Macro Maturity Factors and Their Influence on Micro Level BIM Implementation within Design Firms in Italy

Eleonora Troiani[a], Abdul-Majeed Mahamadu[a]*, Patrick Manu[b], Ernest Kissi[c], Clinton Aigbavboa[d] and Akponanabofa Oti[e].

[a]Department of Architecture and the Built Environment, University of the West of England, Bristol, UK; [b]School of Mechanical, Aerospace and Civil Engineering, University of Manchester, Manchester; [c]Department of Construction Technology and Management, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana; [d]Department of Construction Management and Quantity Surveying, University of Johannesburg, Johannesburg, South Africa; [e]School of Engineering, University of Bolton, University, Bolton, UK

*corresponding author: abdul.mahamadu@uwe.ac.uk

To cite this article: Eleonora Troiani, Abdul-Majeed Mahamadu, Patrick Manu, Ernest Kissi, Clinton Aigbavboa & Akponanabofa Oti (2020): Macro-maturity factors and their influence on micro-level BIM implementation within design firms in Italy, Architectural Engineering and Design Management, DOI: 10.1080/17452007.2020.1738994

Received 25 June 2019

Accepted 26 February 2020

Abstract

Based on conceptual models of macro BIM adoption, several factors have been proposed as indicators of BIM maturity at national level. Such macro level BIM maturity indicators drive policy and the institutional imperatives for smooth adoption of BIM at the micro level (within organisations). The Italian BIM landscape is reported to be slowly progressing with the enactment of various initiatives towards meeting European Union (EU) directives as well as improving macro level BIM maturity. It, however, remains unclear which macro level implementation factors are most relevant to organisations in their BIM implementation. Furthermore, there is a dearth of studies exploring the relevance of proposed macro level BIM implementation factors to BIM implementation at the micro level. In addressing this gap, this study uses the Italian scenario to explore the role of macro BIM maturity factors on facilitating micro level implementation effectiveness in design firms. To achieve this aim, an exploratory study of the literature was conducted to identify macro level factors required at national level for BIM implementation and ascertain which of those factors are most important to design firms through a questionnaire survey of professionals within design firms, which yielded 162 responses. The research found that steps are being undertaken to improve Italy's macro BIM maturity with professionals having overall good degree of awareness and positive attitude towards BIM. Based on statistical analysis, the most important macro level initiatives to design firms is the need for embedding BIM into education curriculum as well as availability of standard deliverables and components such as BIM objects, libraries and standards that regulate their development and use. The findings further suggests that, the needs of design firms is fairly consistent across different organisational scales and backgrounds.

Keywords: BIM, Design, Italy, Maturity, Capability

Introduction

Currently, public administrations and governmental bodies in several countries are making efforts to facilitate the implementation of BIM in the construction industry by promoting various initiatives, including standards, guidelines, mandates and programmes of BIM implementation (Succar and Kassem, 2015). These market and country level initiatives have been referred to as macro-level BIM maturity and acknowledged as the precursors to a successful diffusion of BIM in lower tiers such as organisational and individual levels (Succar 2010). Despite the wide acknowledgement of the importance of macro-level BIM implementation factors, there remains a dearth of knowledge in the literature about their real impact on the micro-level (organisational) implementation, more so in the Italian context. There is therefore a gap not only in Italy, but other countries, where macro-level BIM maturity is perceived to be higher. In some countries, more than 60% of projects adopt BIM due to, among other reasons, institutional initiatives that promote and support BIM (Kassem and Succar and 2017). According to many experts there is a need for urgent adoption of BIM, to maintain or gain competitiveness in the European scene, as well as to improve co-ordination, buildability and information management in a costly and fragmented sector like the Italian architectural engineering and construction (AEC) industry (Santilli, 2015; Ministero dello Sviluppo Economico, 2015).

This research investigated the role of macro BIM maturity factors in facilitating micro level implementation effectiveness in design firms. In so doing, the Italian transition to BIM, is analysed. The following sections present a review of literature relating to macro-level BIM maturity in order to provide an understanding of the components of macro-level BIM maturity and their relevance to BIM implementation. The literature review is then followed by the research methods applied. Subsequently, the research findings, discussion and conclusions are presented.

BIM Maturity at the Macro Level

Many countries are investing into initiatives to increase the adoption of BIM through the enactment of national BIM policy. There, however, remains a dearth of studies examining how this manifests in practice. According to Kassem and Succar (2017) investigating the implementation and diffusion of BIM at the market and country scale represents an adoption maturity referred to as ‘macro BIM adoption or maturity’. This level of implementation refers to the collective initiatives operating within a defined national border at the institutional level and comprising of a set of interrelating technologies, processes and policies representing the collective 'connotations' of BIM readiness or diffusion. Succar and Kassem (2015) examined factors and dynamics involved in the BIM implementation on the national-level rather than on sub-organisations, to define a market-scale BIM diffusion policy. The dynamics identified included top-down, bottom-up and middle-out models, combining horizontal and vertical influences (Kassem and Succar and 2017). This is an alternative way to describe the *pull-and-push effect* where drivers are identified both in the government or the regulatory bodies (normative, incentives or mandates) and in the industry organisations (mimetic pressure). Cheng and Lu (2015) investigated the process in more detail. They organised not only the effects, but also the areas of intervention of the governmental institutions. The authors reviewed the government or public administration (PA) efforts in different countries to implement BIM and concluded that they play six different roles: Initiator and Driver; Regulator; Educator; Funding Agencies; Demonstrator and Researcher. It seems evident that the more the public sector institutions cover these roles, the more the AEC industry familiarises with BIM and the process is effective.

Succar and Kassem (2015) developed a model to explain how macro level initiatives manifests through policy-making which intend influences the market, by combining three activities (communicate, engage, monitor) with three implementation approaches (passive, active, assertive). The same research used the matrix developed by Succar and Kassem (2015) for *low-detailed discovery assessments*, tailored to a first macro-investigation of the market maturity. The sub-topics used are proposed as indicators throughout the progression in five maturity levels, from low or ad hoc, to high or optimised. Succar and Kassem's (2015) eight components are described in Table 1 below and are elaborated further in the next two sections.

Table 1: Components of BIM Maturity at Macro Level (After Succar and Kassem, 2015)

	Macro Maturity Factor	**Description**
1	Objectives and milestones (OM)	Policy objectives defining progressive targets for BIM implementation at market/country level
2	Champions and drivers (CD)	Key individuals or organisations promoting the value of BIM at market/country level
3	Regulatory framework (RF)	The normative, regulatory and legal systems supporting the delivery of BIM projects within a market/country
4	Noteworthy publications (NP)	Availability of relevant BIM documents addressing the implementation
5	Learning and education (LE)	Availability of BIM training and skills development opportunities within academia and market generally
6	Measurements and benchmarks (MB)	Metrics and scales to assess BIM capabilities at market/country level
7	Standardised parts and deliverables (SD)	Availability of standardised BIM components and use within the market

8	Technology and infrastructure (TI)	Hardware and software systems to support information exchange within the market

The Role of Macro Level Maturity in BIM Implementation

In the UK, the BIM implementation was associated with the Government Construction Strategy 2011-2025 (Cabinet Office, 2011), to meet its objectives and targets of reduction in whole-life-costs of built assets; improvement in carbon emissions; improvement in project delivery time and exports of services. A summary of the roadmap is available in the Department for Business, Innovation and Skills (BIS), BIM Strategy Report (BIS, 2011) including milestones, strategies for academic support, training, industry involvement, and legal issues resolution (components I, IV, V i.e. from Table 1).

