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Towards Developing Strategic Assessment Model for Big Data Implementation: A Systematic Literature Review

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Abstract

Most of the business model depends on big data adoption and development as a major strategy to gain valuable insights and business value for competitive advantages. The trend and rapid growth of data required top management to assess the impact of big data development outcomes towards business value. An appropriate strategic assessment model should be developed to measure the capabilities of big data ecosystem during the implementation environment. This review paper presents the systematic literature review of big data assessment models were encompassed with capability components which are customized for assessing big data development. Eight models for big data readiness based on maturity model perspective were assessed and reviewed in detailed. The finding showed that big data strategic assessment model is still lacking and at its infancy stage in Information System (IS) research in helping the organization to maintain their business performance of big data implementation.

Keywords: *Assessment Model, Big Data Development, Big Data Implementation, Strategic Assessment.*

1 Introduction

Practitioners and researchers have shown high interest in big data adoptions and implementations phenomenon. Big organizations have implemented big data adoption and development for business value creations through the result of big data analytics applications [1] that are able to provide valuable insights and support in decision making [2] [3] and ultimately for competitive advantages in the application of big data strategy [4]. Big data have also created greater opportunities to new business data-driven models [5] and acts as a strategic enabler to a new challenge of enterprises and organizations business models [6] as well as plays an important role in formulating executive strategy in the new information era [7]. The investigation on the strategic impact of Big Data implementation showed that it is just departing [6] and therefore, the initiatives of big data are significant to strategy management in many organizations [8].

The aims of this paper are: a) to investigate the assessment model used in big data organizations which facilitate continuous improvement as the business and information system (IS) strategy; b) to provide useful information on big data ecosystem capabilities and its related assessment model; and finally c) to determine opportunities for future research in assessing big data implementation toward sustaining value of the organization profitability.

This paper is organized as follows: Section 2 contains the overview of big data and followed by Section 3 contains the review methodology of the systematic review process. In Section 4 presents the extracted information is analyzed to answer the research questions, and followed by Section 5 results and discussion of research. Lastly, Section 6 serves as the conclusion.

2 Background of Big Data

The earlier understanding of big data was reported by Laney [9] which defined big data as a 3Vs, that means Volume, Velocity, and Variety. Volume refers to the enormous size of data while variety refers to multiple types of data and captured from multiple sources and velocity refers to the speed of data creation. This understanding was agreed upon by De Mauro and his partners [10] in their definition that big data represents information assets and with additional characteristics such a High Volume, Velocity, and Variety, and it requires specific processing technology and analytical methods for its conversion into Value.

Meanwhile, Shim and his colleagues [11] have classified Big Data into 5Vs (Volume, Variety, Velocity, Veracity and Value) and further divided them into two subgroups that comprises of big data characteristics (Volume, Variety and Velocity) and big data processing which includes the validation of truthfulness or credibility data (Veracity) [12] and business value (Value) [13].

According to Halaweh and El Massry [14], the critical success factor of big data implementation includes top management support, organizational adjustment, data availability and quality, infrastructure, required skill set and, privacy and security. Business leaders and project managers are accountable to leverage big data opportunities in business strategy to align with organizations and IT goals. They are also strategically assigned to oversee the effectiveness and impacts of the new business model to organizations. Rahman and Aldhaban [15] further added that big data development and implementation requires monetary investment for acquiring new technologies and tools, trained and skillful people (IT professional and data scientist) who have expertise in the big data area.

In order to ensure that big data business model, trends and technologies continue to be applicable to organizations business, an effective strategy assessment needs to be implemented periodically. The organization needs to position themselves and implements strategic assessment of its data challenges and opportunities as well as embarking on a leading-edge data infrastructure that can flex and scale to changing business demands [16]. It should be noted that strategic assessment is a long-term practice to continuously assess or measure the implementation of big data project and the assessment model shall be properly executed to ensure the outcomes is delivering business value successfully [15].

