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Reflection on BIM development practices at the pre-maturity

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Abstract

This study contemplates prevailing BIM (Building Information Management) development practices at the pre-maturity. BIM stimuli set by developers have zero attention towards integrating qualitative features and induce pessimistic/optimistic information processing. Also, an archival analysis showed that the survey-based methodology, which is predominantly used to assess industry readiness, does not pay adequate attention towards externalities (procurement, policy, technical and organizational contexts) and hence is not comprehensive enough to lead BIM development towards viable strategies. The 'contextual-reflection' is used to describe the effect of externalities and their governing effect towards practitioners' attitudes and state-level BIM strategies. A preliminary study done in South Africa substantiated these arguments. Integrating the findings with the Technology Adoption Model and BIM's Levels of Development, a conceptual framework is suggested to evaluate industry readiness in a holistic manner.

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Keywords: BIM; pre-maturity; technology adoption

1. Introduction

Information management in construction has been advanced significantly during the last few decades. In some countries, traditional methodologies, such as paper-based communication, are replaced by advanced BIM protocols, including the ability of sharing commercial data through proprietary interfaces (pBIM) and working through integrated web services (iBIM) [1, 2]. Though there is a belief that BIM is the future of the construction industry, many nations still practice unmanaged CAD [1] – i.e. the pre-BIM maturity or the Level of Development (LOD) 'zero' according to the Bew-Richard BIM Maturity Model [2]. Regardless of the abundance of literature, it is somewhat of a belief in such contexts that 'BIM is a synonym for CAD' [1], leading to suboptimal uses. However,

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the true value of BIM extends beyond simple spatial representation, and hence its adoption in some countries (for example: UK, USA and Finland) has been justified.

BIM adoption depends on various factors, including practitioners' attitudes which are largely governed by externalities [3] that individuals have little or no control. Also, no standard productivity data is developed so far to estimate BIM's financial sustainability [4]. Under these circumstances, rational decision making is impracticable and hence the necessity of subjective interpretations is acknowledged [5]. Yet, this is a revoke of 'the chicken egg causality dilemma to a novice: BIM should be practiced to know its financial sustainability, but without knowing financial sustainability, managers are reluctant to adopt it. Thus, there is perhaps little ability to drive BIM through individuals' self-motivations, specifically in developing countries where prevailing work ethics are poor. Also, without BIM favorable technical (standards, user-guides and classifications), procurement (integrated procurement for knowledge-centric information exchange), organizational (collaborative) and policy environments (data security, ownership and intellectual property issues), it is unrealistic to promote BIM. Thus, the pre-maturity requires a state-level reformation to sustainably drive BIM. Yet, as this study emphasizes, BIM developers at the pre-maturity do not consider these criteria under setting stimuli, ultimately leading to pessimistic and optimistic behaviors.

State-level strategy development is largely governed by individuals' attitudes and their constructs [2, 4]. In this study, 'attitude' means practitioners' mental state of BIM and could represent in a spectrum between pessimism and optimism. If pessimism derives from personal attributes, such as resistance-to-change, self-motivational stimuli (example: making national protocols available) will have less or no value compared to enforcing such pessimists through regulating BIM compliance project delivery (i.e. a technical pull approach). Also, BIM leadership is influenced by the characteristics of the industry and people: having an adequate level of industry motivations, the United Kingdom and the United States successfully lead their BIM development process via a hybrid leadership between the government and industry [2]. Yet, in New Zealand [1], France and Germany [6], their governments take the leadership. Perhaps, this different leadership constitution is due to lack of industry-led motivations and different procurement, organizational and political characteristics of their industries. In conclusion, behavioral mechanisms behind practitioners' beliefs, desires and acts should be assessed with a strong theoretical background. Yet an archival analysis done to the criteria of industry readiness showed that a disproportionately greater attention is paid towards BIM's internal features compared to externalities, and hence BIM adoption dynamics are hidden. Thus, to enhance credibility criteria in BIM development practices, this study suggests the Technical Adoption Model (TAM) [7] as a theoretical framework, assisting developers to evaluate industry readiness at the pre-maturity.