In Denmark, efforts to implement BIM date back to 2003. Denmark established the 3-year programme Det Digitale Byggeri (2003-2006) to drive the industry towards the application of IT-standards, through the digitalisation of the construction sector and the procurement routes (VIII) (Svidt and Christiansson, 2008). In 2007, Denmark legally mandated the use of BIM for all public funded projects (I), through the Byggherrekravene, and encouraged private projects to explore the advantages of BIM (NBS, 2016a; Kubba, 2017). For a smooth introduction of BIM into the market, stakeholders initially addressed concerns with design process, while the only legal obligation for the clients was requiring digital ICT-contracts (III). Meanwhile, the Danish Enterprise and Construction Authority provided manuals and guidelines to fulfil 3D and database/BIM requirements (IV). Lessons learned and process review determined a significant enhancement of BIM awareness and adoption in 2007-2014, and led to mandate BIM since early 2013 for all Governmental projects over €700,000 or projects exceeding €2,700,000 funded by governmental authorities (I).

In 2010, the Norwegian Government and public bodies (II) commenced their BIM implementation initiatives: the Norwegian Defence Estates Agency started a 3-year programme to test pilot projects; the Statsbygg, required IFC-formats for new construction projects and promoted research and development (R&D) for improved BIM uses. Standards and guidelines were outlined by governmental and non-governmental bodies, such as the Norwegian Home Builder’s Association within the boligBIM project, and by active participation in buildingSMART (IV) (Wong et al., 2009). In 2013, four public authorities signed a Joint Statement mandating the use of openBIM (I, VIII) for their projects by 2016 (BuildingSMART International, 2014).

In Sweden, the most effective trigger for implementing BIM was the Swedish Transportation Administration announcing in 2013 the gradual non-mandatory adoption of BIM, setting targets for the year 2015 (I). The same organisation promoted the BIM Implementation Project to standardise procedures, involve the supply chain, and develop pilot projects for testing processes and educating professionals (V, VII). However, in 2009 the guidelines released by the non-profit organisation Swedish Standards Institute did not show strategic insight for the industry (IV), thus the institution of the Swedish chapter of the OpenBIM was needed (II, VIII) (Cheng and Lu, 2015).

In Netherlands, the efforts to implement BIM were conveyed in the €12million BIM Program (2012-2014) focused on the Public Works and Water Management department (II). In 2011, the Government Buildings Agency, mandated BIM for projects exceeding 7,000,000m2, while manuals, pilot projects and BIM-databases were instituted, to demonstrate the effectiveness of BIM in different types of contract, addressing also the legal field (I, III, IV, VII, VIII) (Cheng and Lu, 2015). Clearly there are several macro level initiatives across countries considered to be among the leading BIM champions in Europe with reported initiatives in other countries. In Switzerland, Portugal, Netherlands and Finland, adoption is reported to be driven equally bottom-up and from top-down while in Spain there are much more micro level initiatives as opposed to a top-down imperative (Kassem and Succar, 2017).

Influence of Macro-Level BIM Maturity on Implementation at the Micro-Level

The effectiveness of comprehensive approach in places such as the USA through guidance by National BIM Standard-United States (NBIMS) and more specifically nationals initiatives like the *3D-4D-BIM Program* and *Roadmap for Lifecycle BIM* is witnessed by the rise (+43%) in the adoption of BIM from 2007 to 2012, and in the increasing majority of BIM users perceiving a positive return on investment (ROI) (McGraw-Hill Construction, 2012). The initiatives included the institution of BIM programmes, committees, seminars, targets, guidelines and standards.

In the UK, institutions committed to BIM include the RIBA, which released the BIM Overlay of the RIBA Outline Plan of Work (IV) (RIBA, 2012) to instruct the BIM adoption throughout the whole life-cycle of construction projects. Furthermore, to involve manufacturers and supply chain, the NBS developed its National BIM Library, a collection of high-quality and certified objects provided by manufacturers (VII). It specifically meets the needs of those professionals who required specifications in the form of BIM objects, to standardise and add long-term value to their projects (NBS, 2016b).

To date, the BIM Level 2 mandate is operative (I), with no restraints for value, size or complexity; however, the UK already developed the Digital Built Britain strategy (HM Government, 2015) to pave the way to Level 3. It is worth to note that the comparative analyses completed during the route to the BIM Level 2 mandate, show that BIM beginner professionals are particularly high in the UK (37%), reflecting the effectiveness of the push-effect performed by the Government (McGraw Hill Construction, 2014). Furthermore, Edirisinghe and London (2015) reviewed the effects of the macro-scale interventions on the AEC sector in general. This study analysed standardisation efforts, policy initiatives and the consequent evolution of the AEC stakeholders in terms of levels of adoption in different countries. Their effectiveness was proven by statistical results, which showed direct effects of the national standards on the adoption of BIM generally.

Macro Level BIM Implementation Initiatives in Italy and the Implications for Design Firms

Design practice within Italy is far advanced and regarded as one of the countries with the most vibrant architectural and design practice. For instance Italy has the highest density of architects in Europe, with an estimated 242 architects per 100,000.00 persons (EU, 2014). Architects undertake responsibilities including building certification, specification and inspections. Other professionals with design responsibility include civil, building engineers and planners who by statute collaborate with delivering projects (EU, 2014; Verin, 2011). These professionals do not only perform architectural design activities but also a broad range of design responsibilities including environmental, structural, energy, fire engineering, buildability, services and disability engineering. Furthermore, one unique characteristic of the Italian sector is a high number of restoration practice due to the abundance of heritage buildings (Biagini *et al.*, 2018). Whereas BIM adoption is considered as generally low, its application within Italian heritage sector is particularly becoming prominent (Lopez *et al.*, 2018).

Recently, research has shed light on the general Italian BIM adoption situation. One of the main Italian BIM experts, Re Cecconi (2016), investigated statistical data about the Italian AEC industry and professionals' knowledge about BIM. The research highlighted the fragmentation of the Italian construction sector mostly made up by micro-enterprises for engineering (81.90%) and contracting (95.10%) operators, not representing a favourable condition for spreading BIM. Figures about BIM literacy and use (Maltese, 2014) reported in the research reflect such condition, showing that many stakeholders do not have a relevant BIM knowledge, or do not take advantage of it.

Re Cecconi (2016) identified macro-level initiatives aiming to rectify the Italian weaknesses. The main one is the 3-year project INNOVance, supported by the Government for half of its budget. Even though in prototype form, it was a promising collaboration gathering 16 partners, the ANCE's publishing company, three universities, two research institutes, six associations, three IT firms and six contractors, to establish the first building national database and integrate technical, scientific, economic, legislative aspects through BIM. Some of the aims were the creation of a high-quality BIM library involving manufacturers, on the experience of the British NBS; the enhancement of BIM procurement and a BIM-GIS server, to allow the public administration institutions to fairly manage projects and tenders (Ministero dello Sviluppo Economico, 2015; Di Giuda, 2016). However, limited results related to standardisation and interoperability were achieved (ANCE, 2013) despite periodical attempts to relaunch it (Daniotti, 2017).

The UNI, the Italian Standard Body, has developed a new standard (UNI11337:2016) which is still at different levels of use (Pavan, 2015). This has been developed based on the lessons learnt from other countries, by incorporating and adapting international standards mainly from the UK which is considered as a market leader. The Italian situation, extensively characterised by restoration and refurbishment works is significantly different from other country contexts thus might require a different approach (Ingenio, 2016). The approved parts of UNI11337:2016 (One, Four, Five, Six) address standardisation of models, objects, deliverables, digital workflows and specification draw-up, while the missing parts (Two, Three, Seven) will regulate naming, classification conventions, products' information management, and set the requirements for the expertise of BIM-professionals.

At the regional level, ANAS, the governmental-owned company for constructing and managing the Italian highway network, announced the full digitalisation of its organisation and resources, aiming to adopt BIM for procurement, design, construction, maintenance, management – before the end of 2019. On the legislative level, the *New Procurement Code* represents a turning point for adopting BIM. Despite several amendments, the final text of the Code (Ministero dell'Economia e delle Finanze, 2016c) set a provisional timescale to the BIM mandate for Italy (Latour, 2017).

