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Influence of big data in managing cyber assets

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Abstract

Purpose

Today big data plays an imperative role in the creation, maintenance, and loss of cyber assets of organisations. Research in connection to big data and cyber asset management is embryonic. Using evidence, we argue that asset management in the context of big data is punctuated by a variety of vulnerabilities that can only be estimated when characteristics of such assets like being intangible is adequately accounted for.

Design/methodology/approach

Evidence for the study has been drawn from interviews of leaders of digital transformation projects in three organisations that are within the insurance industry, natural gas and oil, and manufacturing industries respectively.

Findings

By examining extant literature, we traced the type of influence that big data has over asset management within organisations. In a context defined by variability and volume of data it is unlikely that we will be going back to restricting data flows. The focus now for asset managing organisations would be to improve semantic processors to deal with the vast array of data in variable formats.

Research limitations/implications

Data used as evidence for the study is based on interviews, as well as desk research. Use of real time data with the use of quantitative analysis could lead to insights that has hitherto eluded the research community.

Originality/value

There is serious dearth of research in the context of innovative leadership in dealing with a threatened asset management space. Interpreting creative initiatives to deal with a variety of risks to data assets has clear value for a variety of audiences.

1. Introduction

Assets are at the heart of capacity of organisations, that can be leveraged to acquire sustainable competitive advantages. While traditional conceptualisations of assets purport to physical characterisations yet resource richness of organisations is increasingly based on intangible digital assets held in clouds (Mitra and O'Regan, 2019). With ever increasing interactive use through stakeholder participation, the size of such intangible data assets is likely to snowball in volume. Instant nature of interactions and data exchanges which are all in real time tend to also ratchet up the velocity of such data usage. Almost unique in value contribution to such assets is the multiplicity of data formats that is premised on a diverse range of platforms through which variability of data generation is envisaged (McCreary and Kelly, 2013).

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As organisations transform themselves digitally (Westerman et al., 2014), we can discern a gradual shift in the way that they value assets. While physical assets have been the cornerstone of traditional business, today data and consequent digital assets would be the institutional preference. It is clear, that as expectation of customers to be able to access assets twenty-four by seven has become an accepted mode of practice, organisations are also swiftly moving to convert their physical into digital assets. Damage to physical assets like building and infrastructure can be costly and can be replaced through reconstruction, on the other hand data losses or corruption of data can result in even larger losses and be harder to replace (Mitra et al., 2018). Losses because of, data loss can have debilitating effects on the organisation and can create abiding vulnerabilities for organisations in a market where information assurance tends to play a key role in bolstering trust. The latter would lure customers of buying into the products and services on offer and thus extend trade.

The nature of vulnerabilities of the two types of assets couldn't be any more distinct. While damage from fire, natural calamities, and destruction would be the norm of susceptibilities of physical assets like buildings, digital assets are prone to a myriad of malware attacks as well as are threatened by hackers who may make illegal use of these. At the end of the day while a small number of people could be affected through the destruction of physical assets, millions of peoples' lives could get adversely affected when digital assets are compromised. Beale (2018) talking about the insurance provision of Lloyds of London for cloud based digital assets mentioned that digital assets are stored in the cloud supervised by a few firms. If one of the cloud providers were to come down because of a cyber-attack for three days, it would affect 12.5 million business users in the US alone. The size of the population who would be affected tells us of the enormity of the risk that digital asset loss could bring upon us. So, the reality that stares us in our face is one which is complex – here we are compelled to translate our physical assets into

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digital ones on the one hand and on the other compound the risk of loss due to the vulnerabilities that such digital assets inherently contain.

Beale (ibidem) went on to narrate another instance, which is likely to provide a glimpse of some of the challenges of the type of compromises that assets management might unknowingly bump into.

