d-4d-5d-6d-7d-bim-explained/

20 Kenny (2014). In BIM world, we need standardisation http://www.bimplus.co.uk/people/lafarge-tarmac-seeks-common-language/

21 CoBuilders (2016). What are the BIM standards in the EU? https://cobuilder.com/en/bim-standards-eu/

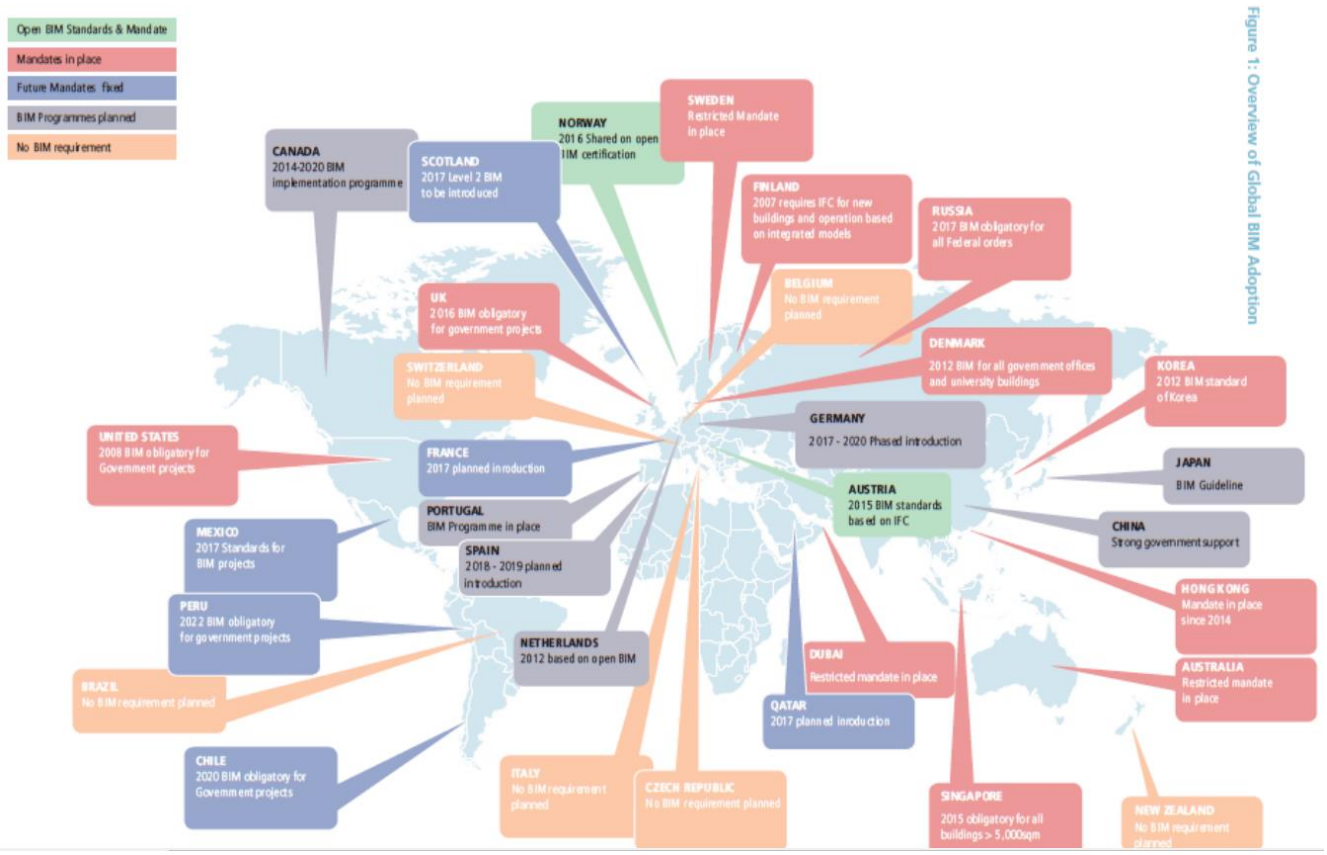
22 Walasek et al.(2017). Analysis of the Adoption Rate of Building Information Modeling and its Return on Investment https://www.researchgate.net/publication/315359204_Analysis_of_the_Adoption_Rate_of_Building_Information_Modeling_BIM_and_its_Return_on_Investment_ROI/fulltext/58cd4b254585157b6dae3ffe/315359204_Analysis_of_the_Adoption_Rate_of_Building_Information_Modeling_BIM_and_its_Return_on_Investment_ROI.pdf?origin=publication_detail

23 Business Wire (2017). Europe Building Information Modeling Market (2017-2023) https://www.businesswire.com/news/home/20171228005373/en/Europe-Building-Information-Modeling-Market-2017-2023-Emphasis

24 Digital Journal (2018). The Europe Building Information Modeling Market will reach $2,436.04 million by 2023. http://www.digitaljournal.com/pr/3793706

25 Silva (2016). Roadmap Proposal for Implementing Building Information Modelling (BIM) in Portugal https://www.scirp.org/journal/PaperInformation.aspx?PaperID=67253

Figure 2 Overview of BIM policies and requirements



Source: EUBIM, 2017[26]

At the same time, the implementation of BIM among European industry players remains limited, impeding the realisation of the potential benefits linked to its adoption (WEF, 2016). In Europe, 29% of construction companies use BIM 3D; while 61% have never used it. The numbers worsen concerning BIM 4D with only 6% of companies implementing it[27]. Companies use BIM mainly for activities relating to spatial coordination to reduce conflicts in the field, visualisation for stakeholder engagement and preparation of preliminary schematic design[28]. The industry identifies the reduction of errors, greater cost predictability and better understanding of the project[29], as the main BIM benefits (in the case of transport infrastructures). BIM is commonly applied for large-scale residential construction projects, and for transport and water infrastructures.

