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# How ‘big data’ can make big impact: Findings from a systematic review and a longitudinal case study

Samuel Fosso Wamba, Shahriar Akter, Andrew Edwards, Geoffrey Chopin and Denis Gnanzou

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**Abstract:**

Big data has the potential to revolutionize the art of management. Despite the high operational and strategic impacts, there is a paucity of empirical research to assess the potential of big data. Drawing on a systematic review and case study findings, this paper presents an interpretive framework that analyses the definitional perspectives and the applications of big data. The paper also provides a general taxonomy that helps broaden the understanding of big data and its role in capturing business value. The synthesis of the diverse concepts within the literature on big data and operations management provides deeper insights into achieving value through big data strategy and implementation.

**Keywords:** ‘big data’, analytics, business value, issues, case study, emergency services, literature review

## 1. Introduction

Why should academics and practitioners be interested in understanding about the impacts of big data? The simple answer to this critical question is because big data has the potential to transform the entire business process and this paper plays a major role in conceptualizing this transformation. Due to its high operational and strategic potential, notably in generating business value, “big data” has recently become the focus of academic and corporate investigation. The extant literature identifies ‘big data’ as the ‘next big thing in innovation’ (Gobble, 2013); “the fourth paradigm of science” (p. 34) Strawn (2012); ‘’the next frontier for innovation, competition, and productivity’’(p. 1) (Manyika et al., 2011); the next “management revolution” (p. 3)(McAfee & Brynjolfsson, 2012); and that ‘big data’ is “bringing a revolution in science and technology" (p. 4) (Ann Keller, Koonin, & Shipp, 2012), etc. The rationale behind such statements is that the ‘big data’ is capable of changing competition by “transforming processes, altering corporate ecosystems, and facilitating innovation” (p.2) (Brown, Chul, & Manyika, 2011); unlocking organization business value by unleashing new organizational capabilities and value (Thomas H. Davenport, Barth, & Bean, 2012); and facilitating firms to tackle key of their business challenges (Gehrke, 2012).

The extant research in academia and industry shows that retailers can achieve up to 15 to 20% increase in ROI by putting big data into analytics (Perrey, Spillecke, & Umblijs, 2013). McKinsey and Company found that “collecting, storing, and mining big data for insights can create significant value for the world economy, enhancing the productivity and competitiveness of companies and the public sector and creating a substantial economic surplus for consumers” (p. 1) (Manyika, et al., 2011). In addition, ‘big data’ has the capability of transforming the decision making process by allowing enhanced visibility of firm operations and improved performance measurement mechanisms (McAfee & Brynjolfsson, 2012).

However, despite the excitement and recent interest in ‘big data’, due to its high operation and strategic potential, little is known about what encompasses the concept. Indeed, potential adopters of ‘big data’ are struggling to better understand the concept and therefore capture the business value from ‘big data’. Very few empirical studies have been conducted to assess the real potential of ‘big data’, with this paper acting to bridge the existing knowledge gap in the literature; drawing upon prior ‘big data’ studies as well as on an in-depth case study of an Australian state emergency service using ‘Big data’ to improve the delivery of emergency services to achieve the following research objectives:

1. Clarify the definition and concepts related to ‘big data’.
2. Develop a conceptual framework for the classification of articles dealing with ‘big data’.
3. Use the conceptual framework to classify and summarize all relevant articles.
4. Conduct an in-depth analysis of a longitudinal case study of an Australian state emergency service which is currently using ‘big data’ for improved operations delivery.
5. Develop future research directions where the deployment and use of ‘big data’ is likely to have huge impacts.

This article is organized as follows: After the introduction (Section 1), Section 2 provides a definition of ‘big data’ and discusses the potential of data-driven organizations. Section 3 introduces the research methodology, followed by Section 4 which presents our results. Section 5 is the discussion section, while Section 6 discusses the implications for research, practice, limitations and suggestions for future research. Then, Section 7 serves as the conclusion.

## 2. What is big data: A step toward an integrative definition?

'Big Data' is generating tremendous attention worldwide. The results of a Google search on the topic rose from about 252,000 hits in November 2011 to almost 1.39 billion hits on April 4, 2012 (Flory, 2012), and then reached the impressive number of 1.69 billion hits in December 2013. This phenomenon is mainly driven by the widespread diffusion and adoption of mobile devices, social media platforms including YouTube, Facebook and Twitter, and 'Internet of Things' related concepts (e.g., RFID technology). In 2011, about 4 billion mobile-phone users were identified worldwide; about 12% of them using smartphones having the capability of turning themselves into data-streams. Meanwhile, the video platform, YouTube, received 24 hours of video every 60 seconds (The Economist, 2011). Also, serialized products identification and tracking, for example, RFID-enabled item-level tagging, is expected to generate not only huge operational and strategic data across the value chain of all industries (Fosso Wamba, 2012; Fosso Wamba & Chatfield, 2009; E. W. T. Ngai et al., 2012; E.W.T. Ngai, Poon, Suk, & Ng, 2009), but also an impressive volume of RFID data. Some analysts estimate that the number of RFID tags rose from 1.3 billion in 2005 to about 30 billion in 2013, thus increasing the speed in which data are generated and disseminated (deRoos, 2013).

Some scholars and practitioners have considered 'big Data' as data coming from various channels including sensors, satellites, social media feeds, photos, video and cell phone and GPS signals (Rich, 2012). However, considering the emerging nature of 'big Data', several definitions of the concept currently exist (Table 1). Some scholars and practitioners use the notion of 'V' to define 'big Data'. (Gartner, 2012), (Kwon & Sim, 2012), (McAfee & Brynjolfsson, 2012) and (Russom, 2011) define 'big Data' in terms of 3Vs: 'Volume' or the large amount of data that either consume huge storage or entail of large number of records data (Russom, 2011); 'Velocity', which is the frequency or the speed of data generation and/or frequency of data delivery (Russom, 2011); and 'Variety', to highlight the fact that data are generated from a large variety of sources and formats, and contain multidimensional data fields including structured and unstructured data (Russom, 2011). Drawing on these definitions, (IDC, 2012), (Oracle, 2012) and (Forrester, 2012) include another 'V', that is, 'Value' (or 4Vs) in order to stress the importance of extracting economic benefits from the available big data. (White, 2012) suggested that a fifth dimension – 'Veracity' – should be added to prior definitions of 'big data' in order to highlight the importance of quality data and the level of trust in various data sources. Some analysts estimate that 1 in 3 business leaders don't trust the information they use to make decisions (S. LaValle, 2009). Therefore, "if data is not of sufficient quality by the time it has been integrated with other data and information, a false correlation could result in the organization making an incorrect analysis of a business opportunity" (p. 211) (White, 2012).

**Table 1: Sample definitions of big data and potential**

**5V's: Volume+ Velocity+ Variety+ Value+ Veracity** (White, 2012)

**4V's: Volume+ Velocity+ Variety+ Value** (IDC, 2012), (Oracle, 2012), (Forrester, 2012)

**3V's: Volume+ Velocity+ Variety** (Gartner, 2012), (Kwon & Sim, 2012), (McAfee & Brynjolfsson, 2012)

| Authors, date | Definition |
|---|---|
| (IBM, 2012b) | Big Data: data captured from sensors, posts to social media sites, digital pictures and videos, purchase transaction records, and cell phone GPS signals, etc. |
| (B. D. Johnson, 2012) | Big Data: extremely large sets of data related to consumer behaviour, social network posts, geotagging, sensor outputs (p. 21). |
| (Thomas H. Davenport, et al., 2012) | Big Data: data from everything including click stream data from the Web to genomic and proteomic data from biological research and medicine |
| (Manyika, et al., 2011) | Big Data: datasets with a size that is beyond the ability of typical database software tools to capture, store, manage, and analyse |
| (Rouse, 2011) | Big Data: description of the voluminous amount of unstructured and semi-structured data a company creates or data that would take too much time and cost too much money to load into a relational database for analysis |
| (Danyel Fisher, DeLine, Czerwinski, & Drucker, 2012) | Big Data: data that cannot be handled and processed in a straightforward manner (p. 53) |
| (Havens, Bezdek, Leckie, Hall, & Palaniswami, 2012) | Big Data: data that you cannot load into your computer's working memory (p. 1130) |
| (Jacobs, 2009) | Big Data: data that is too large to be placed in a relational database and analyzed with the help of a desktop statistics/visualization package—data, perhaps, whose analysis requires massively parallel software running on tens, hundreds, or even thousands of servers." (p. 44) |
| (IDC, 2013) | Big Data has three main characteristics of Big Data: the data itself, the analytics of the data, and the presentation of the results of the analytics. Then there are the products and services that can be wrapped around one or all of these Big Data elements (p. 1) |
| (Boyd & Crawford, 2012) | Big Data: a cultural, technological, and scholarly phenomenon that rests on the interplay of: (1) Technology: maximizing computation power and algorithmic accuracy to gather, analyze, link, and compare large data sets. (2) Analysis: drawing on large data sets to identify patterns in order to make economic, social, technical, and legal claims. (3) Mythology: the widespread belief that large data sets offer a higher form of intelligence and knowledge that can generate insights that were previously impossible, with the aura of truth, objectivity, and accuracy." (p. 663). |

