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► **To cite this version:**

Claudio Vitari, Elisabetta Raguseo. Big Data: Evaluating business value and firm performance. [Research Report] Grenoble Ecole de Management. 2016. hal-01403743

HAL Id: hal-01403743

<http://hal.grenoble-em.com/hal-01403743>

Submitted on 27 Nov 2016

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Big Data: Evaluating business value and firm performance



Claudio Vitari and Elisabetta Raguseo
Sponsored by Grenoble Ecole de Management and Auvergne-Rhône-Alpes region



Preface

The philosophy of this project

This report is an output of a research project co-financed by Grenoble Ecole de Management and Auvergne-Rhône-Alpes French region. This study was conducted with the aim of understanding how Information Technology (IT) provides new opportunities to firms, specifically focusing on the role of Big Data in creating value for the companies. Gartner defines Big Data as *“high volume, velocity and/or variety information assets that demand cost-effective, innovative forms of information processing that enable enhanced insight, decision making, and process automation”*.

Specifically, Big Data are produced around us and are changing the way companies provide their services, the features of products produced and the way people work. We are on the cusp of an analytics revolution that may transform how organizations are managed, and also transform the economies and societies in which they operate. Among companies, this revolution has several dimensions: 1) Companies have more data to use than ever before; 2) By using internal and external data, companies are beginning to understand patterns of consumer activity that had once been impossible to perceive or act upon; 3) Companies are using new technological solutions to understand their own operations at a much finer level of detail.

The increasing importance of Big Data leads us to need of understanding whether companies are ready to extract value from Big Data and how they do that.

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1. Introduction

Big Data is a driving force of business success across a wide range of industries. Organisations are investing considerable resources in Big Data initiatives in search of value creation opportunities to drive their digital business strategies, and to allow them to make better informed business decisions. Big Data are generated every day through tweets, clicks, videos and the plethora of sensors embedded on devices. Furthermore, instruments and machines such as smart meters, manufacturing sensors, equipment logs, and vehicle tracking systems automatically and continuously generate Big Data. When firms use radio frequency identification (RFID) technologies to track items along a supply chain, they produce Big Data, and when customers follow a link to a website, they also produce Big Data. Piccoli and Watson (2008) explain how Caesars-Harrah's Entertainment (the largest casino firm in the United States) uses its well-known Total Rewards loyalty points system to collect extensive data on its customers' gambling behaviours by providing customers with cards that link names to transactions, and that allow Caesars-Harrah's to monitor behaviour over time. Armed with this infrastructure for collecting customer data, Caesars-Harrah's can extract value from data and then tailor the gaming experience to each customer.

Organisations face enormous challenges when accessing, processing, and analysing such massive quantities of data. Indeed, many firms are overwhelmed by enormous amounts of fine-grained data. This recent data-driven revolution can offer firms opportunities to make prompt and accurate decisions based on readily available Big Data, especially for Big Data analytics investments. These investments are "a collection of data and technology that accesses, integrates, and reports all available data by filtering, correlating, and reporting insights not attainable with past data technologies". They can be valuable for companies' business and may change the way companies make business.

Based on these considerations, this project will look at the business value of Big Data and whether it impacts on the firm performance. In so doing, the project will investigate the business value in terms of transactional, strategic, transformational and informational business value, and the firm performance in terms of financial performance and market performance.

2. What is Big Data?

The way organizations capture, create and use data is changing. The underling idea, which is gaining currency among executives, academics and business analysts, reflects a growing belief that we are on the cusp of an analytics revolution that may transform how organizations are managed, and also transform the economies and societies in which they operate (Kiron, 2013). Among companies, this revolution has several dimensions: 1) Companies have more data to use than ever before; 2) By using internal and external data, companies are beginning to understand patterns of consumer activity that had once been impossible to perceive or act upon; 3) Companies are using new technological solutions to understand their own operations at a much finer level of detail.

In the digital world we live in today, growth in the volume of raw data that needs to be captured and that can be easily run in terabytes and petabytes is increasing. Big data is the term used to describe this phenomenon. Specifically, Gartner defines Big Data as “*high volume, velocity and/or variety information assets that demand cost-effective, innovative forms of information processing that enable enhanced insight, decision making, and process automation*”. Clearly, size is not the only characteristic of Big Data. Other characteristics have emerged recently on Big Data. For example, Laney (2001) suggested that Volume, Variety and Velocity (the Three V’s) are three dimensions that can describe Big Data. A fourth critical feature of big data, veracity, can be added to his categorization (Figure 1).

Specifically, *Volume* indicates the size of the massive data generated by machines, networks and human interaction on systems like social media. Big Data sizes are reported in multiple terabytes and petabytes.

Velocity deals with the pace data flows in from sources like business processes, machines, networks and human interaction with social media sites, mobile devices, etc. The flow of data is massive, continuous and real-time. For example, the proliferation of digital devices as smartphones and sensors has led to an unpredictable rate of data creation and is driving a growing need for real-time analytics and evidence-based planning. More traditional

companies, such as Wal-Mart, also process more than one million transactions per hour. The data generated by mobile devices and flowing through mobile apps produce torrents of information that can be used to generate real-time and personalized offers for customers.