In this paper, the aim is limited to suggest a conceptual framework assessing industry readiness by integrating TAM and the annul BIM-survey template [1] with this study's findings. In future studies, this conceptual framework will be used in South Africa in order to identify effective government intervention possibilities for the wider adoption of BIM. The objectives pursued are: 1) finding the effectiveness of BIM stimuli set at the pre-BIM maturity (reviewing with reference to the theoretical rigors of the Selective Information Processing); 2) identifying the effectiveness of current practices to evaluate industry readiness (archival analysis to the BIM-survey template); 3) understanding how externalities influence practitioners' reasoning process under BIM adoption (interviews analyzed via memo writing and coding); and 4) suggesting a comprehensive framework to evaluate industry readiness.

2. TAM

A brief discussion to TAM (Figure 1) is due to its predominant use throughout this study. The model is generic to IT adoption. Yet, it shows credibility to explain BIM adoption. Firstly, BIM literature [4] interconnecting externalities and BIM's properties (i.e. perceived-usefulness and ease-of-use) is explainable via TAM. Further, the influence of technical pull and push elements towards BIM uses is justifiable. For example, new dimensions could emerge to the supply chain side in terms of perceived-usefulness when a client enforces BIM as a bidding requirement (i.e. winning the bid or not?). While having pessimistic attitudes, a contractor could tend to use BIM under such circumstances, in order to win the tender, which is a direct link between perceived-usefulness and behavioral-intention-to-use (Figure 1). Also, the model assists for BIM developers to question about the output of opinion surveys that focus on BIM readiness. As a case, in New Zealand, non-users are more favorable than BIM-users for some of the key criteria measuring BIM's perceived-usefulness (for example: 'coordination between construction documents': 80% versus 74%). Thus, one may question: 'what impede such practitioners from using the technology'? A study [11] done to the New Zealand context shows that an element called the contextual-reflection (i.e. '*practitioners' careful consideration of externalities and subsequent dependence beyond BIM's internal properties, before acting*'), crates a categorical model entitled 'process versus technology' in terms of user biasness [11]; regardless of positive perceptions, the process-biased category tends to avoid BIM due to prevailing unfavorable procurement and organizational characteristics (externalities referenced to TAM). Notwithstanding TAM's ability to explain those dynamics, the contexts of the construction industry and BIM should be reflected in the concepts of TAM. This was achieved by using operational definitions for TAM's concepts (refer to Table 1).

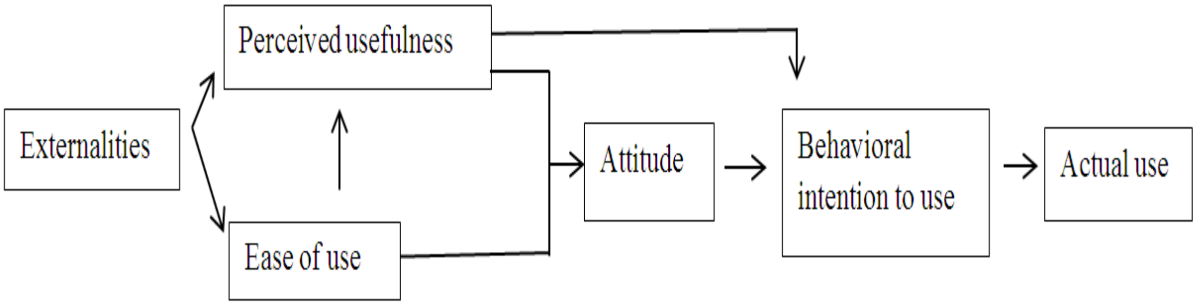

Figure 1: Technical Adoption Model by Davis et al. (1989) [7]

3. Attitudes: pessimism, realism and optimism?

To explain the nature of BIM stimuli set by developers, New Zealand is considered as an example for the pre-maturity [1]. Referencing to BIM practices in the United State, the Productivity Partnership (PP) follows an entirely positivist approach to set stimuli that focus on enhancing practitioners' perceived-usefulness. According to TAM, enhanced perceived-usefulness leads to actual-use, but the Selective Information Processing (SIP) [8] stresses that the nature of stimuli is more important.