The BIM implementation is fragmented along the value chain, with BIM being mostly used in the design and construction phases, rather than the operations and maintenance phase[30]. Therefore, mainly architects and

26 EUBIM (2017). European Leadership in BIM https://www.ace-cae.eu/fileadmin/New_Upload/1._ACE_Meetings/General_Assembly/Special_Sessions/2017_-_BIM_IN_EUROPE/4._Matthew_EU_BIM_Task_Group_ACE_Dec_2017_--Matthews_v1.pdf

27 Roland Berger (2016). Digitisation in the construction industry. https://ecs.pwc.lu/sites/ECSO/Documents/04.%20Working%20Docs/WP3%20AR%20and%20TP/TP%20Year%201/01.%20Digitalisation/01.%20Library/Roland%20Berger%204.0%20Industry.pdf

28 Mc Graw (2014). The Business Value of BIM for Owners https://i2sl.org/elibrary/documents/Business_Value_of_BIM_for_Owners_SMR_(2014).pdf

29 Deloitte (2017). The Business Value of BIM for Infrastructure 2017 https://www2.deloitte.com/content/dam/Deloitte/us/Documents/finance/us-fas-bim-infrastructure.pdf

30 BCG (2016). Digital in Engineering and Construction https://www.bcg.com/industries/engineered-products-infrastructure/digital-engineering-construction.aspx

general contractors (rather than engineers or trade contractors) use BIM. The case of the UK confirms this trend, with 90% of design teams (architects) using BIM without being requested to do so, in comparison to a mere 25% of trade contractors[31]. Looking forward, 68% of European architecture firms agree that architects failing to provide BIM-compatible information will already fall behind in three years' time. The percentage falls to 30% when it comes to construction firms. This suggests that BIM value and benefits are harder to achieve when it comes to operation and maintenance phase than during the design and construction phases. In fact, BIM is "*an opportunity for architects to gain status and power*", as architects are increasingly contracted to act as BIM-coordinators in projects[32]. Engineering companies adopted BIM to better respond to the increased complexity of projects, and comply with project's owners requirements. This contrasts with operation and maintenance companies, whose exposure of, and interest in, BIM is limited.

BIM implementation is also affected by the market structure and the size of companies. BIM implementation is led by large companies, while SMEs across the value chain have limited BIM experience. In the case of the transport sector, large companies use BIM more commonly than smaller ones, whether they are engineering companies (85% vs. 71% respectively) or contractors (81% vs. 54% respectively). This is partly explained by three factors:

- Larger companies have more capacity and human and economic resources to implement BIM than SMEs
- Larger companies will more likely work on large and complex projects, requiring strong coordination, and making BIM benefits more tangible.
- Larger companies are also more likely to be requested to use BIM than smaller ones.

Some studies also point out the lack of demand from projects' owners, mainly explained by the lack of awareness around BIM benefits (rather than a lack of acceptance), especially at the construction and operations and maintenance stages. In the case of Sweden, project's owners were for example the latest group to support the adoption of BIM[33]. Such observation may be extended to other European countries. That being said, with the emergence of BIM requirements in public procurement, the (public and private sector) demand is also slowly shifting towards more BIM requests.

31 Mc Graw (2014). The Business Value of BIM for Owners https://i2sl.org/elibrary/documents/Business_Value_of_BIM_for_Owners_SMR_(2014).pdf

32 Davies et al. (2015). BIM in Europe: innovation networks in the construction sectors of Sweden, France and the UK http://centaur.reading.ac.uk/67468/

33 Davies et al. (2015). BIM in Europe: innovation networks in the construction sectors of Sweden, France and the UK http://centaur.reading.ac.uk/67468/

3. Policies and instruments to foster digitalisation

This section looks at BIM implementation in the context of Denmark, France and Poland. These country case studies will present the state of play of BIM in each of the countries, and illustrate some of the key challenges and opportunities the public sector and the industry face when supporting BIM implementation. The objective is to highlight some of the factors and actors explaining the success (or the failure) of BIM implementation initiatives.

This section is divided into three sub-sections: the first one will present the state of play of BIM implementation in Denmark, France and Poland. The second will introduce the policies and instruments put in place by the government in each of the three countries to foster BIM implementation; while the third sub-section will look at the industry's initiatives supporting BIM adoption.

3.1. State of play of BIM implementation

Denmark has put in place BIM-requirements in its public procurement law since 2007. With over a decade of experience, Denmark has become one of the European leaders in terms of BIM implementation. In 2016, 78% of Danish design companies were aware of BIM and used it to produce 3D visualisation, carry out performance analysis on BIM and perform clash detection. Over 30% have passed on models to those responsible for the Facility Management of buildings, showing that BIM implementation also concerns operation and maintenance phases of construction (and not only the design phase).

While the public procurement law was the main driver for BIM implementation, the Danish construction industry has been increasingly impacting its development[34]. In fact, over 65% of companies that use BIM, expect to use it for all projects during the next five years[35][36]. This is driven by several perceived benefits:

- 84% of companies believe that BIM can create value on the construction site;
- 79% that BIM is about collaboration and cooperation across all parties;
- 31% that BIM is necessary to create a sustainable environment.

In France, BIM implementation has progressed significantly, especially with the introduction of the plan for the digital transition in the building Industry (PTNB) in 2015 - a strategic plan meant to boost BIM implementation. The BIM adoption rate reached 38% in France in 2017, while BIM awareness among businesses in building and real estate sectors raised from 22% to 35% between 2016 and 2017. In addition, 26% of construction projects' owners started imposing BIM on construction projects, although only 12% actually require a digital model[37]. In practice, this led to the building of 500,000 houses, using BIM, in 2017[38].

France is the only country where the rate of adoption by engineers (44%) is slightly ahead of the architects' (40%)[39]. This is partly explained by the market structure of the French construction industry, where the architecture segment is mostly composed of SMEs, while the engineering segment is characterised by large companies. These have larger capacities and seek to seize business development opportunities through BIM implementation (Davies et al., 2015).

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34 Interview with Danish construction company

35 NBS (2016). International BIM Report 2016 https://bauen-digital.ch/assets/Downloads/de/1603-NBS-International-BIM-Report.pdf

36 BIPS (2014). BIM Survey 2014. https://bips.dk/files/news_files/bim_survey_2014_r0.pdf

37 Galiano-Garrigos et al. (2018). Building Information Modelling (BIM) in Design, Construction and Operations II. https://books.google.lu/books?id=SzozDwAAQBAJ&pg=PA137&lpg=PA137&dq=France,+with+38%25+adoption,+is+the+only+country+where+the+rate+of+adoption+of+engineers+(44%25)+is+slightly+ahead+of+architects+(40%25)+&source=bl&ots=5fIvLgWtfb&sig=7HqaG6M7V03MJ8eu05QAXfWVYKc&hl=en&sa=X&ved=2ahUKEwjB8tCq8LfdAhWEI1AKHTYFBBAQ6AEwAnoECAgQAQ#v=onepage&q=France%2C%20with%2038%25%20adoption%2C%20is%20the%20only%20country%20where%20the%20rate%20of%20adoption%20of%20engineers%20(44%25)%20is%20slightly%20ahead%20of%20architects%20(40%25)&f=false

38 Cupastone (2018). Current state of BIM in the major countries of the world https://cupastone.com/bim-countries-world/

39 Trace (2017). The BIM Revolution: French Insights http://www.trace-software.com/blog/the-bim-revolution-french-insights/

Poland is at an early stage of BIM adoption. The Polish government has recently introduced policies and instruments supporting BIM implementation in its construction industry. The BIM adoption rate is relatively low, with only 12% of construction companies using BIM in their daily work. They do so mainly for activities relating to visualization, 3D models, and to a lesser extent for collision detection and use of schedules or optimization[40]. This low adoption rate is partly explained by the lack of knowledge, the absence of (systematic) BIM requirements in public procurement law[41], and the high cost of BIM initial implementation[42].

