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Big Data Use in Performance Measurement and Management: A Call for Action

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Abstract: Big Data is starting to permeate the field of performance measurement and management. With data being referred to as the "new oil of the 21st century" and organizations more and more striving for utilizing this to their advantage, the notion of Big Data has become a hallmark for the modern decision maker. We argue that albeit promising for performance measurement and management, there are several aspects that need to be addressed within research. This paper builds on a literature review of extant research, and, a case study, and raises issues that if left unchecked could have negative impacts on the field of performance measurement and management. Despite the many positive aspects associated with Big Data, there is a need for a sound, critical perspective. The findings are discussed in relation to the three Vs regarded as the core definition of Big Data (volume, variety and velocity) and illustrated by a case study.

Key words: performance measurement and management; big data; critical reflection
JEL code: M15

1. Introduction

Big Data has received worldwide attention in most areas of society for some years now. The volumes, variety and velocity of both structured and unstructured data generated by the Internet, social media, and the "Internet of Things" are unfolding massive innovation opportunities. But, Big Data is also challenging our technical capacity to manage it (Chiang, Goes & Stohr, 2012) and puts new, advanced and unique requirements on "data storage, management, analysis, and visualization technologies" (Chen, Chiang & Storey, 2012, p. 1164). Chiang et al. (2012) claim that the major challenge is to develop capabilities to understand and interpret Big Data to take advantage of the opportunities it provides. This was also found in a study of leading organizations who implemented big data initiatives: "The leading obstacle to widespread analytics adoption is lack of understanding of how to use analytics to improve the business." (LaValle, Lesser, Shockley, Hopkins & Kruschwitz, 2011, p. 23). This is also noted by Keim, Mansmann, Oelke & Ziegler (2008, p. 2): "For decision makers it is an essential task to rapidly extract relevant information from the immense volumes of data."

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The challenges to develop capabilities to understand and interpret Big Data has spurred a discussion around education program development and which knowledge, skills and content that will meet this challenge (Chiang et al., 2012). *Data Scientist* is a new role regarded as necessary for achieving success with Big Data initiatives, and, according to Chiang et al. (2102), a Data Scientist will have analytical skills, information technology knowledge skills and business knowledge and communication skills. In the US alone, "an additional 1.5 million managers and analysts with a sharp understanding of how big data can be applied" is needed (Brown, Chui & Manyika, 2011, p. 11) and being a data scientist is perceived to be the "sexiest job of the 21st century" (Davenport & Patil, 2012, p. 70).

The main discourse surrounding Big Data is positive and many authors claim that it will enhance and reform management control, performance measurement and decision-making, as we know it. McAfee and Brynjolfsson (2012) predict that the incorporation of Big Data tools and philosophies create a "management revolution" and that better visibility of business activities and performance measurement will convert decision making. Chui, Löffler & Roberts (2010) believe that the "internet of things" networks will generate better information and analysis, which can enhance decision making significantly and that we will see more sensor-driven business models and sensor-driven decision analytics over time. Lim, Chen & Chen (2013) mean that data from social media users will give companies important social and business insights that can be used for customer relationship management and product innovation Further, they believe Web and social media analytics present unique opportunities for business researchers to treat the market as a conversation between businesses and customers instead of traditional business-to-customer marketing (Lim, Chen & Chen, 2013). According to Brown et al. (2011) Big Data may become a new kind of a corporate asset similar to brands and that it will become a basis for competition.

To date, there is limited empirical research available when it comes to how Big Data is affecting business and how it is used and managed in particular (Wamba, Akter, Edwards, Chopin, & Gnanzou, 2015). The actual use of Big Data in organizations is still "… *in its infancy*" (Powell, 2013). Supply side actors (Ax & Bjørnenak, 2005) report that many organizations have or plan to develop strategy for dealing with Big Data (Russom, 2011; Talend, 2012). The main driver is to increase the accuracy of predictive analytics, i.e., forecasts (Talend, 2012), to gain competitive advantage through better business decisions and improved business efficiency (Rowe, 2013). TDWI Research (Russom, 2011) states that 34% use Big Data for analysis and that the top five desired benefits are, in order: better target marketing, accurate business insights, segmentation of customers, recognition of sales and marketing opportunities and automated decisions. From the above we find similar patterns with earlier diffusion of management accounting innovations (e.g., Ax & Bjørnenak, 2007; Malmi, 1999) and conclude that the actual application and use of Big Data is far from the hype created by the supply side.

Much has been written when it comes to Big Data issues outside the organization, but there is still much to be done about Big Data inside the organization. The purpose of this paper is to critically reflect on the implications of Big Data on management control in general and performance measurement and management in particular. This is achieved through a systematic literature review and illustrated through a short case study.

The paper proceeds as follows: After this brief introduction, we present the current state of the art within Big Data and Performance measurement and management. Following this and the method of the study, we present the results of the literature review along with the case study. After this, a brief discussion and conclusion is presented.

2. Big Data — Definitions and Characteristics: A Brief Overview

Big Data is used across many areas and disciplines, ranging from global economy to public administration (e.g., health care, insurance, banking, public sector administration, manufacturing and e-commerce) from scientific disciplines (e.g., astronomy, atmospheric science, medicine, genomics, biologic, biogeochemistry and other interdisciplinary scientific disciplines) to national security. Further, Big Data involves data from personal locations, recent hot spots, social computing and Internet search indexing, text and documents (Chen & Zhang, 2014, pp. 314-315). Key sources of data can be (George, Haas & Pentland, 2014, p. 322) (1) public data, (2) private data, (3) data exhaust, (4) community data, and (5) self-quantification data. The plethora of applications and sources makes a precise definition of Big Data difficult. However, Mayer-Schönberger and Cukier (2013, pp. 6-7), frequently cited within the IS discipline, define Big Data as:

> "Big Data refers to things one can do at a large scale that cannot be done at a smaller one, to extract new insights or create new forms of value, in ways that change markets, organizations, the relationship between citizens and governments, and more. But this is just the start. The era of Big Data challenges the way we live and interact with the world."

As can been from the above definition, Big Data is often defined as an umbrella concept, with a high level of interpretive viability. From their review, Wamba et al. (2015) identified 10 similar definitions (similar to the above definition) of Big Data. They conclude that Big Data, in the main, is characterized by three major attributes, for which they use the TDWI definitions (Russom, 2011):

Volume: Large volume of data that either consume huge storage or consist of large number of records.

Variety: Data generated from greater variety of sources and formats, and contain multi-dimensional data fields.