Variety refers to the many sources and types of data available both structured and unstructured. However, only the 5% of all existing data are structured (Cukier, 2010). With Big Data, indeed, data comes in the form of emails, photos, clickstreams, videos, monitoring devices, PDFs, audio, text, which born in an unstructured format. This variety of unstructured data creates the necessity to adequate technological solutions in order to storage and analyze them. For example, clickstream data provides a panpplly of information about customer behaviour and browsing patterns to online retailers. It advises also on the timing and sequence of pages viewed by a customer. This information can be leveraged in decisions related to product promotions, placement, and staffing. Even small and medium enterprises, more financial constrained than big companies, can mine massive volumes of semi-structured data to improve website designs, implement effective cross-selling and personalized product recommendation systems.

Finally, *Veracity* refers to the uncertainty of data in terms of biases, noise and abnormality. For example, customer sentiments in social media are uncertain in nature, since they entail human judgment. Yet they comprise valuable information, thus, the necessity to deal with inaccurate and uncertain data is another facet of Big Data. This state of uncertainty is studied using analytic tools specifically developed for managing and mining uncertain data.

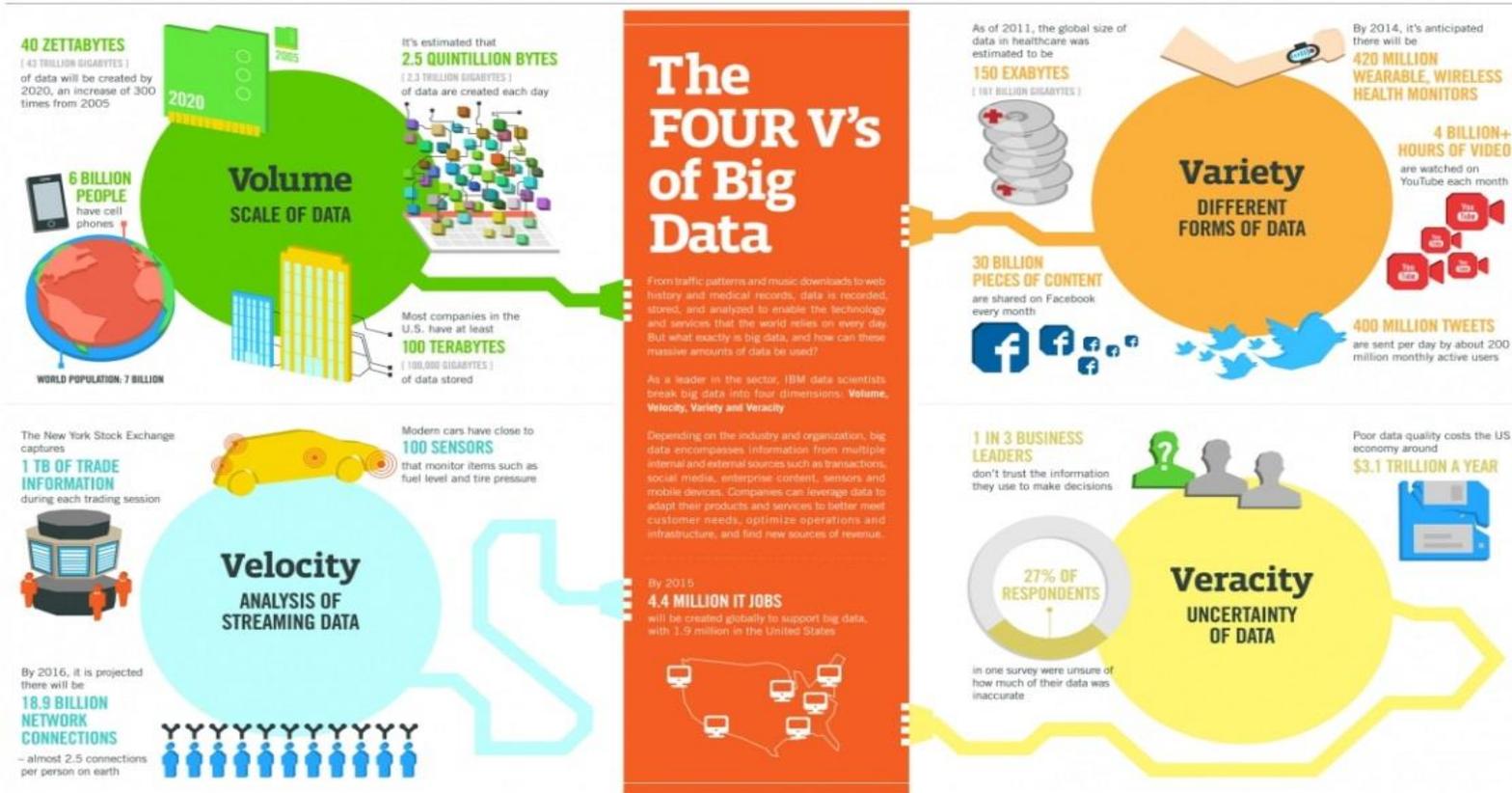


Figure 1 The four V of big data

As mentioned before, Big Data involves unstructured data, too. Gartner defines unstructured data as a content that does not conform to a specific, pre-defined data model, and which is typically text-heavy. Thanks to Big Data technologies, unstructured data can become structured data (see for example Figure 2).