According to Kassem and Succar (2017) the Italian BIM landscape is characterised by unbalanced diffusion and enactment of macro level initiatives of adoption. The level and type of diffusion thus exposes organisations to various challenges of adoption when compared to markets with more advanced and balanced maturity such as the UK. With this backdrop there is a need for a detailed understanding of which macro level initiatives will affect effective implementation at the organisational level in Italy. Design firms are naturally the first line of focus in BIM investigations as a result of a number of reasons (Mahamadu et al., 2017). Furthermore, design practices are regarded as among the early and leading adopters of BIM in many other contexts of high diffusion such as in the UK (NBS, 2014). According to Mahamadu et al. (2017) and Mahamadu et al. (2014) designers should be one of the critical areas of focus in BIM implementation efforts as a result of their ability to act as champions in the broader diffusion agenda. Despite periodic surveys across the world for establishing level of adoption (e.g. McGraw Hill Construction, 2014; NBS 2016), none of such surveys has examined the peculiar influences of a comprehensive set of macro level factors on micro level adoption. Existing academic studies are either focussed on development of conceptual frameworks (Succar 2010; Succar and Kassem, 2015) or determination of maturity levels (Edirisinghe and London, 2015; Kassem and Succar, 2017) without jointly looking at which aspects of maturity affect implementation ease within organisations. In addressing this gap, this study uses the Italian scenario to explore the role of macro BIM maturity factors in facilitating micro level implementation effectiveness in design firms.

Research Methodology

An extensive background investigation was required to organise and deepen the knowledge in the existing literature. Journal articles, academic dissertations and thesis were analysed to acquire reliable secondary data and understand the optimal national-level strategies to facilitate the BIM adoption. Emphasis was given to countries where BIM has already been successfully implemented, to learn from actual experiences. The review uncovered the eight areas-maturity model from Succar and Kassem (2015) which facilitated this exploration. Based on this model extensive literature review was performed to identify a set of factors relative to each of the eight pillars of macro level maturity. This is summarised in Table 2.

On the basis of quantitative research method, questionnaire was disseminated among Italian AEC professionals with design responsibility or working within design practice, including architects, engineers and surveyors. The questionnaire included both closed and open ended responses. The open ended questions allowed respondents to elaborate further on their responses where necessary. A quantitative study design was identified as the most suited because it allows generalisation of the results more effectively (Saunders et al., 2009). The first section of the questionnaire investigated the respondents' background (Naoum, 2013). The second section used close-ended questions with single or multiple options, to assess knowledge and awareness of BIM. The third section investigated which macro-level factors are perceived as the most relevant to BIM implementation within design organisations and practices, and included both closed and open ended responses. The method adopted was the rating scale to quantitatively evaluate each factor. To test the suitability of the questionnaire, a pilot questionnaire was shared among a restricted number of professionals to assess clarity, focus and level of depth of the questions. The population to address was Italian design professionals. To frame and define a representative sample (Naoum, 2013), the questionnaire was distributed among Italian AEC professionals through LinkedIn.com, a widely used professional social network.

Table 2: Macro Level BIM Maturity Factors.

Measure	Items	References					
		A	B	C	D	E	F
Objectives and milestones (OM)	1.Definition of clear national maturity level milestones for BIM adoption in Italy	✓	✓	✓	✓	✓	✓
	2.Definition of progressive criteria of optional adoption of BIM in projects (size/cost/complexity)	✓	✓		✓		✓
	3.Definition of clear objectives for BIM implementation by the Italian Government or Professional Institutions	✓	✓				✓
Champions and drivers (CD)	4.Support and promotion by Italian Government or nation-wide organisations (buildingSMART Italia, INNOVance)		✓	✓	✓	✓	✓
	5.Financial incentives by adopting BIM (i.e. tax reduction)	✓	✓				✓
	6.Demand of BIM from clients or the industry			✓			✓
Regulatory framework (RF)	7.Clearly defined legal and regulatory framework to support the use of BIM in Italy		✓	✓		✓	✓
	8.Clearly defined intellectual property rights			✓			✓
	9.Clearly defined liabilities and indemnity insurances	✓					✓
Noteworthy Publications (NP)	10.Definition of procurement guidelines (digital procurement, contract forms, risk management)	✓	✓	✓	✓	✓	✓
	11.Definition of guidelines to support BIM throughout the entire lifecycle of a facility	✓			✓	✓	✓
	12.Definition of design and deliverables standard (UNI11337:2017 - LOI, LOD, naming conventions, interoperable formats)	✓		✓	✓		✓
Learning and education (LE)	13.Inclusion of BIM tools, concepts and workflows in academic programmes		✓		✓	✓	✓

	14.Institution and promotion of dedicated degrees or training courses	✓					✓
	15.Promotion of extra-curricular conferences, workshops, pilot projects	✓	✓	✓	✓		✓
Measurements and benchmarks (MB)	16.Certification of the BIM maturity level or standard compliance					✓	✓
	17.Professional board credits for BIM implementation achievement					✓	✓
Standardised parts and deliverables (SD)	18.Institution of standardised model uses	✓			✓	✓	✓
	19.Institution of official standardised components and libraries	✓	✓			✓	✓
	20.Certification of suppliers and manufacturers providing BIM components			✓			✓
Technology and infrastructure (TI)	21.Technical and technological support	✓		✓		✓	✓
	22.BIM toolkits for assisting in developing the project in compliance with design and procedural standards					✓	✓

A: Cheng and Lu (2015); B: Edirisinghe and London (2015); C: Fenby-Taylor, H et al, (2016); D: Kassem (2014); E: Kassem and Succar (2017); F: Succar and Kassem (2015).

The total number of valid responses collected was 162. All the respondents, except one, was established as not eligible, hence the active response rate was 74% from a total of 220 distributed questionnaires (Saunders et al., 2009).The data collected was analysed through descriptive statistics, cross tabulation and inferential analyses relying on t-tests and Analysis of Variance (ANOVA) to determine peculiarities across different organisational characteristics. After screening of the data for quality the questionnaires were coded in Microsoft Excel and subsequently exported into IBM SPSS Statistics version 23 for analysis. The questionnaire sought to understand the level of importance attributed to each macro level implementation factor on a 5-point Likert scale (1- Not important at all; 2-Of little importance; 3-Of average importance; 4-Very important; and 5- Absolutely essential). Aligned to this, a one-sample *t*-test was conducted to ascertain whether the level of importance attributed to a factor could be considered as being critical. Macro level maturity factors with mean scores that are statistically significantly greater than the test value of 3.5 (i.e., with 1-tailed $p \leq 0.050$) were thus deemed to be critical as the 3.5 test value approximates to the scale point “4” (i.e. very important).

Additionally, analysis were carried out to explore associations between organisational characteristics and variations of their perceptions of the relevance of macro level BIM initiatives on their organisations. Independent samples *t*-tests were conducted and ANOVA were conducted to compare the mean scores thereof. The characteristics investigated were size of firm, firms experience, firm’s previous BIM experience, professional role of firm and BIM maturity within firm.

Findings

The results are presented below under two main headings: demographic background information; and Importance of macro level BIM factors on BIM implementation in Italy.