Velocity: Frequency of data generation and/or frequency of data delivery.

Further, they identify to more attributes that are not that as frequently used as the latter 3 V:s and they are:

Veracity: Inherent unpredictability of some data requires analysis of big data to gain reliable prediction (Beulke, 2011)

Value: The extent to which big data generates economically worthy insights and or benefits through extraction and transformation (Wamba et al., 2015).

2.1 Big Data — Major Interest and Focus for Attention

From a Google Scholar search we conclude that the academic interest surrounding Big Data has increased exponentially for the past three to four years. As seen in Figure 1, the general growth of interest in Big Data outweighs the interest both within Information Systems as well as Accounting.

The same pattern is reflected in a comparison of Information Systems (IS) vs Accounting publications in Big Data. Based on a brief overview, the difference in impact, as measured by the number of citations, is substantial (see Table 1). A selection of the top five publications from Accounting indicate a total of 35 citations, while the same for IS shows a staggering 1,774 citations. Thus, outweighing the impact of accounting by a factor of 50. Looking more closely at the publication outlets used within each field, we find that the IS domain is dominated by monographs published through well-established publishing houses as well as premier outlets such as MIS Quarterly (ABS4) and Harvard Business Review. Within Accounting, only one of the publications is published in a relatively high ranked journal (Management Accounting Research (ABS3).

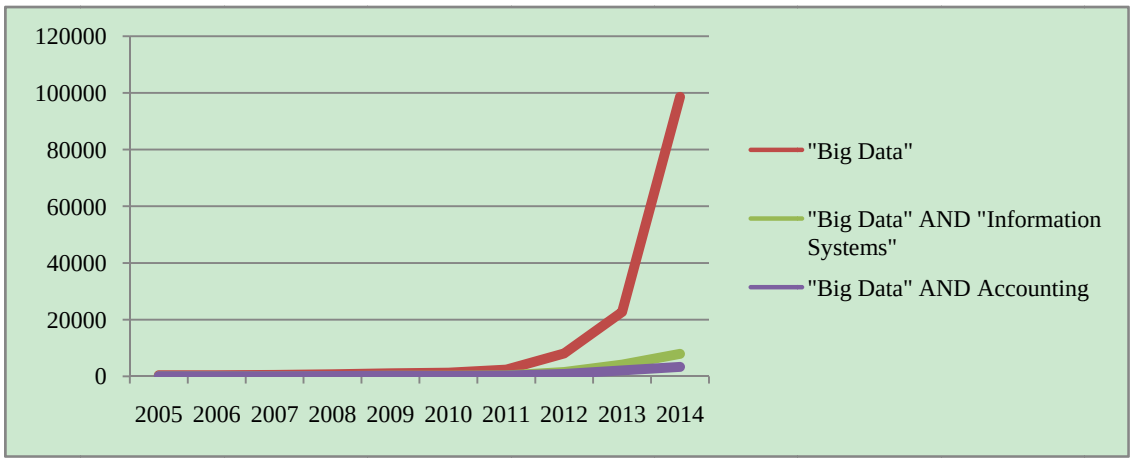

Figure 1 Google Analytics Search Results 2005-2014

Table 1 Overview of Top Cited Articles within Two Fields

Accounting publications on Big Data		IS publications on Big Data	
Source	Citations	Source	Citations
Nixon and Burns (2012)	15	McAfee et al (2012)	517
Zhang et al (2012)	8	Mayer-Schönberger and Cukier (2013)	503
Titera (2013)	4	Chen, Chiang and Storey (2012)	293
Bhimani and Willcocks (2014)	4	Boyd and Crawford (2012)	231
Vasarhelyi (2012)	4	Zikopoulos and Eaton (2011)	230

Pospiech and Felden (2012) reviewed 46 papers that addressed the challenge, "… how the increasing amount of data can be recorded, stored and preceded to meet performance requirements." Each paper was classified according to perspective addressed: (1) a data utilization perspective or (2) a data provisioning perspective. The papers were also classified according to focus of the paper: (3) technical solutions or (4) functionality. Their classification revealed that 87% of the papers were positioned in the section data provision and technical solutions. A schematic presentation of their findings is shown in the matrix below.

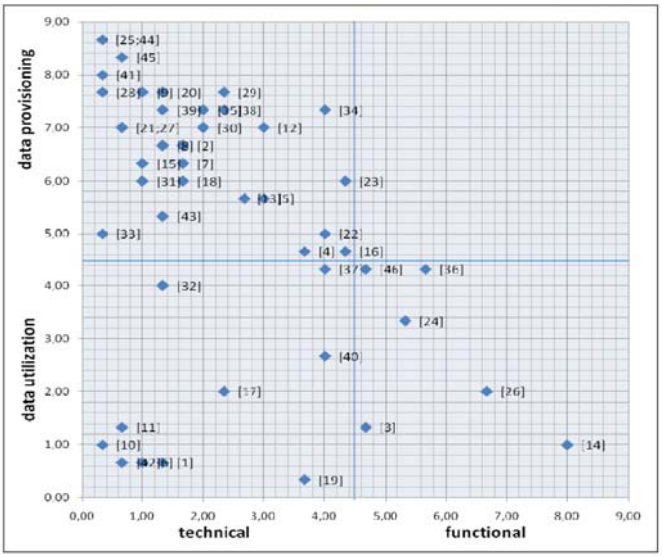

Figure 2 Illustration Taken from Pospiech and Felden (2012)

No paper was categorized into the functional/data-provision segment. Addressing the challenges from this segment would mean a focus on information management, the supply of information and information demand analysis. Some papers dealt with technical/data-utilization, which mainly address challenges by machine learning and statistical methods. Pospiech and Felden (2012) conclude that Big Data, within the IS research, to a large extent has taken a technical/data provision path, and that there is a need for research on functional aspects on data provisioning in order for to better understand information needs and use in real organisations.

In a special issue of MIS Quarterly, Chen et al. (2012) provide a framework which identifies the evolution, applications, and emerging research areas that have great potential to transform Big Data into something that has big impact. Applications are classified into five major areas: (1) e-commerce and market intelligence; (2) e-government and politics 2.0; (3) Science and technology; (4) Smart health and well-being and (5) Security and public safety. Within each application area Chen et al. (2012) offers new research directions for business intelligence and analytics research, which they perceive as a unified term including big data analytics as a related research field. The research directions are directly tied to Big Data Analytics, Text Analytics, Web Analytics, Network Analytics and Mobile Analytics. In the table below these applications and how they are described and categorised is presented (Chen et al., 2012, p. 1173).