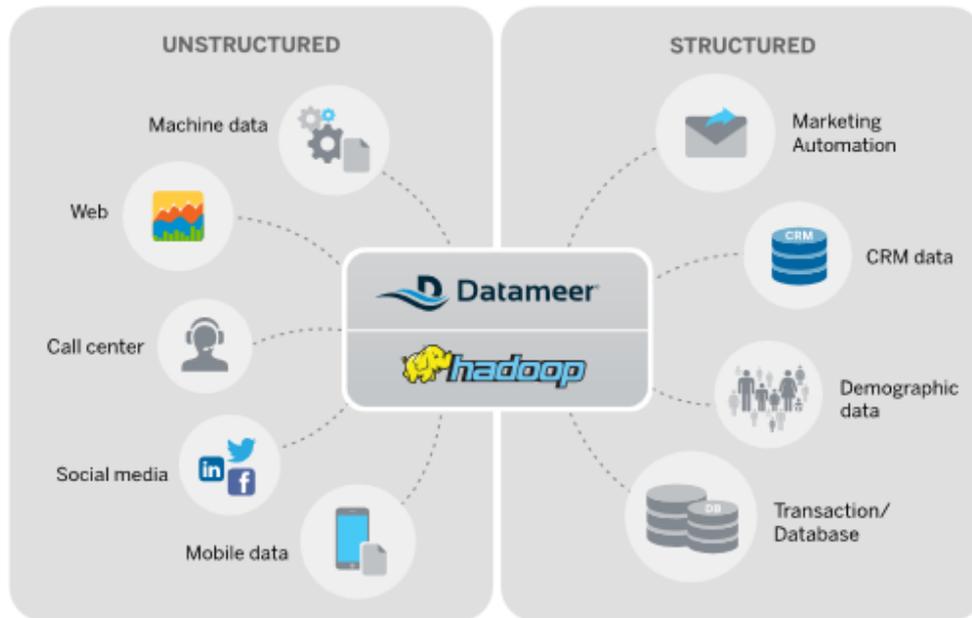


Figure 2 From unstructured to structured data (Source: <http://www.datameer.com/product/index.html>)

Big data can be also classified as Machine-generated, which refers to data that is created by a machine without human intervention, or as Human-generated, which refers to data that humans, in interaction with computers, supply. Examples are shown in Table 1.

Generation source	Big data sources
Machine generated	<ul style="list-style-type: none"> • Video-cameras data, Microphone audios, etc. • Sensor data: Radio Frequency Identification (RFID) tags (they track location), Identification Location Conditions (ILC) sensors (they monitor the conditions of goods in the supply chain and variables as light temperature, whether a package has been opened, etc...), smart meters, medical devices, and Global Positioning System (GPS) data (they support the supply chain management and inventory control) • Point Of Sales (POS) data (When the cashier swipes the bar code of any product that you are purchasing, all that data associated with the product is generated)

Human generated	<ul style="list-style-type: none"> • Twitter tweets • Free-form text (e.g., books, articles, body of e-mail messages, documents, PDFs) • Social media posts • Weblog • Input data in a computer (Such as name, age, income, non-free-form survey responses, and so on. This data can be useful to understand basic customer behaviour) • Data in a spreadsheet • Clickstream data (Data is generated every time you click a link on a website) • Web content • Voice • Mood
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Table 1 Big data types

3. From traditional analytics to big data: what is new and what is not?

Big data differ from traditional analytics for several aspects, as the type of data, the volume of data, the flow, the analysis methods and the primary purpose (Table 2).

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

Table 2 Traditional analytics and big data (Davenport, 2014)

The main problem in managing big data is more related to the lack of structure for the data rather than their size. Therefore, the adequate technological solutions, and the adequate people with the right skills are necessary in order to be successful in the Big Data initiatives. Indeed, as discussed by Davenport (2014), three elements count for the success of Big Data in an organization: technology, data and people. The data is often free and cheap, the hardware and software are free or inexpensive, but the people are expensive and difficult to hire.

Nowadays, the way data is stored and processed and the hardware and software for achieving this goal, are being transformed by the IT solutions that are tied to Big Data. Some of the technological solutions are new whereas other technologies are applied in different ways. Indeed, Big Data cannot be handled with traditional database software or with single servers. This happens because if traditional database stored data in columns and rows of numbers and texts, Big Data comes in a variety of formats. Therefore, with Big Data, several aspects change from the traditional information management. First, new data processing software need to be used for managing Big Data, as Hadoop (Table 3). One of the reasons why Hadoop is necessary is based on the fact that the volume of Big Data available cannot be processed so

quickly on a single server. Therefore, splitting a computer task on multiple servers can reduce processing time. There are other technological solutions for Big Data management, as new forms of databases as columnar (or vertical) databases; new programming languages - interactive scripting languages as Python, Pig and Hive; new hardware architectures for processing data. Second, traditional data were segregated into a separate pool for analysis, which was typically a data warehouse. However, with Big Data that are characterized by volume and velocity, the segregation approach can be rapid. This happens because many organizations are using Hadoop and similar technologies to briefly store large quantities of data, and then flushing them for new batches.