3 Review Methodology

The review strategy is based on the System Literature Review (SLR) guidelines for Software Engineering by Kitchenham and Charters [17], and Okoli and Schabram [18]. The SLR consisted of 3 stages that include planning the review, executing the review and formatting the report as shown in Fig. 1. The planning stage looked into a protocol which structure is based on specific research context, defined reviewing protocol and constructing of research questions. This is followed by the executing stage that performed search strategies and data extractions to categorize data items as outputs. Finally, the reporting stage will be summed up discussion and the results.

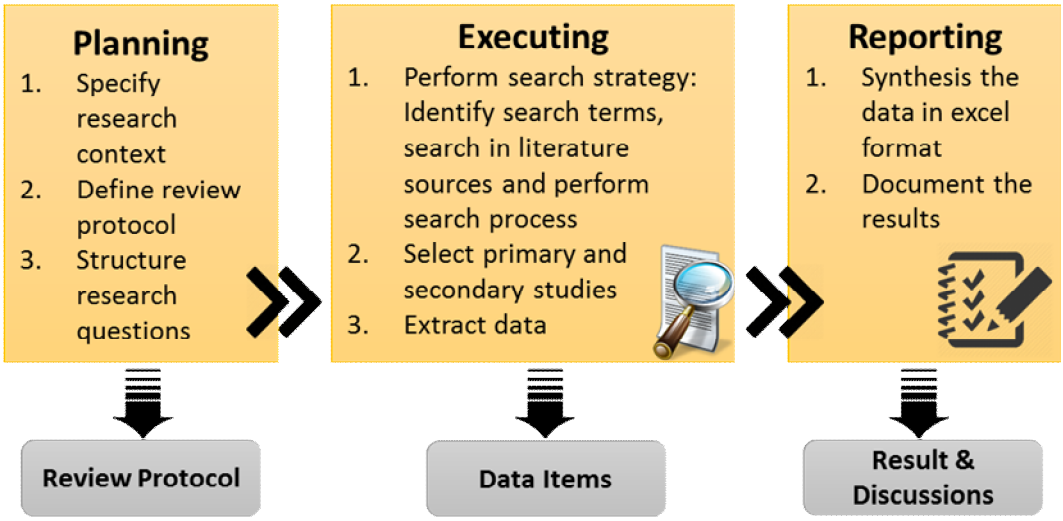

Fig. 1: Systematic review phases

3.1 Research Questions

In the planning stage, the research questions for this study were structured based on PICOC (Population, Intervention, Comparison, Outcomes and Context) [19]. The scope for structuring review questions is shown in Table 1.

Table 1: Identified scope for structuring research questions

Criteria	Scope
Population	Big data organizations
Intervention	Limitations of the existing big data assessment models
Comparison	*Not applicable*
Outcomes	Type, criteria and components of big data assessment models
Context	Review of any investigations on big data assessment models

Four (4) research questions (RQ) were designed based on the finalized criteria and scope as in Table 1.

RQ1: How many studies are conducted on big data assessment for development and implementation?

RQ2: What models have been used for assessing the big data development and implementation?

RQ3: What are the criteria of the assessment model?

RQ4: What are the limitations of existing assessment models?

3.2 Search Strategy

In the execution stage, the search strategy was performed to include the formulation of the search term, search data sources from online databases, formulate inclusion and exclusion criteria, and study quality assessment.

3.2.1 Search Term

The search term is a combination of integration of synonyms word strings using the boolean OR operator as in Table 2, and structure of search string by integrating search terms using the boolean AND operator as Table 3.