However, BIM implementation in the Polish market has a strong potential with the Polish construction market partly driven by the new construction (rather than renovation works). Other sectoral factors such as labour shortage, and external factors such as increasing price of materials and external competition, may push the Polish construction industry to implement BIM.

In conclusion, the Danish construction industry shows the highest BIM adoption rate, following its early engagement and the government support. Businesses currently drive BIM implementation, which is now reaching all stages of the value chains, including the operations and maintenance one (though BIM implementation rates remain much lower than in design and engineering phases). **The French case seems to indicate that the market structure of the construction sector also shape and influence BIM implementation**. Large companies seem to be the key drivers behind the high BIM implementation rate of engineering companies.

3.2. BIM policies and instruments

This section will provide examples of BIM policies and instruments initiated by the Danish, French and Polish government to boost BIM adoption among the industry. In doing so, we will highlight some of the underlying challenges and opportunities around their implementation. Most of the policies and instruments can be divided into the following policy areas: public procurement; education, research and development; and standardisation.

3.2.1. Public procurement

As part of its public procurement law, the Danish government published the regulation 1365, adopted in 2007 (extended in 2011 with the ICT regulation 1381, and in 2013 with the ICT regulations 118 and 119). These regulations aim to foster the integration of ICT in the construction sector, thus boosting its productivity. In practice, it required the use of BIM for public sector renovation projects since the 1st of January 2008 and for state supported social housing projects since the 1st of January 2009. Since June 2011, the Danish Parliament extended the mandatory adoption of BIM to all local and regional projects worth over EUR 2.7 million, while central government projects had a lower threshold of EUR 677,000[43]. Since April 2013, BIM has been mandatory in national, regional, municipal projects, including those on social housing[44]. The Danish government involved the academia and the industry in the preparation of the regulations, through consultations and pilot projects. This helped ensure that BIM requirements are in line with and relevant for the industry, which can then play a key role in BIM implementation.

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40 Juszczyk et al. (2015). Prospects for the use of BIM in Poland and the Czech_Republic https://www.researchgate.net/publication/284096482_Prospects_for_the_use_of_BIM_in_Poland_and_the_Czech_Republic_-_Preliminary_Research_Results

41 The demand for BIM remains fairly low, with only 10% of companies implementing BIM because they were requested to do so by the project's owners41 (Antal, 2017). BIM requirements in its public procurement law is not applied on a systematic basis – more details in the section on Polish government's policies and instruments.

42 Juszczyk et al. (2015). Prospects for the use of BIM in Poland and the Czech_Republic https://www.researchgate.net/publication/284096482_Prospects_for_the_use_of_BIM_in_Poland_and_the_Czech_Republic_-_Preliminary_Research_Results

43 CITA (2017). Global BIM Study https://issuu.com/constructionitalliance/docs/global_bim_study_bicp

44 BIPS (2014). BIM Survey 2014. https://bips.dk/files/news_files/bim_survey_2014_r0.pdf

The French government followed a different path, opting for a non-binding approach with the publication of the 2015 Plan for the digital transition in the building Industry (PTNB, hereafter the Plan). By not imposing BIM requirement in its public procurement law, the French government wanted to avoid excluding SMEs (with limited capacities to implement BIM) from accessing public procurement opportunities in the short-term[45]. The Plan aims to foster the use of BIM in the construction sector instrument, with a view to achieve sustainability and reduce construction costs. It also responds to the needs of the construction industry to build and renovate cheaper and faster. The Plan includes a budget of EUR 20 million from the Building Insurance Compensation Fund (Fonds de Compensation de l'Assurance Construction) to foster its implementation. This Plan has been established for 3 years and applies to all construction enterprises operating in France.

The Polish government followed a binding but flexible approach in regards with BIM implementation. An amendment to the public procurement law was published in 2016, stating, that "*in the case of construction contracts, the contracting authority may require the use of electronic data modelling tools or similar tools. In this case, the project's owner needs to make the access to such tools available until such tool becomes publicly available*"[46]. Therefore, the Polish government does not require BIM on a systematic basis, contrary to the Danish government. Since the publication of the amendment, the Polish government (including its agencies) have published two tenders including BIM aspects in 2017. The Generalna Dyrekcja Dróg Krajowych i Autostrad (GDDKiA) – the National Agency for Motorways - is launching pilot projects where BIM use is required for the development of the Zatory bypass on national roads DK28 and DK44. The Polskie Koleje Państwowe (PKP) - Polish State Railways - is consulting with industry for the use BIM on national rail infrastructure works[47].

While the governments in each of the three countries follow a different approach in terms of including BIM requirements in public procurement, they all played a key role in driving the early stages of BIM implementation. Whether binding or non-binding, BIM implementation accelerated significantly when the governments demonstrated their interest and willingness to have the construction industry implement BIM.

The way governments included (or not) BIM requirements in their public procurement law reflect their concerns and interests, and sometimes those of the industry. The Danish government made space for the industry to provide inputs on the regulation 1365, and was hence comfortable with imposing BIM on a systematic basis in part of their public procurement activities (it started with social housing and renovation projects, before being extended to all public procurement projects). The French government adopted a non-binding approach to give SMEs (which represents the majority of construction companies) an opportunity to implement BIM gradually, and avoid having their public procurement projects captured by large construction companies.