Big data technology	Definition
Hadoop	Open-source software for processing Big Data across multiple parallel servers
MapReduce	The architectural framework on which Hadoop is based
Scripting languages	Programming languages that works well with Big Data (e.g., Python, Pig, Hive)
Machine learning	Software for rapidly finding the model that best fits a data set
Visual analytics	Display of analytical results in visual or graphic formats
Natural language processing (NLP)	Software for analyzing text - frequencies, meanings, etc.
In-memory analytics	Processing Big Data in computer memory for greater speed

Table 3 Technologies for big data (Davenport, 2014)

Contrarily, the way data are analyzed is not new for Big Data, because Big Data technologies are used to store Big Data or to transform it from unstructured or semi-structured format into the typical rows and columns of texts and numbers. Once they are in this format, Big Data can be analysed as any other data set. It is useful to use multiple commodity servers, but the basic statistical and mathematical algorithms for conducting the analysis are quite the same. The difference in data analysis consists in the approach. Instead of the traditional hypothesis-based approach to statistical analysis, involving an analyst formulating a hypothesis and then testing the hypothesis with the available data, Big Data analysis is more likely to involve machine learning. The benefit of this approach is based on the fact that it quickly generates models to explain and predict relationships in fast moving data. The drawback, instead, is that it generally leads to results that are difficult to interpret and explain.

Big companies usually follow a coexistence strategy between the usage of their traditional data warehouse and the new power of Big Data solutions (see Figure 3). The coexistence of data environments minimizes disruption to existing analytical functions while at the same time it accelerates the new or strategic business processes that might benefit from increased speed. The Big Data environment includes: 1) some data sources for the enterprise data

warehouse; 2) the staging and exploration area to refine information for data that can eventually populate the data warehouse for subsequent analytics; 3) the preprocessing step for data transformation, exploration, and discovery of patterns and trends.

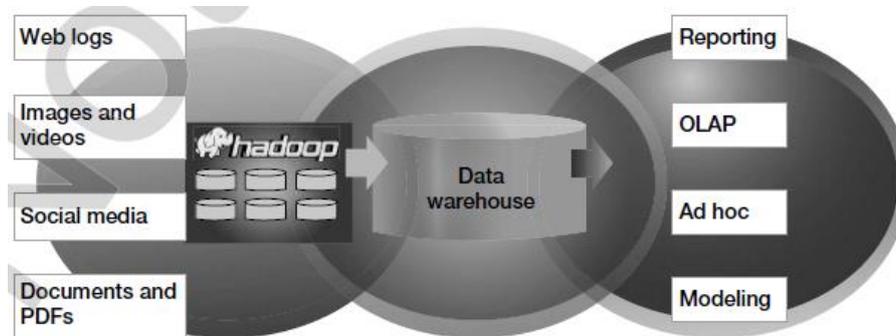


Figure 3 Big Data and data warehouse coexistence (Source: SAS best practices)

4. The companies surveyed and the methodology

The data used in this research project are derived by one survey analyses carried out in 2016 among 200 companies located in France. The survey was conducted on all the economic sectors. We surveyed exclusively medium (50 and 249 employees) or large size (with 250 employees or more) companies, because they are pioneers in Big Data investments. The Table 4 shows the sample composition divided by the companies' sector and size, which is based on the number of employees.

SECTOR	SECTOR NAME	Size		
		Large	Medium	Total
A	AGRICULTURE, FORESTRY AND FISHING	0	2	2
B	MINING AND QUARRYING	0	0	0
C	MANUFACTURING	7	60	67
E	WATER SUPPLY; SEWERAGE, WASTE MANAGEMENT AND REMEDIATION ACTIVITIES	1	1	2
F	CONSTRUCTION	3	10	13
G	WHOLESALE AND RETAIL TRADE; REPAIR OF MOTOR VEHICLES AND MOTORCYCLES	5	34	39
H	TRANSPORTATION AND STORAGE	4	9	13
I	ACCOMMODATION AND FOOD SERVICE ACTIVITIES	2	7	9
J	INFORMATION AND COMMUNICATION	0	6	6
K	FINANCIAL AND INSURANCE ACTIVITIES	0	0	0
L	REAL ESTATE ACTIVITIES	1	3	4
M	PROFESSIONAL, SCIENTIFIC AND TECHNICAL ACTIVITIES	2	21	23
N	ADMINISTRATIVE AND SUPPORT SERVICE ACTIVITIES	1	11	12
P	EDUCATION	0	1	1
Q	HUMAN HEALTH AND SOCIAL WORK ACTIVITIES	1	7	8
R	ARTS, ENTERTAINMENT AND RECREATION	0	1	1
S	OTHER SERVICE ACTIVITIES	0	0	0
	<i>Total</i>	27	173	200

Table 4 Sample composition

The survey questions were adaptations of questions formulated in other research studies. The questionnaire was tested on an initial sub-sample of 30 French companies. In general a

first email was sent in order to make companies aware about the project. Then, the survey was performed following the Computer-Assisted Telephone Interviewing method. We looked for the Chief Information Manager, and in case he/she was not available, the interviewer asked for the General Director, the Proprietary, or another person with managerial responsibility in the Information Technology department. On average, the call lasted 20 minutes. Finally, data gathered were analyzed with the statistical software SPSS.