Table 2: Integration of synonyms word strings using the boolean OR operator

Criteria	Integration of synonyms
Population	big data organization OR big data initiative OR big data adoption OR big data development OR big data implementation
Intervention	assessment methodology OR maturity model OR continuous improvement
Method	process OR technique OR procedure OR model

Table 3: Structure of search string by integrating word strings using the boolean AND operator

(big data organization OR big data initiative OR big data adoption OR big data development OR big data implementation) AND (assessment methodology OR maturity model OR continuous improvement) AND (process OR technique OR procedure OR model)

3.2.2 Literature Sources

The review exercise was based on 7 electronic database resources such as Scopus, IEEE Explore Digital Library, Emerald, Springer Link, Science Direct, ACM Digital Library and Google Scholar to extract data based on the title and abstract information. Some papers were cited using snowballing technique search *via* electronic databases. The relevant papers were then stored in reference management tools for selection. The literature cited in this review paper only taking into consideration publications between January 2010 and April 2016.

3.2.3 Inclusion and Exclusion Criteria

The inclusion and exclusion criteria were used to exclude papers that are not relevant to answer the research questions. Both of inclusion and exclusion criteria were determined and presented as in Table 4.

Table 4: Determination of inclusion and exclusion criteria

Inclusion	Exclusion
1. All papers are published in English.	1. Papers not published in the English language.
2. All papers are published from 1 January 2010 to 30 April 2016.	2. Paper published before 2010 OR out of period range.
3. Papers that focuses on assessing big data development and implementation.	3. Papers with less than 3 papers.
	4. Papers that are out of research questions scopes.
	5. Duplicate study areas.

3.2.4 Study Quality Assessment

The quality assessment was formulated to evaluate the completeness of papers and advantageous for data extraction. These questions are presented in Table 5. Each question has only 3 alternative answers: Yes=1; Partially=0.5; and No=0.

Table 5: Study quality assessment criteria

Quality ID	Quality Assessment Questions	Answer
Q1	Is there a clear description of the aims and objectives of the investigation?	Yes/Partially/No
Q2	Is the investigation based on review product?	Yes/No
Q3	Is it solely a 'lessons learned from company product' report based on expert opinion?	Yes/No
Q4	Is the paper explained the model structure in detail?	Yes/Partially/No

4 Findings

Based on systematic review phase in Fig. 1, the study selection was divided into 3 stages of selection. Firstly, the digital search was carried out and selection processes are based on the title, which resulted in a total of 528 references that are deemed relevant to this topic. In the next stage, the abstract and brief content of the selected papers were evaluated. Duplicate and irrelevant papers were rejected and 38 relevant papers were then filtered by applying the quality assessment criteria. Finally, 12 papers (31 percent of 38 papers) were accepted for data synthesis of evidence after conducting exclusion criteria and screening detailed abstracts and full text (Appendix A). Fig. 2 shows results of the search and selection paper processes.

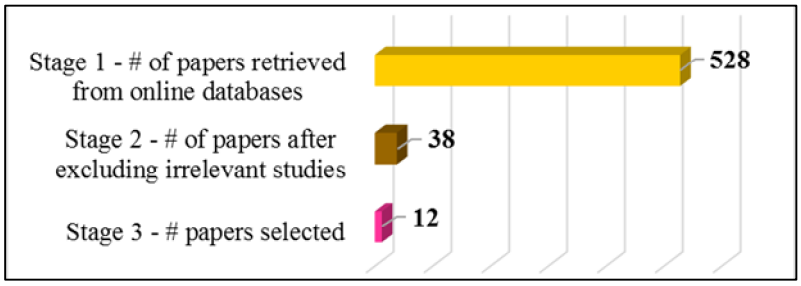

Fig. 2: Selection papers stages

Fig. 3 illustrates the filtering result of the quality assessment. The assessment shows that 5 of the papers scored 4 (S5, S6, S7, S11, and S12), 3 papers scored 3.5 (S8, S9, and S10) and 4 papers scored 3 (S1, S2, S3, and S4). The detailed scores of the quality assessment are presented in Appendix B.