3.2.2. Education, research and development

The Danish government supported BIM implementation by investing heavily in research and development[48]. To support BIM adoption, Byggeri Informationsteknologi Produktivitet Samarbejde (BIPS) - the Construction Information Technology Productivity Association - published several standards to support the development of digital constructions, which include the Danish Building Classification System and 3D Working Method

[45] Ordre des architectes (2018). Les cahiers de la profession 61. https://www.architectes.org/sites/default/files/atoms/files/cdp-n61.pdf

[46] RICS (2018). Implementing BIM in Poland http://bpcc.org.pl/uploads/ckeditor/attachments/13516/20181001_RICS_BPCC_BIM.pdf

[47] Europtima (2018). A compelling case for bim adoption in poland http://www.europtima-cee.com/en/index.php/a-compelling-case-for-bim-adoption-in-poland-iain-leydens-article-for-contact-magazine/

[48] Smith (2014). BIM implementation – global strategies. https://core.ac.uk/download/pdf/82420605.pdf

guidelines[49][50][51]. In addition, a number of universities, such as Aalborg University, Aarhus School of Architecture and the Technical University of Denmark, provide courses in the area of interoperability and 3D modelling.

In France, the government has also been active in terms of promoting education, research and development around BIM. The KROQI is a collaborative platform launched in 2018 as part of the PNTB, to help build SMEs' BIM capacities. The KROQI offers free BIM mock-ups, and access to tools supporting BIM processes and collaborations such as platforms for BIM models sharing, visualisation and checking[52]. Another initiative (outside of the PNTB) supported by the French government is the **EduBIM**, a network of BIM teachers, trainers and researchers, collaborating with the industry and in charge of supporting BIM implementation through research and new learning methods. This includes several universities, such as Ecole des Ponts ParisTech, École Spéciale des Travaux Publics or Ecole Superieure d'Architecture de Marseille.

The Polish government also invested in BIM education, training and awareness raising. Some universities such as the Warsaw University of Technology developed courses relating to BIM ("Implementation of BIM in Structural Design" and "BIM in Digital Construction"). The courses have become one of the most highly ranked courses[53]. The aim of the courses is to demonstrate the BIM process and how it is realised in a practical way.

These investments in education research and development are a sine qua non condition for the implementation of BIM, as shown in the case of Denmark[54]. They addresses potential BIM related skill shortage; help companies put in place BIM processes thus alleviating some of the costs linked to BIM implementation; and help shifting the construction mindset towards innovation adoption.

3.2.3. BIM standardisation

The Danish government took the lead in the development of BIM standards, with a view to also influence international (including EU) BIM standards. This initiative was referred to as the **Cuneco initiative**. The Cuneco team hence develops, tests and implements common BIM standards (for the Danish construction industry) for enhanced exchange of data throughout the whole construction value chain.

In France, the government also played a key role in the BIM standardisation process, with the standardisation roadmap (2017) published as part of the Plan. This roadmap aims to i) share experience and lessons learnt to foster BIM awareness and use; ii) elaborate trainings and tools adapted to SMEs; and iii) improve information exchange processes and build the framework for facilitating reliable data exchanges throughout the life cycle of built asset[55]. Finally, the French government also helps the BIM standardisation process, through its financial support to the construction industry's initiative 'Modélisation des INformations INteropérables pour les INfrastructues Durables project' (MINND) - Modeling of Interoperable INformation for Sustainable INfrastructures. The latter aims to develop a global model based on the use of BIM tools and processes, including geometric data in a complete information system.

The Polish government is less active in the field of BIM standardisation, as it only recently engaged in BIM implementation. However, the Polish government is part of the EU BIM Task Group (as Denmark and France). The latter aims to bring together national efforts into a common and aligned European approach to develop a world-class digital construction sector. To do so, it focuses on four pillars: grow capability and industry

49 These include (Byggestyrelsen, 3D CAD Manual 2006; Byggestyrelsen, 3D Working Method 2006; Byggestyrelsen 3D CAD Project Agreement 2006; Byggestyrelsen Layer and Object Structures 2006)

50 CITA (2017). Global BIM Study https://issuu.com/constructionitalliance/docs/global_bim_study_bicp

51 Cheng (2015). A review of the efforts and roles of the public sector for bim adoption worldwide https://www.itcon.org/papers/2015_27.content.01088.pdf

52 KROQI (2018). PLATEFORME PUBLIQUE AU SERVICE DES TPE/PME DE LA CONSTRUCTION https://www.kroqi.fr/static/docs/KROQI_fiche_presentation_juillet_2018.pdf

53 Allplan (2018). Winners of the Students' BIM Competition in Poland https://blog.allplan.com/en/bim-competition-in-poland

54 Smith (2014). BIM implementation – global strategies https://core.ac.uk/download/pdf/82420605.pdf

55 CoBuilder (2017). BIM Standardisation Roadmap for the French Construction Industry – Part 1 https://cobuilder.com/en/bim-standardisation-roadmap-french-construction-industry-part-1/

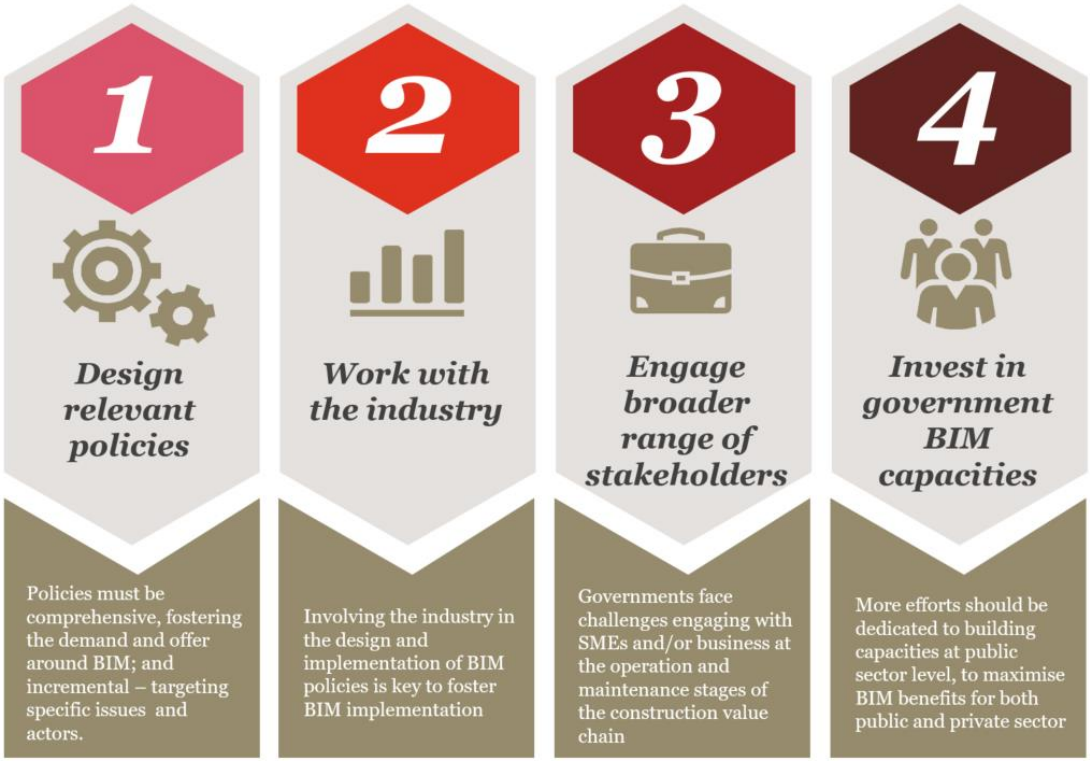
capacity, build common collaborative framework and foundation for public leadership, and communicate vision and foster communities[56]. A concrete example of such collaboration is the recently published handbook on the introduction of BIM by the European Public Sector. The latter provides recommendations about how the public sector can foster BIM implementation.