Table 2. BI&A Applications: From Big Data to Big Impact

	E-Commerce and Market Intelligence	E-Government and Politics 2.0	Science & Technology	Smart Health and Wellbeing	Security and Public Safety
Applications	• Recommender systems • Social media monitoring and analysis • Crowd-sourcing systems • Social and virtual games	• Ubiquitous government services • Equal access and public services • Citizen engagement and participation • Political campaign and e-polling	• S&T innovation • Hypothesis testing • Knowledge discovery	• Human and plant genomics • Healthcare decision support • Patient community analysis	• Crime analysis • Computational criminology • Terrorism informatics • Open-source intelligence • Cyber security
Data	• Search and user logs • Customer transaction records • Customer-generated content	• Government information and services • Rules and regulations • Citizen feedback and comments	• S&T instruments and system-generated data • Sensor and network content	• Genomics and sequence data • Electronic health records (EHR) • Health and patient social media	• Criminal records • Crime maps • Criminal networks • News and web contents • Terrorism incident databases • Viruses, cyber attacks, and botnets
	Characteristics: Structured web-based, user-generated content, rich network information, unstructured informal customer opinions	Characteristics: Fragmented information sources and legacy systems, rich textual content, unstructured informal citizen conversations	Characteristics: High-throughput instrument-based data collection, fine-grained multiple-modality and large-scale records, S&T specific data formats	Characteristics: Disparate but highly linked content, person-specific content, HIPAA, IRB and ethics issues	Characteristics: Personal identity information, incomplete and deceptive content, rich group and network information, multilingual content
Analytics	• Association rule mining • Database segmentation and clustering • Anomaly detection • Graph mining • Social network analysis • Text and web analytics • Sentiment and affect analysis	• Information integration • Content and text analytics • Government information semantic services and ontologies • Social media monitoring and analysis • Social network analysis • Sentiment and affect analysis	• S&T based domain-specific mathematical and analytical models	• Genomics and sequence analysis and visualization • EHR association mining and clustering • Health social media monitoring and analysis • Health text analytics • Health ontologies • Patient network analysis • Adverse drug side-effect analysis • Privacy-preserving data mining	• Criminal association rule mining and clustering • Criminal network analysis • Spatial-temporal analysis and visualization • Multilingual text analytics • Sentiment and affect analysis • Cyber attacks analysis and attribution
Impacts	Long-tail marketing, targeted and personalized recommendation, increased sale and customer satisfaction	Transforming governments, empowering citizens, improving transparency, participation, and equality	S&T advances, scientific impact	Improved healthcare quality, improved long-term care, patient empowerment	Improved public safety and security

Figure 3 Table Taken from Chen et al. (2012, p. 1173)

2.2 Performance Measurement and Management

Performance measurement and management have, over the years, been studied from several different perspectives. Its natural domain is within management control research (Otley, 1999). Its contemporary form is connected to the balanced scorecard concept (Hoque, 2014; Neely, 2005; Kaplan & Norton, 2008) and benefit from a proliferation of approaches across many disciplines (Chenhall & Langfield-Smith, 2007). In the main, performance measurement and management systems are used for facilitating strategy implementation and enhancing performance (Melnyk, Bititci, Platts, Tobias, & Andersen, 2014), decision-facilitating and for accountability (Artz, Homburg & Rajab, 2012), and can be defined as the process of quantifying the efficiency and effectiveness of action (Neely, Gregory, & Platts, 2005).

Despite a perceived research fragmentation, slow progress in the area and doubts about the use and usefulness of performance measurement and management (e.g., Artz et al., 2012; Merchant, 2012), IT is claimed to have an important role to play in the design and use of performance measurement systems (Chenhall & Langfield-Smith, 2007; Nudurupati, Bitici, Kumar & Chan, 2011). Advances in IT may improve the collection, measurement, analysis and communication of data within and between organizations (Burns & Vaivio, 2001) and is pushing performance measurement as part of the strategy management process forward in an increasingly faster pace (Davenport, 2000). Innovation in IT and IT integration with management control leverages the use of enterprises systems databases and provide strong analytic capabilities and extended support for decision making, planning and control (Berry, Coad, Harris, Otley & Stringer, 2009; Elbashir, Collier & Davern, 2008; Granlund, 2011; Rom & Rohde, 2006). The primary objective of accounting (management) information systems is to provide useful, relevant, and timely information for decision-making (Mancini, Vaassen & Dameri, 2013; Vaasen, Meuwissen & Schelleman, 2009).

Adopting Big Data and the innovation within IT seems, as voiced by supply side actors, to unfold new opportunities for design and use of performance measurement and management. To gain advantage of Big Data application within the realms of AIS and performance measurement and management, we would need to consider how to qualify performance measures that successfully would fulfil the decision-facilitating function.

Neely and Cook (2011) use fitness-for-use as a concept relating to the quality of data and information used by decision makers for decision making purposes. They perceive quality as multi-dimensional (referring to Wang and Strong, 1996 who included 15 dimensions), but identify accuracy (reliability), relevance and understandability as critical. Reliability (validity, accuracy and completeness are sub-dimensions) and relevance (precision, timeliness and understandability are sub-dimensions) are major dimension put forward by Vaasen et al. (2009). Artz et al. (2012) use reliability (amount of noise or representation and reasonably free of error and bias) and functional specificity in their study.

3. Method

With the purpose of this paper being to explore and critically reflect on the challenges brought forth by Big Data to performance measurement and management, the core method has been that of systematic literature review (Hart, 1998). As the impact of Big Data has been relatively scarce within performance measurement and management in particular and accounting in general, the scope of the literature review has included sources from the Information Systems field. The practical work with conducting the literature review has been inspired by work from previous literature reviews of Big Data (Artz et al., 2012; Wamba et al., 2015).

In section 5.4 we present a citation analyse based on one of the more influential books in the field, "Big Data — a revolution that will transform how we live, work and think" written by Mayer-Schönberger and Cukier (2013). It has been cited by 548 other text, as presented by Google Scholar, and we have classified them according to the area each citation have been written within. This is inspired by studies that work with co-citation and by doing so try to understand research structures, in a form of bibliometric way (Galvagno & Dalli, 2014).

"Co-citation analysis, which is used in information science to map a research field's structure and development, is based on the idea that science has a structure that can be empirically defined by a measure based on the intellectual link between documents …" (Galvagno & Dalli, 2014, p. 646).