> 'An employee in a chain of opticians received an email saying she had been caught speeding on camera. She clicked on the link and it offered to show her a photograph of her being caught in the act of speeding. This was a cyber attack as the email was not genuine. By clicking on the link, she triggered a virus that infected all the files on her company's servers. Then she received the email that said, your files are all encrypted, and we need a fee from you, payable in bitcoin to unlock the encryption. The files contained sensitive patient records as well as the software to run the business. Without access to them the business couldn't operate. They had no choice but to pay up to these hackers, whoever they were. The company's insurer's paid for the ransom and provided the reimbursement for the entire costs for getting up and running. But of course, it didn't end there because the encryption key that the hackers then released only covered 90% of the files and the company needed an IT contractor to come in and rebuild and recover the remainder of them. The company eventually got up and running again but it was a traumatic experience for everyone involved.'

The abovementioned account vividly demonstrates vulnerabilities of cyber assets and the way big data is the bed of an interconnected range of strengths and weaknesses. While on the one hand data needs to be freely available for companies to do business while at the same time there are these constant threats from hackers who are omnipresent and growing in numbers with the passage of time. As mentioned before big data enables organisations to maintain and grow digital assets while at the same time offering potential avenues to hackers who are waiting to pounce on unwitting asset managers.

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Valuation of digital assets also tend to have a dynamic that in a way determines its net worth. This is where big data tends to play an imperative role in the creation and sustenance of such assets. Value of digital assets are usually borne out by among others a preponderance of customer information. Along with this there is also the reviews and comments that customers write about their experiences of consuming products and services. There could also be organisations that engage with customers before designing their products (Mitra et al., 2018). In any case the size of user generated data is of such a magnitude that cloud based infrastructure is the only appropriate platform to accommodate these sorts of unlimited volumes. The dynamic nature of these assets is also something that needs to be factored in if we are to effectively monitor their value.

Essentially big data involves a couple of specific types of challenges. The first relates to the messiness as a result of heterogeneous sources of data along with exponential growth of data within very short time horizons. The second is about the semantic processes that will be employed to make sense, discern patterns when making sense of this vast volume of data. In tandem with these challenges contemporary asset management is also not without its unique characteristics. First increasingly we need to deal with digital assets or data assets instead of physical infrastructure. Second, asset destruction or any kind of compromise is immensely harmful to firm reputation in any industry (Ransbotham, et al., 2016). Therefore, security and protection of big data assets usually resident in clouds is priority for organisations. Third the greater the movement of data between different stakeholders, the higher the value addition (Hawlitschek, et al., 2018).

2. Review aim:

Despite a growing interest in big data use by businesses, researchers know relatively little about estimating influence of specific characteristics of big data in cyber asset management. Industries such as insurance, natural gas and oil, and manufacturing, can be characterised as generating big

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data that is central to efficient cyber asset management. Because of their unique products and services, cyber asset management within the mentioned industries today is tied up with vast cyber assets whose vulnerabilities are the target by interests that could profit from jeopardising the reliance of millions of peoples' livelihoods. Given recent historical and potentially increasing importance of big data for all types of organisations and industries and given the centrality of cyber asset management in organisational capacity, addressing issues of vulnerabilities of such big data assets is timely. The paper primarily examines the relationship between big data and asset management with specific reference to the insurance, oil and natural gas, and manufacturing sectors.

The paper is structured such that it can explore the relationship between big data and cyber asset management through anecdotal as well as extant literature-based evidence. Following the section on introduction we have considered the nature of data from the perspective of challenges to format and processing. This if followed by data characteristics in the context of analytics that are now widely used. The next section is on analytics and big data is primarily focused on extant literature implications. We briefly dwell on the methodology that we have followed to develop the paper next. Following the section on extant literature we have a section on discussion which essentially consider the principal relationship of big data and asset management. Finally, the section on conclusion is the next section in which we have considered the contribution that this paper makes, some of the key limitations and areas of further research that may be worth pursuing in future work.

3. Method:

The literature review which is the central basis of this paper is entirely premised on desk research. The latter was undertaken to explore a couple of key dimensions of big data that have been alluded to in the previous sections. Unlike traditional data that conforms to specific formats, big data is messy and exists in various forms. Inherently this agglomeration of different

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types of data creates challenges for processing to come up with meaningful outputs. So, the characteristic messiness of big data was the first filter that we used to locate papers in the survey for this study. Within extant literature we selected papers that reported on messiness of data spanning across a variety of formats. Second criteria we used to include papers in our survey is that of locating research that were focused on micro dimensions of big data. So far, big data seems to be successfully used when it comes to macro data. However, to locate person specific data, specific algorithms need to be written which are both costly as well as resource intensive to develop.