Governments play a key role in BIM standardisation, whether at the domestic or international level. By influencing BIM standards at the European and/or international level, governments have the opportunity to ensure that BIM standards match their industry's interests and ambition. This in turn can generate more interest from domestic construction industry to engage in BIM.

3.2.4. Lessons learnt

Through their policies and initiatives, governments played a central role in starting the BIM implementation process. In doing so they play a leadership role, driving the process around BIM implementation. At the same time, governments also facilitated and stimulated industry initiatives, which is of prime importance to ensure the construction industry ownership and buy-in to the BIM implementation process. This was the case in France with the government support to the MINND project. The Danish government also play a supportive role, with the Danish construction industry driving BIM implementation. Some of the key lessons learnt are presented below.

Figure 3 Key lessons from policies and initiatives



Source: PwC analysis

Government policies and initiatives aiming to foster BIM implementation are comprehensive, including public procurement, education and development, and standardisation. By doing so, governments are combining a top down and bottom-up approach: on the one hand they adopted public procurement amendments/regulations requiring BIM for public infrastructure projects. On the other hand, they provided downstream investments to foster research and development around BIM, which come to support companies'

[56] EUBIM (2018). http://www.eubim.eu/about-the-eu-bim-task-group/

efforts to implement it. This way, governments managed to ensure a balance between additional requirements and incentives for the industry

While governments' support may be comprehensive, the governments adopted an incremental approach towards BIM implementation. For instance, the Danish regulation on public procurement required BIM first for social housing and renovation project, before extended to all local, regional and national projects. In Poland, the government started with a sub sector (transport infrastructures and particularly road and rails) to experiment BIM pilot projects. BIM may benefit from more traction in this sub-sector, therefore generating interest from industry. This is key as the BIM implementation ultimately relies on industry's buy-in and demand.

Effective implementation of BIM requires governments and the industry to work together. For instance, the Danish government engaged early on with the industry to design its BIM requirement in its public procurement law; the French government proves to be responsive toward the private sector concerns and needs, which were integrated in the PTNB. This contrasts with Poland, where there seems to be limited exchange between the industry and the public sector, beyond general BIM workshops and seminars.

However, governments faced more difficulties engaging SMEs and the businesses in the operation and maintenance stages of the construction value chain. In Denmark, when the regulations were implemented, different set of actors came on board sequentially – first the architects, then the contractors, which took another three to four years to come on-board with BIM[57]. Today, BIM execution plans often do not provide for the data required by the contractors on projects, also impeding the multi stakeholder collaboration and information sharing[58]. This issue has become less common in recent years, with contractors adopting BIM slowly (whether they are now convinced from its benefits, or whether they follow the lead of major international constructors). In France, the Plan ran the risk to leave SMEs (who have limited financial and human resources) behind, thus increasing the technological/financial gap between SMEs and large companies. Some French SMEs reported their reluctance to upskill their workforce with BIM training, fearing that employees will later join bigger companies[59]. In the cases of France and Poland, the government had limited success in engaging and fostering private sector demand for BIM construction projects, which remained rather low[60].

Finally, in parallel with the development and promotion of policies fostering BIM implementation, it is important for governments to invest in their own BIM capacities. For instance, the Polish government seems to show limited awareness of BIM benefits. According to RICS[61], BIM implementation barriers from public authorities' perspective include:

- additional cost can exceed additional value;
- limited proof of value for BIM;
- SMEs can be marginalized during tenders;

In Denmark, while BIM benefits at the design and engineering stages are well-understood, public authorities seem to be less aware of the BIM benefits relating to the operations and maintenance. The EU BIM Task Group, which is supported by the European Commission, partly addressed this issue. In particular, it supports the common use of BIM, as 'digital construction', in public works with the common aim of improving value for public money, quality of the public estate and for the sustainable competitiveness of industry.

57 Bimplus (2016). A BIM mandate lesson from Denmark http://www.bimplus.co.uk/people/bim-ma4ndate-lesso4n-den7mark/

58 MTHojgaard (2018). Closing the gap with VDC and early involvement. http://mth.dk/-/media/MTH/Viden/Publikationer/Whitepapers/Opdaterede-whitepapers-aug-2018/Closing-the-gap-with-VDC-and-early-involvement_August2018.pdf

59 Batiactu (2016). Il faudra former 80.000 salariés au BIM d'ici à 2020, selon Syntec-Ingénierie https://www.batiactu.com/edito/il-faudra-former-80000-salaries-au-bim-ici-a-2020-selon-46393.php

60 NBS (2016). International BIM Report 2016 https://bauen-digital.ch/assets/Downloads/de/1603-NBS-International-BIM-Report.pdf

61 RICS (2018). Implementing BIM in Poland http://bpcc.org.pl/uploads/ckeditor/attachments/13516/20181001_RICS_BPCC_BIM.pdf

3.3. BIM industry initiatives

This section will provide examples of BIM industry initiatives initiated in Denmark, France and Poland to boost BIM adoption among the industry. In doing so, we will highlight some of the underlying challenges and opportunities around their implementation. Industry initiatives will be divided into the following categories: BIM capacity building and awareness raising, and establishment of BIM guidelines and standards.