In addition to the literature review, we also present a short case from a local wholesaler, focusing on strategic change management issues to illustrate the critical reflections in practice. The empirical material for this case was collected through interviews and studying documents, in a field study, case oriented manner (Bruns & Kaplan, 1987; Yin, 2004).

4. Critical Reflections on Volume, Variety, Velocity and a Citation Analysis

We believe that Big Data will find its inroads into PMM and especially into the customer, operations, and learning and growth perspectives, but to the finance perspective we cannot see that Big Data will make a significant difference. For the customer perspective we would expect to get more and better knowledge of customers, and how they view our organisation and products and services from the abundance of customer data on social media. Chen et al. (2012) highlights some areas, such as analytics of customer opinions, text analysis and sentiment analysis, product recommender systems, and long-tail marketing via highly targeted searches and personalized recommendations.

In terms of Big Data and the operations perspective, organizations would benefit from the "internet of things" and all devices that are connected. Here we would assume that this will merge with the Business Activity Monitoring (BAM) domain and expand the perspective with an external (but linked) view of the organizations operations. One area where we already see applications is within logistics where location data is used. Connected to learning and growth, Wamba et al. (2015) identified 25 articles discussing how Big Data provides value to organizations in terms of innovating new business models, products and services. Thus, Big Data will definitely have an impact on this perspective. From a general perspective, we know that the benefits of the information technology and communications revolution has well-known dark sides such as technostress, information overload, multitasking, technology "addiction" and misuse (D'Arcy, Gupta, Tarafdar & Turel, 2014).

Interestingly, Big Data is characterized by factors that we know create information overload. There is a risk that the amount of this new data and information at some point becomes excessive and overwhelming, reaching a level of information overload (Dean & Webb, 2011). When information overload occurs "…information received becomes a hindrance rather than a help when the information is potentially useful" (Bawden, Holtham & Courtney, 1999, p. 249). From her literature review, Bettis-Outland (2012, p. 818) concludes that "information overload as a multidimensional construct, consisting of three components: (1) equivocality, (2) quantity, and (3) variety. Equivocality refers to the existence of multiple valid interpretations of information. Quantity measures the volume and availability of information; while variety measures the different sources of information". Thus, it is not only volume aspects, but also variety is affecting users and the potential threat of information overload.

4.1 Challenges Related to Volume

According to a study by the industry analyst firm Forrester (2013), firms use but 10% of their available data as input for management control. Coupled with the radical increase in information volume currently happening, this is destined to decrease substantially over the coming years. With the majority of firms (76%) regarding information as a key strategic asset, this low level of utilization reported is significant (ibid). Obviously, there will be major challenges to address both new and already existing volumes of data when organizations apply Big Data.

Dealing with abundance of data requires some kind of "filters" as part of data management processes (e.g., capture, store, clean, analyze and represent data) (Chen & Zhang, 2014), in the Extract, Transform and Load (ETL) processes (Chen et al., 2012) and/or through the data management expertise of Data Scientists (Davenport & Patil, 2012). Data Scientist "make discoveries while swimming in data. It's their preferred method of navigating the world around them. At ease in the digital realm, they are able to bring structure to large quantities of formless data and make analysis possible. They identify rich data sources, join them with other, potentially incomplete data sources, and clean the resulting set." (Davenport & Patil, 2012, p. 73). Reflecting on Data Scientist and their role, we should be aware of the danger that Bawden and Robinson (2009, p. 181) put forward. They mean that "over-zealous information specialists", may create and/or seek problems to which they can provide solutions. Similarly, "information specialists may promote solutions to problems which are largely recognized only by themselves". This would lead to a risk of garbage can model (Cohen, March & Olsen, 1972) revisited, where we have access to solutions but are uncertain to which problems they are solutions.

Further, we have to contemplate the skills perceived as necessary. According to Chiang et al. (2012) Data Scientists need major analytical skills (from disciplines such as statistics and computer science, particularly machine learning and quantitative methods) and IT knowledge and skills (about a variety of evolving topics with reference to Chaudhuri, Dayal & Narasayya, 2011) and, finally, business skills which seem to be of minor concern. There is already a major gap between IT specialists and managers in the business operations (e.g., Hostmann, Rayner & Friedman, 2006) and we believe that engaging Data Scientist, with the above profile, would certainly not decrease the gap. There is a major risk that a black boxing of the decision making process and increased complexity in the decision making algorithms (as Big Data analytics suggest) would lead to managers focusing even more on choice instead of design and intelligence in their decision making (Boland, Collopy, Lyytinen & Yoo, 2008).

We find strong rhetoric telling us that more data is better and that "the data tell us that's the surest bet" (McAfee & Brynjolfson, 2012, p. 68) and "…With enough data, the numbers speak for themselves" (Anderson, 2008). This resembles what was put forward in managerial science where perfect rationality and optimization were the "name of the game" (see for example Simon, 1979). We know that bounded rationality (March, 1978) exist and we need to be careful in the selection of data. First, bigger is not always better (Boyd & Crawford, 2012) and we may instead look for the "smart" data (George et al., 2014) and the data that is relevant. According to McAfee and Brynjolfson (2012, p. 62) "*data-driven decisions tend to be better decisions. Because of big data, managers can measure, and hence know, radically more about their businesses, and directly translate that knowledge into improved decision making and performance*". Are we ready for fact-based decision making around the Globe? At least from a Scandinavian perspective (e.g., Jönsson, 1996), we are not sure that managers are ready for this.

4.2 Challenges Related to Variety

Variety in terms of performance management is, nowadays, often visualized in multi-dimensional dashboards

containing measures and information representing different parts and perspectives of the business. With variety of structured and "unstructured" data we have to observe that the information representation match task characteristics and the cognitive style or competence and experience level of a decision maker (Dilla, Janvrin & Raschke, 2010). In a context of interactive visualization with many choices regarding information representation, little is known about *to which extent* and *under what conditions* decision makers are able to choose the representation that provides the best fit to the task and their own individual characteristics. If there is a miss-match, performance may be less efficient and decision making less accurate (Dilla, Janwrin & Raschke, 2010, p. 4). To take advantage from Big Data visualisation and analytics close cooperation between decision scientists and decision makers/managers would be of great importance.