At the same time there are three types of sources, viz. examination of organisations that have been influenced in their asset management by their use of some type of big data. The insurance industry, natural resources, and manufacturing are the three sectors in which organisational big data instances have been drawn upon for this study. Second, we have also examined a wide range of extant literature on big data and asset management. We did find that while there is burgeoning literature in big data or for that matter literature with a specialist focus on asset management, literature with a focus on the relationship between big data and its influence on asset management was either non-existent or is embryonic in nature. Third we have drawn from anecdotal accounts of key managers in well-known organisations who are now managing their assets through extensive reliance on big data sources.

4. Data characteristics

Insert figure 1 about here

The diagram in figure 1 is aimed to illustrate the voluminous nature of big data and the ensuing types of data structures that are compatible with it. The diagram illustrates the increasingly unstructured nature of growth of big data.

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From a management perspective, the advent of big data has made it impossible to think of businesses in the same way as in the past. Whereas traditional approaches have used analytics to understand and fine tune processes to keep management informed while alerting them to anomalies (business intelligence is driven by the idea of 'exception reporting'). In contrast big data has flipped such an analytical orientation on its head. The central view of big data is that the world and the data that it describes, are in a state of change and flux, those organisations that can recognise and react quickly have the upper hand in this space. The sought-after business and IT capabilities are discovery and agility, rather than stability (Davenport 2014). The table 1 below projects a few key differences between big data and traditional analytics.

Insert table 1 about here

The dimension of primary purpose of big data in table 1 reveals how the entire industrial world is reorienting itself with regard to customer data. The traditional information management approach has been to use analytics to cater to better internal decision making through creation of reports and presentations that advise senior executives on internal decisions. In contrast data scientists are today involved in data driven products and services through the creation of customer facing and customer touching applications.

5. Analytics and big data

Generally, the business world could in theory question any differences with standard analytics and that of big data. However, there are three key dimensions that seem to make it obvious that big data would require different ways of capturing as well as novel techniques of analysis in comparison to traditional analytics. These three dimensions include volume, velocity, and variability (McCreary and Kelly, 2013). The big data context of volume focuses on being able to process large amounts of data – here the guiding logic is always more data is better than smaller amounts of higher quality data. The primary considerations here relate to scalability, distribution, the ability to process the acquired data and the like. The speed at which data gets generated is the dimension that relates to velocity of big data. Obviously here we relate to the amount of time

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that is taken for action to be initiated after the receipt of that data. Issues of concern here include granularity of data streams, appreciating what is irrelevant and the amount of inactivity that may be tolerable in relation to data, decision making and action taking. In an interconnected world of numerous data sources through which data gets generated – it is often unstructured, punctuated with errors, and inconsistent in nature. Relevant issues in this messiness context include amount of information loss in data clean up, semantic integration and versatility in representation (Lycett, 2013). As early as 2012, about 2.5 exabytes of data has been getting generated each day, further this amount seems to be doubling every 40months or so. Every second sees the passage of data across the internet compared to what was stored in the entire internet 20 years ago (McAfee and Brynjolfsson, 2012).

With the burgeoning growth of data assets in comparison to physical ones we are also gradually moving into a world where intangibleness of assets is also becoming a key feature of the value of organisational capacity. All the feedback generated through customer comments on satisfaction levels along with counter comments of other users would today be considered an important contributor to the asset value of a company. As a matter of fact, in manufacturing organisations like modern car manufacturers the whole design process is becoming dependent on the engagement of prospective customers whose design expectations get embedded in the design phase of car model development (Mitra et al., 2018). Data assets in the form of blog posts, tweets, likes on Facebook all make up the gamut of data assets that are vital for the modern organisation that is trying to get near to customer expectations and in the process garner competitive advantages in an environment that expects swift reactions to online feedback. In a way big data enriches the ties between customer and manufacturers as it strengthens the relationship between the two. In the contemporary context, every organisation wants to develop and strengthen customer relationship management (CRM) capacities so that they are able to sell all of their products without actually having to deal with unsold stock. If organisations can use

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the data generated by customer participation in social media, it might be feasible for them to then enhance their CRM capacities, leading to greater customer satisfaction and reduction of losses from excessive unsold stock.