5. The creation of value from Big Data

5.1 Conceptual model

In order to study the relationship between the business value brought by Big Data at firm level and the firm performance, the conceptual model shown in Figure 4 was followed in this project. Specifically, two main blocks constitutes the conceptual model at the base of this project:

1. The first block includes the business value dimensions related to the exploitation of Big Data at firm level: the transactional business value, the strategic business value, the transformational business value, and the information business value.
2. The second block includes the firm performance dimensions: the financial performance and the market performance.

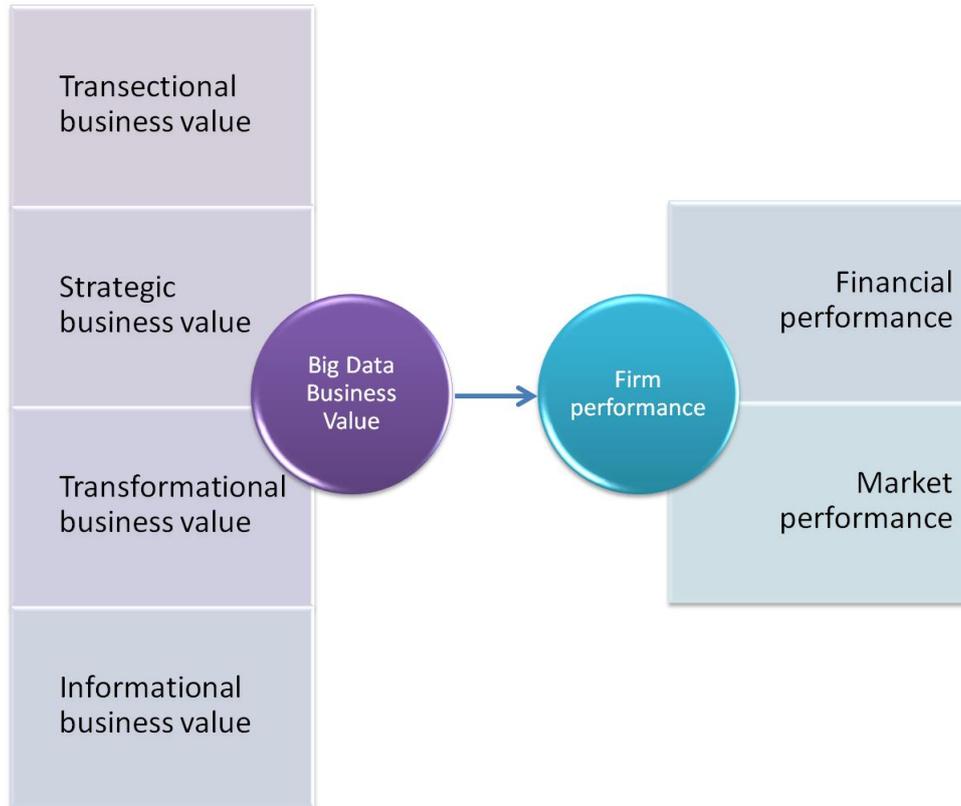


Figure 4 Conceptual model of the project

5.2 Defining the business value

Big Data can provide value to companies in different ways. They can be clustered in four dimensions, all of which are investigated in this project. The first refers to the “Transactional value” that focuses on improving efficiency and cutting costs. Specifically the companies were asked to evaluate whether Big Data analytics solutions have determined the following benefits:

1. Savings in supply chain management;
2. Reducing operating costs;
3. Reducing communication costs;
4. Avoiding the need to increase the workforce;
5. Increasing return on financial assets;
6. Enhancing employee productivity.

The second refers to the “Strategic value” which deals with gaining competitive advantages from leveraging on Big data analytics solutions. Specifically the companies were asked to evaluate whether Big Data analytics solutions have determined the following benefits:

1. Creating competitive advantage;
2. Aligning IT with business strategy;
3. Establishing useful links with other organizations;
4. Enabling quicker response to change;
5. Improving customer relations;
6. Providing better products or services.

The third refers to the “Transformational value” which refers to the way Big data analytics are able to transform different aspects of the company business. Specifically, through the questionnaire, the companies were asked to evaluate whether Big Data analytics solutions have determined the following benefits:

1. An improved skill level for employees;
2. Developing new business opportunities;
3. Expanding capabilities;
4. Improving business models;
5. Improving organization.

The last refers to the “Informational value” which sheds light on real-time decision-making of the Big Data analytics solutions. Specifically the companies were asked to evaluate whether Big Data analytics solutions have determined the following benefits:

1. Enabling faster access to data;
2. Enabling easier access to data;
3. Improving management data;
4. Improving data accuracy;
5. Providing data in more usable formats.