Demographic and Background Information

This section provides an overview of respondents and their organisational backgrounds as well as awareness and competencies in BIM. From the response of the 162 participants, the highest proportion were Architects (49.0%), followed by Building Engineers (29.6%) and Civil/Structural Engineers (23.5%). With regards to experience 57.4% had between 1 to 5 years of experience while 12.3% had between 6 to 10 years' experience. The majority of the respondents' organisation (66.8%) were SMEs (i.e. up to 50 employees per European Commission classification), with only 18.5% working for companies employing more than 50 members. As a result, the projects the professionals mainly work on are small (i.e. Less than €250, 000) and medium (i.e. between €250,000–€2,000,000), in a proportion of 40.1% and 38.3%. There was also higher involvement of professionals is the residential building sector (34.6%), followed by the commercial building sector (23.5%) mostly in the private sector with only 22.3% working in the public sector. A significant proportion of respondents (65.4%) are users of 3D BIM modelling software with some respondents using BIM related tools for multidisciplinary collaboration (22.8%) while more advanced users (17.9%) were involved in BIM use for tasks such as structural and energy analysis. There was high awareness of BIM among respondents with 73.5% having attended a course, workshop, trained or studied BIM related subject at some point in their career. All respondents (100%) were involved or responsible for the use of digital modelling tools. Furthermore, all respondents identified correct definitions of BIM as a check of their awareness. The responses to the perception of BIM as an opportunity for the design practice show an overwhelming majority of positive answers (84.6%). Only five respondents (3.1%) answered negatively and twenty (12.3%) were undecided about the potential benefits of BIM to Italian design firms.

Overall the demographic information shows a diverse group of respondents with adequate knowledge about current state of BIM within their organisations and in Italy as a whole.

Importance of Macro Level Maturity Factors on Micro Level Implementation

Table 3 provides a summary of the results in relation to perceptions about the importance of the 22 macro level BIM implementation factors to organisations in their BIM implementation efforts. This provides a description of each area of intervention, the mean scores, the rank as well as standard deviation. The most important factors that facilitates the BIM implementation within Italian design-based organisations were: the "*Inclusion of BIM tools, concepts and workflows in academic programmes"* (Mean = 3.914; Std. D = 1.282); "*Institution of standardised model uses"* (Mean = 3.858; Std. D = 1.074); and "*Promotion of extra-curricular conferences, workshops, pilot projects*" (Mean = 3.852; Std. D = 1.116). These were interpreted as factors of high importance to micro level implementation of BIM. None of the factors was considered by respondents as 'not important' although from the ranking the following emerged as having less importance: "*Clearly defined intellectual property rights"* (Mean = 3.284; Std. D = 1.177); and "*Clearly defined liabilities and indemnity insurances*" (Mean = 3.315; Std. D = 1.089).

In relation to the key categories of macro level maturity (see Succar and Kassem, 2015), the most important category is *"Standardised parts and deliverables (SD)"* (Mean = 3.830) which has100% of the sub factors in this category being regarded as critical to BIM implementation. This was followed by "Learning and education (LE)" (Mean = 3.770). The availability of *"Regulatory framework (RF)"* (Mean = 3.410) was ranked the least category when compared to all the other eight categories as summarised in Table 4 and depicted in Figure 1.

A one-sample t-test, was performed to interpret the statistical significance of the findings in order to ascertain the most critical factors. As previously mentioned, a *test-value* equal to 3.5 was used. The factors whose mean are significantly higher than the *test-value* were 10 in total out of the 22 factors as presented in Table 5 and Figure 2 where critical factors have been differentiated from non-critical factors.

Table 3: Summary of Important Macro Level BIM Maturity Factors for Design Firms in Italy

Category	Factors	Statistics							*Relevance to Organisations	
		N	Mean	Rank	Std. D	Coeff. variation	Mode	Median	AI	VI
Objectives and milestones	1. Definition of clear maturity level milestones for BIM adoption in Italy	162	3.611	15	1.133	31.36	4	4		✓
	2. Definition of progressive criteria of optional adoption of BIM in projects (size/cost/complexity)	162	3.623	12	1.04	28.69	4	4		✓
	3. Definition of clear objectives for BIM implementation by the Italian Government or Professional Institutions	162	3.605	16	1.292	35.84	5	4		✓
Champions and drivers	4. Support and promotion by Italian Government or nation-wide organisations (buildingSMART Italia, INNOVance)	162	3.327	20	1.21	36.36	4	3	✓	
	5. Financial incentives by adopting BIM (i.e. tax reduction)	162	3.722	8	1.287	34.56	5	4		✓

	6. Demand of BIM from clients or the industry	162	3.636	11	1.168	32.12	4	4		✓
Regulatory framework	7. Clearly defined legal and regulatory framework to support the use of BIM in Italy	162	3.617	14	1.286	35.55	5	4		✓
	8. Clearly defined intellectual property rights	162	3.284	22	1.177	35.83	3	3	✓	
	9. Clearly defined liabilities and indemnity insurances	162	3.315	21	1.089	32.85	3	3	✓	
Noteworthy Publications	10. Definition of procurement guidelines (digital procurement, contract forms, risk management)	162	3.698	9	1.169	31.63	5	4		✓
	11. Definition of guidelines to support BIM throughout the entire lifecycle of a facility	162	3.673	10	1.194	32.52	4	4		✓
	12. Definition of design and deliverables standard (UNI11337:2017 - LOI, LOD, naming conventions, interoperable formats)	162	3.457	19	1.093	31.61	3	3		✓
Learning and education	13. Inclusion of BIM tools, concepts and workflows in academic programmes	162	3.914	1	1.282	32.77	5	4		✓
	14. Institution and promotion of dedicated degrees or training courses	162	3.531	17	1.31	37.1	5	4		✓
	15. Promotion of extra-curricular conferences, workshops, pilot projects	162	3.852	3	1.116	28.97	4	4		✓
Measurements and benchmarks	16. Certification of the BIM maturity level or standard compliance	162	3.519	18	1.132	32.18	4	4		✓
	17. Professional board credits for BIM implementation achievement	162	3.821	4	1.12	29.3	4	4		✓
Standardised parts and deliverables	18. Institution of standardised model uses	162	3.858	2	1.045	27.08	4	4		✓
	19. Institution of official standardised components and libraries	162	3.821	4	1.074	28.12	4	4		✓
	20. Certification of suppliers and manufacturers providing BIM components	162	3.796	7	1.121	29.53	5	4		✓
Technology and infrastructure	21. Technical and technological support	162	3.802	6	1.051	27.63	4	4		✓
	22. BIM toolkits for assisting in developing the project in compliance with design and procedural standards	162	3.623	12	1.075	29.67	4	4		✓
*Note: Relevance to of factor to BIM implementation by organisation based on approximation of mean score to nearest point on five-point scale : AI – averagely important and VI – very important										

Table 4: Summary of Important elements of Macro Level Maturity Factors for Designers in Italy

Factor Categories	N	Mean	Rank
Objectives and milestones (OM)	162	3.61	5
Champions and drivers (CD)	162	3.56	7
Regulatory framework (RF)	162	3.41	8
Noteworthy Publications (NP)	162	3.61	5
Learning and education (LE)	162	3.77	2
Measurements and benchmarks (MB)	162	3.67	4
Standardised parts and deliverables (SD)	162	3.83	1
Technology and infrastructure (TI)	162	3.72	3