Closely tied to the growth of intangible assets of an organisation is the need to be able to measure it. As Green (2008) by using an engineering concept has decomposed intangible assets by rendering them into their primitive formats of business intelligence (BI) metadata to align with operational data. Green (ibidem) argues that by aligning operational data with BI implies that it might be feasible to create cross-tab views of data that can then be modelled into multidimensional views that are compatible with establishing accountability and valuation of tangible assets. Perhaps knowledge assets have a good deal of intangibility embedded in them. In a sense, big data could be the only mechanism to get to developing or assessing the value of intangible assets.

An example of intangible knowledge assets would be the accessibility of innovative approaches to develop solutions. During the first gulf war (circa 1990) there were a lot of Westland Helicopters that were used by coalition forces in Iraq. Because the Iraq war was primarily fought in desert like environments the amount of sand in the air was much higher than normal. In this operation, the Westland helicopter pilots of the Royal Airforce (RAF) had to deal with sand getting into the engine and thus the flights/sorties were disrupted and soon it was almost impossible to use these helicopters as they were not built to operate in these sandy conditions. The RAF personnel devised unique ways through which they could keep the helicopters flying despite the high percentage of sand in the air. So, the After the Iraq war ended most of the helicopter pilots retired as it was normal for Royal Airforce pilots at the earmarked points in their forces career. However, with the passage of a decade there was the second gulf war (circa 2003) when pilots were expected to operate Westland helicopters in amongst the desert sand.

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But this time all the intangible knowledge that was an operational asset was lost forever as there was no compilation of those experiences anywhere that could be used by pilots in the second gulf war.

The issue of garnering greater, deeper insights from big data to enhance competitive capacities of organisations is an abiding dimension of big data use that has also been reflected within the extant literature. However, Dutta and Bose (2015) are probably unique in their quest to conceptualise a framework through which analytics and project implementation using outcomes of data analysis could lead to effective implementation of big data projects in the realm of asset management. According to Bizer et al. (2011) there are essentially a couple of key issues with regard to successful implementation of big data use. While the first relates to managing such exorbitant volume of data, the second has to be getting the right decoding mechanisms to locate patterns and make sense of the data. It is perhaps intriguing to appreciate that even though potential of exploitation of big data has been around for a while now yet hardly anything out of the ordinary seems to be undertaken by large conglomerates. For instance, it was reported by the Economic Intelligence Unit in 2015, that as high a proportion of firms as 56% of manufacturing firms didn't seem to have made much progress in using or applying big data to progress current business potential of the organisation. Lee et al. (2013) have reported that there seems to be an upsurge in the uptake of technologies by manufacturing companies to use technologies such as advanced analytics and cyber physical approaches to augment productivity and make systems more effective. The remit of big data enables organisations to be ambitious in the way they can predict consumption patterns of consumers such that substantial advantages can be garnered by having exactly what customers might be looking for. Obviously, predictive analysis using big data is able to focus on a variety of sources that would not be considered relevant in normal data mining.

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Dutta and Bose (2015) go on to devise a framework for implementing big data projects. But this framework seems particularly simplistic. As if it would be feasible to pre-define all stages to then take the implementation forward. In essence, big data given it's three vs, i.e. volume, velocity, variability, has a nature that seems unlikely to conform to linear progression. Therefore, it is very different to other types of technology projects that have hitherto been envisaged for organisations. Various stages have been mentioned by Dutta and Bose (ibidem) – these could have more clearly defined KPIs or measures by which you could assess if that part of the development conforms with expectations for the stage. Chang et al. (2014) have drawn attention to the fact that despite the advent of a multidimensional data frame through big data use, there is need to recognise a paradigm shift in the way data is viewed and then used as evidence. Chang et al. (ibidem) have argued that theory continues to be relevant in the domain of data analytics. Something that has been taken for granted is the interdisciplinary nature of the data that needs to be factored into the compilation and analysis of big data. Unlike the world of social media where demons are being created through the relentless generation of data, Chang et al. (ibidem) have stressed that there needs to be connections to some simple logic and understanding of the expectations of the audience of a business if the management were to succeed in garnering advantages through the use of vast amounts of data that big data provides. As McAfee and Brynjolfsson (2012) have pointed out in the end it will be humans who will be responsible to design the processes, while discovering insights will be as a result of a combination of algorithm and system-based data analysis and intuition of people using the systems. So following Chang et al. (ibidem) we could say that in the context of asset management the same type of mindset would work well whereby we use intuition and our knowledge of the assets and then marry this with the outcomes of big data analysis.