| Attributes | Nature | Examples |
|---|---|---|
| Volume | Large volume of data that either consume huge storage or consist of large number of records (Russom, 2011) | • Tesco generates more than 1.5 billion new items of data every month (Manyika, et al., 2011).<br>• Wal-Mart's data warehouse includes some 2.5 petabytes of information (Manyika, et al., 2011).<br>• Dell initiated to develop a database that includes 1.5 million records related with sales and advertisements (Thomas H Davenport, 2006) |
| Variety | Data generated from greater variety of sources and formats, and contain multidimensional data fields (Russom, 2011). | • Procter & Gamble, created a group consisting of more than 100 analysts from such functions as operations, supply chain, sales, consumer research, and marketing to improve total business performance by analysing interrelationships among functional areas(Thomas H Davenport, 2006).<br>• Tata Motors analyzes 4 million text messages every month, spanning everything from product complaints to reminders about service appointments to announcements about new models and also connected with customer satisfaction polling (Agarwal & Weill, 2012). |
| Velocity | Frequency of data | • Amazon manages a constant flow of new products, suppliers, |

| | | |
|---|---|---|
| | generation and/or frequency of data delivery (Russom, 2011). | customers, and promotions without compromising promised delivery dates (Thomas H Davenport, 2006).<br>• Retailers can now track individual customer's data including clickstream data from the Web and can leverage from their behavioral analysis. Moreover, retailers are now capable of updating such increasingly granular data in near real time to track changes in customer behavior (Manyika, et al., 2011). |
| Veracity | Inherent unpredictability of some data requires analysis of big data to gain reliable prediction (Beulke, 2011) | • eBay Inc. faced an enormous data replication problem, with between 20 to 50 fold versions of the same data scattered throughout its various data marts. Later, eBay developed an internal website (data hub) which enables managers to filter data replication (Thomas H. Davenport, et al., 2012). |
| Value | The extent to which big data generates economically worthy insights and or benefits through extraction and transformation. | • Premier Healthcare Alliance used enhanced data sharing and analytics to improve patient outcomes while reducing spending by US$2.85 billion (IBM, 2012a).<br>• Match.com reported more than 50% increase in revenue in the last two years' time, with more than 1.8 million paid subscribers in its core business, most of which driven through data analytics (Kiron & Shockley, 2011). |

There are also a set of 'big data' definitions that highlight different aspects of the concept (Table 1). For example, while (B. D. Johnson, 2012) and (Thomas H. Davenport, et al., 2012) focus more on the variety aspect of data sources, other authors (e.g., Havens, et al., 2012; Jacobs, 2009; Manyika, et al., 2011; Rouse, 2011) emphasize the storage and analysis requirements when it comes to dealing with 'big data'. IDC (2013) identifies three main characteristics of 'big data': the data itself, the analytics of the data, and the presentation of the results of analytics that allow business value creation in terms of new products or services. Finally, (Boyd & Crawford, 2012) propose a more holistic definition of 'big data' that entails: technology (e.g., storage, computation power), analysis (e.g., patterns identification for economic, social, technical, and legal claims), and mythology (e.g., the widespread belief that 'big data' offers a higher level of generating valuable insights). Overall, we need to think about 'big data' not only in terms of analytics, but more in terms developing high-level skills that allow the use of new generation of IT tools and architectures to collect data from various sources, store, organize, extract, analyze, generate valuable insights and share them with key firm stakeholders for competitive advantage co-creation and realization. Therefore, we define 'big data' as a holistic approach to manage, process and analyze 5 Vs (i.e., volume, variety, velocity, veracity and value) in order to create actionable insights for sustained value delivery, measuring performance and establishing competitive advantages.

## 3. Research Methodology

In this study, a research methodological approach that encompasses two phases was adopted. In the first phase, a comprehensive literature review of journal articles dealing with 'big data'-related topics was conducted. In the second phase, an analysis of an in-depth case study of an Australian state emergency service which is currently using ‘big data’ for improved emergency service delivery is realized.

### 3.1. A comprehensive literature review of journal articles on Big Data

In the first phase of the study, a comprehensive review of articles dealing with ‘big data’ related topics based on a similar approach used by Ngai and Wat (2002) in electronic commerce, (E. W. T. Ngai, Xiu, & Chau, 2009) in CRM and data mining and (E. W. T. Ngai, Moon, Riggins, & Yi, 2008), (Samuel Fosso Wamba, Abhijith Anand, & Lemuria Carter, 2013) and (Lim, Bahr, & Leung, 2013) for their review of RFID related topics. The approach entails three key characteristics: (i) the development of a classification framework; (ii) conduct the literature review and (iii) realize the classification of relevant journal articles. In addition, the study follows the recommendations of (E. W. T. Ngai & Wat, 2002) and focuses only on journal articles as these authors highlight that “academics and practitioners alike use journals most often for acquiring information and disseminating new findings and represent the highest level of research” (p. 416).

#### 3.1.1. Classification framework

In this study, elements from the paper on ‘big data’ by McKinsey Global Institute are being used to back-up our classification framework. More precisely, we extracted five (5) dimensions related to business value creation from big data, namely: (i) creating transparency; (ii) enabling experimentation to discover needs, expose variability, and improve performance; (iii) segmenting populations to customize actions; (iv) replacing/supporting human decision making with automated algorithms; and (v) innovating new business models, products, and services. Also, five (5) dimensions on ‘big data’-enabled business value issues were identified as follows: (i) data policies; (ii) technology and techniques; (iii) organizational change and talent; (iv) access to data; and (v) industry structure (Appendix 1) (Manyika, et al., 2011)..

#### 3.1.2. Literature review search strategies

A search within the timeframe ranging from 2006 to 2012 was considered to be representative of the period covering the emergence of ‘big data’, with a comprehensive search using the descriptor, “big data” conducted within the following databases: ABI/Inform Complete, Academic Search Complete, Business Source Complete, Elsevier (SCOPUS), Emerald, IEEE Xplore, Science Direct, and Taylor & Francis. In addition, a similar search was realized within the Association of Information Systems (AIS) basket of top journals. This outlet comprises a list of journals that are considered to be the leading journals in the IS field: European Journal of Information Systems (EJIS), Information Systems Journal (ISJ), Information Systems Research (ISR), Journal of AIS (JAIS), Journal of MIS (JMIS), MIS Quarterly (MISQ), Journal of Strategic Information Systems (JSIS) and the Journal of

Information Technology (JIT). This list has been used among other things to assess IS research rankings (Venkatesh, 2013), or to analyze both the level of knowledge development on RFID technology (S. Fosso Wamba, A. Anand, & L. Carter, 2013) and the 'types of research' published within the outlet (Liu & Myers, 2011). By adding up the basket of top journals, it is possible not only to extend to usual key databases used by prior studies using a similar approach (Samuel Fosso Wamba, et al., 2013; Lim, et al., 2013; E. W. T. Ngai, et al., 2008; E. W. T. Ngai, et al., 2009), but also to take into account important findings from Information System (IS) leading journals. Indeed, IS literatures provide important insights into the implementation, adoption and use of IS, as well as its business value (Venkatesh, Brown, & Bala, 2013) – which may be considered as a key facilitator or enabler of 'big data' when exploring its potential by managers.

Our search started on November 30, 2012 and ended on December 27, 2012. The initial search resulted in 1153 articles (with 24 articles from the top basket of AIS journals). The references, including the abstracts of all articles, were downloaded into Endnote, a reference management software package, for further analysis. Then, one co-author conducted the screening of the abstract of each article in order to assess its relevance with our research objectives and identify duplicated articles (Samuel Fosso Wamba, et al., 2013; Kitchenham, 2004; E. W. T. Ngai & Gunasekaran, 2007; E. W. T. Ngai, Hu, Wong, Chen, & Sun, 2011). Afterwards, 919 articles were removed, resulting in 234 articles for further analysis. Each of the remaining 234 articles was analyzed by two co-authors independently. Subsequently, several joint meetings were held by the two authors to compare their results, and where required, make some verification to reach a consensus. At the end of this process, 62 articles (172 articles removed) were deemed relevant for our research objectives, so they were selected for classifications.