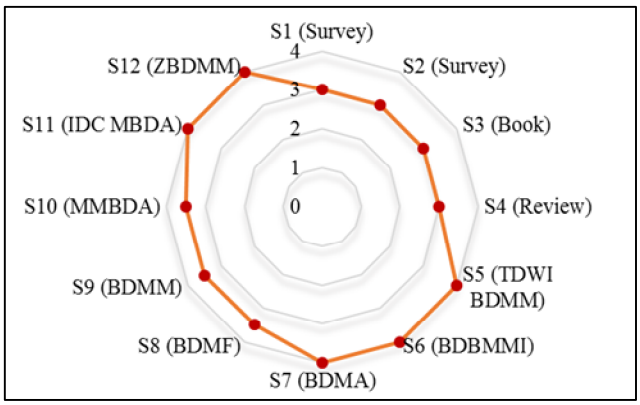

Fig. 3: Quality assessment filtering scored

5 Discussion

In this section, we discussed in detail and presented the results related to the research questions in Section 3.1.

5.1 How many studies are conducted on big data assessment development and implementation? (RQ1)

This review exercise managed to review 12 papers on big data assessment development and implementation (Appendix A). Out of this, 4 papers are of survey and review types, 1 paper is an experimental research paper and the rest are of industrial type papers. It was very surprising to note that the big data assessment only started in 2013 with 1 book chapter publication (S3) and 1 industry whitepaper (S5) by TDWI (The Data Warehousing Institute), followed by 3 other industry whitepapers in 2014 (S7, S8, and S9). In 2015, the number of big data assessment increased with 2 industry whitepapers (S10 and S11), 1

review paper (S4) and 3 research studies that include 2 survey papers (S1 and S2) and 1 experiment paper (S12). However, only 1 paper was published in 2016 of which is industrial whitepaper (S6). Overall, the publication trend on big data assessment has increased significantly since the year 2013 until 2015 as shown in Fig. 4.

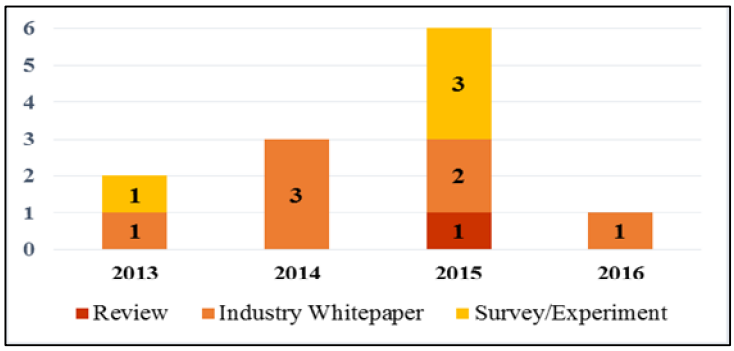

Fig. 4: Papers distribution by publication years

5.2 What models have been used for assessing the big data development and implementation? (RQ2)

Big data is still new and in its infancy stage, so the assessment model definition for big data has not been precisely defined [20]. Therefore, the purpose of this research question is to investigate the type of models that have been used to assess big data development and implementation. This review managed to identify 8 types of assessment models that is also described as 'maturity model' such as TDWI Big Data Maturity Model, Big Data Business Maturity Model Index, Big Data Maturity Assessment, Big Data Maturity Framework, Big Data Maturity Model, A Maturity Model for Big Data and Analytics, IDC (International Data Corporation) MaturityScape Big Data and Analytics, and Zakat Big Data Maturity Model. Most of these models were found to be fitted for organizations' readiness to assess the current state and the desired future state of maturity of big data development. Meanwhile, Big Data Maturity Model (S9) has extended its purpose of including the assessment of big data implementation. Table 4 summarized the model type, abbreviation, purpose and focus area of the assessment models.