Kwon et al. (2014) have looked at benefit perceptions of adoption intentions of big data analytics by firms. Kwon et al.'s (ibidem) work is interesting from the differentiation between internal

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corporate and external source data use by firm's perspective and its connections to big data analytics that their empirical data seems to project. On the one hand they contend that a firm's intentions for big data analytics can be positively affected by its competence in maintaining the quality of corporate data. Further a firm's encouraging experience in using external data sources could promote future acquisition of big data analytics. Remarkably Kwon et al.'s (ibidem) work goes on to show that a firm's positive experience in using internal source data could hamper its adoption intention for big data analytics.

Whyte et al. (2015) have looked at the role of big data and its role within asset management of complex projects. Using three organisations viz. Airbus, CERN, and Crossrail, Whyte et al. (ibidem) have pointed out that new challenges arise as asset information has become a project deliverable; as data increases in volume, velocity and variety; and as it is aggregated and re-used; with connections (and potential connections) across internally and externally held data sets. This dimension of asset management becoming a project deliverable is an important development in the context of big data. Such a change in expectations from a project perspective is probably indicative of the extensive role that meta data or dynamic data generation within the realm of big data is able to provide. As project management is becoming more customer directed, it is also clear that flexibility that big data provides is ultimately a sought-after attribute that attracts asset managers. As a matter of fact, Whyte et al.'s (ibidem) focus mainly stems from the flexibility that big data is able to provide in the context of complex projects. Change management can also be a complex process in a project setting which is again facilitated by big data. However, when integrity is central to a project there can be also critical requirements of flexibility. So, Whyte et al. (ibidem) have unearthed the limits of flexibility within the context of complex projects when integrity is of paramount importance.

An important feature of contemporary project delivery is to do with managing change in asset information as data-sets are aggregated and reused through life. Volume, velocity, and variety of

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data brings new challenges of version control, linkages across project stages and with other data sets; and approaches to arranging and organising. Whyte et al. (ibidem) also point out that there might be increasing integration between data-sets in project delivery yet digital systems are not seamlessly connected but are heterogeneous with significant modifications in the use of data through the project life cycle.

A significant issue regarding asset management alluded to by Whyte et al. (ibidem) concerns users who do not follow prescribed processes involved in configuration management. At a time when big data was not so expressly recognised as today, Mitra (2009) reported similar experiences when IT project management for the Commonwealth Games in Manchester revealed engineers' propensity to move away from prescribed solution approaches and to use personal preferences and choices to determine a unique path to create solutions for clients.

Insert figure 2 about here

In figure 2 above we have shown how asset valuation may be envisaged to grow in a big data context. The greater the movement of assets among key stakeholders the greater will be the propensity of valuation of the asset within specific industry contexts. The challenge of protection of assets from being compromised is also another important caveat when assets are dynamic and moving. So although greater movement of assets is likely to generate higher valuation at the same time vulnerability of such assets being compromised would also gradually ratchet up. Asset characterisation would be reliant on the three vs (McCreary and Kelly, 2013) as well as the type of semantic tools that are going to be applied to process the burgeoning data within specific assets.