One stimulus is that *'57% of designers (in the US) state BIM reduces errors during design phase'* [9]. SIP emphasizes that humans frequently tend to see the glass half-full or half-empty. Explaining further, the Optimistic SIP drives practitioners to focus on the 57% of successful situations only and hence to neglect the associated risk of failure (43%). Perhaps, it is reasonable to assume that this success rate correlates with procurement methods in which those projects were delivered: in the Integrated Project Delivery (IPD), contractors actively engage with the designer regarding design issues, and hence information exchange is effective. As long as PP does not include relevant qualitative variables related to the stimulus (i.e. no attention to intra-paradigm issues, such as context-stripping), an optimistic designer/architect will not reflect on this risk and hence will adopt BIM under traditional procurement methods, without a proper risk management plan. This may lead to inefficiencies while information is exchanged back and forth with the contractor during the design confirmation interface, leading to disappointments. On the other hand, *"a pessimist's attention is focused on the glass half empty… allocates a disproportionately greater attention to the negative cues, while tending to forget the positive aspects"* [8]. Since the construction industry is highly risk-averse towards new technologies [6], there is high possibility to occur the Pessimistic SIP (i.e. focusing only on the 43% of failures). More importantly, neither case drives to realistic decisions. Thus, the credibility of PP's stimuli is highly skeptical.

On the other hand, realistic decision making on BIM adoption by a novice-user is fuzzy: from one side, there are plenty of qualitative features which interact with each other and ultimately influence success [2, 3, 4]; on the other hand, no standard productivity data established to assist rational decision making [4]. According to the Unconscious Though Theory [5], such scenarios are categorized as 'complex'. Further, the theory argues that rational data-driven decision making leads to wrong or suboptimal choices, and hence 'intuition' is encouraged to make judgments. Yet, as long as intuition associates with experience, it is unrealistic to encourage a novice-user to make intuitive decisions (i.e. the chicken egg causality dilemma).

For example, Figure 2 illustrates two hypothetical situations that rational models could be used under collaborative (a) and individual (b) decision making. The first scenario is a decent of the Game Theory. In case 1 (no BIM by both parties), the lowest payoff values (1, 1) occur. When only the contractor adopts BIM, the client gets no advantage (1, 3); thus, the relevant BIM implementation cost should be spent by the contractor. Yet, when the client adopts BIM, the contractor's payoff is twice as of case 1. However, the case 4 has the highest payoff, and hence both are encouraged to use BIM collaboratively. In addition to optimum payoffs, this model tells the highest beneficiary, and hence the most responsible person for BIM adoption in terms of cost and time. However, the question remains: how a novice-user decides payoff values? The same question is relevant to individuals (Figure 2-b). To become financially viable, the net value of [a x GAIN - (100 - a) x LOSS] should be positive [LOSS = BIM implementation cost; GAIN equivalent value of expected benefits]. Yet, there is no standard productivity data established to decide payoff values and 'a%', as long as they are subjected to the interactive effects of externalities and human factors [4]. In conclusion, SIP and the chicken egg causality dilemma emphasize limitations associated with individuals' self-motivations to enhance BIM uptake. Thus, similar to BIM competitive countries, a state-level reformation [2, 3] is required at the pre-maturity.

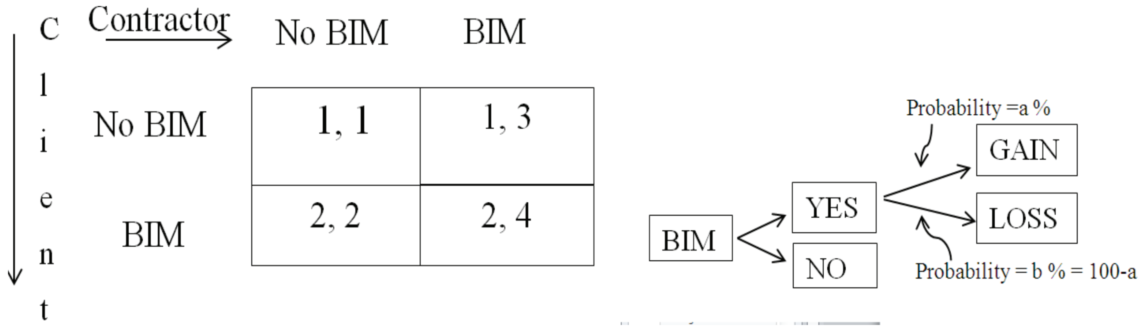

Figure 2: (a) Decision making collaboratively; (b) and individually: (1,1), (1,3), (2,2) and (2,4) are payoff values in (client, contractor) order

In the United Kingdom, BIM competitiveness is achieved via mixed perspectives including: developing state-level technical protocols (example: Uniclass1/2, AVANTI, CPIC, BS/PAS 1192) and regulating BIM for public-sector projects (>£5 million) since 2016 [2]. Also, a sound leadership (for example: BIM Task Group (UK); Building and Construction Authority (Singapore)) is required at the pre-maturity for this reformation. In this study, leadership teams and their compositions are not discussed. Rather, the focus is to establish a framework assisting BIM developers to assess industry readiness reliably at the pre-maturity.