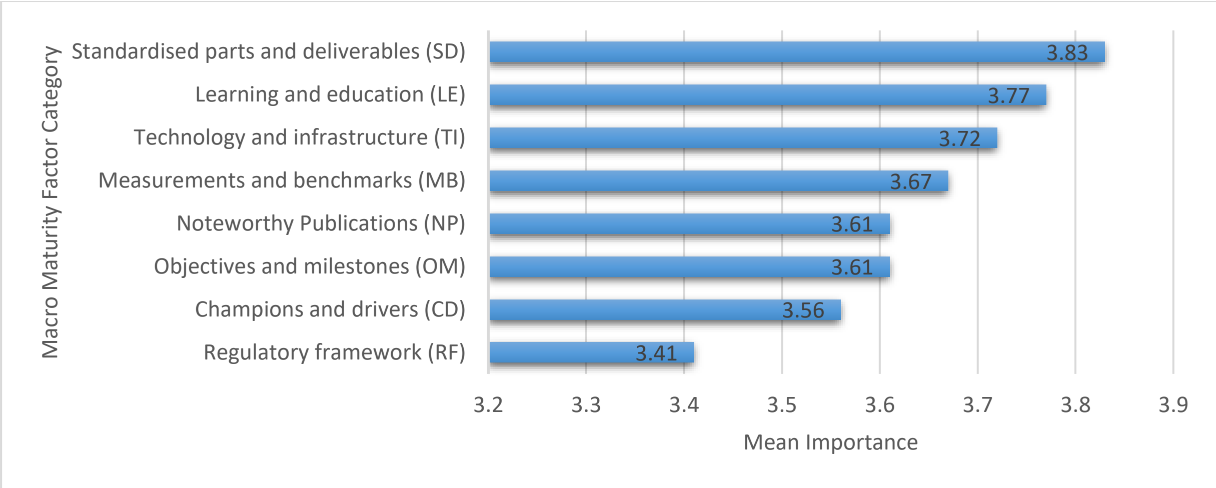
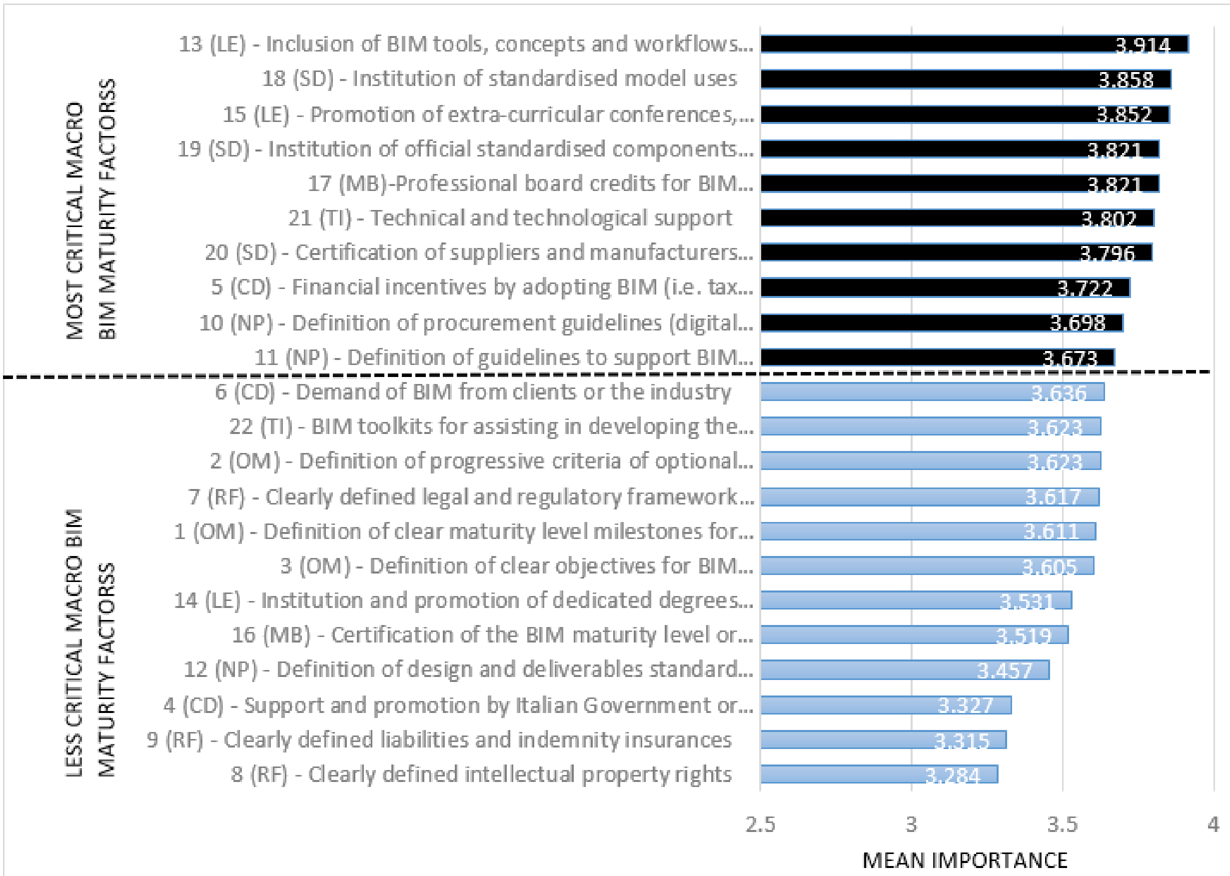


Figure 1: Summary of Important Elements of Macro Level Maturity Factors for Designers in Italy



***Note:** Refer to Table 2 for full description of factor using preceeding factor number (1-22).*
Catgory Defntinion: Objectives and milestones (OM); Champions and drivers (CD); Regulatory framework (RF); Noteworthy publications (NP); Learning and education (LE); Measurements and benchmarks (MB); Standardised parts and deliverables (SD); Technology and infrastructure (TI)

Figure 2: Results showing most critical Macro Level BIM maturity factors for Italian design firms based on One sample t-test

Table 5: One sample t-test results showing most critical Macro Level BIM maturity factors for Italian design firms*

Factors	Category**	N	Mean	Rank	SD	Std. Error Mean	One-sample t-Test (Test Value = 3.5)						
							t	df	Sig. (2-tailed)	Sig. (1-tailed)	Mean Difference	95% Confidence Interval of the Difference	
												Lower	Upper
13. Inclusion of BIM tools, concepts and workflows in academic programmes generally	LE	162	3.914	1	1.282	0.101	4.105	161	0.0001	0	0.414	0.21	0.61
18. Institution of standardised model uses	SD	162	3.858	2	1.045	0.082	4.362	161	0	0	0.358	0.2	0.52
15. Promotion of extra-curricular conferences, workshops, pilot projects	LE	162	3.852	3	1.116	0.088	4.014	161	0.0001	0	0.352	0.18	0.52
19. Institution of official standardised components and libraries	SD	162	3.821	4	1.074	0.084	3.803	161	0.0002	0.0001	0.321	0.15	0.49
17. Professional board credits for BIM implementation achievement	MB	162	3.821	4	1.12	0.088	3.649	161	0.0004	0.0002	0.321	0.15	0.49
21. Technical and technological support	TI	162	3.802	6	1.051	0.083	3.665	161	0.0003	0.0002	0.302	0.14	0.47
20. Certification of suppliers and manufacturers providing BIM components	SD	162	3.796	7	1.121	0.088	3.365	161	0.001	0.0005	0.296	0.12	0.47
5. Financial incentives by adopting BIM (i.e. tax reduction)	CD	162	3.722	8	1.287	0.101	2.198	161	0.0293	0.0147	0.222	0.02	0.42
10. Definition of procurement guidelines (digital procurement, contract forms, risk management)	NP	162	3.698	9	1.169	0.092	2.15	161	0.0331	0.0165	0.198	0.02	0.38
11. Definition of guidelines to support BIM throughout the entire lifecycle of a facility	NP	162	3.673	10	1.194	0.094	1.842	161	0.0673	0.0337	0.173	-0.01	0.36

*Note: For the sake of brevity only significant results are shown

**Catgory Defntinion Objectives and milestones (OM); Champions and drivers (CD); Regulatory framework (RF); Noteworthy publications (NP); Learning and education (LE); Measurements and benchmarks (MB); Standardised parts and deliverables (SD); Technology and infrastructure (TI)

Role of Respondents Experience

Independent samples t-test was conducted to ascertain whether or not the experience of respondent had influence on their perceptions about factors that influence BIM implementation. Generally, the perceptions of all respondents were not different except in the case of two factors, “milestones for BIM adoption” and level of “Support and promotion by Italian Government or nation-wide organisations”.