Therefore, through the questionnaire the business value of Big Data analytics was investigated among four main and complementary dimensions.

5.3 Defining the firm performance

By extracting value from Big Data, companies may be able to achieve better firm performance. In order to evaluate this relationship, this project looks at two dimensions that refer to the firm performance. The first is the “Market Performance” which refers to the firm’s ability to gain and retain customers. Specifically the companies were asked to evaluate whether Big Data analytics solutions have determined the following impacts:

1. Customer retention;
2. Sales growth;
3. Profitability.

The second is the “Financial performance” which refers to the firm’s ability to improve sales, profitability and return on investment. Specifically, the companies were asked to evaluate whether Big Data analytics solutions have determined the following impacts:

1. The company has entered new markets more quickly than competitors
2. The company introduced new products or services to the market faster than competitors
3. The company success rate of new products or services has been higher than competitors
4. The company market share has exceeded that of competitors

5.4 Exploring trends in France

Within the 200 surveyed companies, 76 enterprises have Big Data analytics solutions while the others did not invest in this type of solutions (Figure 5).

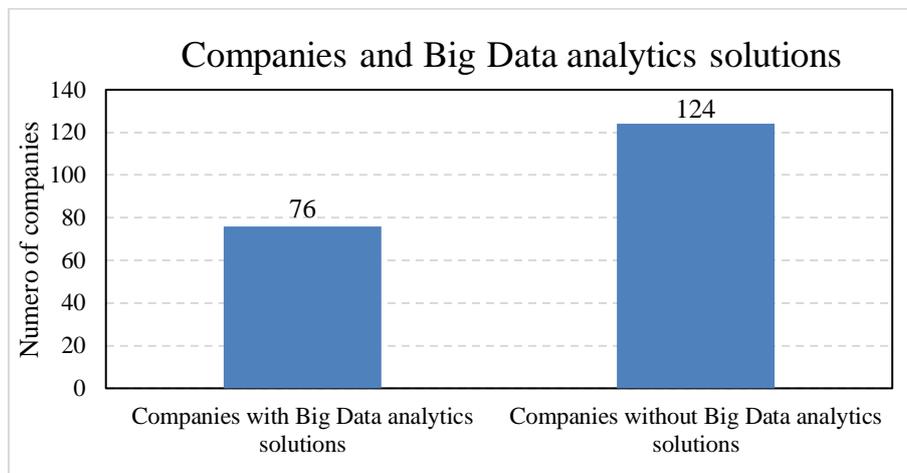


Figure 5 Companies with and without Big Data analytics solutions

Figure 6 shows the way Big Data analytics bring value to the companies that have already invested in these solutions, how they could bring value to the companies that did not invest in it and the overall average opinion all companies included. Data show that the companies that invested in Big Data analytics achieve higher levels of business value from it compared to the expectation of companies that did not invest in these solutions. This means that companies

that do not invest in these solutions are skeptical about the real potentialities of Big Data and that their expectations are very low compared to the real generated value.

Specifically, data show that the business value more observed by companies with Big Data analytics solutions is the “Informational business value”, followed by the “Strategic business value”, the “Transformational business value”, and finally the “Transactional business value”. This means that the highest value of Big Data enables a faster and easier access to data, an improvement in data management, data accuracy, and that it provides more usable data formats.

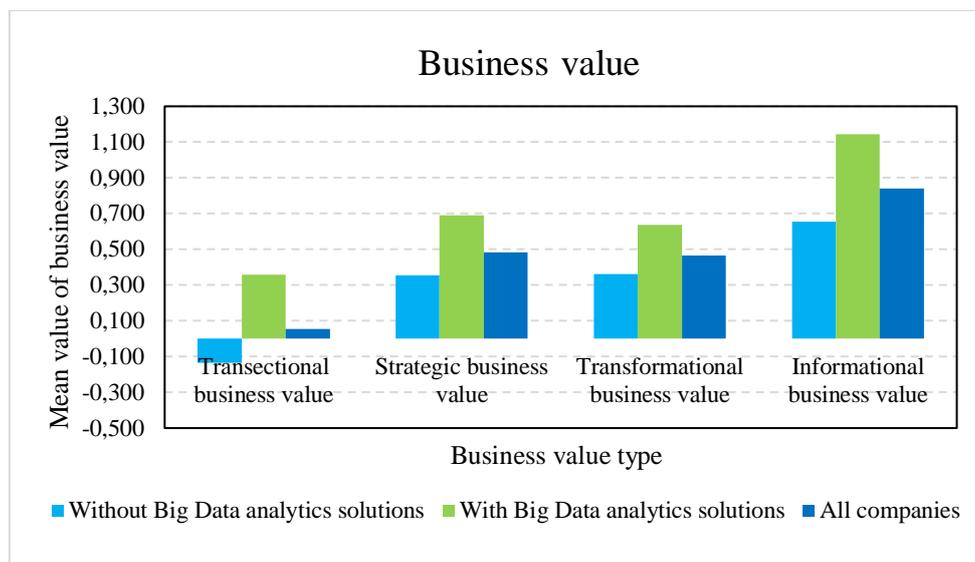


Figure 6 Business value from Big Data (the mean value is on a scale from -3 to +3)

Figure 7 shows the way Big Data analytics lead to better firm performance for companies that invested in these solutions, and the expectations about the way Big Data analytics lead to better firm performance for companies that did not invest in these solutions, and the overall average. Data show that the companies that invested in Big Data analytics achieve higher firm performance Data compared to the performance expectations of companies that did not invest in these solutions. Also in this case, as it is for the business value, companies that do not invest in these solutions are skeptical about the real potentialities of Big Data and their expectation are very low compared to the real benefits perceived by companies having invested in Big Data analytics.