3.3.1. BIM capacity building and awareness raising

In Denmark, the Dansk Byggeri (Danish Construction Association) implements BIM educational programme to facilitate BIM implementation among construction companies. It offers three courses relating to BIM: Effective amount calculation with BIM; Quick and efficient quality assurance with digital tools; Learn how to handle the advisor's 3D material. These one day (or half-a-day) courses target mainly architectural and engineering professions.

In France, the Federation Française du Batiment (FFB) has also developed several tools to mainstream BIM in construction projects. FFB conceived a specific website dedicated to BIM[62], which features videos explaining what BIM is about, how to implement it and some interviews from BIM implementers. The Federation Nationale des Travaux publics (FNTP) is also active, proposing companies BIM trainings such as the Public work BIM Passport course. This course includes 30 days of e-learning and workshops gathering the course participants (construction companies) to exchange and share their insights. In addition, Bouygues travaux public, Eiffage tp, FNTP, NGE, Spie Batignolles and Vinci Construction came together to start the MINND project in 2014 (still ongoing). This project involves 60 partners from the industry, academia, engineering companies, software publishers and project's owners. It aims to enhancing BIM capabilities for infrastructure modelling and management. This research project specifically targets four thematic:

- **Uses and Change management** to identify recommendations for the improvement of tools, of technology and processes;
- **Use Case – Experimentation** to undertake trials of tools, of methods and processes on some real use cases;
- **Information Structure** to lead to functional specifications to describe the data model needed to specify data attributes, handle them, share them, and store them in a sustainable way; and
- **Proposals to adapt the regulations** to prepare proposals for changing texts, and help guide the drafting of contracts between project stakeholders.

The Polish construction industry contributed to the creation of two main initiatives: one set up in 2017 (BuildingSMART Polska) and the other in 2018 (BIM standard PL project). While these contribute through events and workshops to raise awareness about BIM among the Polish industry, their focus is on BIM standards, as described below. In parallel with these initiatives, international events aiming to facilitate the connection between British and Finnish construction businesses and Polish businesses were organised, to facilitate BIM knowledge and expertise transfer. For instance, the Polish Chamber of Commerce and the British Embassy in Warsaw organised a conference aimed at senior decision-makers in public and private sector construction and infrastructure to discuss British experience in the implementation of Building Information Modelling (BIM). Likewise, the Business Finland's Energy Growth/Smart Construction program arranged meetings in April 2018 in Warsaw, to facilitate relationships between Finnish companies and major players on the local construction market.

[62] www.ffbim.fr

In conclusion, business initiatives play a key role in facilitating BIM implementation among the industry. Their roles are at least threefold. First they help understand what BIM is about (including its benefits), and what it means in practice (shift in terms of business processes). Second, they allow connecting companies, thus creating a network of BIM practitioners, which can develop over the years and influence BIM implementation domestically but also internationally. Third, they give construction companies a stronger leverage, when it comes to influencing national construction policy development.

3.3.2. Establishment of BIM guidelines and standards

Several industry's initiatives focus on establishing BIM guidelines and standards, at the domestic and sometimes international level. In Denmark, seven leading operators in the Danish construction sector started the Digital Convergence (DiKon), which is a business platform, aiming to implement and disseminate common IT standards in the entire Danish construction sector. DiKon published several non-binding guidelines, including the DiKon's Delivery Specification, the DiKon's Building Parts Specifications or the Structuring of tender materials, to support companies implementing BIM (throughout e.g. a common understanding of standards), allowing them to access public procurement tenders. DiKon also developed standards based on open standards and publications from Molio (former BIPS – government body) and Building Smart[63]. Vice versa, Molio recently used the component specifications developed by DiKon[64]. This demonstrates a strong coordination and cooperation between the public and the industry.

In France, BuildingSMART – Media Construct plays a key role in BIM standardisation. This association focuses on supporting the digitalisation of the construction sector, by supporting the construction industry to develop and mainstream common construction standards. In turn, this should contribute to the interoperability of the sector. Building SMART – Media Construct members include other construction professional associations and the construction industry (from architects, to engineers, constructors and software publishers). The association dedicated a specific working group to BIM standardisation, which capitalises information and resources available to foster interoperability and exchange experience and knowledge around standards application. This led to the creation of the BIM standards website in 2018. In addition, the association closely collaborates with the French government on BIM standardization process.

The Polish construction industry has set up BIM standardisation initiatives, such as the buildingSMART Polska (2017). Hochtief Polska, WARBUD, Mostostal Warszawa, Electra M&E Polska, MOTA-ENGIL and ENGIE Technika Instalacyjna established this initiative, with a view to foster the integration of BIM in the sector, and contribute to its development at the domestic and international level. In addition, the Polish Construction Association together with the Polish Association of Construction Engineers and Technicians launched the BIM Standard PL project in February 2018, to develop BIM standards and facilitate the industry's collaboration. The participants of BIM Standards PL appreciate the BIM potential when it comes to manage complex projects, complete them in time, but also cope with raw material price increase and labour shortage. This association involves the Polish Association of Construction Employers (representing 92 construction stakeholders including 6 associations), and the Polish Association of Civil Engineers and Technicians. These initiatives are recent, thus providing limited information is available on their activities and impacts.

The construction industry dedicates particular attention and efforts to the issue of BIM standardisation, as this issue may generate further business opportunities (or constraints). Most of them include major construction players and associations as their members, thus helping generating traction for a collective approach (rather than individual player generating their own standards). To influence policy development at the domestic and international level, the industry initiatives often involve the public sector. The case of Denmark provides interesting insights on how public and industry can work together and coordinate, thus

63 Proactively facilitate with key leaders the active use and promulgation of open data standards enabling civil infrastructure and building asset data and life-cycle processes to be seamlessly integrated, improving the value achieved from investments in the built environment and enhancing opportunities for growth.

64 DiKon (2018). www.dikon.info/en/

building synergies between their respective initiatives and fostering the BIM standardisation process at national level.

3.3.3. Lessons Learnt

Some insights and lessons learnt can be drawn from the industry initiatives aiming to foster BIM implementation in Denmark, France and Poland. These are summed up in three points, as presented in the figure below.

Figure 4 Lessons learnt from industry initiatives

Source: PwC analysis

Industry's initiatives play an important role in the BIM implementation process, providing construction businesses (from project's owners to architects, engineers and constructors) with relevant support and incentives. By helping the industry build BIM capacities through courses and trainings; knowledge and experience sharing; and workshops, industry initiatives offset some of the costs relating to BIM implementation. In some cases, the support provided also helped construction companies to exploit new business opportunities. This was the case of DiKon and its guidelines on Structuring of tender materials, which help enterprises (including SMEs) in accessing public procurement opportunities.