As shown in Table 6, independent samples t-test showed respondents with up to 5 years of experience were more receptive of the idea of having national milestones of BIM implementation while more experienced respondents (more than 5 years’ experience) preferred general Government support and promotion through institutions such as buildingSMART Italia and INNOVance. Thus more experienced BIM users appeared to be in favour of initiatives reminiscent of those in the UK and the United Arab Emirate (UAE), whereas non experienced BIM users appeared to favour non-Government lead interventions. From the responses to open-ended questions, the organisations who perceived Government support as important identified economic incentives from Government and clients as the most critical aspect of Government support relevant for their BIM implementation, although it is unclear what forms of support.

Influence of Respondents’ Organisations Size and Sector

From independent samples t-test based on size of respondent firm, *n*one of the factors emerged as significant. This means both respondents from the smaller firms (i.e. up to 50 employees) and larger firms (i.e. over 50 employees) perceive the importance of the macro level BIM implementation factors in the same manner. Thus from the findings there is no significant difference in the requirements of small and larger design organisations in terms of their expectations of macro level BIM implementation imperatives required for them to be able to be able to successfully adopt BIM. Furthermore, there were no significant differences in the perceptions of architectural when compared to more engineering focussed design firms.

Table 6: Independent samples t-Test for perceived importance of BIM implementation factor - by respondent experience

Factor	Experience	N	Mean	Std. Dev	Std. Error Mean	Levene's Test for Equality of Variances			t-test for Equality of Means						
						Equality of Variances	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
														Lower	Upper
Definition of clear national maturity level milestones for BIM adoption	Up to 5 years	116	3.72	1.068	0.099	Equal variances assumed	1.938	0.166	**2.037**	**160**	**0.043**	**0.398**	**0.195**	**0.012**	**0.784**
	Over 5 years	46	3.33	1.248	0.184	Equal variances not assumed			1.904	72.530	0.061	0.398	0.209	-0.019	0.815
Support and promotion by Italian Government or nation-wide organisations (buildingSMART Italia, INNOVance)	Up to 5 years	116	3.47	1.205	0.112	Equal variances assumed	1.883	0.172	**2.495**	**160**	**0.014**	**0.518**	**0.207**	**0.108**	**0.927**
	Over 5 years	46	2.96	1.154	0.170	Equal variances not assumed			2.542	86.028	0.013	0.518	0.204	0.113	0.922

The Influence of Current Level of BIM Application and Use

One-way ANOVA was used to establish whether or the level of current BIM implementation within an organisation influenced their perception of importance of factors. As indicated in Table 7 and 8 (Tukey post-hoc test) the level of BIM application is categorised in four groups: (1) None, representing firms who only use of 2D processes; (2) Low for firms who use basic 3D modelling techniques only; (3) Moderate, for firms with some multidisciplinary collaboration processes supported by 3D, 4D, 5D BIM; and (5) High, for firms relying on advanced multidisciplinary collaboration and analysis using integrated BIM (3-nD applications). Only one factor emerged as significant from the ANOVA test, which is "*Certification of suppliers and manufacturers providing BIM components*". However, The Tukey's post-hoc as presented in Table 8, showed that these differences were marginal. From this finding, more advanced users of BIM appear to understand the importance of openly available BIM objects and components from manufacturers.

Table 7: One-way ANOVA test for the importance of Macro level BIM implementation factors across levels of BIM implementation

Factor	Comparison	Sum of Squares	df	Mean Square	F[a]	Sig.
Certification of suppliers and manufacturers providing BIM components	Between Groups	10.102	3	3.367	3.190	0.039
	Within Groups	192.176	158	1.216		
	Total	202.278	161			

Note: [a] Welch's F is us

Table 8: Tukey post hoc test multiple comparisons table for importance of Macro Level BIM implementation factors across levels of BIM implementation

Factor	*Level of BIM application (I)	Level of BIM application (J)	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Certification of suppliers and manufacturers providing BIM components	None	Low	-0.476	0.458	0.727	-1.67	0.71
		Moderate	-1.043	0.422	0.068	-2.14	0.05
		High	-0.814	0.408	0.194	-1.87	0.24
	Low	None	0.476	0.458	0.727	-0.71	1.67
		Moderate	-0.566	0.289	0.209	-1.32	0.19
		High	-0.338	0.268	0.591	-1.03	0.36
	Moderate	None	1.043	0.422	0.068	-0.05	2.14
		Low	0.566	0.289	0.209	-0.19	1.32
		High	0.229	0.200	0.664	-0.29	0.75
	High	None	0.814	0.408	0.194	-0.24	1.87
		Low	0.338	0.268	0.591	-0.36	1.03
		Moderate	-0.229	0.200	0.664	-0.75	0.29

*Level of BIM Implication: None - Only use of 2D processes; Low –Basic 3D modelling; Moderate – Some multidisciplinary collaboration based on 3D, 4D, 5D BIM; High – Advanced multidisciplinary collaboration and analysis using integrated BIM (3-nD applications)

Discussion

This study has highlighted a high degree of BIM awareness among Italian professionals with most alluding to acquiring BIM knowledge from events and courses. Furthermore, the study has established that a majority of Italian design firms use 3D BIM modelling software with significant proportion involved in more advanced BIM use for tasks including multidisciplinary collaboration, structural and energy analysis. Kassem and Succar (2017) reported BIM diffusion in Spain commenced among small architecture and engineering firms before larger organizations. However, in the Italian case there appears to be a more even-level of implementation across organisational sizes.

Critical Macro Level Maturity Factors that Influence Micro Level Implementation

The availability of standardised parts and deliverables was found to be the single, most important area of macro BIM maturity relevant for Italian design firms. This includes standards to streamline the availability and use of standardised parts, components, objects and libraries. Furthermore, this underscores the importance of current efforts towards standardisation in Italy (i.e. UNI11337:2017). However, there needs to be much more effort beyond process and policy aspects to include requirements for standard BIM uses, objects and libraries. This can take the form of a BIM object standard that includes specification for object categorization, IFC element definitions and other information and data categorisations, similar to the UK's National Building Standard (NBS), BIM Object Standard (NBS, 2018). Based on this finding, there is a need for a central BIM object library or platform where manufacturers and other stakeholders can contribute or host generic BIM objects that designers can downloaded freely. There are two options, either adopt existing and internationally recognised libraries and standards such as the NBS in UK or development of Italian specific system.

The only detailed macro level maturity assessment in Italy has been presented in Kassem and Succar (2017). Their assessment however shows that the areas where Italy is known to have more BIM maturity are not regarded as very important to the implementation efforts of design firms. This includes noteworthy publications, regulatory frameworks and technology infrastructure. The findings from this study places most emphasis on availability standard BIM model deliverables and components as well as learning and education. Albeit being a major opportunity, internationally promoted standards (i.e. ISO 19650) will need to be interrogated in terms of their fitness for purpose within the local context (i.e. UNI11337).

The other prominent macro BIM maturity factor for design firms in Italy was learning and education, with the incorporation of BIM within academic programmes identified a critical to Italian organisation's BIM implementation success. The implication of this finding is that, whereas, Italian professionals are highly aware of BIM and its benefits, there appears to be deficiency in terms of formal knowledge acquisition opportunities. According to Agostinelli et al., (2019), there has been the introduction of BIM courses within Italian Universities since 2015 with new courses introduced, in Rome and Milan, as well as Naples, Pisa, Ferrara, Turin, Reggio Calabria and Genoa. Despite the upsurge in the delivery of these BIM courses, it is felt that the availability of more opportunities for retraining or knowledge acquisition within the education system will facilitate easier BIM implementation. It is also unclear the extent to which BIM has been embedded in the traditional curriculum of designers including Architects and Civil Engineers as opposed to specific programmes for developing BIM professionals (Agostinelli et al., 2019). Based on the findings from this study, the developments within the Italian educational sector is regarded by design firms as important to facilitating easier BIM implementation. However, the findings are also indicative of potential short supply of BIM-enabled graduates who can work within design firms in Italy. According to Kassem and Succar (2017), Italy is regarded as medium-low in terms of its Macro BIM maturity. Thus, this explains the desire for further individual competency development starting with formal knowledge acquisition before future on-the-job skill acquisition when adoption is more widespread (Succar et al., 2013; Abdirad and Dossick, 2016).