4. Industry readiness

Readiness means the state of 'preparedness' to adopt BIM optimally. Certainly, the term 'optimal' is subjective to LODs. For example, at LOD1, preparedness, in terms of technicalities, means the availability of national protocols that guide the industry to establish common data environments. However, at LOD2, additional technicalities should be assessed, including the availability of proprietary interfaces/ bespoke middleware [2]. The Bew Richard BIM Maturity Model could assists BIM developers to make operational definitions for 'readiness' while considering multiple dimensions, such as procurement, organizational, policy and technical requirements. Yet, surprisingly, conclusions given at the pre-maturity for industry readiness [1] are independent of LODs.

Table 1: Themes in the annual BIM survey template – operational definitions and frequencies

Theme	Operational definition	Frequency
Actual use (U1)	indicate BIM uses in a construction project(s) (zero, suboptimal or optimal)	30, 54.5 %
Behavioral-intention-to-use (U2)	implying future use with an adequate certainty, regardless of when	05, 9.1%
Perceived-usefulness (I1)	independent of externalities, BIM's capacity to influence success or critical success factors	31, 56.3 %
Ease-of-use (I2)	independent of externalities, easiness to interact with n-D software features and interfaces	10, 18.2%
Technical readiness (E1)	standards, user-guides and classifications specific to BIM implementation	10, 18.2%
Organizational readiness (E2)	commitments to project, own organization or other organizations	05, 9.1%
Procurement readiness (E3)	process of executing a project	05, 9.1%
Policy readiness (E4)	principles and guidelines having legal significance	03, 5.5%
Capital assets readiness (E5)	firm's asset capacity required to adopt BIM	01, 1.8%

Table 2: Themes identified in the annual BIM survey template

Criteria	Questions/Statements in the questionnaire template (n=55)	Themes
Awareness and adoption of BIM	Awareness and use of BIM (aware and using, aware, neither aware nor using), Where on the BIM journey are you?	U1, U2
	Is the use of BIM growing in your organization?	U1
	You hear more and more about BIM these days	I1,U1
	BIM is the future of project information	I1,U2
	BIM is all about real time collaboration	I1
	The industry is not clear enough on what BIM is yet, I trust what I hear about BIM, BIM does not facilitate bespoke design or construction methods	I1/ I2
	BIM is all about software, BIM is just a synonym for 3D CAD drawings, Unless specifications are linked to the CAD model, it's not BIM, We will need BIM so we can design sustainable buildings, BIM is only for new build, not refurbishment, BIM leads to bland buildings	I1
	Information models only work in the software they were made on	I2
	I think the government is on the right track with BIM	E4
Use of BIM in current projects	Within your organization have you adopted BIM for your projects, We produce hand drawings/2D CAD/3D CAD	U1
	We work collaboratively on design/ We only share our CAD models inside our organization/ We share our CAD models with design team members outside our organization/ All the design team produce 3D building information models, but we don't have one model that includes all the information/ All the design team contribute to one 3D information model that we all share and contribute to, We use the model from the very start to the very end	U1/E2 / E3
	The model we use depends on one piece of software	I1
	When producing CAD drawings, which of the following tools do you mainly use?	U1
	We produce 2D visualizations using our CAD models/We produce 3D visualizations using our CAD models, We automatically generate schedules from our CAD models, We automatically generate bills from our CAD models, We carry out performance analysis (energy consumption/structural/acoustic) on our CAD models	U1/ I1
	We export information from our CAD models to a non-proprietary format (IFC/gbXML)	I1/ E1 / U1
	We need to have access to well-structured generic CAD objects, not just manufacturer's objects	I2/ E1