Data generated from a greater variety of sources and formats and information creates complexity, which often is referred to as "…the number of different items that must be dealt with at any given point of time by the organization…" (Scott, 1987). To perceive, understand and reason about complex and dynamic data and situations visual analytics can be applied to facilitate the analytical reasoning process. Such visual analytics should be based on understanding of the reasoning process, as well as an understanding of underlying cognitive and perceptual principles, to provide mission-appropriate interactions that allow a true discourse with the information (Thomas & Cook, 2005, p. 6). The cognitive fit perspective (e.g., Vessey, 1991; Vessey & Galletta, 1991) suggests that interactive visualizations that allow decision makers to choose which data are viewed and how they are represented are superior to static visualizations, which are those where the data views and representations are selected by a designer (Dilla et al., 2010, p. 4). This indicates that managers and decision makers need to be involved in the integration of the analytical reasoning process and the design of data and information representation and visualisation possibilities. Since the superiority is dependent on task and decision maker characteristics and the decision maker's insight into which representation is best for a given task, decision makers has to be involved.

The close cousin to information overload and complexity is attention fragmentation, which also is related to cognitive processing. With increasing variety we would expect that managers will suffer on the attention. Here we would need to know more how Big Data and PMM interact for both selective attention and executive and vigilance attention and how top-down (goal or schema-driven) and bottom-up (data driven) attention processes (Ocasio, 2011) may co-exist. Big Data (analytics) seem to lean on bottom up attention processes and in such a process stimuli is very important. Empirical evidence suggests that sustained attention is limited in duration, and an individual's probability to detect the stimuli decreases over time (Ocasio, 2011). In a Big Data setting, it may prove relevant to understand how individuals attach attention to a particular stimulus and how they detach their attention and reallocate to a different stimulus.

4.3 Challenges Related to Velocity

At the core of the issue of velocity in terms of Big Data lies the strive to utilize data not solely in aggregated, retrospective format. Instead, the notion of real-time data comes into play, particularly in terms of the massive amounts of data discussed previously related to the Internet of Things (McAfee & Brynjolfson, 2012). As noted by George et al. (2014), the capabilities for real-time analytics are still in its infancy, which leads to challenges for pushing the level of utilization of this particular type of data. Another perspective on this issue was first identified by Dearden (1972), in that albeit technologically feasible that we in the (then) near-future will have the ability to integrate real-time data into management decision making, the drawbacks on this are substantial. As Dearden (ibid) argues, the blurring of vision that integration of real-time data has for strategic management is a potential threat to

the sustainability of the firm. Through in-memory database technology now becoming commonplace, the previous lag between analytics and transactional data is no longer a pre-requisite for the design of PMM (Hahn & Packowski, 2015). This brings with it a potential risk for management becoming caught in a balderdash of data.

Following this line of thought, we see that the supply-side push for Big Data with velocity being one of three identifiable traits will lead to suppliers black-boxing PMM practice into new functionalities. This reliance on algorithms, hidden beneath the surface of, e.g., KPIs and other techniques for PMM is just now starting to be questioned as noted by Pasquale (2015). With the integration of real-time data into new analytical practices such as prescriptive analytics, PMM practitioners and researchers alike need to be alert to which type of data is actually utilized for which particular purpose. Whereas perhaps suitable for operational PMM, the intricate relationship between the operational, tactical and strategic needs to be transparent and carefully monitored.

4.4 A Citation Analysis

On of the more influential books over the last years, within the field of big data, is the book "Big Data — a revolution that will transform how we live, work and think" written in 2013 by Viktor Mayer-Schönberger and Kenneth Cukier. Both authors have a background in management/economics, and they look at the effects of internet in business and society, which would qualify their book as important in the growing interest for theories about the big data phenomenon. In 2013 and 2014 the book was cited 548 times where 447 of the citations were written in English. When these citations were categorised it was clear that even though there were some interest among management scholars, it was within a more general social science field the book had been most cited. In this section the findings from analysing these citations will be presented.

In the book there are several clear references to how thinking about big data consequences and issues have affected and are effecting management in general and management control and performance management in particular, which could be used as a departure for further interest. One is that they compare how big data have revolutionised they way we look at information in the same way as accounting techniques once revolutionised the way we would understand a company.

> "Today double-entry bookkeeping is usually considered only for its consequences for accounting and finance. But it also represents a landmark in the evolution of the use of data. It enabled information to be recorded in the form of 'categories' that linked accounts. It worked by means of a set of rules about how to record data — one of the earliest examples of standardized recording of information." (Mayer-Schönberger & Cukier, 2013, p. 81)

The authors continue with discussions about how new ways of working with big data volumes also changes the mind-sets of managers in companies. This is presented as different approaches that companies have to the big data phenomenon and what makes them successful.

> "For certain firms, the data and the know-how are not the main reasons for their success. What sets them apart is that their founders and employees have unique ideas about ways to tap data to unlock new forms of value." (Mayer-Schönberger & Cukier, 2013, p. 124)

There are several other examples of how the authors and the ideas presented in the book is relevant for and should influence the way scholars within management control could benefit from studying big data. But even though the book is well known and have spread around the globe, it has not been used that much to initiate research within management control and performance management.

When categorising the citations seven broad categories where used. They, in a way also illustrate three different theoretical fields, which has shown interest when it comes to big data. The first broader theoretical field

is social science with the more narrowed categories and topics *management* and *journalism/media*. In the larger, more general category *social science* topics like geography, the governance of societies and ethical issues were found. In a second larger category, *engineering* there was also one more narrowed category added, which could be named *information systems*. A third broader category was *medicine* and in addition to those three categories a fourth category, *other topics* was added. The citations were also divided into which year they had been published and if it was in the form of a book or as an article.

Table 2 Citation Categories

	2013		2014	
	Articles	Books	Articles	Books
Social science	20	2	102	28
Management	11	1	40	11
Journalism/media	3	0	23	2
Engineering	6	2	28	10
Info systems	16	0	76	5
Medicine	8	0	34	3
Others	3	0	13	0

It is clear that the book one year after publication had created quite large interest within social science in general. Also in the area of information systems there was a larger interest but in the other areas there was a more quite interest. However 40 articles were published in 2014, which used the book as a reference and among different topics within the management field, such as supply chain and logistics, tourism, HR, public management, quality management, innovation, SME's marketing, financial markets and business and management research methods, could be found. But there were rare examples of articles that dealt with management control and performance management.

One such example was "Digitisation, 'big data' and the transformation of accounting information" written by Bhimani and Willcocks (2014). It focused on how "… data explosion create significant alterations, dilemmas and possibilities for enterprises and there finance function." Another example is "Intelligent operational dashboards for smarter commerce using big data" written by Yesudas, Menon & Ramamurthy (2014). It describes how streaming data could provide basis for operational intelligence, shifting away from static data models. There were also examples of how big data changed the way business models could be understood (Bulger, Taylor & Schroeder, 2014), how more general market information and performance could be analysed and how data quality could be assessed when it comes to industrial decision-making.