Specifically, data show that Big Data analytical solutions bring, first of all, to better financial performance, but also to market performance. This means that Big Data investments are a way to increase the customer retention, to achieve sales growth and high levels of

profitability, to enter new markets more quickly than competitors, to introduce new products or services to the market faster than competitors, to have a higher success rate for new products or services, and a larger market share, compared to competitors.

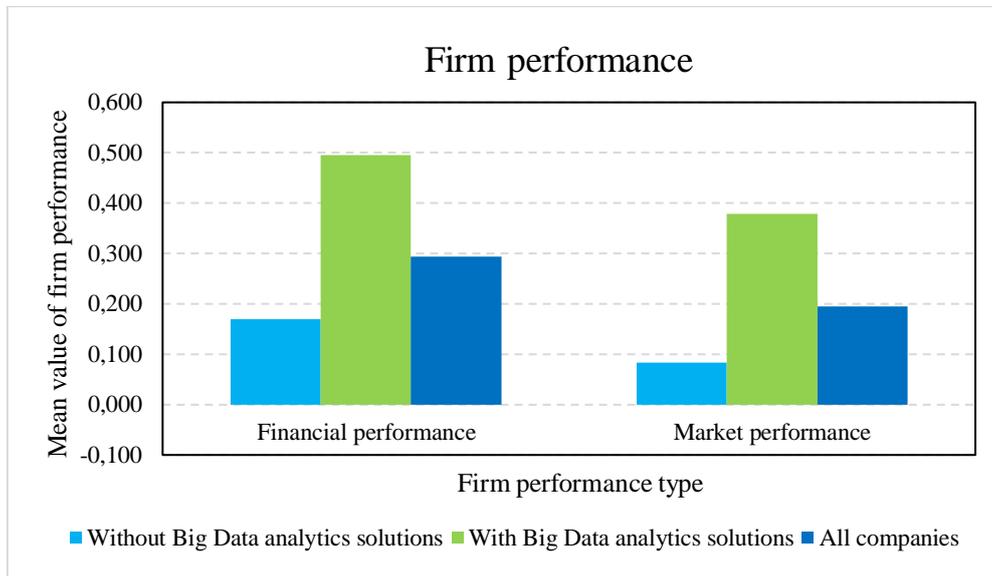


Figure 7 Firm performance from Big Data (the mean value is on a scale from -3 to +3)

5.5 From business value to firm performance

Explaining the variation in the degree of success of business organizations is an evergreen issue in management. This is the reason why we investigated whether or not the business value generated from Big Data provides better firm performance to companies. Specifically, Figure 8 and Figure 9 show that companies able to achieve higher levels of business value are also able to achieve higher levels of financial performance and market performance. This means that companies that leverage Big Data solutions save in supply chain management, reduce operating costs, communication costs, avoid the need to increase the workforce, increase return on financial assets, and enhance employee productivity. At the end they also achieve better financial performance, such as increasing their sales and profitability.

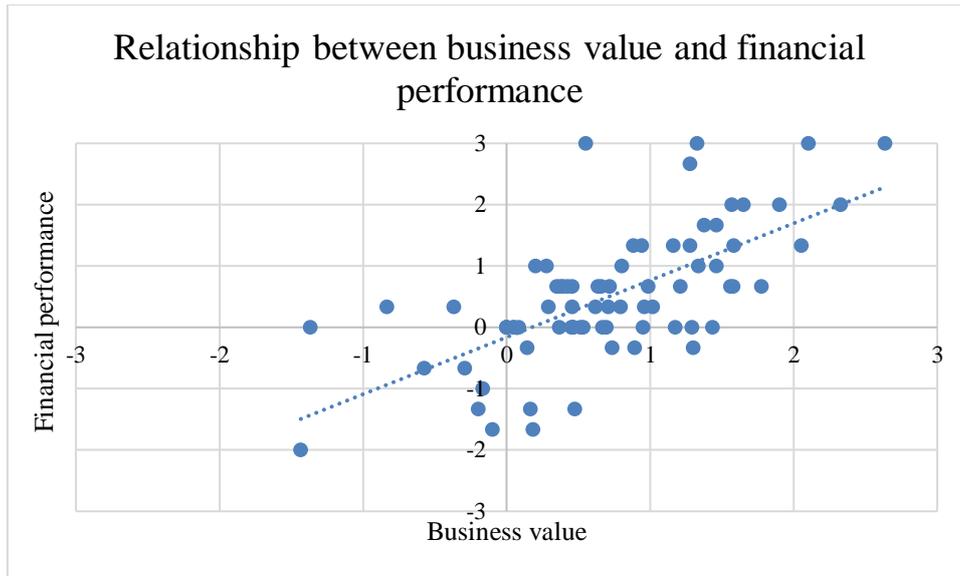


Figure 8 Relationship between business value and financial performance (base: companies that invest in Big Data analytics solutions)