Table 4: Big data assessment model

Study ID	Assessment model name	Abbr.	Purpose of the model used	Focus area
S5	TDWI Big Data Maturity Model	TDWI BDMM	To describe maturity stages of organization's capabilities and readiness towards big data development.	Organization readiness
S6	Big Data Business Maturity Model Index	BDBMMI	To measure the maturity business models in the context of using big data and analytics.	Organization readiness (business model)

S7	Big Data Maturity Assessment	BDMA	To provide an assessment tool for organization's big data maturity across five key dimensions.	Organization readiness
S8	Big Data Maturity Framework	BDMF	To categorize the numerous ways in which data can be an advantage, from selective adoption to large-scale implementation.	Organization readiness
S9	Big Data Maturity Model	BDMM	To socialize the concepts and critical success factors around Big Data maturity, to assess the level of existing Big Data maturity and then to help build a Big Data vision and roadmap.	Effectiveness of the big data adoption and implementation
S10	A Maturity Model for Big Data and Analytics	MMBDA	To provide a guide on identifying business value using big data and analytics.	Business model
S11	IDC MaturityScape Big Data and Analytics	IDC MBDA	To assess organizations' competencies to leverage and manage the BDA solutions.	Organization readiness
S12	Zakat Big Data Maturity Model	ZBDMM	To gauge the readiness of zakat institutions to embark into a big data evolution.	Organization readiness for non-profit organization

5.3 What are the criteria of the assessment model? (RQ3)

Table 5 presents the criteria of assessment models that comprised the structure of maturity level/stage, assessment scale, capabilities components and assessment instruments. The structure of maturity level/stage is described as the assessment's stage of big data development. Six (6) of big data maturity models (S5, S6, S9, S10, S11, and S12) have 5 levels of assessment which begins with infancy stage until the organization is ready and mature for big data adoption. Meanwhile, models S7 and S8 have 4 stages of maturity assessment. The qualitative or quantitative assessments are the scale types usually used in the maturity models. Model TDWI BDMM (S5) uses both qualitative and quantitative assessment approach. However, 4 of the big data maturity models (S6, S8, S9, and S12) are using a qualitative approach, and followed by quantitative approach uses in the other 3 models (S7, S10, and S11). The assessment instrument used in model S5 and S7 is a software tool while the rest of the model used text document as an instrument for the assessment.

The main criteria that differentiate the big data maturity models from the rest are their capability components. It described the elements of big data ecosystem involved in the assessment and is able to scope and summarized the capability components which include organization, data, process, system architecture and people as in Appendix C. The 'Y' sign indicates the capability components included in the selected maturity models. Organization capability is the main

component for assessing the organizations' readiness towards big data development. Meanwhile, people's capability has been given little attention throughout the assessment of the organizations' readiness for big data adoption.

5.4 What are the limitations of existing assessment models? (RQ4)

In general, big data strategic assessment is still in its infancy stage of research and has limited literature at the moment. Most of the maturity model for big data adoptions and developments are recently constructed [20]. During this review exercise, it was discovered that the selected assessment models have some limitations such as poor documentation to guide organizations to conduct a smooth assessment for big data adoption and most of the assessment models are limited to organization readiness. In addition, the assessment lacks the ability in identifying the need for people's skills and competency in processing and analyzing big data. Furthermore, most of the existing assessment models are lacking support tools such as software tool as assessment's instrument and adaptable visualization report for decision making. Fig. 5 illustrates the limitation criteria of the selected assessment models.

Since we have limited access to the industry's whitepapers, this review exercises solely based on the information published and shared through the web pages and online databases which were subscribed by Universiti Putra Malaysia, Serdang, Malaysia.

Table 5: Assessment model criteria

Study ID	Abbr.	Level/Stage structure	Assessment scale	Capability components	Assessment instrument
S5	TDWI BDMM	1-Nascent 2-Pre-adoption 3-Early adoption 4-Corporate adoption 5-Mature/visionary	Qualitative Quantitative	Data Management, Infrastructure, Analytics, Organization and Governance.	Software tool
S6	BDBMMI	1-Business monitoring, 2-Business Insights 3-Business Optimization 4-Data Monetization 5-Business Metamorphosis	Qualitative	Organization, Business process and Organization's situation.	Text document
S7	BDMA	1-Infancy, 2-Technical Adoption, 3-Business Adoption, 4-Data & Analytics as a Service	Quantitative	Business Need, Technology Platform, Operating Model, Analytics, and Information Management.	Software tool
S8	BDMF	1-Performance Management 2-Functional area 3-Value Proposition enhancement 4-Business model	Qualitative	Technical/ infrastructure, Data availability & governance, Data-driven, Decision-making culture, Organization & resources,	Text document