### 3.2. A longitudinal case study: The Case of The New South Wales State Emergency Service

In the second phase, the study draws on an in-depth case study on the use of 'big data' by The New South Wales State Emergency Service (NSW SES), Australia for improved emergency service delivery, so as to draw lessons for the effective use of 'big data'. A case study is considered a suitable research approach when exploring emerging complex phenomena (e.g., 'big data' adoption and use) within real-life settings (Eisenhardt, 1989), in order to induce theories (Benbasat, Goldstein, & Mead, 1987). Besides, a case study is considered a relevant research approach when answering research questions such as 'how' and 'why' things are done (Yin, 1994). Additionally, the case study approach is greatly suggested for researches where theories are at their formative stage (Benbasat, et al., 1987).

### 3.2.1. Data collection methods

In this study, the data collection resorted to multiple sources of evidence, which allowed us to increase the validity of our constructs (Yin, 1994). They involved: on-site observations, semi-structured interviews with key respondents (e.g., top managers, middle-level managers, project teams and end users), industrial reports, strategic planning reports, annual reports, newsletters, technical or non-technical documents and project reports. Each interview took approximately one hour and was recorded, then transcribed by a consulting firm. Finally, open coding analysis was realized using our target constructs.

### 3.2.2. Research settings: Case of the NSW SES

The NSW SES represents a unique form of organization dealing with emergency services, which has received little attention from scholars and practitioners (Fosso Wamba, Edwards, & Sharma 2012). They are in charge of responding to crises and disasters such as floods, cyclones, storms, tsunamis, and other natural and man-made disasters. Such disasters are responsible for important human and economic losses worldwide. In 2011 only, these losses were estimated at about 244.7 million victims and US $366.1 billion – economic losses (Ponserre, Guha-Sapir, Vos, & Below, 2012). The prevention and preparation for these disasters as well as their effective management when they occur is at the core of various governments' strategies worldwide. Accordingly, rendering such emergency services with efficiency is essential to government entities. The effective management of these extreme events requires not only the availability and integration of information (such as archived data and real-time data from weather agencies, sensors, satellites, social media feeds, photos, video and mobile phone GPS signals), but also a high level of coordination and collaboration between decision makers, emergency response stakeholders, and community-based nongovernmental organizations (Chatfield, Fosso Wamba, & Tatano, 2010), which is reflected in the Fig. 1

In April 1955, The NSW SES was formed by the New South Wales (NSW) State government, Australia, as its response to the many disastrous floods experienced by the state. The main objective for the NSW SES was to provide support to the community facing flood disasters. From those beginnings, NSW SES has now evolved to providing leadership and relief in various emergency situations such as storms, tsunami, disasters management, resupplying the communities affected by disasters; launching air, flood, and road crash rescue operations; and developing community responder, vertical rescue, land search, evidence search, logistics support, and support for primary industries. The NSW SES is geographically dispersed covering the entire NSW state, an area of approximately 800,000 sq. km, which is equivalent to about four times the size of the United

Kingdom. The NSW SES has unique characteristics. For example, the agency relies on a small core of approximately 280 staff who support a large contingent of 9,000 volunteers. Further, the NSW SES has built a strong collaboration with a network of key state players for emergency service delivery within the entire NSW state (Fig.1). The organization has close relationships with other state emergency organizations, such as the Fire and Rescue NSW and the NSW Rural Fire Service (Fig. 1). In addition, the NSW SES draws on in close collaboration with the Bureau of Meteorology to tackle essential issues, such as the development and dissemination of official flood and storm warnings. The NSW SES headquarter (HQ) is located in the Wollongong area and the organization is organized around 17 regions and 229 volunteer units to increase the efficiency and effectiveness of emergency services delivery to citizens across each region (Fig. 1).

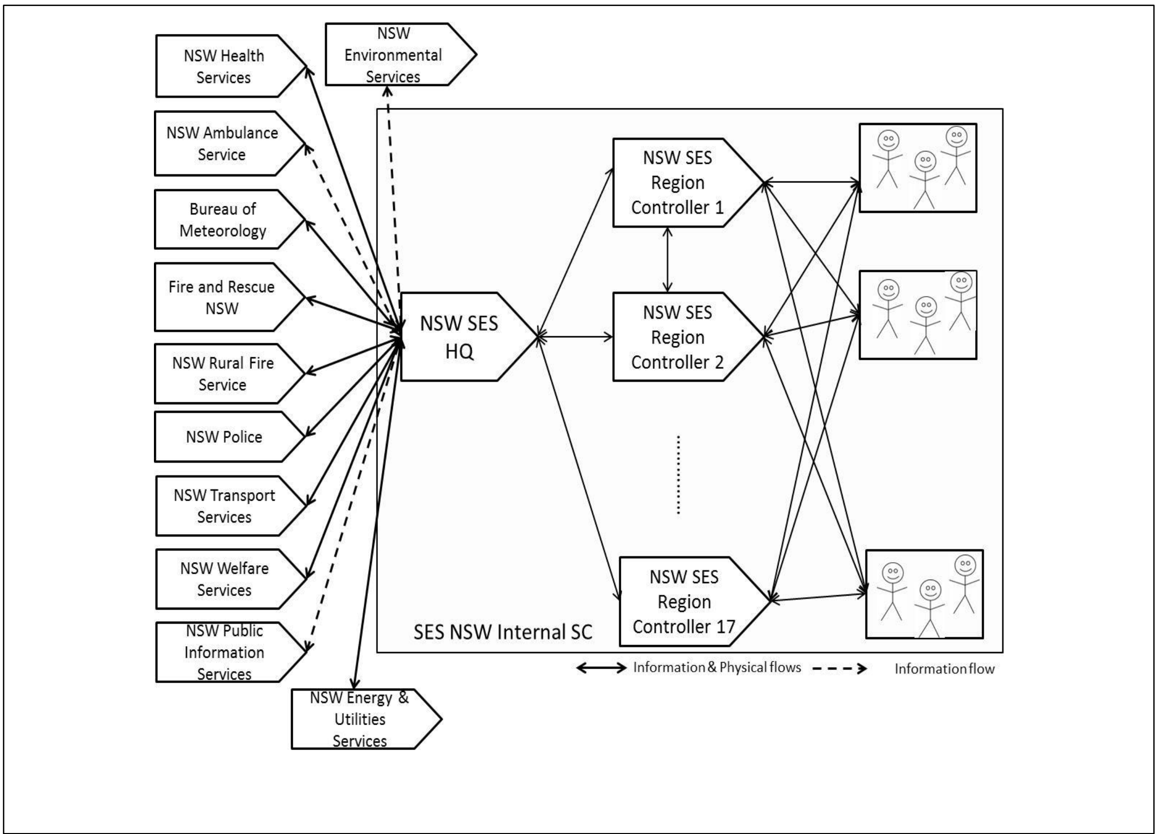



**Fig. 1: The NSW SES network for emergency services delivery**

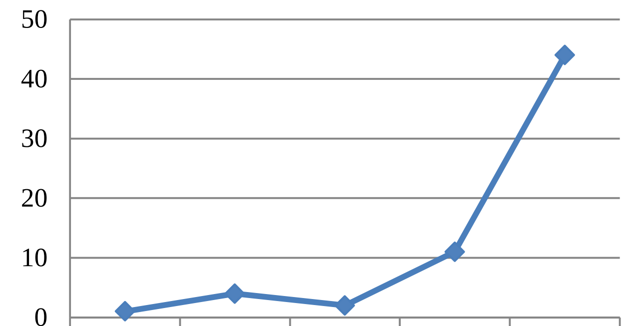
## 4. Results

### 4.1. Findings from the literature review

In the following sections, we will present and discuss the results of the review of past journal articles dealing with 'big data'.

#### 4.1.1. Distribution of articles by the year of publication

Fig. 2 presents the distribution of articles by the year of publication. We can clearly see that publications on 'big data' related topics started only in 2008 (with only 1 article or 2% of publications). In 2009, there was a small increase in the number of publications (4 articles or 6% of all publications), followed by a short decrease in 2010 (3% of all publications or 2 articles). However, from 2011, we noticed a steady increase of the number of publications, ranging from 11 articles (or 18% of all publications) in 2011 to 44 articles by the end of 2012 (or 71% of all publications), and thus highlighting the increase in interest about 'big data' related topics.




| | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|
| No. of Articles | 1 | 4 | 2 | 11 | 44 |

**Fig. 2: Distribution of articles by the year of publication**

#### 4.1.2. Distribution of articles by the type of value creation from 'big data'

Table 2 presents the distribution of articles by the types of value creation from 'big data'. First, we can notice that many of the publications covered more than one type of value creation from 'big data'. Clearly, the vast majority of the publications are in 'Replacing/supporting human decision making with automated algorithms' (35 articles or 28% of all publications). Indeed, improving the decision making process within organizations is at the core of the current hype around 'big data'. This may be one explanation of this high level of publication on 'Replacing/supporting human decision making with automated algorithms'. Followed by 'Enabling experimentation to discover needs, expose variability, and improve performance' and 'Innovating new business models, products, and services', with respectively 28 articles (or 22% of all publication) and 25 articles (or 20% of all publications). Finally, we have 'Segmenting populations to customize actions' with 20 articles (or 16% of all publications), followed by 'Creating transparency' with 17 articles or 14% of all publications.