Industry initiatives also allow the construction industry to speak with one voice, which helps the industry as a whole to influence policy-making in the construction sector. This element is of prime importance in view of the fragmentation of the construction sector, which is mostly composed of SMEs. Large companies seem to be playing an important role in industry's initiatives by influencing other construction companies to join the initiative and/or implement some of the guidelines and tools they helped shaping, as in the case of Denmark.

Industry initiatives are more effective when they are aligned and coordinated with public sector policies and instruments. This is well illustrated by the case of Denmark: the government developed the BIM standards, which then served as a basis for DiKon's guidelines and component specifications. In turn, the government used DiKon's component specification to develop other tools and guidelines. By doing so public and private stakeholders acted in a coherent fashion, avoid reinventing the wheel, and maximising the use of their resources.

4. Key insights

4.1. Public and private sector differentiated roles and coordination

Public and private sector actors play a different (but complementary) role in fostering BIM implementation in the construction sector. As described in the case studies, the public sector support towards BIM implementation is a major driving force behind the use of BIM, and is often translating by the following activities and investments:

1. **The public sector contributes to the development of definition and guidelines around BIM processes, thus fostering a common BIM understanding and standardisation at the national level.** Indeed, if only led by the industry, there would be non-uniformities in the nationwide implementation of BIM, as each market stakeholder would implement its own BIM system. The example of Denmark showed a clear lead of the government in producing several BIM guidelines. In other cases, the government also supported industry initiatives or platforms, to develop further guidelines on BIM. This shows that the public sector can drive and/or facilitate initiatives relating to the standardisation and common understanding around BIM processes.
2. **The public sector invested in research and development related to BIM, with universities and public agencies developing their own BIM courses.** These programmes also contribute to the development of the guidelines mentioned above, and help ensure that the industry can also rely on an increasing number of BIM professional, which are ready to perform BIM related tasks and activities. The case of Poland shows that even if the demand is limited, the government already invested in the development of curricula relating to BIM. The education process is not limited to the private sector or labour, but also to public sector officials, who need to understand BIM definition, rationale and benefits.
3. **Where the actions of the government are most noticeable by businesses, is however when they boost demand for BIM – as they do when integrating BIM requirements in their public procurement legislation.** Public sector accounts for 20-30% of total construction spending in Europe[65], representing significant business opportunities for the private sector. Public procurement projects are hence one of the main incentives for companies to implement BIM.
4. **Government actions have a real impact when supported by construction industries.** Governments need industry support to ensure BIM implementation within the sector. The French case shows that government engagement in digital transformation in the construction industry was due to private sector needs for official framework and governmental actions. The survey conducted by the steering committee of the PTNB is the example that since the government's involvement in BIM and the development of digital mock-up, construction industry increased its awareness about the importance of this sectoral transformation.

However, these activities and investments from the public sector would generate limited results, if the private sector is not strongly involved and does not demonstrate ownership over BIM development and implementation on the ground. Indeed, while the government can incentivise and push for the BIM implementation in the construction industry, the final implementer remains the private sector. Hence, while the government driven approach in terms of BIM implementation seems to be effective in driving early adoption, the private sector plays a key role in driving the widespread BIM adoption throughout the industry[66].

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65 The Economist (2017). The construction industry's productivity problem https://www.economist.com/leaders/2017/08/17/the-construction-industrys-productivity-problem

66 Walasek et al.(2017). Analysis of the Adoption Rate of Building Information Modeling and its Return on Investmen https://www.researchgate.net/publication/315359204_Analysis_of_the_Adoption_Rate_of_Building_Information_Modeling_BIM_and_its_Return_on_Investment_ROI/fulltext/58cd4b254585157b6dae3ffe/315359204_Analysis_of_the_Adoption_Rate_of_Building_Information_Modeling_BIM_and_its_Return_on_Investment_ROI.pdf?origin=publication_detail

The case studies point out several activities undertaken by the private sector. These include:

1. **Proactive contribution to guidelines and common standards for BIM implementation**: private sector initiatives often aim to support companies understanding of BIM processes and benefits, and adopting them. They do so by providing guidelines, workshops, and courses.
2. **Collaboration to foster BIM related knowledge sharing and experience (including lessons learnt):** Some private sector initiatives aim to share knowledge among the industry about the challenges and benefits from BIM implementation, thus facilitating the adoption of innovation, which is crucial especially at early stages. As the Danish experience shows, providing technical as well as business support (i.e. facilitating BIM related business development opportunities) is most relevant to engage companies, and generate strong buy-in within companies.
3. **BIM related business development opportunities:** Some of the private sector initiatives such as the DiKon developed guidelines (structuring tender material) to help companies seize BIM related opportunities. This in turn incentivises companies to integrate BIM in their tenders and proposals.
4. **Ensuring BIM implementation at scale:** Large companies and SMEs have different needs and interests, which are not always easy to capture from a public sector perspective. Private sector initiatives are hence key to bring up some of the obstacles that MSMEs face in implementing BIM, and can influence in turn policy-makers. The French case shows that start-ups are for instance developing more accessible and friendly user BIM tool to support smaller size construction companies in their project development.

While the public and private sector play different roles, their coordination is of utmost importance to build synergies and foster the effective implementation of BIM in the construction industry. Denmark is a case in point: the private sector initiative in regards with standardisation and definition of BIM related concepts is based on the standards initially defined by the Danish government (Cuneco). By doing so, the industry avoids reinventing the wheel, but also supports the Danish government efforts of promoting BIM standards internationally (including in the EU). This example also shows that coordination and synergies often work when both sector of actors have the same interests.

4.2. Thinking based on systemic/ecosystem approach, targeting incremental change

"The benefits of many technological advances, such as BIM, will materialize only if the whole ecosystem is ready"[67]. This highlights the need to think of BIM implementation from a systemic perspective, i.e. a holistic perspective taking account of the public and private sector actors along the value chains, and trying to understand how their interests shape BIM implementation, and the process to scale it up in a sustainable way. In the case of Denmark, while BIM implementation succeeded at the design, engineering and construction phases, its use is limited when it comes to the operation and maintenance phases. In turn this impedes productivity gains linked to BIM adoption. Indeed, early adopters of 3D modelling are engineering firms and architects, who do not have full control of construction costs and schedules[68].