This shows that even though a popular and highly relevant departure for research within the big data field has not attracted attention from the management control and performance management field as it has done in other fields within business studies, such as logistics, marketing and more general information systems. Since "… *the primary substance of big data is the information itself.*" (Mayer-Schönberger & Cukier, 2013, p. 126) there is an urgent need to understand how big data affects how we work with management control in general and performance measurement and management in particular. The urgency is rooted in the way big data affects a business ability to compete. "As big data becomes a source of competitive advantage for many companies, the structure of entire industries will be reshaped. … Data is to the information society what fuel was to the industrial economy: the critical resource powering the innovations that people rely on." (Mayer-Schönberger & Cukier, 2013, pp. 145, 182).

5. A Short Case Illustration

As an illustration of what Big Data might bring to a business we will use a short case, which we ran into when doing another study about strategic changes and performance measurement. The studied organisation, Electra is a Swedish wholesale that over the years have proven themselves to be able to change their core business in order to stay competitive in highly competitive market, electronic consumer goods. Operations are carried out partly by sales to end-user customers in the consumer electronics market through the specialist retail chains Audio Video, RingUp and DigitalaButiker and sales to other web-based retailers and other chains and partly done by working with a third-party logistics services and IT systems and solutions. Electra is a large and important player in e-commerce and has great potential to influence it. Several of the major e-commerce players are linked to and purchase from Electra, for example Webhallen, CDON, Dustin and Halléns. Electra is listed on NasdaqOMX Stockholm and had sales in 2014 of 1.7 billion SEK.

Since Electra is a wholesale the customer is the organisations that purchase from Electra, which in most cases are specialist retailers and stakeholders in third-party logistics. One challenge is that many of the customers have different profiles and specializations, which means that one customer might have fairly basic needs while another one runs a complex operation. Electra is also working with what could be called value-added services for the stores. It has for many years been important for Electra to give the stores the best opportunity to sell the product, which for example could be done through advanced back-office support. This is done, for example, via the SMART system where various shops can follow their own development but also to compare themselves with other stores. The system also promotes selling additional services to the products such as insurance, rental or financing. It also works with a marketing plan, where every shop can adjust and change parts of the marketing as planned.

Electra uses an open inventory system where suppliers can go in and see volumes, such as how much is in stock and which groups of customers who buy what. This system is something that is quite unique and that suppliers may not find this openness with other customers, e.g., competitors. There is also the opportunity for suppliers to contact end-user customers directly, for example if you want to send an SMS to the end-user consumer who bought a phone for a number of years ago with an offer. This service is paid for and it allows Electra to establish a tighter connection with the supplier. In many cases the figures and statistics, something that is valuable to the provider, is something that can be sold by Electra. This means that you can negotiate, for example, targeted marketing. It is also common to look at prices from the supplier all the way to the end-user consumer. A price cut from the supplier, for example is communicated out to the store via Electra.

The continuing change in the relationship with suppliers has become more and more important in recent years. Electra meets regularly with suppliers and discusses what could be done together, and how to develop the value chain. In this way, suppliers have become more of a partner and Electra is trying to sow the seeds around collaborations that have the potential to develop. Over the resent years it has become more and more interesting for suppliers to analyse all the information that is gathered by Electra about different end-user consumer behaviour. This has even become so interesting that it has become a commodity that the suppliers are willing to pay for. In this way the waste amount of information processed in an on-going manner is transformed into something that could be used to increase revenues. Data stored in the regular systems has then a new value and is not only used to analyse performance and make decisions in the organisation but could also be used in a form of information market.

6. Discussion

There are several different areas that need to be addressed in a more detailed and sophisticated way in the coming research when big data meets management control and performance measurement and management. It needs to be studied within organizations to a larger extent. Much of the research done to date is done outside the organization and in a way forms the bases for understanding markets and customers. But more research is needed when it comes to turning large data volumes inside an organization into useful and valuable information. It is also clear that big data as a concept and phenomenon is an umbrella concept, which includes several different topics and areas. This is not a problem in itself but different research fields have different agendas, which makes it hard to build on previous research to add new understanding. The context becomes in a way even more important and interesting when studying big data.

As concluded by Pospiech and Felden (2012) we agree that there is a need to focus research on functional aspects and data provision. This is very much in line with how performance management could or even should be understood. The process that transforms data into valuable information in an internal, management control setting needs to be studied further. One of the major challenges is, as mentioned earlier, the fragmentation when it comes to how research within the field have been done. This makes it important to understand in what sub-fields new knowledge needs to be added and what methods and questions that is crucial to address. Even though concepts and models like volume, variety and velocity is easy to understand and use in theory, the short-case shows that it in a way is harder to use in an empirical setting. It is however clear that the increasing volumes, in a variety of forms and collected in a higher speed could be turned into something valuable, something that for example a supplier is prepared to pay for as illustrated by the short-case. As Mayer-Schönberger & Cukier (2013) puts it, “If nothing else, putting a price tag on data’s option value certainly represents a rich opportunity …” (Mayer-Schönberger & Cukier, 2013, p. 121).

7. Conclusions

As seen in this brief paper, there are a multitude of different challenges associated with the introduction of Big Data into the field of PMM. We have argued that the very definition of Big Data following the three V’s Volume, Variety and Velocity brings with it clear paradoxes in the way that it would be applied towards PMM. For instance, the notion of massive volumes brings with it both the increased possibility of fact-based decision making and information overload. The notion of a wide variety of data brings with it increased relevance and increased complexity. The notion of velocity brings with it operational benefits and strategic risks of decreased validity.

Seen from this perspective, it is not surprising to see that research within PMM as a subset of accounting is finding it difficult to address issues of Big Data. The inherent difficulties in the very definition of the concept and in the application of it to PMM practice leads to a shortage of empirical examples where it has been applied in a grand scale. The more influential school of Information Systems has a predominant technological and conceptual perspective on Big Data, addressing the phenomenon in very much of an empirical vacuum.

With the strong supply-side push currently in place for Big Data solutions such as different analytical technologies we believe in the importance for PMM researchers to pre-emptively address Big Data challenges for PMM. With the technology available, we believe that it is only a matter of time before we see grand-scale adoption, and if this happens without the involvement of PMM practitioners and researchers, this will prove to be

a substantial risk for firms. With Data Scientists more and more becoming part of the organizations, we believe that PMM needs to avoid retreating from the issues.