**Table 2: Types of value creation from 'big data'**

| Dimension | References | # | % |
|---|---|---|---|
| Creating transparency | (Schadt, Linderman, Sorenson, Lee, & Nolan, 2010), (Brown, et al., 2011), (Bughin, Livingston, & Marwaha, 2011),(Steve LaValle, Lesser, Shockley, Hopkins, & Kruschwitz, 2011), (Ann Keller, et al., 2012), (Beath, Becerra-Fernandez, Ross, & Short, 2012), (Boyd & Crawford, 2012), (Hsinchun, Chiang, & Storey, 2012), (Cole, Newman, Foertter, Aguilar, & Coffey, 2012), (Thomas H. Davenport, et al., 2012), (Danyel Fisher, et al., 2012), (R. Griffin, 2012), (Huwe, 2012), (Smith, Szongott, Henne, & Von Voigt, 2012), (Tankard, 2012), (Wagner, 2012), (McAfee & Brynjolfsson, 2012) | 17 | 14% |
| Enabling experimentation to discover needs, expose variability, and improve performance | (Brinkmann, Bower, Stengel, Worrell, & Stead, 2009), (Bughin, Chui, & Manyika, 2010), (Schadt, et al., 2010), (Brown, et al., 2011), (Steve LaValle, et al., 2011), (Long & Siemens, 2011), (Cole, et al., 2012), (Sobek et al., 2011), (Allen et al., 2012), (Anderson & Blanke, 2012), (Ann Keller, et al., 2012), (Beath, et al., 2012), (Boja, Pocovnicu, & Batagan, 2012), (Boyd & Crawford, 2012), (Hsinchun, et al., 2012), (Thomas H. Davenport, et al., 2012), (Demirkan & Delen, 2012), (Danyel Fisher, et al., 2012), (Havens, et al., 2012), (Huwe, 2012), (Wagner, 2012), (J. E. Johnson, 2012), (Soares, 2012), (Kolker, Stewart, & Ã-Zdemir, 2012), (Strawn, 2012), (Tankard, 2012), (White, 2012), (McAfee & Brynjolfsson, 2012) | 28 | 22% |
| Segmenting populations to customize actions | (Bughin, et al., 2010), (Schadt, et al., 2010), (Steve LaValle, et al., 2011), (Long & Siemens, 2011), (Sobek, et al., 2011), (Ann Keller, et al., 2012), (Beath, et al., 2012), (Danyel Fisher, et al., 2012), (Boyd & Crawford, 2012), (McAfee & Brynjolfsson, 2012), (Demirkan & Delen, 2012), (Thomas H. Davenport, et al., 2012), (Hsinchun, et al., 2012), (Cole, et al., 2012), (R. Griffin, 2012), (Highfield, 2012), (Smith, et al., 2012), (Soares, 2012), (Tankard, 2012), (Wagner, 2012) | 20 | 16% |
| Replacing/supporting human decision making with automated algorithms | (Bughin, et al., 2010), (Schadt, et al., 2010), (Cole, et al., 2012), (Brown, et al., 2011), (Bughin, et al., 2011), (Steve LaValle, et al., 2011), (Hsinchun, et al., 2012), (Long & Siemens, 2011), (Meijer, 2011)<br>(Sobek, et al., 2011), (Boyd & Crawford, 2012), (Allen, et al., 2012), (Anderson & Blanke, 2012), (Ann Keller, et al., 2012), (Boja, et al., 2012), (Beath, et al., 2012), (McAfee & Brynjolfsson, 2012), (Thomas H. Davenport, et al., 2012), (Demirkan & Delen, 2012), (Danyel Fisher, et al., 2012), (Gehrke, 2012), (R. Griffin, 2012), (J. Griffin & Danson, 2012), (Huwe, 2012), (J. E. Johnson, 2012), (B. D. Johnson, 2012), (Kolker, Stewart, & Ã-Zdemir, 2012), (Lane, 2012), (Ohata & Kumar, 2012), (Smith, et al., 2012), (Soares, 2012), (Strawn, 2012), (Tankard, 2012), (Wagner, 2012), (White, 2012) | 35 | 28% |
| Innovating new business models, products, and services | (Bughin, et al., 2010), (Bughin, et al., 2011), (Steve LaValle, et al., 2011), (Brown, et al., 2011), (Long & Siemens, 2011), (Ann Keller, et al., 2012), (Cole, et al., 2012), (Beath, et al., 2012), (Boyd & Crawford, 2012), (McAfee & Brynjolfsson, 2012), (Thomas H. Davenport, et al., 2012), (Hsinchun, et al., 2012), (Demirkan & Delen, 2012), (Danyel Fisher, et al., 2012), (Gehrke, 2012), (R. Griffin, 2012), (J. Griffin & Danson, 2012), (Huwe, 2012), (J. E. Johnson, 2012), (Kolker, Stewart, & Ã-Zdemir, 2012), (Ohata & Kumar, 2012), (Soares, 2012), (Strawn, 2012), (Tankard, 2012), (Wagner, 2012) | 25 | 20% |
| | Total | 125 | 100% |

*Note: Some articles are counted more than once because they cover more than one type of business value*

### 4.1.3. Distribution of articles by the type of issues related to 'big data'- enabled business value

The distribution of articles by the type of issues related to 'big data enabled business value' is presented in Table 3. Not surprisingly, the vast majority of articles (47, 34%) are on 'technology and techniques' issues, followed by articles dealing with 'access to data' issues (39 articles, 28%). Indeed, developing technologies and techniques to store, compute, analyze, visualize and integrate the growing number of data from various sources is a key concern of many scholars (McAfee & Brynjolfsson, 2012) and practitioners (Manyika, et al., 2011). Then, 22 articles (or 16% of all publications) deal with 'Organizational change and talent' issues. Having the required knowledge (e.g., skills and HR), as well as buy-in from top management are considered to be important inhibitors to unlock the business value from 'big data'(Manyika, et al., 2011; McAfee & Brynjolfsson, 2012). Our review also indicated that there is shortage of articles dealing with 'Industry structure' (16 articles or 12% of all publications) and 'data policies' (13 articles or 9% of all publications).