		transformation		and Sponsorship.	
S9	BDMM	0-In the Dark 1-Catching up 2-First Pilot(s) 3-Tactical Value 4-Strategic Leverage 5-Optimize & Extend	Qualitative	Vision, Strategy, Value & Metrics, Governance, Trust & Privacy, People & Organization, Data Sources, Data Management, and Analytics & Visualization	Text document
S10	MMBDA	1-Ad hoc 2-Foundational 3-Competitive 4-Differentiating 5-Breakaway	Quantitative	Business strategy, Information, Analytics, Culture and Operational Execution, Architecture and Governance.	Text document
S11	IDC MBDA	1-Adhoc 2-Oppurtunities 3-Repeatable 4-Managed 5-Optimized	Quantitative	Vision, Technology, People, Process, Portability & Integration	Text document
S12	ZBDMM	1-Ignorance 2-Coping 3-Undestanding 4-Managing 5-Innovating	Qualitative	Organization, Leadership, Data Governance & Integration, and Analytics.	Text document

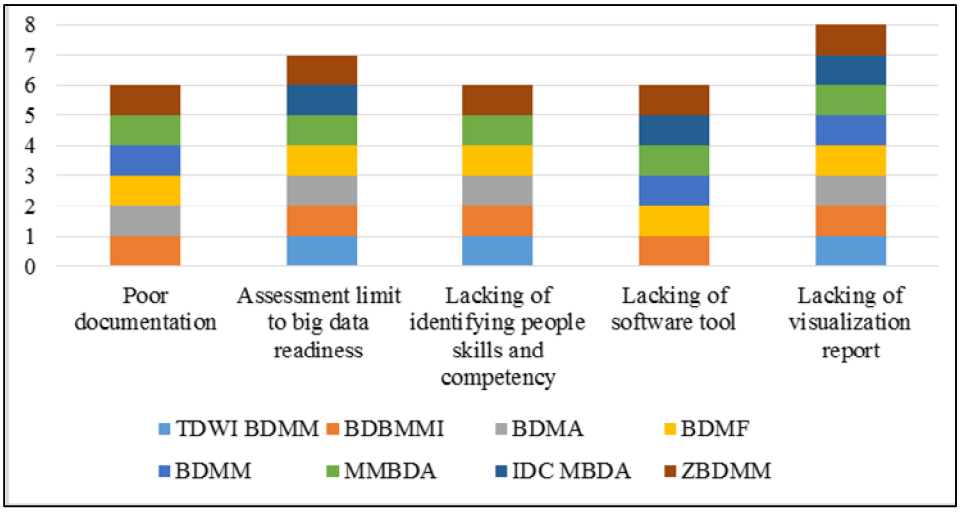

Fig. 5: Limitation criteria

5.5 Initial big data strategic assessment model proposal

Based on the gap that has been discussed in Subsection 5.2 to Subsection 5.4, it is proposed that a strategic assessment model is to be used for big data implementation (Fig. 6) in future research. Big data strategic assessment is defined as the central idea of developing this theory. Big data strategic assessment

is supported by 2 independent variables which include motivation and capability strategy. It is believed that the assessment for big data implementation and activities have a significant impact to business concern as illustrated in Fig. 6. The development of motivation category was adopted from [21] and [22], which categorized causal condition to indicate to events or incidents that are of advantages to the occurrence or development of a phenomenon. Motivation refers to the analytics and insights benefits prior to big data implementation that includes business model transformations [23] [24], business opportunities to organizations [25], big data as strategic enabler [6] and better decision making [26]–[28].