	We keep a library of CAD objects we create for re-use	U1/ E1
	Where do you get the CAD objects your organization uses (CAD package/created in-house and then re-used/created as needed for a project/manufacturers/..specialists outside our organization)?	I2/ E1 / U1
Data coordination	Which of the following statements best describes how your organization normally links CAD drawings to project specifications (automatically, manually, not relevant, etc.)?	U1/ I1
	How does your organization co-ordinate the information in your CAD model and your specification (Masterspec/CBI section or clause numbering on drawings/internal, etc.)?	E1 /U1
Use of BIM collaborative protocols	Do you use IFC (Industry Foundation Classes) on your projects?	E1, E2, U1
	Do you generate COBie on your projects?	E1/ E3/ E2/ U1
Barriers to BIM adoption	Lack of expertise	E1, I2
	Don't see benefit	I1
	Liability concerns	E4
	Lack of standardized tools and protocol	E1
	Lack of collaboration	E2/ E3
	Cost	E5
	How confident are you in your knowledge and skills in BIM?	I2
BIM the future for the construction industry	BIM the future for the construction industry (currently using/n years' time)?	U1, U2
	Adopting BIM has required changes in our workflow, practices and procedures	E2 / I2
	Adopting BIM has improved visualization, Adopting BIM has increased coordination of construction documents , Adopting BIM has brought cost efficiencies, Adopting BIM has increased speed of delivery, Adopting BIM has increased our profitability, Adopting BIM has made traditional bills of quantities redundant within our organization, Adopting BIM has made traditional specifications redundant within our organization, I'd rather we had not adopted BIM	I1/ U1
	We have adopted BIM ***successfully***	I1/ I2/U1
	Adopting BIM has improved productivity due to easy retrieval of information	I1/ U1
	Clients will increasingly insist on us using BIM	E3, E4
	Contractors will increasingly insist on us using BIM	E3

To assess industry readiness, annual BIM surveys are launched in both pre-maturity (i.e. New Zealand) and BIM-advanced contexts (UK and Finland). Since a universally accepted template [1] is used, its ability to uncover unique contextual characteristics seems to be controversial. Since the current study focuses only on the pre-maturity, the arguments brought in this section could have less relevance to BIM-advanced contexts.

The survey template has minimum consideration towards externalities. To understand this, the universal template was analyzed for its content, with the operational definitions focusing on differentiating BIM uses (U), internal properties (I) and externalities (E) (Table 1) [Note: subjective interpretations were done: for example, using COBie (Construction Operations Building Information Exchange) demands life-cycle integration, and was considered under E3; but the same can be categorized under other themes. Also, providing BIM objects by vendors (internal stakeholder with respect BIM) is under I2, but by manufactures (external stakeholders with respect to BIM) is under E1]. One may refer to Table 2 in order to understand the themes assigned for each question.

According to the frequencies of the themes counted for the 55 questions (Table 1), the descending order is: Perceived-usefulness > Actual-use > Ease-of-use = Technical readiness > Behavioral-intention-to-use = Organizational readiness = Procurement readiness > Policy readiness > Capital assets readiness. Thus, externalities (E2, E3, E4 & E5), which are key drivers of sustainable BIM adoption [3], are given a minimum consideration compared to BIM's internal properties (I1) and actual use (U1). Perhaps, such efforts are suitable for BIM-advanced contexts due to richness of other sources of BIM literature [2]. Yet at the pre-BIM maturity, including New Zealand, the scarcity of literature and unreliable survey outputs could hinder unique criteria relevant to BIM adoption dynamics. The field study carried out in South Africa as a part of the main study strengthened this argument.

5. Design of the study

The findings substantiating the rationale of the conceptual framework, which is provided under the discussion, will be generalized under future studies, and hence quantitative techniques, such as frequency of count, were not considered here. Due to limited BIM literature, South African BIM adoption dynamics were assumed as unknown (i.e. minimum pre-conceptions), allowing the participants to define the problem. Face-to-face interviews were used and memo writing was the main mechanism to work with the data. Sorting and coding were done using the memos to understand participants' behaviors. Contribution from this study to the main (future) research and the availability of resources to answer the questions related to effective government intervention possibilities for the wider adoption of BIM were considered as criteria for selecting the interviewees. P (participant) 1 (BIM-vendor) and 7 (general consultant) had BIM experience in average of 18 years including more than 60% of that in the United Kingdom. The remaining participants were both BIM users and non-users subjected to the threshold criteria of minimum 10 years' experience in South Africa and represented executives from regulatory bodies (P3, P4, P5 and P11), construction manager (P2), architects (P6 and P9), general consultant (P7), quantity surveyor (P8), client (P10) and real estate consultant (P12). The interviews were continued until no new theme was emerged (theoretical saturation at n=12).