If BIM is to be adopted by all the actors in the industry, thus leading to productivity gains, public sector policies and instruments need to better reflect the specific interests and constraints of the industry. Indeed, these face different challenges and different opportunities depending on i) the stage of the value chains they operate at; ii) their size (from micro to small, medium or large enterprises) and resources; iii) their behaviour (innovators, early adopters, early majority, late majority or laggards) etc.

While thinking based on a systematic approach is most relevant, the case studies also show that identifying areas of traction for BIM implementation and prioritising specific activities/investments is of crucial

[67] WEF (2018). An Action Plan to Accelerate Building Information Modeling (BIM) Adoption http://www3.weforum.org/docs/WEF_Accelerating_BIM_Adoption_Action_Plan.pdf

[68] Novade (2017).

importance. For instance, Poland started BIM implementation by implementing BIM requirements for public procurement in the transport infrastructures (road and rail), where there seems to be most traction for BIM implementation. It may also be explained by the appetite of the road and agency agencies who championed BIM implementation. Denmark also used an incremental approach by requiring BIM for public sector renovation projects at first, and then for state supported social housing, before expanding it to all local and regional projects.

Finally, initiatives aiming to stimulate private sector demand for BIM are limited, whether coming from the public or private sector. There is limited awareness of BIM benefits, and often insufficient BIM capacities among private sector project's owners in the countries studied[69]. This is an important issue to tackle to achieve BIM implementation at scale. However, the French case shows that even if companies are still not fully aware of BIM advantages and technologies, 3 years after the Plan's implementation, the awareness and the interest about BIM increased. Thus, it would be a matter of time for BIM to be fully included in the construction industry process.

4.3. Education

Education, including through university and academia is a key component and actors of the BIM ecosystem. The case studies show that the public and private sector actors sometimes show limited awareness of BIM potential. This is the case even in Denmark, where contractors are starting implementing BIM 10 years after the inclusion of BIM requirement in public procurement law. On the other hand, it was also acknowledged that public sector actors tend to see the value of BIM mostly at the design, modelling and engineering stages, but much less at the construction operation and maintenance stages. Reinforcing the capacities of public and private sector actors and their understanding of BIM is hence of crucial importance. As noted by Mads Carlsen, BIM manager in Denmark, BIM education is not only a technical issue: it is not only about training workers to use BIM software, but also changing the working methods and process in a company. BIM education is hence about change management.

In this process, the academia can play a key supportive role to both private and public sector actors. The case studies showed the importance of having universities developing BIM related curricula. This responds to the industry's needs to hire BIM specialists; and may in turn help it improve its understanding and adapt its processes and methods towards BIM implementation. The academia was also involved in Denmark when the government started thinking about integrating BIM in public procurement. This clearly shows the important roles the academia can play in the BIM ecosystem.

[69] WEF (2018). An Action Plan to Accelerate Building Information Modeling (BIM) Adoption http://www3.weforum.org/docs/WEF_Accelerating_BIM_Adoption_Action_Plan.pdf

5. Policy recommendations

This report looked at BIM implementation in Denmark, France and Poland, and analysed the drivers and challenges around its implementation. While the public sector plays a key role in promoting and supporting BIM implementation – especially at an early stage, it proves to be a highly complex process. Indeed, BIM implementation potentially provides further opportunities and/or challenges for a wide range of private sector actors depending on the stage of the value chain they operate at, the size of the company and their appetite for innovation. In turn, these opportunities and challenges may incentivise or on the contrary discourage the private sector to implement BIM. To achieve BIM implementation at scale in a sustainable way, policy-makers need to embrace such complexity and provide differentiated support to the private sector depending on its characteristics. In practice, this means at least four steps:

5.1. Strengthen collaboration with the private sector

Public sector interventions aiming to foster BIM implementation are more effective when aligned and/or coordinated with private sector initiatives. Such coordination process becomes even more crucial as the BIM maturity level in the industry is increasing. Indeed, if public sector support and even leadership was acknowledged as key at the early stage of BIM implementation, the industry leadership is required to upscale the use of BIM in the construction industry. Fulfilling this condition requires engaging and generating sufficient buy-in among private sector actors from an early stage onwards. This way, synergies between public and private sector initiatives can be exploited, thus maximising the effectiveness of their respective interventions. Fostering collaboration is best achieved when public and private sector's interests converge.

5.2. Provide differentiated support

Architects, engineers and constructors have a different costs-benefit view on BIM implementation. As this study shows, constructors are especially late in implementing BIM, impeding the realisation of BIM benefits at industry level. It is therefore important for policy-makers to adapt their support to the activities of construction companies. Likewise, policy-makers may further tailor their support to the type of construction companies: Multi National Enterprises will have certainly different needs than SMEs when it comes to BIM implementation. This is crucial especially when the construction industry is fragmented (with few large players and a majority of MSMEs), as in France, which dedicated a specific platform targeting SMEs. However, this requires policy makers to equip themselves with sufficient capacities and knowledge about BIM implementation.

5.3. Exploiting different types of incentives

Public sector support can take different shapes including public procurement law; Education and Research & Development, or private sector platform support etc. But some areas have been unexploited to this day: building private sector demand for BIM has been limited – while it represents about 70 to 80% of the construction market in Europe. Likewise, public financial institutions like the European Investment Bank or National Development Banks could also progressively integrate BIM requirements in their public procurement policy.

Industry knowledge and expertise could be further leveraged. More could be done to incentivise BIM champions (often large firms) to share their expertise, knowledge and experience on BIM with their project's collaborators (especially SMEs), thus facilitating BIM implementation widespread in the industry. As BIM is not only a technology but also a new way of working, the public or private sector associations could also provide change management support that would help companies to put in place BIM processes.

5.4. Identify the right entry point for BIM

While BIM can help address several issues ranging from waste, workers shortage or lack of productivity, it is important that policy-makers and the private sector target some specific issues they are affected by, thus framing a specific narrative around BIM implementation. Some opportunities for furthering BIM implementation are emerging with increasing issues such as labour shortage in the construction industry, or the increased price of raw material in some EU MSs, or the rise of new concepts, such as "Smart Cities". The latter could provide a relevant entry point for BIM implementation, as BIM does not allow only to build new buildings but also look at and take account of, how buildings and infrastructures (transport, utilities etc.) are connected. Indeed, 3D modelling and BIM are a boon for smart cities, with 3D software enabling constructors to even model infrastructure to be built underground. Therefore, policy-makers could leverage cities, i.e. by requiring constructors to use BIM in urban infrastructure projects, to foster BIM implementation and hence contribute to sustainable and smart cities.