References:

Anderson C. (2008). "The end of theory: Will the data deluge makes the scientific method obsolete?", available online at: http://edge.org/3rd_culture/anderson08/anderson08_index.html.

Artz M., Homburg C. and Rajab T. (2012). "Performance-measurement system design and functional strategic decision influence: The role of performance-measure properties", *Accounting, Organizations and Society*, Vol. 37, No. 7, pp. 445-460.

Ax C. and Bjørnenak T. (2005). "Bundling and diffusion of management accounting innovations — The case of the balanced scorecard in Sweden", *Management accounting research*, Vol. 16, No. 1, pp. 1-20.

Bawden D., Holtham C. and Courtney N. (1999). "Perspectives on information overload", *Aslib Proceedings*, Vol. 51, No. 8, 249-255.

Bawden D. and Robinson L. (2009). "The dark side of information: Overload, anxiety and other paradoxes and pathologies", *Journal of Information Science*, Vol. 35, No. 2, pp. 180-191.

Berry A. J., Coad A. F., Harris E. P., Otley D. and Stringer C. (2009). "Emerging themes in management control: A review of recent literature", *The British Accounting Review*, Vol. 41, No. 1, pp. 2-20.

Bettis-Outland H. (2012). "Decision-making's impact on organizational learning and information overload", *Journal of Business Research*, Vol. *65*, No. 6, pp. 814-820.

Beulke D. (2011). "Big data impacts data management: The 5 Vs of big data", available online at: http://www.DaveBeulke.com.

Bhimani A. and Willcocks L. (2014). "Digitisation, 'Big Data' and the transformation of accounting information", *Accounting and Business Research*, Vol. 44, No. 4, pp. 469-490.

Boland R. J. Jr., Collopy F., Lyytinen K. and Yoo Y. (2008). "Managing as designing: Lessons for organizational leaders from the design practice of Frank O. Gehry", *Design Issues*, Vol. 24, No. 1, pp. 10-25.

Boyd D., and Crawford K. (2012). "Critical questions for big data: Provocations for a cultural, technological, and scholarly phenomenon", *Information, Communication & Society*, Vol. 15, No. 5, pp. 662-679.

Brown B., Chui M. and Manyika J. (2011). "Are you ready for the era of 'big data'?", *McKinsey Quarterly*, October, pp. 1-12.

Bulger M., Taylor G. and Schroeder R. (2014). *Data-Driven Business Models: Challenges and Opportunities of Big Data*, Oxford Internet Institute, Oxford: UK.

Burns W. and Kaplan R. (1987). *Accounting & Management — Field Study Perspectives*, Harvard Business School Press, Boston:MA.

Burns J. and Vaivio J. (2001). "Management accounting change", *Management Accounting Research*, Vol. 12, No. 4, pp. 389-402.

Chaudhuri S., Dayal U. and Narasayya V. (2011). "An overview of business intelligence technology", *Communications of the ACM*, Vol. 54, No. 8, pp. 88-98.

Chen H., Chiang R. H. L. and Storey V. C. (2102). "Business intelligence and analytics: from big data to big impact", *MIS Quarterly*, Vol. 36, No. 4, pp. 1165-1188.

Chen C. P. and Zhang C. Y. (2014). "Data-intensive applications, challenges, techniques and technologies: A survey on Big Data", *Information Sciences*, Vol. 275, pp. 314-347.

Chenhall R. H. and Langfield-Smith K. (2007). "Multiple perspectives of performance measures", *European Management Journal*, Vol. 25, No. 4, pp. 266-282.

Chiang R. H. L., Goes P. and Stohr E. A. (2012). "Business intelligence and analytics education, and program development: A unique opportunity for the information systems discipline", *ACM Transactions on Management Information Systems*, Vol. 3, No. 3, Article 12.

Chui M., Löffler M. and Roberts R. (2010). "The internet of things", *McKinsey Quarterly*, No. 2, pp. 1-9.

Cohen M. D., March J. G. and Olsen J. P. (1972). "A garbage can model of organizational choice", *Administrative Science Quarterly*, pp. 1-25.

D'Arcy J., Gupta A., Tarafdar M. and Turel O. (2014). "Reflecting on the 'dark side' of information technology use", *Communications of the Association for Information Systems*, Vol. 35, No. 1, pp. 109-118.

Davenport T. H. (2000). *Mission Critical: Realizing the Promise of Enterprise Systems*, Harvard Business Press.

Davenport T. H. and Patil D. J. (2012). "Data scientist", *Harvard Business Review*, Vol. 90, pp. 70-76.

Dean D. and Webb C. (2011). "Recovering from information overload", *McKinsey Quarterly*, No. 1, pp. 80-88.

Dearden J. (1972). "MIS is a mirage", *Harvard Business Review*, Vol. 50, No. 1, pp. 90-99.

Dilla W., Janvrin D. J. and Raschke R. (2010). "Interactive data visualization: New directions for accounting information systems research", *Journal of Information Systems*, Vol. 24, No. 2, pp. 1-37.

Elbashir M. Z., Collier P. A. and Davern M. J. (2008). "Measuring the effects of business intelligence systems: The relationship between business process and organizational performance", *International Journal of Accounting Information Systems*, Vol. 9, No. 3, pp. 135-153.

Forrester (2013). *Competitive Differentiation through Innovation in Business Intelligence — Making the Most of Existing and Emerging BI, Analytics, and Big Data Tools*, Forrester Research Inc.

Galvagno M. and Dalli D. (2014). "Theory of value co-creation: A systematic literature review", *Managing Service Quality*, Vol. 24, No. 6, pp. 643-683.

George G., Haas M. R. and Pentland A. (2014). "Big data and management", *Academy of Management Journal*, Vol. 57, No. 2, pp. 321-326.

Granlund M. (2011). "Extending AIS research to management accounting and control issues: A research note", *International Journal of Accounting Information Systems*, Vol. 12, No. 1, pp. 3-19.

Hahn G. J. and Packowski J. (2015). "A perspective on applications of in-memory analytics in supply chain management", *Decision Support Systems*, Vol. 76, pp. 45-52.

Hart C. (1998). *Doing a Literature Review: Releasing the Social Science Research Imagination*, Sage.

Hostmann B., Rayner N. and Friedman T. (2006). "Gartner's business intelligence and performance management framework", Gartner Research, ID Number: G00142827.

Hoque Z. (2014). "20 years of studies on the balanced scorecard: Trends, accomplishments, gaps and opportunities for future research", *The British Accounting Review*, Vol. 46, No. 1, pp. 33-59.