6. Contextual-reflection by the participants

Though the main study considered current maturities, pertinent LOD transitions [2] and perceived-usefulness, only unique characteristics of the contextual-reflection are described due to the limited scope of this paper. The capital assets readiness ***(E5)*** is not discussed, as long as the themes emerged were too general (e.g. cost).

Technical readiness (E1): the unavailability of common protocols was mentioned frequently by the BIM users (P1, 7, 9, 11), which is a general issue occurring beyond the LOD0. In addition to difficulties in reusing data and prevailing misinterpretations, unavailability of user-guides incurs difficulties in understanding minimum information requirements, leading to over-complicated BIM models (P7, 11). Insufficient internet infrastructures largely obstruct BIM implementation (P1, 7). Under ideal BIM implementation, stakeholders could not wait until information is transferred through USB sticks and DVDs, but exchanging BIM models, which may exceed 500 megabytes, is an enormous challenge (P1, 7) using the slowest internet speed in the world [12]. Thus, simplification of BIM models through minimum information requirements has contextual importance to South Africa.

Organizational readiness (E2): In South Africa, contractors tend not to check design errors and constructability in advance, but rather are reactive under the presence of such issues to minimize consequences (for example, using cheap casual labors to recover schedule losses) (P6, 9, 10, 11). Thus, it is skeptic whether practitioners tend to use deliberate strategies to reduce design errors (such as using BIM), specifically when BIM's financial sustainability is unknown (P1, 10, 11). This is an indication that pull strategies are more appealing to South Africa.

Procurement readiness (E3): while half of the participants (P2, 7, 4, 5, 8, 11) were unable to answer, the rest believed that favorable procurement methods, similar to IPD, should be established, except P3 (representing a regulatory body) who believed that *'any procurement method could support BIM'*. As described in the discussion, P3 could not differentiate collaboration and integration adequately with respect to BIM maturities.

Policy readiness (E4): though there is a possibility to encourage BIM through existing policy regimes for contractors (example: the Best Practice Project Assessment and Best Practice Contractor Recognition), no regulatory body starts such initiatives until the industry lays the foundation (P3, 11). Yet, the industry (P1, 9, 10, 12) does not believe that BIM implementation is mainly driven by them due to prevailing work ethics. Having no such policy schemes for other stakeholders, significant development cannot be expected from regulating policies only for contractors (P10). Also, under the Regulatory Impact Assessment, existing policy regimes, such as the Black Employment Empowerment, could become critical considerations (P3, 10, P11) as described under the discussion.

7. Discussion

SIP and the Unconscious Thought Theory emphasize the limitations of individual-driven stimuli to drive BIM sustainably at the pre-maturity. The alternative focus is to use state-level technical pull and push elements, similar to global competitors (UK, USA and Finland) [2]. However, individuals' beliefs/desires/acts, which are greatly influenced by externalities [7], govern the nature of state-level strategies, and hence could not be neglected. In addition, there is a strong link between externalities (procurement, organizational, technical and policy environments) and state-level reformation [2, 3]. Yet, a universally accepted questionnaire template is repeated at the pre-maturity as the only method to assess industry readiness, paying no adequate attention towards externalities or uniqueness [11]. The filed study substantiated the essence of integrating externalities under readiness.

Some issues, such as insufficient internet infrastructures, have no or little control to the construction industry. Yet, at least, these issues should be considered when BIM execution/development is planned (examples: ability to work distantly; use of web-based servers?). Also, using casual labors (perhaps, unskilled) may recover schedule loss, but could reduce project quality also. This should motivate clients to enforce BIM mandate project delivery under contractual obligations (i.e. a pull element), providing a platform to identify and communicate design issues in advance. Under BIM regulations, conflicts could occur with existing policy regimes, such as the Black Employment Empowerment, especially if advanced BIM maturities are driven by international joint-ventures (P7). Thus, in addition to right threshold limits for BIM mandating, a knowledge diffusion framework will be applicable, transferring BIM skills to medium and small scale firms. Misconceptions among regulatory perspectives could be a barrier towards the state-level reformation. For example, P3 could not differentiate 'integration' from 'collaboration', leading to his belief that procurement change is unnecessary. Though P3's misbelief is not that significant for data-centric processes where collaboration is adequate, with no integrated protocols, knowledge-centric processes (i.e. LOD3) are not viable [10].