Based on a review of 11 projects in Italy, Azzouz et al., (2018) rated Italy's BIM maturity as comparable to many other parts of Europe, although lack of standards and macro institutional strategies is identified as a challenge. In recognition of this, Italian Government is making efforts on mandating the use of BIM following the UK example by 2025 (Ciribini, et al., 2018). Italian public institutions are therefore currently involved in European Union BIM Task Group through the Italian BIM Commission and the Ministry for Infrastructure and Transport; Roads and Italian Railway (FS Group) Administrations (EU-BIM, 2018). The primary strategies being proposed currently relate to the adoption of standardised publications (i.e. UNI11337:2017, Employers Information Requirements (EIR) and BIM Execution Plan (BEP) templates) as well as collaborative procurement models enabled by the UNI11337:2017 and a New Procurement Code (Ciribini, et al., 2018). Respondents agreed on the critical importance of these initiatives, although, they rated them as being of lower importance as compared to standardised deliverables and components as well as learning and education.

The Importance of Regulatory and Legal Factors on Micro Level Implementation

Although respondents agreed on the importance of Government driven initiatives and support, they were less pronounce about the importance of legal and regulatory factors. With less importance placed on legal and regulatory factors, regarding BIM, issues such as contracts, intellectual property and insurance were not viewed as important as other factors such as education in Italy. From Kassem and Succar's (2017) assessment, however, regulatory frameworks is one of the areas where Italy has invested efforts although from this study it does not appear to be as important for design firms as other issues. Furthermore, rather than a top-down, assertive or mechanistic BIM implementation programme, Italian design firms appear to support a more passive BIM diffusion approach. Top-down approaches have been adopted in countries including UK, Hong Kong and the United Arab Emirates (UAE) (Mehran, 2016; Khosrowshahi and Arayici, 2012; Wong *et al.*, 2011). On the other hand, the passive approach to diffusion recognise other market and industry forces that equally dictate implementation similar to contexts such as USA or other European neighbours such as Spain, Portugal and the Netherlands (Kassem and Succar, 2017). This has been referred to as Middle-out dynamics of BIM diffusion and is consistent with most countries especially in Europe (Succar and Kassem, 2015; Kassem and Succar, 2017). Thus, this study contributes further to the debate on the best approach to BIM facilitation in countries underscoring the popularity of middle-out macro implementation dynamics in the European context given the mix of approaches respondents believed to be important. Furthermore, although top-down regulatory initiatives have worked in some markets, it appears to work in much fewer cases and may be more effective where there is greater public funding of projects. With the dominance of the private sector in Italy, it is worth broadening considerations in the enactment and structure of legislative mandates such as the Infrastructure and Transport Ministry Decree (560/2017) which are expected to drive BIM implementation mainly within the public sector (Ciribini, et al., 2018).

Conclusion

A macro-level implementation plan is critical to facilitating the adoption of BIM in any country, and Italy is no exception. BIM concepts and adoption continue to proliferate within organisations, although there is less insight about how market and country level initiatives facilitate this process in the organisational context. In line with this, the study adopted a quantitative approach to explore the perceived relevance of macro-level BIM interventions to the BIM implementation efforts of Italian design firms. The study addressed this challenge by adopting 22 macro level BIM implementation factors from the literature. As evident from the findings, the main areas perceived as important to design firms is the need for embedding BIM into education curriculum as well as availability of standard deliverables and components such as BIM objects and libraries. The implications of the findings are that, current institutional efforts such as the development of Italian national BIM standards (UNI11337), as well as national mandate (Infrastructure and Transport Ministry Decree 560, 2017) are very important to design firms. However, BIM education initiatives are still regarded as more critical. Furthermore, design firms do not consider legal and regulatory frameworks as very important as other factors such as standardised deliverables as well as education. This study provides validation for the relevance of some institutional initiatives in Italy but also highlights misalignment of some macro level BIM initiatives in terms of their perceived relevance at the micro level for design firms. This includes legal and regulatory factors that might support enactment of mandates for compulsory use of BIM as well as legal frameworks for managing associated BIM risks including insurance issues. Firstly, design firms view legal and regulatory factors as less important. Secondly, any mandates enacted must take cognisance of the high level of private participation within the Italian built environment and their potential role in the diffusion of BIM.

This study specifically recommends the need for a review of BIM implementation policy with intensification of BIM education requirements. This can be achieved not only through the introduction of BIM courses but also mainstreaming of BIM within existing curriculum in the education of designers including architects and civil engineers. There are many examples of such education initiatives in countries such as UK and USA where there is higher levels of adoption (Abdirad and Dossick, 2016). The curriculum should also focus on areas around legal and regulatory frameworks in order address perceptions around its importance in Italy. This cannot be overemphasised given the pervasiveness of BIM and the associated information, technology and intellectual property risks. More specifically Italy would benefit from having an education task group to establish a list of competencies required within design practices for a digital or BIM economy. Furthermore, there needs to be better private sector engagement in the promotion of BIM given this sector is currently more vibrant as compared to public sector. Thus, plans towards mandating BIM use should involve strategies for involving private clients.

References

Abdirad,H. & Dossick, C.S. (2016). BIM curriculum design in architecture, engineering, and construction education: a systematic review. *Journal of Information Technology in Construction (ITcon)*, 21, 250-271.

Agostinelli, S. Cumo, F. & Ruperto, F. (2019). Strategies and Outcomes of BIM Education: Italian Experiences. WIT Transactions on The Built Environment, 192, pp.217-227

ANCE (2013) *INNOVance* [website]. Retrieved from: http://www.innovance.it/it/index.html.

Aranda-Mena, G., Crawford, J., Chevez, A. & Froese, T. (2009). Building information modelling demystified: does it make business sense to adopt BIM? *International Journal of Managing Projects in Business*, 2(3), 419-434.

Azzouz, A., Hill, P. & Papadonikolaki, E. (2018). **Which countries have the highest levels** of BIM adoption in Europe? Retrieved from: http://www.bimplus.co.uk/people/which-country-most-bim-mature-europe

Biagini, C., Capone, P., Donato, V. & Facchini, N. (2016). Towards the BIM implementation for historical building restoration sites. Automation in Construction, 71(1), 74-86.

BIS (2011). A report for the Government Construction Client Group Building Information Modelling (BIM) Working Party Strategy Paper [online]. Retrieved from: http://www.bimtaskgroup.org/wp-content/uploads/2012/03/BIS-BIM-strategy-Report.pdf.

BuildingSMART International (2014). Statements and Guidelines supporting open standards in the construction industries [online]. Retrieved from: http://iug.buildingsmart.org/resources/statements-and-guidelines.

Cabinet Office (2011). *Government Construction Strategy* [online]. Retrieved from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/61152/Government-Construction-Strategy_0.pdf.

Cheng J.C.P. & Lu Q. (2015). A review of the efforts and roles of the public sector for BIM adoption worldwide. *Journal of Information Technology in Construction (ITcon)* [online], 20, pp. 442-478.

Ciribini, A., Di Giuda, G. & Valaguzza, S. (2018). UK procurement framework informs Italy's move to mandate BIM. Retrieved from: http://www.bimplus.co.uk/people/uk-procurement-framework-informs-italys-move-manda.