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6. Discussion:

To answer the question of how big data influences asset management in organisations, we considered the use of a framework through which antecedents of cloud computing in multinational companies have been assessed. Borrowing from Mitra et al.'s (2018) study on resource-based valuation of cloud implementation among multinational companies it is feasible to discern patterns within influences of big data on the way organisations manage assets. Mitra et al. (ibidem) study has special relevance here as cloud computing is usually the type of platforms on which big data is resident and second the whole issue of resource based valuation is also clearly connected to assets of organisations. It is important to bear in mind that big data capacities enable asset management to be both focused on the macro as well as the micro dimensions of a business (Bizer et al., 2011). Predictive analysis can substantially enhance an organisation's ability to acquire and generate assets. We agree with Boyd and Crawford, (2012) that bigger data are not always better data. Without taking into account the sample of a data set, the size of the data set is meaningless. For instance, a researcher may seek to assess the topical frequency of tweets, at the same time if Twitter were to remove all tweets that contain tricky words or content from the stream, the topical frequency would be erroneous.

6.1 Industry expectations:

It is clear from the assessment of evidence so far that as assets of organisations become digital in nature, their reliance on big data increases exponentially. However, within this messiness of data is also a key feature of the burgeoning growth in data. Data generated by users is a significant contributor to big data. In turn, assets of organisations are also made up of the type of customer data that gets generated through interaction among and with customers. As a matter of fact the greater the volume of customer feedback, the greater will be the likely asset valuation. The type of semantic processors that will be used can also determine the eventual curation of meaning and enable organisations to direct offers that fit with customer expectations. While user generated

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data is a boon to the valuation of organisations at the same time 'Without taking into account the sample of a data set, the size of the data set is meaningless' (Boyd and Crawford, 2012, pp. 669). So it is borne out by the analysis so far that ultimately protection of customer generated data would be an obvious way to protect assets in a fast moving data space. Using Green's (2008) arguments it might be feasible to decompose intangible organisational assets that could then enable the creation of accountability of assets which is an industry expectation.

6.2 Process standardisation:

Cost reduction by creating standardised features that organisations use to deploy various functionalities is increasingly the goal of capacity development in organisations. Just as cloud computing enabled organisations to move away from excessive customisation (Mitra et al., 2018) and in the process reduce costs, big-data based asset management can do both, i.e. it will be able to provide both a macro visualisation of assets, at the same time through the reliance on analytics it will be able to provide specific solutions for individual clients/customers for the organisation. As data generation becomes more oriented towards customer feedback so will it become possible for industries to fine tune offerings to individual audiences. So here both process standardisation (Dutta and Bose, 2015) could likely be feasible along with the fact that there will not be any significant cost rises due to specific customisations.

6.3 Scalability:

Another type of development that affects large multinational organisations with assets that serve various countries around the world is the issue of scalability. With the reliance of cloud computing infrastructure organisations in the insurance industry, oil and natural gas sector as well as manufacturing organisations would find it imperative to rely on big data analytical capacity. One of the multinational oil and natural gas companies that were part of the study conducted by Mitra et al. (2018) needed to scale their information management deployment to cater for 835k employees who worked in more than seventy locations around the world. Here also to reduce duplication of effort and to manage assets that are increasing in size almost every

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day, asset managers would be using big data approaches to make sense of global patterns that provide indicators for initiating action. Another key dimension here is speed of response. Probably without semantic processors that are being used for the acquired big data on assets, it would be impossible to act and of course not being able to act quickly could lead to major calamities for organisations that have critical assets being deployed in such a way that they impact lives of users.

6.4 Investment optimisation:

Use of data banks across various locations around the world is the likely home of big data among all of the organisations that have been used for this study. All of these data banks are cloud repositories and hence they do not have capital expenses. In a way operational expenses are what would be the driving logic for analytics that are applied on the assets to generate various insights that would then enable greater fit with customer or client expectations. Use of third party resources to store big data and also use of third party tools including NoSQL and Hadoop clusters for predictive analysis is something that is becoming common across most big data using organisations. So here there are clear ways through which organisations can focus on creating reliable assets that they then use to query/mine using big data tools without much of a commitment of capital expenses up front.