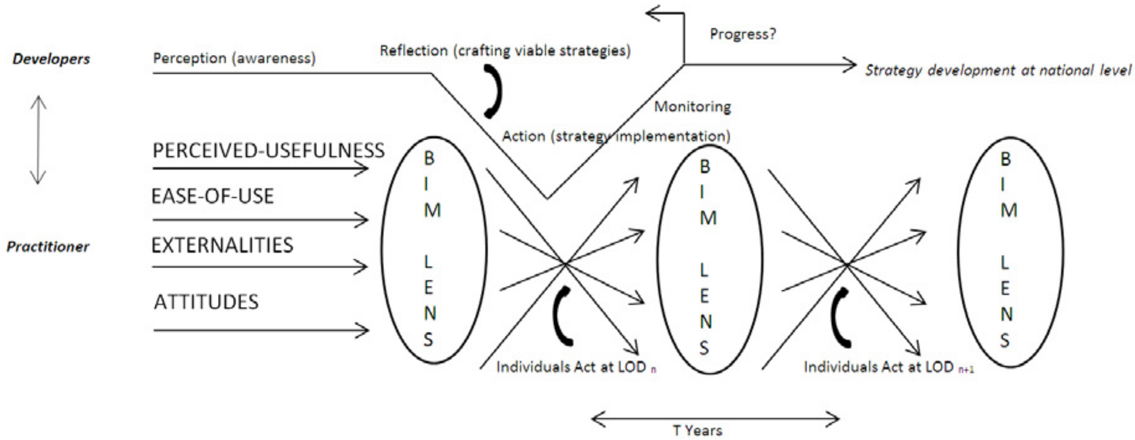

Figure 3: Conceptual framework for the evaluation of industry readiness at the pre-maturity

Considering the requirements of the state-level reformation and identifying practitioners' behavioral mechanisms, the conceptual framework (Figure 3) is suggested to assess industry readiness holistically. Also, there are certain elements in the framework where survey based methodologies could bring merits. For example, surveys could provide independent views of industry awareness (perception) and effectiveness of strategies developed at the state-level (monitoring). Thus, outcomes become indications for further progression or taking corrective actions to enhance the effectiveness of existing BIM strategies [2]. However, the challenging part is to identify practitioners' attitudes which have a strong influence on the viability of state-level strategies (as explained before, a realist needs favorable collaborative and/or integrated protocols, but a pessimist needs enforcement driving to the do-or-die dilemma). These behavioral mechanisms could be found from exploratory studies and TAM seems to provide a theoretical background to carry out such qualitative inquiries through an anti-common-sense hypothetico-deductivist model. Yet, in the conceptual framework, TAM's elements are integrated differently. This is to represent diverse interrelationships among the constructs. For example, one may perceive externalities and then reflect on perceived-usefulness and ease-of-use, ultimately shaping up his/her attitudes. Another practitioner may entirely forget about externalities, driving to optimistic attitudes. Also, personal attitudes, such as resistance-to-change, could lead to reject BIM with no reflection at all towards externalities and BIM's internal properties. Thus, predecessor and successor elements could not be fixed into a nomothetic model in BIM adoption. The identification of those interrelationships seems to be evidence-based and 'BIM lens' emphasizes the process of those interpretations.

8. Conclusion

Under setting stimuli at the pre-maturity, BIM developers do not pay adequate attention to align their practices with the theoretical rigors established in the science of decision making (SIP) and technology adoption (TAM). This could lead to pessimistic and optimistic attitudes, and both could hinder sustainable BIM adoption. On the other hand, making realistic decision in BIM adoption by a novice is similar to the chicken egg causality dilemma, and hence the pre-maturity requires a state-level reformation to the construction industry that is run by a proper leadership. The state-level reformation is directly influenced by externalities and in addition, there is an indirect effect from them towards practitioners' behavioral mechanisms, and hence to the nature of state-level BIM strategies. The field study substantiated that those externalities are unique. Thus, the applicability of a universally accepted questionnaire template is skeptic to assess industry readiness. Therefore, a conceptual framework is introduced to enhance the reliability of BIM development practices focusing on industry readiness at the pre-maturity. The framework will be used in South Africa under future studies and it is believed that this would guide BIM developers at the pre-maturity to convert current outputs into reliable outcomes.

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