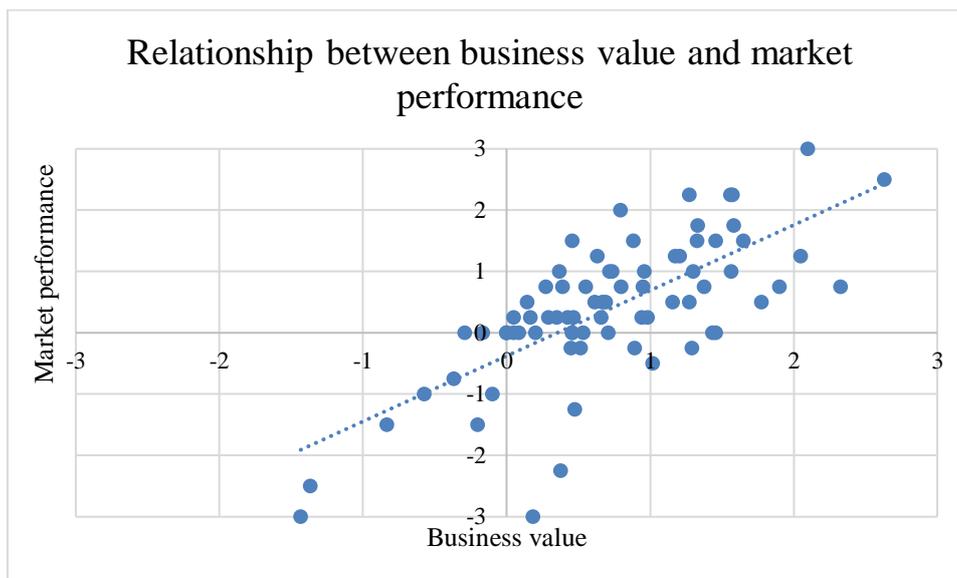


Figure 9 Relationship between business value and market performance (base: companies that invest in Big Data analytics solutions)

6. Clustering companies

Investigating the companies that invested in Big Data analytics solutions, we can find that some of them are really excellent in achieving high firm performance, while others are not. Overall, there are four types of companies (see Table 5).

Firm performance	Low	High
Business value		

Without Big Data analytics solutions	<i>Not applicable</i>	<i>Not applicable</i>
Low Big Data analytics solutions	<i>Type A (26 companies)</i> 34.21%	<i>Type B (0 companies)</i> 0.00%
High Big Data analytics solutions	<i>Type C (0 companies)</i> 0.00%	<i>Type D (50 companies)</i> 65.79%

Table 5 Clustering the companies

Type A

Companies “Type A” have achieved low levels of business value from Big Data and low levels of firm performance. These companies should understand the value of Big Data investments and their benefits in terms of strategic, transactional, transformational and informational business value. By investing in Big Data solutions they could achieve higher financial and market performance.

Type B

Companies “Type B” have achieved low levels of business value from Big Data and high levels of firm performance. As expected, there are no companies in this cluster, since it is improbable that companies with low levels of business value may achieve higher firm performance. Therefore no advice is provided.

Type C

Companies “Type C” have achieved high levels of business value from Big Data and low levels of firm performance. In this cluster there are no companies, too. This means that no companies have achieved business value without returns in terms of financial performance and market performance.

Type D

Companies “Type D” have achieved high levels of business value from Big Data and high levels of firm performance. This means that these companies leverage properly on the Big Data investments. Therefore the business value is achieved, such as developing new business opportunities or having faster access to data. This business value is finally translated in firm performance as growth in sales, in profitability or entering new markets more quickly than competitors.

7. Conclusions

As organizations increasingly rely on data to conduct their business, changes in data availability and timing influence a firm’s ability to create value, in the form of new products, services, or processes. The emergence of Big Data is creating strategic opportunities for existing firms.

Since Big Data is a recent phenomenon that demands research attention, in this project we focused on understanding the Big Data business value among companies that invested in Big Data analytical solutions, and the expectation on Big Data of those companies that did not invest in these solutions. Similarly, we investigated the firm performance in terms of financial and market performance. Results are interesting since companies that did not invest in Big Data technologies are not able to realize the real value of Big Data, as it seems more valuable than that expected, if we look at the value created for the companies that invested in Big Data technologies.

Thus, firm managers should be aware about the potentialities of Big Data in the different processes of a company and firms should behave accordingly in order to exploit this Big Data potential.

8. Further research

Future research could be carried out through a longitudinal study for capturing the dynamics of the technology use phenomenon. Complementary data from other sources, such as interviews, can be used for enriching the understanding of the dynamics behind Big Data investments.

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