6.5 Focus on core capacities:

Although information management has become an integral part of most of the industries included in this study as well as the fact that reliance on IT tools is also a clear part of all the organisations that we used, yet the organisations and their employees actually have certain competencies which are different than pure IT use (Chang et al., 2014). With the use of semantic processors on the data assets it is feasible that employees could get on with their actual specialism related work while big data tools could work on developing insights using various pre-defined constructs. In a way uniqueness of employee competencies could also lead to garnering specific advantages within specific industry contexts (Mitra and Neale, 2014). Of course, given

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the three vs of big data (McAfee and Brynjolfsson, 2012), asset data is different from traditional data and would require almost continuous processing which would also enable the key players in the organisation to concentrate on core competencies while enriching the data with insights that are emerging through the big data analysis.

7. Conclusion:

The paper has so far demonstrated that big data has clear and substantial influence in the way asset management is envisaged and administered. While the three vs are a principal mechanism of visualising big data related assets yet both variability and the volume of data are quite substantial challenges that stakeholders have to grapple with. We are in a world where even when data is not born digital, it becomes part of data assets through various semantic processors that are available within industry. But while there is considerable success that predictive analysis has brought to organisations, yet the messiness of data brought about by variability is something that is an ongoing challenge in big data based asset management. While customer expectations are being successfully gleaned through specific semantic processor yet more confusing data gets generated by the minute that then extends challenges for interpreting it. The other specific vulnerability of a data defined asset environment is its availability. Any time there is any attack that compromises big data on assets, organisations will suffer with consequences that will affect multiple markets. Beale's (2018) experiences in the insurance sector vividly projects some of these challenges both for individual organisations as well as for entire industries.

From a technology perspective big data always seems to point to greater capacity to develop certainty about the asset management space. However, Boyd and Crawford (2012) have reminded us of the instinct of apophenia, i.e. seeing patterns where there are none. So, some of the confidence because of data mining capacities brought about by the access to large amounts of data might be misplaced. Boyd and Crawford (2012) has cited Leinweber's (2007) research in which it was shown how data mining techniques could show a strong but spurious correlation

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between changes in S&P 500 stock index and butter production in Bangladesh. Limited archiving capacities can also lead to uncertainties about historical data on assets. If Twitter and Facebook were considered as examples of big data sources, then they offer very poor archiving and search functions.

The paper by examining extant literature traced the type of influence that big data has over asset management among organisations. It is clear that in a cloud-based world we are likely to improve predictive analytics and there is no chance of reverting to static comparative static data sets any more. Also in a world that is primarily defined by variability and volume of data it is unlikely that we will be going back to restricting data flows, rather the focus now among asset managing organisations would be to improve semantic processors to deal with this vast volume of variable format data. The fact that we used only secondary data and anecdotal evidence has restricted the type of inferences we have been able to draw from the study. Second, we have considered industries that may be unique in the way they handle big data and so assuming that asset management will be in all likelihood be the same across the oil and natural gas, manufacturing and insurance industry might have been simplistic. At the same time, we have been referring to user generated or data on users of these industries so there might have been commonalities among assets. Use of more real time data aided by quantitative analysis could be a way forward for developing abiding insights into big data's influence on specific assets or organisations.

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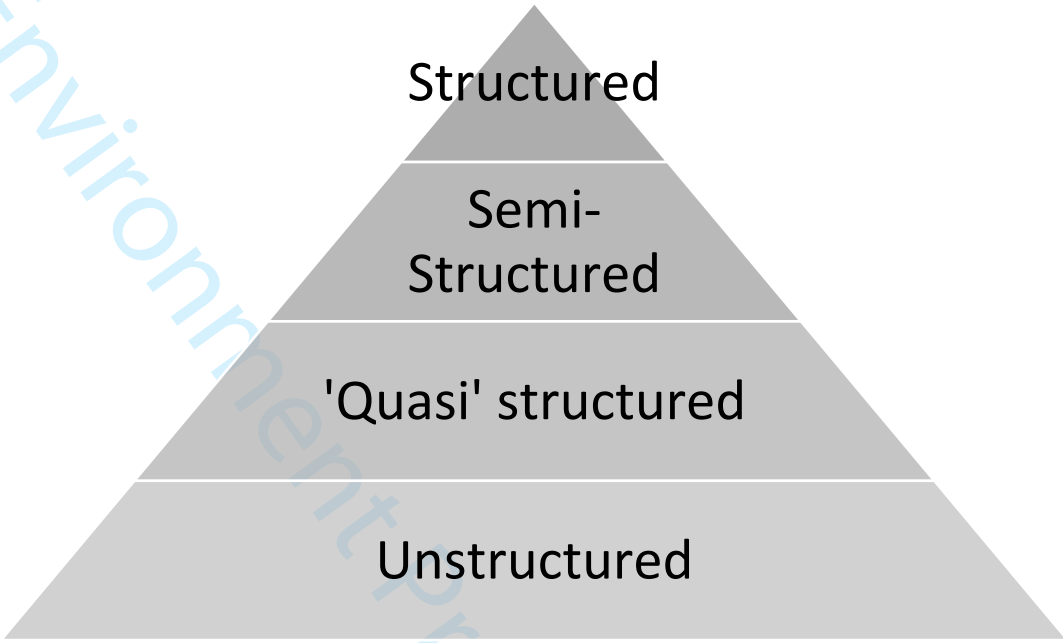