The capability strategy category was developed based on findings of capability components in Subsection 5.3 that was used in most existing big data maturity models for big data development. The elements of capability strategy components also taking into consideration suggestions by De Mauro and partners [10] on the understanding of big data phenomenon on information, technology, methods, and impact. The initially proposed component of capability strategy includes organizational culture, data management, people, process, and system architecture. Studies by Gupta [29] and Olama with his colleagues [30] opined that organizational culture has links to the 3V's Big Data for the success of big data initiatives. Organizations with a flexible structure and an external focus are likely to have an absolute impact on the 3V's of Big Data in this manner increasing their chances of deriving maximum benefits from Big Data initiatives. In addition, data management is a key strategy function in big data to derive valuable insights from enormous of data [9] [31]. The data management tasks include data governance, data development, data architecture management, data quality, database operations, data security, data warehousing and business intelligence as well as document management [30].

People capability is considered a very important component in big data implementation. According to Chatfield and her colleagues [32], data scientist acts as game changers in big data environments, while Lavelle and his colleagues [33] described that big data scientist must have the analytics capabilities such as aspirational, experienced and willingness to transform. They need new skills to manage, analyze and view large data set to obtain necessary information for constructing important decisions [34]. In this regards, talent gap in optimization analytics, descriptive analytics, and predictive analytics are critical for business analytics in big data era.

Big data is altering the manner of understanding, learning and varying the analytics dynamically. It also requires analytical techniques in unlocking big data into business value and opportunities [35] [36]. In general, organizations would gain potential value from data analytics in one of the following three techniques: descriptive, predictive and prescriptive analytics [37]. The processes of big data analytics involving data selection, data pre-processing, data analysis, data visualization, and result in interpretation [38]. Better business outcomes are achievable by harnessing the new insights from big data which may conclude

higher quality and enhanced understanding between the client and the enterprises [39].

Big data system architecture capability is associated with specific advancement technology that empowers its utilization [10]. A study by Demchenko and his colleagues [12], suggested that big data architecture framework consisted of data models and structures, big data infrastructure, analytics applications, tools, and security. Big data environment also taking into consideration several technologies, techniques and analytics application for collecting, storing, processing and data analysis. [34]. Hu and his colleagues [37] presented that big data value chain is associated with data generation, data acquisition, data storage and analytics applications.

The aim of developing the big data strategic assessment model is to assess big data implementation for the sustaining value of the organization profitability. The outcomes of the assessment have a significant relation to the business concerned in maintaining their business performance through better decision making. The components of the business concern that need to be considered including future business impact [2] [40], continuous business model innovation [41], sustainable competitive advantage [26] [42] and, new issues and challenges related to big data ecosystem [43] [44]. It is hoped that by adopting capability component of maturity model, the proposed model comprehensiveness will be strengthened towards big data implementation.

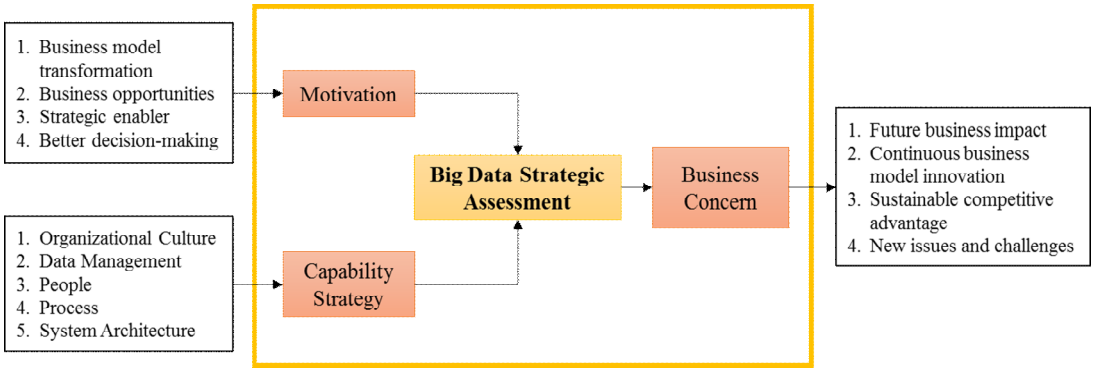

Fig. 6: Initial proposed strategic assessment model for big data implementation

6 Conclusion

The majority of the current business model depends on big data adoption and development as a major strategy to gain valuable insights and business value for competitive advantages. The rapid growth of data required strategy management to assess the impact of big data development outcomes to business value and opportunities. Therefore, big data capabilities such as organizational culture, data management, people, process, and system architecture will be useful in the