Jönsson S. A. (1996). "Perspectives of Scandinavian management", BAS and Gothenburg Research Institute (GRI), School of Business, Economics and Law, University of Gothenburg, Sweden.

Kaplan R. S. and Norton D. P. (2008). "Mastering the management system", *Harvard business review*, Vol. 86, No. 1, p. 62.

Keim D. A, Mansmann F., Oelke D. and Ziegler H. (2008). "Visual analytics: Combining automated discovery with interactive visualizations", *Discovery Science*, Springer Berlin Heidelberg, pp. 2-14.

LaValle S., Lesser E., Shockley R., Hopkins M. S. and Kruschwitz N. (2011). "Big data, analytics and the path from insights to value", *MIT Sloan Management Review*, Vol. 52, No. 2, pp. 21-31.

Lim E.P., Chen H. and Chen G. (2013). "Business intelligence and analytics: Research directions", *ACM Transactions on Management Information Systems*, Vol. 3, No. 4, Article 17.

Malmi T. (1999). "Activity-based costing diffusion across organizations: An exploratory empirical analysis of Finnish firms", *Accounting, Organizations and Society*, Vol. 24, No. 8, pp. 649-672.

Mancini D., Vaassen E. H. and Dameri R. P. (2013). *Accounting Information Systems for Decision Making*, Springer-Verlag, Berlin.

March J. G. (1978). "Bounded rationality, ambiguity, and the engineering of choice", *The Bell Journal of Economics*, pp. 587-608.

Mayer-Schönberger V. and Cukier K. (2013). *Big Data: A Revolution that will Transform How We Live, Work and Think*, Houghton Mifflin, Harcourt.

McAfee A. and Brynjolfsson E. (2012). "Big data: The management revolution", *Harvard Business Review*, Re-print, October, pp. 1-9.

Melnyk S. A., Bititci U., Platts K., Tobias J. and Andersen B. (2014). "Is performance measurement and management fit for the future?", *Management Accounting Research*, Vol. 25, No. 2, pp. 173-186.

Merchant K. A. (2012). "Making management accounting research more useful", *Pacific Accounting Review*, Vol. 24, No. 3, pp. 1-34.

Neely A. (2005). "The evolution of performance measurement research: Developments in the last decade and a research agenda for the next", *International Journal of Operations & Production Management*, Vol. 25, No. 12, pp. 1264-1277.

Neely M. P. and Cook J. S. (2011). "Fifteen years of data and information quality literature: Developing a research agenda for accounting", *Journal of Information Systems*, Vol. 25, No. 1, pp. 79-108.

Neely A., Gregory M. and Platts K. (2005). "Performance measurement system design: A literature review and research agenda", *International Journal of Operations & Production Management*, Vol. 25, No. 12, pp. 1228-1263.

Nixon B. and Burns J. (2012). "The paradox of strategic management accounting", *Management Accounting Research*, Vol. 23, No. 4, pp. 229-244.

Nudurupati S. S., Bitici U. S., Kumar V. and Chan F. T. S. (2011). "State of the art literature review on performance measurement", *Computer & Industrial Engineering*, Vol. 60, pp. 279-290.

Ocasio W. (2011). "Attention to attention", *Organization Science*, Vol. 22, No. 5, pp. 1286-1296.

Otley D. (1999). "Performance management: A framework for management control systems research", *Management Accounting Research*, Vol. 10, No. 4, pp. 363-382.

Pasquale F. (2015). *The Black Box Society*, Harvard Business School Press.

Pospiech M. and Felden C. (2012). "Big data — A state-of-the-art", in: *Proceedings of the18th Americas Conference on Information Systems (AMCIS)*, Seattle, Washington August 9-11, 2012**.**

Powell J. E. (2013). *Big Data in Its Infancy*, The Data Warehousing Institute (*TDWI*).

Rom A. and Rohde C. (2006). "Enterprise resource planning systems, strategic enterprise management systems and management accounting: A Danish study", *Journal of Enterprise Informaton Management*, Vol. 19, No. 1, pp. 50-66.

Rowe N. (2013). *Data Management for BI: Getting Accurate Decisions from Big Data*, Research Report, Aberdeen Group.

Russom P. (2011). *TDWI Best Practices Report: Big Data Analytics*, The Data Warehousing Institute.

Scott R. W. (1987). *Organizations: Open, Rational and Natural Systems*, Prentice Hall International, Englewood Cliffs.

Simon H. A. (1979). "Rational decision making in business organizations", *The American Economic Review*, pp. 493-513.

Talend (2012). "How big is big data adoption", Talend White Paper, Talend.com

Thomas J. and Cook K. (2005). *Illuminating the Path, the Research and Development Agenda for Visual Analytics*, Phoenix, AZ: IEEE CS Press.

Titera W. R. (2013). "Updating audit standard-Enabling audit data analysis", *Journal of Information Systems*, Vol. 27, No. 1, pp. 325-331.

Vaasen E., Meuwissen R. and Schelleman C. (2009). *Accounting Information Systems and Internal Control*, John Wiley and Sons, Ltd. Chichester, UK.

Vasarhelyi M. A. (2012). "AIS in a more rapidly evolving era", *Journal of Information Systems*, Vol. 26, No. 1, pp. 1-5.

Vessey I. (1991). "Cognitive fit: A theory-based analysis of the graphs versus tables literature", *Decision Sciences*, Vol. 22, No. 2, pp. 219-241.

Vessey I. and Galletta D. (1991). "Cognitive fit: An empirical study of information acquisition", *Information Systems Research*, Vol. 2, No. 1, pp. 63-84.

Wamba S. F., Akter S., Edwards A., Chopin G. and Gnanzou D. (2015). "How 'big data' can make big impact: Findings from a systematic review and a longitudinal case study", *International Journal of Production Economics*, Vol. 165, pp. 234-246.

Wang R. Y. and Strong D. M. (1996). "Beyond accuracy: What data quality means to data consumers", *Journal ofManagement Information Systems*, Vol. 12, No. 4, pp. 5-34.

Yesudas M., Menon G. and Ramamurthy V. (2014). "Intelligent operational dashboards for smarter commerce using big data", *IBM Journal of Research and Development*, Vol. 58, No. (5/6), pp. 13-21.

Yin R. K. (2004). *The Case Study Anthology*, Sage.

Zikopoulos P. and Eaton C. (2011). *Understanding Big Data: Analytics for Enterprise Class Hadoop and Streaming Data*, McGraw-Hill Osborne Media.