**Table 3: Issues related to 'big data'- enabled business value**

| Dimension | References | # | % |
|---|---|---|---|
| Data policies | (Field et al., 2009), (Schadt, et al., 2010) (Steve LaValle, et al., 2011), (Boyd & Crawford, 2012), (Callebaut, 2012), (Hsinchun, et al., 2012), (Gehrke, 2012), (R. Griffin, 2012), (Huwe, 2012), (Lane, 2012), (Smith, et al., 2012), (Soares, 2012), (Tankard, 2012) | 13 | 9% |
| Technology And techniques | (Frederiksen, 2012), (Gorton, Greenfield, Szalay, & Williams, 2008), (Brinkmann, et al., 2009), (Jacobs, 2009), (Thomas H. Davenport, et al., 2012), (Cole, et al., 2012), (Boja, et al., 2012), (Callebaut, 2012), (Hsinchun, et al., 2012), (Boyd & Crawford, 2012), (Field, et al., 2009), (Bughin, et al., 2010), (Schadt, et al., 2010), (Steve LaValle, et al., 2011), (Long & Siemens, 2011), (Meijer, 2011), (Reddi, Lee, Chilimbi, & Vaid, 2011), (Sobek, et al., 2011), (Allen, et al., 2012), (Anderson & Blanke, 2012), (Ann Keller, et al., 2012), (Beath, et al., 2012), (Demirkan & Delen, 2012), (Danyel Fisher, et al., 2012), (Gehrke, 2012), (R. Griffin, 2012), (J. Griffin & Danson, 2012), (J. E. Johnson, 2012), (B. D. Johnson, 2012), (Ishii & Fernandes de Mello, 2012), (Janowicz, 2012), (Kauffman, Srivastava, & Vayghan, 2012), (Kolker, Stewart, & Ozdemir, 2012), (Kwon & Sim, 2012), (Lane, 2012), (Lee, Lee, & Sohn, 2012), (Meijer, 2012), (Ohata & Kumar, 2012), (Schlieski & Johnson, 2012), (Smith, et al., 2012), (Soares, 2012), (Strawn, 2012), (Tattersall, 2012), (Tankard, 2012), (Wagner, 2012), (White, 2012), (McAfee & Brynjolfsson, 2012) | 47 | 34% |
| Organizational change and talent | (Frederiksen, 2012), (Gorton, et al., 2008), (Bughin, et al., 2010), (Ann Keller, et al., 2012), (Beath, et al., 2012), (Boyd & Crawford, 2012), (Thomas H. Davenport, et al., 2012), (Schadt, et al., 2010), (Brown, et al., 2011), (Kiron & Shockley, 2011), (Steve LaValle, et al., 2011), (Long & Siemens, 2011), (Allen, et al., 2012), (Hsinchun, et al., 2012), (Danyel Fisher, et al., 2012), (J. E. Johnson, 2012), (Lane, 2012), (Ohata & Kumar, 2012), (Tankard, 2012), (Wagner, 2012), (White, 2012), (McAfee & Brynjolfsson, 2012) | 22 | 16% |
| Access to data | (Gorton, et al., 2008), (Bughin, et al., 2010), (Thomas H. Davenport, et al., 2012), (Demirkan & Delen, 2012), (Schadt, et al., 2010), (Alexander, Hoisie, & Szalay, 2011), (Bradbury, 2011), (Steve LaValle, et al., 2011), (Meijer, 2011), (Boyd & Crawford, 2012), (Boja, et al., 2012), (Reddi, et al., 2011), (Sobek, et al., 2011), (Cole, et al., 2012), (Allen, et al., 2012), (Hsinchun, et al., 2012), (Callebaut, 2012), (Beath, et al., 2012), (Anderson & Blanke, 2012), (Ann Keller, et al., 2012), (Danyel Fisher, et al., 2012), (Gehrke, 2012), (R. Griffin, 2012), (Huwe, 2012), (Janowicz, 2012), (J. E. Johnson, 2012), (B. D. Johnson, 2012), (Kolker, Stewart, & Ozdemir, 2012), (Ishii & Fernandes de Mello, 2012), (Lane, 2012), (Lee, et al., 2012), (Meijer, 2012), (Ohata & Kumar, 2012), (Schlieski & Johnson, 2012), (Smith, et al., 2012), (Tattersall, 2012), (Tankard, 2012), (Wagner, 2012), (McAfee & Brynjolfsson, 2012) | 39 | 28% |
| Industry structure | (Brown, et al., 2011), (Steve LaValle, et al., 2011), (Sobek, et al., 2011), (Thomas H. Davenport, et al., 2012), (Anderson & Blanke, 2012), (Long & Siemens, 2011), (Danyel Fisher, et al., 2012), (Fitzgerald, 2012), (Gehrke, 2012), (R. Griffin, 2012), (Huwe, 2012), (J. E. Johnson, 2012), (Soares, 2012), (Strawn, 2012), (Tankard, 2012), (McAfee & Brynjolfsson, 2012) | 16 | 12% |
| | | 137 | 100% |

*Note: Some articles are counted more than once because they cover more than one type of issue*

#### 4.1.4. Distribution of articles by industry

The distribution of articles by industry is shown in Table 4. We were not able to classify 16 articles (36 of all publications) in a specific industry. The highest number of published articles is in ‘Technology’ industry (7 articles or 16% of all publications), which may highlight the fact that ‘big data’ is increasingly viewed as a technology concept. Seven (7) articles (16% of all publications) indicated the use of ‘big data’ within the service industry. Followed by 5 articles (11% of all publications) dealing with ‘big data’ in the healthcare. Surprisingly, only 3 articles (7 % of all publications) were identified focusing on the retailing and the government sector. Finally, we have 2 articles (4% of all publication) dealing with the education sector. While only 1 article (2% of all publications) is concerned with the ecology and manufacturing.

**Table 4. Classification based on industry**

| Applications | No. of articles (%) | References |
|---|---|---|
| Retail | 3 (7%) | (Brown, et al., 2011), (Lee, et al., 2012), (McAfee & Brynjolfsson, 2012), |
| Healthcare | 5 (11%) | (Brinkmann, et al., 2009), (Field, et al., 2009), (Callebaut, 2012), (Hsinchun, et al., 2012), (Cole, et al., 2012), |
| Ecology | 1 (2%) | (Hochachka et al., 2009), |
| Education | 2 (4%) | (Long & Siemens, 2011), (Soares, 2012), |
| Government | 3 (7%) | (Sobek, et al., 2011), (Hsinchun, et al., 2012), (Mervis, 2012), |
| Manufacturing | 1 (2%) | (Brown, et al., 2011), |
| Services | 7 (16%) | (Acker, Gröne, Blockus, & Bange, 2011), (Demirkan & Delen, 2012), (J. E. Johnson, 2012), (Kauffman, et al., 2012), (Kolker, Stewart, & Ozdemir, 2012), (Kubick, 2012), (McAfee & Brynjolfsson, 2012), |
| Technology | 7 (16%) | (Bradbury, 2011), (Reddi, et al., 2011), (Allen, et al., 2012), (Hsinchun, et al., 2012), (Highfield, 2012), (Huwe, 2012), (Smith, et al., 2012), |
| Others | 16 (36%) | (Jacobs, 2009), (Bughin, et al., 2010), (Schadt, et al., 2010), (Alexander, et al., 2011), (Brown, et al., 2011), (Bughin, et al., 2011), (Kiron & Shockley, 2011), (Steve LaValle, et al., 2011), (Hsinchun, et al., 2012), (Cole, et al., 2012), (Thomas H. Davenport, et al., 2012) , (R. Griffin, 2012), (J. Griffin & Danson, 2012), (Kauffman, et al., 2012), (Mervis, 2012), (Strawn, 2012), |
| Total | 45 | |

#### 4.1.5. Distribution of articles by research approach

The distribution of articles by research approach is shown in Table 4. The vast majority of publications (43, 63%) are review articles, followed by ‘data analysis’ (9 articles, 13%), experiment (7 articles, 10%), conceptual articles (4 articles, 6%) and survey (4 articles, 6%). Only 1 article (1%) uses case study approach. This low level of case studies is probably due to the fact that the adoption and use of ‘big data’ by organizations is at its early stages.

**Table 5. Classification of articles by research approach**

| Approaches | No. of articles (%) | References |
|---|---|---|
| Review | 43 (63%) | (Gorton, et al., 2008), (Field, et al., 2009), (Jacobs, 2009), (Bughin, et al., 2010), (Schadt, et al., 2010), (Acker, et al., 2011), (Alexander, et al., 2011), (Bradbury, 2011), (Brown, et al., 2011), (Bughin, et al., 2011), (Long & Siemens, 2011), (Sobek, et al., 2011), (Anderson & Blanke, 2012), (Ann Keller, et al., 2012), (Beath, et al., 2012), (Boyd & Crawford, 2012), (Callebaut, 2012), (Hsinchun, et al., 2012), (Thomas H. Davenport, et al., 2012), (Frederiksen, 2012), (Danyel Fisher, et al., 2012), (Fitzgerald, 2012), (R. Griffin, 2012), (J. Griffin & Danson, 2012), (Huwe, 2012), (J. E. Johnson, 2012), (B. D. Johnson, 2012), (Kauffman, et al., 2012), (Kolker, Stewart, & Ã-Zdemir, 2012), (Kolker, Stewart, & Ozdemir, 2012), (Kubick, 2012), (Lane, 2012), (Little, 2012), (Mervis, 2012), (Ohata & Kumar, 2012), (Schlieski & Johnson, 2012), (Soares, 2012), (Strawn, 2012), (Tattersall, 2012), (Tankard, 2012), (Wagner, 2012), (White, 2012), (McAfee & Brynjolfsson, 2012), |
| Data analysis | 9 (13%) | (Hochachka, et al., 2009), (Jacobs, 2009), (Bradbury, 2011), (Meijer, 2011), (Allen, et al., 2012), (Cole, et al., 2012), (D. Fisher, Drucker, & König, 2012), (Gehrke, 2012), (Meijer, 2012), |
| Experiment | 7 (10%) | (Brinkmann, et al., 2009), (Reddi, et al., 2011), (Allen, et al., 2012), (Danyel Fisher, et al., 2012), (Havens, et al., 2012), (Ishii & Fernandes de Mello, 2012), (Kwon & Sim, 2012) |
| Conceptual | 4 (6%) | (Boja, et al., 2012), (Demirkan & Delen, 2012), (Highfield, 2012), (Janowicz, 2012), |
| Survey | 4 (6%) | (Kiron & Shockley, 2011), (Steve LaValle, et al., 2011), (Lee, et al., 2012), (Smith, et al., 2012), |
| Case study | 1 (1%) | (Highfield, 2012) |
| Total | 68 | |

*Note: Some articles are counted more than once because they cover more than one type of research approach*

#### 4.1.6.Distribution of articles per journal

Table 6 presents journals with a minimum of 3 articles on ‘big data’ related topics. 17 articles (27%) are from journals with at least 3 articles. For example, The Financial Executive and MIT Sloan Management Review have the same amount of articles on ‘big data’ related topics, mainly 4 articles each (6%). Followed by the "Association for Computing Machinery Communications of the ACM", "EDUCAUSE Review" and "McKinsey Quarterly" with 3 articles each (5%).