Daniotti, B. (2017). Il punto su INNOVance: la Piattaforma Italiana per il settore delle costruzioni, basata su librerie BIM. Milano: Politecnico di Milano [online]. Retrieved from http://www.ingenio-web.it/immagini/Articoli/PDF/MadeExpo_INNOVANCE_Ingenio_nPlV.pdf.

Di Giuda G. M. (2016). *Riflessioni sulla transizione digitale per il futuro dell'industria delle costruzioni.* 27 June 2016 [online]. Retrieved from: http://www.ilnuovocantiere.it/riflessioni-sulla-transizione-digitale-per-il-futuro-dellindustria-delle-costruzioni/.

Edirisinghe, R. & London, K. (2015). Comparative Analysis of International and National Level BIM Standardization Efforts and BIM adoption. In Proceedings of the 32nd International Conference of CIB W78 (pp. 149-158). University of Technology, Eindhoven, 27-29 October 2015.

EU (2014) Mutual evaluation of regulated professions: Overview of the regulatory framework in the business services sector by using the example of architects. Report, Meeting of European Council, 30th September 2014

EU-BIM (2018). Handbook for the introduction of Building Information Modelling by the European Public Sector. EU BIM Task Group[Online]. Retrieved from: www.eubim.eu

Fiordalisi, M. (2015). BIM: Italia in ritardo con la direttiva UE, fino a 400 miliardi di mancati risparmi. *Edilizia e Territorio. Quotidiano del Sole 24 Ore* [online]. Retrieved from: http://www.ediliziaeterritorio.ilsole24ore.com/art/progetti-e-concorsi/2015-01-09/italia-ritardo-direttiva-fino-170616.php?uuid=Ab8iUSuK

HM Government (2015). *Digital Built Britain Level 3 Building Information Modelling - Strategic Plan* [online]. Retrieved from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/410096/bis-15-155-digital-built-britain-level-3-strategy.pdf .

Ingenio (2016). Ecco la norma italiana sulla digitalizzazione del settore delle costruzioni, la Uni 11337 del 2017. [*YouTube* video]. Retrieved from: https://www.youtube.com/watch?v=IVsdCxhKDg8.

Kassem, M., & Succar, B. (2017). Macro BIM adoption: Comparative market analysis. *Automation in Construction*, *81*, 286-299.

Kassem, M., Succar, B. & Dawood, N (2014). Building Information Modeling: Analyzing Noteworthy Publications of Eight Countries Using a Knowledge Content Taxonomy, in: R. Issa, S. Olbina (Eds.), Building Information Modeling: Applications and Practices in the AEC Industry, ASCE Press, 2014, Retrieved from: http://dx.doi.org/10.1061/ 9780784413982.ch13.

Kassem, M., Succar, B. & Dawood, N. (2013). A proposed approach to comparing the BIM maturity of countries. In Proceedings of the 30th International Conference on Applications of IT in the AEC Industry, CIB W078, Beijing, China, 2013.

Khosrowshahi, F. & Arayici, Y. (2012). Roadmap for implementation of BIM in the UK construction industry, *Engineering Construction Architectural Management*, 19 (6), 610–635.

Kubba, S. (2017). Handbook of green building design and construction. 2nd ed. Oxford: Elsevier.

Latour, G. (2016b). Anas accelera sull'innovazione: a inizio 2017 la prima gara Bim, in 3 anni il passaggio al digitale. *Edilizia e Territorio. Quotidiano del Sole 24 Ore* [online]. Retrieved from: http://www.ediliziaeterritorio.ilsole24ore.com/print/ADbTaCvB/0.

López, F.J., Lerones, P.M., Llamas, J., Gómez-García-Bermejo, J. & Zalama, E. (2018). A review of heritage building information modeling (H-BIM). Multimodal Technologies and Interaction, 2(2), 21.

Maltese, S. (2014). BIM: tutti sanno cos’è, ma quanti lo usano? *Ingegneri*,1,5.

McGraw-Hill Construction (2012). *The business value of BIM in North America: multi-year trend analysis and user ratings (2007-2012)*. New York: McGraw-Hill Construction.

Mehran, D. (2016). Exploring the Adoption of BIM in the UAE Construction Industry for AEC Firms, *Procedia Engineering*, 145, 1110-1118.

Ministero dell'Economia e delle Finanze (2016a). Decreto legislativo 18 aprile 2016, n. 50. *Gazzetta Ufficiale* [online]. Roma: Ministero dell'Economia e delle Finanze. Retrieved from: http://www.gazzettaufficiale.it/atto/serie_generale/caricaDettaglioAtto/originario?atto.dataPubblicazioneGazzetta=2016-04-19&atto.codiceRedazionale=16G00062.

Naoum, S.G. (2013). *Dissertation research & writing for construction students*, 3rd Ed, London: Routledge

NBS (2016a). *International BIM Report 2016* [online]. Retrieved from: https://www.thenbs.com/-/media/files/pdf/nbs-international-bim-report-2016.pdf?la=en.

NBS (2016b). *National BIM Report 2016* [online]. Retrieved from: https://www.thenbs.com/-/media/files/pdf/bim-report-2016.pdf?la=en.

NBS (2018) BIM Object Standard. Version 2.0. National Building Specification, UK.

Pavan, A. (2015). Rivoluzione" BIM. Anche nella normazione tecnica. *UNI - Ente Italiano di Normazione* [online]. Retrieved from: http://www.uni.com/index.php?option=com_content&view=article&id=3554%3Arivoluzione-bim-anche-nella-normazione-tecnica&catid=171&Itemid=2612.

Re Cecconi (2016). *Building Information Modelling in Italy* [online]. Milano: Politecnico di Milano. Retrieved from: http://www.ingegneri.cc/wp-content/uploads/2016/01/160125_BIM_Italy.pdf.

Santilli G., (2015). Con il BIM rivoluzione di costi e filiera – Bellicini: "Risparmi fino al 30%". *Edilizia e Territorio. Quotidiano del Sole 24 Ore* [online]. Retrieved from: http://www.ediliziaeterritorio.ilsole24ore.com/art/progetti-e-concorsi/2015-02-25/rivoluzione-costi-filiera-bellicini-100020.php?uuid=AbDnbOIL

Saunders, M., Lewis, P. & Thornhill, A. (2009). *Research Methods for Business Students*, 6th ed. GB: Pearson Education M.U.A.

Succar, B. (2010). Building Information Modelling Maturity Matrix - Handbook of Research on Building Information Modeling and Construction Informatics: Concepts and Technologies. IGI, pp. 65-103.

Succar, B. & Kassem, M. (2015). Macro-BIM adoption: Conceptual structures, *Automation in Construction*, 57, 64-79.

Succar, B., Sher, W. & Williams, A. (2013). An Integrated Approach to BIM Competency Assessment, Acquisition and Application, *Automation in Construction*, 35, 174-189.

Svidt, K. & Christiansson P. (2008). Requirements on 3D Building Information Models and Electronic Communication: Experiences from an Architectural Competition. In: Rischmoller, L. ed. *Proceedings of 25th International Conference on Information Technology: Improving the Management of Construction Projects Through IT Adoption,* Universidad de Talca, Santiago, 15-17 July 2008.

Vérin, H. & Gouzévitch, I. (2011) The rise of the engineering profession in eighteenth century Europe: an introductory overview, Engineering Studies, 3(3), 153-169

Wong, A.K.D., Wong, K.W.F. & Nadeem A. (2011). Government roles in implementing building information modelling systems: Comparison between Hong Kong and the United States, Construction Innovation, 11(1), 61-76.

Wong, K.D., Wong, K.W. & Nadeem, A. (2009). Comparative roles of major stakeholders for the implementation of BIM in various countries. In: *Proceeding of Changing Roles 2009*. The Netherlands Conference, The Netherlands, 5-9 October 2009. PolyU, pp. 23-33.