Figure 1: Big data growth is increasingly unstructured
Source: Adapted from EMC Education Services (2015)

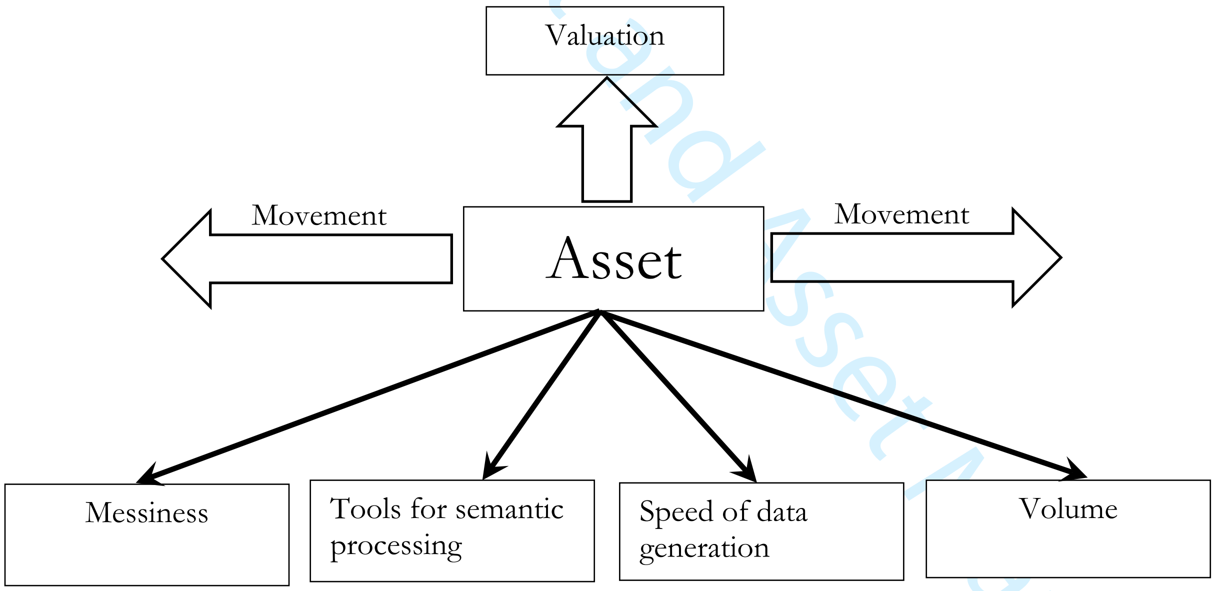

Figure 2: Dynamics of asset valuation

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Table 1: Big data and traditional analytics

Dimensions	Big data	Traditional analytics
Type of data	Unstructured formats	Formatted in rows and columns
Volume of data	100 terabytes to petabytes	Tens of terabytes or less
Flow of data	Constant flow of data	Static pool of data
Analysis methods	Machine learning	Hypothesis based
Primary purpose	Data-driven products	Internal decision support and services

Source: Adapted from Davenport (2014)

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