**Table 6: Classification of articles per journal (with minimum of 3 publications)**

| Journal | No. | % |
|---|---|---|
| Financial Executive | 4 | 6 |
| MIT Sloan Management Review | 4 | 6 |
| Association for Computing Machinery. Communications of the ACM | 3 | 5 |
| EDUCAUSE Review | 3 | 5 |
| McKinsey Quarterly | 3 | 5 |
| Total | 17 | 27 |

### 4.2. Insights and lessons learned from the case study

In the following sections, we will present key insights and lessons learned from the in-depth analysis of the longitudinal case study of the NSW SES which is currently using ‘big data’ for improved operations delivery.

#### 4.2.1. Importance of a robust platform to handle multiple sources of data for superior emergency service management

The better management of emergency operations required the integration of multiple sources of data (structured and unstructured) across multiple agencies; the combination of these data with historical information for better emergency service delivery. In the case of The NSW SES, the agency has developed a range of IT capabilities over time. For example, the NSW SES has a bi-directional direct communication between its website and the Bureau of Meteorology website during major operations to offer the public a real-time access to accurate weather or emergency information (Fig. 1). The same capabilities allow the NSW SES to share resources (humans and assets) with other states during major disaster events. The organization has been aggressively using cutting edge tools and technologies such as paging, telephony, radio, spatial systems, enterprise resource planning (SAP), communications, and mapping tools, in order to provide improved capabilities to its volunteers during emergency response operations. A typical response operation would involve multiple information gathering, processing and dissemination technologies.

Emergency response operations are directed from a command control center at the NSW SES headquarters. A dashboard is a key resource employed by teams coordinating responses to specific events. Among the data elements displayed on the dashboard is real-time data coming from the Bureau of Meteorology through a direct link to display critical information on the dashboard. The relevant information is then routed via various channels, including the NSW SES website, twitter and Facebook, radio, and Smartphones to the dedicated set of stakeholders (Fig. 3). These include the front-line volunteers involved in the response operation as well as the police, the Roads and Transport Authority, and the wider community.

In October 2009, the NSW SES upgraded the corporate IT infrastructure to implement a new collaborative platform based on Microsoft SharePoint (Fig. 3). In December 2009, it completed a successful implementation of the emergency services shared SAP system with other states emergency agencies to enhance their level of information sharing and collaboration at the local and state levels for improved service delivery. The emergency services shared SAP system is currently available for use by about 95,000 staff members and volunteers across the state to support their day-to-day duties within each location as well as on the field of operations. During the same month, the NSW SES launched a new collaborative platform to facilitate the collection and sharing of information among key stakeholders using Web 2.0 tools.

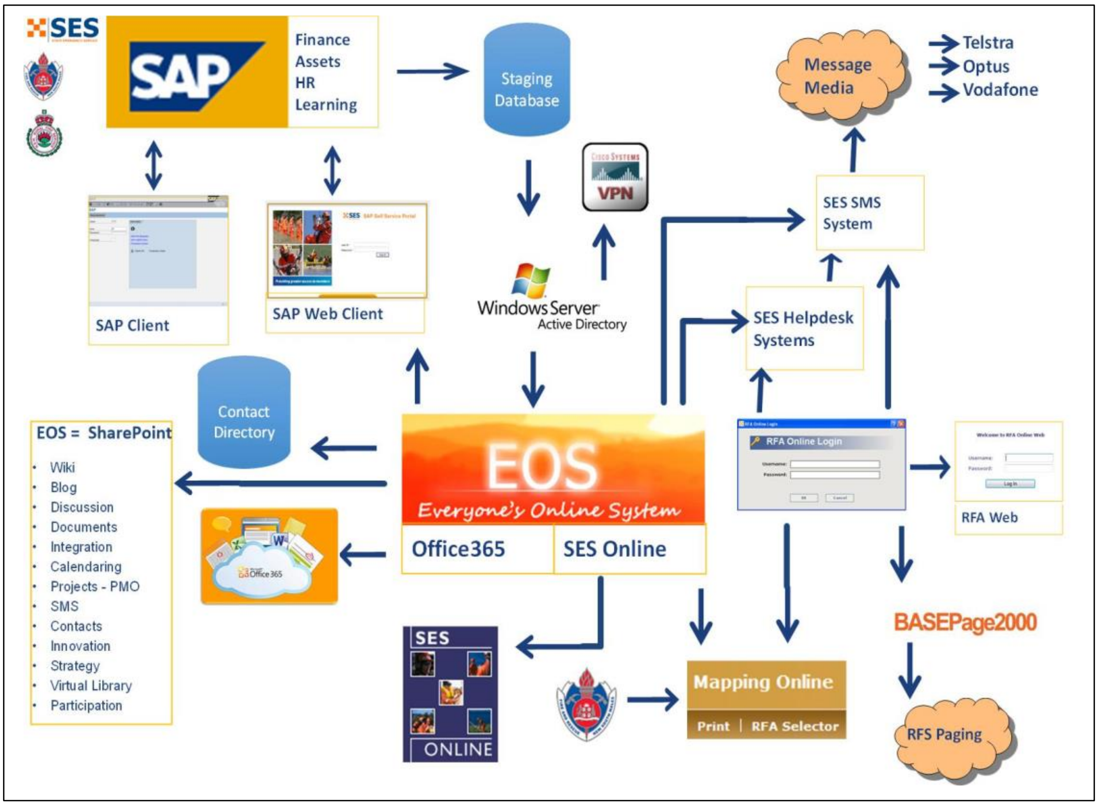



**Fig. 3: The NSW SES IT architecture: A simplified view**

NSW SES started embracing social media tools to expand the service's communication with key stakeholders during emergency events and to assist in a positive profiling of the organization and its members. More recently, it started a project of equipping all staff members and selected volunteers in regions with Smartphones to support field operations while on the move. Other key elements of NSW SES' IT infrastructure to support its response capabilities includes computers and peripherals (over 1800 desktops & laptops, 20 servers, 800 uninterruptable power supplies), telecommunications infrastructure (over 450 Broadband modems, 246 Routers & Switches, 250 Network sites), and telecommunication devices (over 2000 Pagers, 2000 Mobile phones, 300 Smart Phones, 4200 Radios and 170 Satellite Phones).

Integrating all these sources of data for improved emergency service delivery is achieved through a single SAP instance as their shared platform by three emergency services for collecting, storing and sharing key intra- and inter-organizational data as well as supporting all their core intra- and inter-organizational processes. In addition, this shared platform integrated with the SharePoint solution is the ‘backbone’ of the IT infrastructure that allows a connection between the agencies and both the various data sources and existing legacy systems containing structured data, unstructured data and historical data (e.g., records of flooding that we have received for the last 200 years) related to emergency services operations.

Using this improved IT infrastructure, the NSW SES can now integrate information from various databases and flood plans so as to identify the potential risks to which different regions may be exposed, and then take preventive actions (e.g., evacuation, alert messages). For example, by merging the Bureau of Meteorology’s external data with its own internal data (e.g. data from flood plan, historical data information from various databases), the NSW SES can now apply predictive analysis and therefore anticipate the impact of a disaster on a given region. It will be easier for the NSW SES to formulate evacuation strategies that incorporate real-time data from its own system to move the required assets across the region when it comes to dealing with a disaster. In addition, the new infrastructure offers a higher degree of visibility, which allows each manager, no matter what their level of involvement, to better predict future needs and even streamline access to emergency support services. Furthermore, the NSW SES is now capable of measuring, monitoring and reporting on progress against its strategic direction of the organization. The extant literature on ‘big data’ has recognized the importance of robust IT infrastructure, which is reflected in (Barton & Court, 2012)’s statement, “a clear strategy for how to use data and analytics to compete, and deployment of the right technology architecture and capabilities” (p. 4). The authors further highlighted that “existing IT architecture may prevent the integration of siloed information, and managing unstructured data often remains beyond traditional IT capabilities. Many legacy systems were built to deliver data in batches, so they can’t furnish continuous flows of information for real-time decisions” (p. 5). Therefore, in order to tackle such challenges and capture business value from big data, (Barton & Court, 2012) emphasized that “firms need to upgrade IT architecture and infrastructure for easy merging of data”(p. 6). In addition, this SAP-enabled shared platform is now acting as the “single source of truth” when dealing with data. Finally, this shared platform allows a single-point of data integration for all key agency stakeholders (e.g., employees, volunteers, senior managers).