organization's effort to develop new big data business model in the future, sustaining competitive advantages and to address new issues and challenges. An appropriate strategic assessment model would be needed to assess the capabilities of big data ecosystem for the next business journey. Using the big data strategic assessment model, business leaders and strategic managers would be able to make better decision-making in creating greater business models for organization's business advantages and strategize the essentials of big data advancement.

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Appendix A. Studies comprised in the review

Study ID	Year	Type of studies	Publication Type	Keywords	Reference
S1	2015	Survey	Conference	big data, maturity models, assessment criteria	[20]
S2	2015	Survey	Thesis	NA	[45]
S3	2013	Survey	Book	NA	[46]
S4	2015	Review	Conference	NA	[15]
S5	2013	Industry (Whitepaper)	Webpage	TDWI big data maturity model	[47]
S6	2016	Industry (Guide)	Webpage	big data business maturity model index	[48]
S7	2014	Industry (Guide)	Webpage	big data maturity assessment	[49]
S8	2014	Industry (Guide)	Webpage	big data maturity framework	[23]
S9	2014	Industry (Guide)	Webpage	big data maturity model	[50]
S10	2015	Industry (Guide)	Webpage	big data and analytics	[51]
S11	2015	Industry (Guide)	Webpage & Survey	big data and analytics	[52]
S12	2015	Experiment	Conference	big data, zakat, maturity model, strategy, levels	[53]

NA – Not Applicable

Appendix B. Quality assessment result

Study ID	Q1	Q2	Q3	Q4	Total
S1	1	1	0	1	3
S2	1	1	0	1	3
S3	1	1	0	1	3
S4	1	1	0	1	3
S5	1	1	1	1	4
S6	1	1	1	1	4
S7	1	1	1	1	4
S8	1	1	1	0.5	3.5
S9	1	1	1	0.5	3.5
S10	1	1	1	0.5	3.5
S11	1	1	1	1	4
S12	1	1	1	1	4

Appendix C. Capability components in big data assessment models

Capability Components	S5	S6	S7	S8	S9	S10	S11	S12	Total
ORGANIZATION									
Business Need			Y						1/8
Culture and Operational Execution						Y			1/8
Decision-making culture				Y					1/8
Governance	Y					Y			2/8
Leadership								Y	1/8
Organization	Y	Y						Y	3/8
Organization and resources				Y					1/8
Organization's situation		Y							1/8
Sponsorship				Y					1/8
Strategy					Y				1/8
Value and Metrics					Y				1/8
Vision					Y		Y		2/8
DATA									
Data Availability and Governance	Y			Y					1/8
Data Management	Y				Y				2/8
Data Sources					Y				1/8
Data-driven				Y					1/8
Data Governance and Integration								Y	1/8
Governance, Trust and Privacy					Y				1/8
PROCESS									
Analytics	Y		Y			Y		Y	4/8
Analytics & Visualization					Y				1/8
Business Process		Y							1/8
Operating Model			Y						1/8
Process							Y		1/8
SYSTEM ARCHITECTURE									
Architecture						Y			1/8
Information						Y			1/8
Information Management			Y						1/8
Infrastructure	Y								1/8
Operating Model			Y						1/8
Portability and Integration							Y		1/8
Technical/Infrastructure				Y					1/8
Technology							Y		1/8
Technology Platform			Y						1/8
PEOPLE									
People							Y		1/8
People and Organization					Y				1/8