#### 4.2.2. Implementation project of IT-enabled ‘Big Data’ capabilities: Overcoming challenges related to the management of volunteers organizations

One of the key lessons learned from this case study is the importance of the active engagement of the team that implemented the new IT-enabled ‘big data’ infrastructure in collaboration with the employees – especially the volunteers – during the whole project. As key stakeholders in the project, the service’s volunteers were given the opportunity to contribute. Volunteers from the all emergency services created a working group that collaborated to provide a secondary layer of governance, coordination, direction and advice for the execution of the project with the group tasked with the analysis of all contingent, exhaustive issues and the provision of advices and recommendations to the steering committee.

### 4.2.3. Going beyond top management support: Active involvement of Top management integrating bidirectional communication with all key stakeholders

Early studies on IT implementation posited a strong relationship between top management support and buy-in and implementation success. This study emphasizes not only the support but also the active involvement of senior management for successful implementation of the shared platform to leverage 'big data' capabilities. As the Director of ICT of the NSW SES stated: "the one consistency across the project has been that the CIOs from each agency have had a place on the steering committee, which I think has been invaluable as has the level of executive support. Indeed, the executive support has probably been the most important thing across all of it…So that was a key fundamental and that really came out of the direction from government saying you all come together and do all of this and at that point in time we – and I say the royal 'we' and it really was the CIOs who said to the CEOs: we will make this work for you…– so we made that commitment and we have been doing that now for three years and will continue to do that, although it does cause a few grey hairs at times".

### 4.2.4. Transforming firm capabilities: 'big data' as enabler of improved decision making for enhanced firm performance

For firms operating in an extremely compound environment such as emergency services, mission-critical assets visibility, allocation and coordination across affected regions represent a big challenge. Therefore, being able to know the 'where' and 'when' to move these resources need to be "factored into the decision making equation" (p. 12) (Manocha, 2009). For emergency service delivery to be efficient, it is critical to obtain the right information about the nature of the disaster as well as the required asset (HR and mission-critical asset). For example, accessing the accurate information can have huge impact on 'when' and 'how' to evacuate the population of a given region during a flood or a bushfire. Indeed, the costs of making an erroneous decision can have significant implications at the management and political levels.

#### 4.2.4.1. Real-time resource allocation, coordination, and asset movement

By leveraging the capabilities of the new IT-infrastructure, the agency is now able to better forecast the needs and availability of volunteers. Indeed, each volunteer can now log into the system and indicate whether they are available or not. The management team can therefore capitalize on such information to assess in real time the availability of volunteers across the 17 regions for better emergency delivery. In fact, the management team now has the capabilities to tailor emergency services accurately and meet each region's needs in terms of HR and critical assets (e.g. flood rescue boats and motors, personal floatation devices, vehicles, water pumps, first-aid kits, helmets, backpacks, safety vests and gloves etc). In future they will be able to move assets (HR and materials) from regions with a surplus of resources to regions with fewer resources during critical emergency operations, based on a real-time access to accurate information. Furthermore, the new IT-infrastructure now provides the manager better visibility, which is essential for improved decision making, through an analysis of workers' skills and qualifications. In parallel, employees can now enjoy a greater access to training event information. This is why the Director of ICT of the NSW SES stated: "the other things that we are using SAP for now are also availability. We have got a whole lot of availability stuff inside there so that if we know that an emergency is going to occur then we can go into – or tell people to go into SAP, put their availability in there and then we can use SAP to tell us who is available and who is not so we can do our rosters. We will see whether we are going to be short-staffed from our volunteers in any particular area and it will tell us".

#### 4.2.4.2. Improved emergency command control center management for better service delivery

The new infrastructure can enable a real-time synchronization of the command control centers of the 17 region headquarters by means of a single standard access to identify the available resources, thus providing them the information they need to make decisions at the local level. Now the NSW SES HQ has a greater capability in disseminating the relevant customized information to each key stakeholder in the emergency service delivery. For example, by aggregating various sources of information, the manager can now provide relevant information on various devices to the field personnel, so as to support and conduct emergency services operations. From the agency headquarters' control centre, the management team can now access timely information to identify the emergency services to be delivered, and direct them to each qualified, available volunteer connected to the system – the HR SAP provides information on the skills and availability of each volunteer while the GIS systems enable the geolocation of each response. The mapping functions on the devices can guide the field operators, giving information on where and how to go etc. Once they have accomplished their mission in the field, they can register the information back to the enterprise system via their device, thus streamlining the emergency service delivery.

## 5. Discussions

In this study, the results of a comprehensive review of 'big data' articles as well as an in-depth analysis of a longitudinal case study of the NSW SES are presented and discussed. We started by clarifying the definition and concepts related to 'big data'. Then drawing on the extant literature (Manyika, et al., 2011), a conceptual framework for the classification of articles dealing with 'big data' was developed. Using this framework as a conceptual guideline, we performed an analysis of 62 articles identified from ABI/Inform Complete, Academic Search Complete, Business Source Complete, Elsevier (SCOPUS), Emerald, IEEE Xplore, Science Direct, Taylor & Francis, as well as the AIS basket of top journals.

With regard to the literature review, 'big data' relevant journal articles have started appearing frequently in 2011. Prior to these years, the number of publications on the topic was very low: 0 articles before 2008, 1 article in 2008, 4 articles in 2009 and 2 articles in 2010. When looking at articles on value creation from 'big data', the results show that the vast majority of the publications are in 'Replacing/supporting human decision making with automated algorithms' (35 articles, 28%), followed by 'Enabling experimentation to discover needs, expose variability, and improve performance' and 'Innovating new business models, products, and services', with respectively 28 articles (22%) and 25 articles (20%). Finally, we have 'Segmenting populations to customize actions' with 20 articles (or 16% of all publications), followed by 'Creating transparency' with 17 articles or 14% of all publications. However, the realization of this value is contingent to a set of issues including in the order of importance: 'technology and techniques' issues (47 articles, 34%), 'access to data' issues (39 articles, 28%), 'Organizational change and talent' issues (22 articles, 16%), 'Industry structure' issues (16 articles, 12%) and 'data policies' issues (13 articles, 9%).

Key insights from the in-depth case study indicate that creating and capturing business value from 'big data' can allow a real-time access and sharing of information across local and national government agencies for improved decision making to enhance emergency service response. For example, having real-time information on 'who' and 'where' is allowing not only the realignment and movement of critical assets across the state to deliver emergency service, but also informing strategic decision about where to invest in the future to develop new capabilities and to reduce local community vulnerability. Another key benefit realized from 'big data' by the NSW SES is the improvement of intra- and inter-organizational transparency and accountability, which represent major issues in the government environment. Moreover, the ability of the NSW SES to handle and support data from various sources and formats (structured and unstructured), as well as to push 'intelligence' from these data to various channels so as to support emergency operation on the field, was a critical success factor in this process of creating and capturing business value from 'big data'.

Furthermore, this study highlights the importance of having a visionary CEO who is able, on the one hand, to reengineer the organization in order to implement innovative IT-enabled emergency service solutions that can leverage ‘big data’ capabilities, and on the other hand, to promote the adoption and use of IT-enabled emergency service delivery among the staff members, most of whom are volunteers.

## 6. Implications for research and practice

Prior to the presentation of implications for practice and research of the present study, we need to acknowledge some of the limitations. First, we only used a limited number of databases for our search. In addition, only articles in English were selected to be included in our literature review. Future literature review on ‘big data’ related topics should include more databases (English and non-English speaking). Finally, even though a systematic approach was used during this literature review, the selection of papers dealing with ‘big data’ that were included into our final sample was based on our subjective judgment. It will be interesting to replicate our results in a future study.

This study extends the big data research in several ways. First, our work contributes to managerial perspective that emphasized the importance of cross-functional adoption and application of big data. Our study also extends the understanding of the big data implications within the operations literature by synthesizing diverse concepts. Second, the study presents a general taxonomy for big data implementation and identifies key elements within each component. Third, the study significantly extends this research stream with the findings of a systematic literature review and a longitudinal case study. Finally, our work puts forward a grounded contribution that offers managers critical insight into the formulation and execution of big data strategies in the operations atmosphere. This taxonomy can be used by companies to address several issues, including identifying key aspects in big data issues, focusing on the key components of big data strategy, highlighting what critical factors of big data strategy should receive priority, creating a platform for implementing overall big data initiatives. Overall, our exhaustive literature review of papers dealing with ‘big data’ offered the opportunity to evaluate the level of knowledge development on the topic.

The study identifies the best practices for managers as well as initiates and directs future empirical research on the topic. The study proposes a set of definitions of ‘big data’, that we believe will contribute to clarify the current debate on the definitional aspects. Also, the study identifies not only a list of value creation from ‘big data’, but also issues that needed to be addressed in order to maximize this value. These two lists (value creation and issues) may help managers in the decision process of adopting ‘big data’ related topics within their organizations.  Overall, the research findings show that managers can realize full benefits from big data by establishing big data driven organizational culture and capabilities (McAfee & Brynjolfsson, 2012), having HR talents capable of “understand both the human and technical sides of transformative information sources.” (p. 349) (Frederiksen, 2012) and embracing good quality data (Beath, et al., 2012), as noted below.

In order to reap the full benefits from big data, managers need to align existing organizational culture and capabilities across the organization. Barton and Court (2010) highlighted that the key challenge for using big data is to make big data trustworthy and understandable to all employees. They exemplified that frontline employees in a retail industry were reluctant to use big data since they did not rely on either big-data based model or are not capable to understand how it works. Shah et al. (2012) for example, opined that business analytics skills are still confined to ‘expert’ level and not yet disseminated to all in an organisation; however, in order to add value from using big data, it is essential that all level of employees are well equipped about big data which can be achieved through training. Similarly, while organisations might have access to reliable information, owing to lack of clear and coherent contents of big data, employees could find it difficult to locate them properly when necessary. As such, in the process of gaining greater acceptance by employees and other end-users, managers should line up big data in an understandable format such as dashboard, reports or visualisation system (Bose, 2009). Indeed, return on investment in big data would not be materialized unless employees at all levels are able to understand and include data in their decision making (Shah, et al., 2012).

Managers believing in a ‘big data’ environment should emphasize the finding of the right skills including technical, analytical, governance skills and networked relationships for successful operationalization and implementation of analytics (Schroeck, Shockley, Smart, Romero-Morales, & Tufano, 2012). As argued by McAfee and Brynjolfsson (2012) the enormous amount of ‘big data’ requires cleaning and organising, which necessitates recruiting technically and analytically sound data scientists. Managers should make sure that data scientists are well conversant about business and governances issues and the necessary skills to talk in the language of business. The findings show that data scientists should be trained to build networked relationships which is an important skill (Thomas H. Davenport, 2012). As such, managers should grow, nurture and retain data scientists in order to grasp regular opportunities. Another challenge of using ‘big data’ for organisations is to develop both their technology infrastructure and business processes in the initial phase (IBM, 2013). The findings show that such developments are likely to assist managers to compare ‘big data’ results in a longitudinal fashion. Bose (2009) in this regard argued that because all such processes and protocols involve high initial investment, and require substantial change on the organizational processes, vigilant management of such phase in applying advanced analytics is critical.

The findings also emphasize on the availability of good quality of big data, which is key to add value in the organisation. Inferior and/or poor quality or inappropriate data have little potential to assist managers to take correct decisions; rather, it would waste organisational resources. Poor quality data might arise out of redundant applications and databases, which add to data storage costs and make data more difficult to access and use (Beath, et al., 2012). Although increased data can be leveraged to improve business value, there is always risk of redundant, inaccurate and duplicate data which might undermine service delivery and decision making processes. The study found that poor data quality or ineffective data governance is a key challenge for big data (Schroeck, et al., 2012). It is noteworthy that the use of even most sophisticated analytical system is meaningless if inappropriate data is in place or poor quality data is used (Bose, 2009). This study also urges managers to ensure safe handling of individual and organizational privacy in the context of big data (i.e., keeping individual & business customers name, address, social security numbers, credit card numbers, and financial information confidential and undisclosed to third parties), which poses enormous challenge for organizations (Bose, 2009). In this regard, McAfee and Brynjolfsson (2012) highlighted that the privacy concern is becoming more significant in the big data environment and should receive greater attention.

## 7. Future Research and Conclusions

This paper presents findings of a systematic review and a longitudinal case study that managers can use to unlock the power of big data along the cross cutting themes identified in the study. The findings show that the big data revolution is evolving and organizations should embrace it in order to build superior capabilities which can become a decisive competitive advantage. Organizations need to leverage the information eco-system arising out of the big data adoption to share the real time information, better understand customers, optimize supply chains and human resources, improve financial metrics and develop the critical insights for decision making. The findings also show that there are many avenues for exploring and conceptualizing the multifaceted nature of big data. It is important to have an acceptable conceptual framework for capturing the business value in a systematic manner in this research stream. Therefore, future research can focus on developing explanatory and predictive theories that encompasses all cross functional facets for better understanding and growth of knowledge in this domain. Specifically, future research can explore topics, such as, leadership, talent management, technology and tools, information eco-systems, company culture, data privacy, business value and decision making process, which have an enormous impact on 'big data' implementation.

The review and the taxonomy we propose in this study offer a potentially useful starting point for the development of improved insight into these aspects of emerging 'big data' research. This case study reveals insights with important implications in leveraging business value from the 'big data' in emergency service environments. The lessons learnt from this in-depth case study apply not only to emergency service, but also to other sectors, such as the healthcare, as well as to companies (e.g. multinationals) with complex enterprise architecture and multiple data sources that allow them to tailor customer demands in order to achieve a competitive advantage in the marketplace. In addition, the definitional perspectives and findings can be used as a research agenda for future in this nascent area. We emphasize the importance of 'big data' orientations and related managerial and operations issues as an area in which further research is urgently needed. Future organizational performance is inextricably interlinked with these orientations, which can ensure hard to replicate competitive advantage and business results.

## Appendix 1

| Dimension | definition |
|---|---|
| **Value creation from 'big data'** | |
| Creating transparency | Reduce search and processing time and; reduce time to market and improve quality. |
| Enabling experimentation to discover needs, expose variability, and improve performance | IT-enabled firms to instrument processes and then set up controlled experiments. Now, they can collect more accurate data and use them to analyze variability in performance (in real or near real time) to understand its root causes, and thus enabling leaders to manage performance to higher levels. |
| Segmenting populations to customize actions | Big data allows organizations to create highly specific segmentations (e.g., real-time micro segmentation) and to tailor products and services precisely to meet those needs. |
| Replacing/supporting human decision making with automated algorithms | -Improved decision making, minimize risks, and unearth valuable insights that would otherwise remain hidden (e.g., Automation of risk engines to flag candidates for further examination, automatic fine-tuning of inventories and pricing in response to real-time in-store and online sales, access and analysis of huge, entire datasets using big data techniques and technologies rather than just smaller samples that individuals with spreadsheets can handle and understand) |
| Innovating new business models, products, and services | Big data enables companies to create new products and services, enhance existing ones, and invent entirely new business models (e.g., use of data obtained from the use of actual products to improve the development of the next generation of products and to create innovative after-sales service offerings). |
| **Issues related to value creation from 'big data'** | |
| Data policies | Privacy (e.g., Personal data such as health and financial records), security, intellectual property, and liability. |
| Technology and techniques | Technologies encompass: storage, computing, and analytical software, while techniques are more related to new types of analyses of big data. Both are needed to help individuals and organizations to integrate, analyze, visualize, and consume the growing torrent of big data. |
| Organizational change and talent | Currently, organizational leaders often lack the understanding of the value in big data as well as how to unlock this value. In addition, many organizations do not have the talent in place to derive insights from big data. Furthermore, many organizations today do not structure workflows and incentives in ways that optimize the use of big data to make better decisions and take more informed action. |
| Access to data | The access and integrate information from various data sources is the key for the realization of "big data"-enabled firm transformative opportunities. |
| Industry structure | The full business capture and realization from "big data" will be function of the industry structure (e.g., industry with a relative lack of competitive intensity and performance transparency, high competition vs. low competition, high performance transparency vs. low performance transparency, high concentrate profit pools vs. low concentrate profit pools). " For example, in the public sector, there tends to be a lack of competitive pressure that limits efficiency and productivity; as a result, the sector faces more difficult barriers than other sectors in the way of capturing the potential value from using big data" (p. XX). |

**Source: (Manyika, et al., 2011)**

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