Big Data in Data-driven Innovation: The Impact in Enterprises' Performance

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Abstract
In the "knowledge-based economy", enterprises have to be innovative in order to build and sustain a competitive advantage against rivals. However, innovation is complex due to fast changing technology, globalization (extremely competitive market conditions) and changing customers' needs. As innovation is dependent on the combination of technologies and exploitation of knowledge, the capacity of enterprises to access information and create valuable knowledge provides them a competitive advantage in the innovation race against rivals. In this context, "Data-Driven Innovation" (DDI) related to techniques and technologies for processing and analysing "big data", is the method to innovate using data-based decision process. The scope of this study is to present evidence about the significance of big data in data-driven innovation orientation of businesses and their performance.

Keywords: big data, data-driven, innovation, competitiveness

JEL classifications: O32, O33

Introduction

In the era of Industry 4.0 (4th industrial revolution), data has major impact on businesses, since the revolution of networks, platforms, people and digital technology changed the determinants of firms' innovation and competitiveness (OECD, 2015). In modern economies, characterized as "knowledge-based", innovation plays crucial role concerning enterprises performance and competitiveness. Hence, enterprises have to adopt strategies innovation-oriented in order to build and sustain competitive advantage in the globalized and technology changing environment they operate. The changing customer needs, technological evolutions and the competitive market pressure have made innovation a vital determinant of enterprises' success (Daud, 2012).

Innovation is extremely dependent on the proper knowledge management, which is a significant mechanism enhancing absorptive capacity, innovation and performance. Speed of innovation is changing rapidly following technological revolutions, leading enterprises on the need of

new business strategies in order to build and sustain a competitive advantage. The real power of enterprises related to their competitiveness is the capacity to access information and create valuable knowledge (Sarvan et al., 2011).

Knowledge arising from the information given from data analysis processes. The ability to manage, analyse and act on data is significant to enterprises. Therefore, data are characterized as an asset from enterprises' C-suite indicating the significance of data-driven approach within enterprises. In this context, one arising form of innovation is "Data-Driven Innovation" (DDI) that is referred to techniques and technologies for processing and analysing "big data", which is the method to innovate using data-based decision process, where data provides knowledge about processes, customers, human capital and technology significant to enterprise. Data-driven innovation relies on the context of knowledge-based capital (KBC) associated with digital information, innovative capacity and economic aspects (OECD, 2015). Large streams of data generated through information and communication technologies (ICT) and Internet of Things (IoT) named "Big data" are datasets with large volume that cannot be captured, stored, managed and analysed by typical database software tools (Manyika et al., 2011).

Big data is characterized as a major resource for enterprises to obtain new knowledge, present added value and foster new products, processes and markets. Big data is described with the 4 Vs: volume, variety velocity and veracity.

- Volume refers to the sizes of data that are extremely huge- measured in exabytes, 90% of the data in the world today was generated in just the last 2 years (IBM, 2016), because of the huge increase of sensors and connected devices known as "Internet of Things (IoT)".
- Variety refers to heterogeneity of data types, since technological evolution allows enterprises concentrate various types of data (unstructured, semi-structured and structured).
- Velocity is related with the ratio of data generation and the speed needed for their analysis. The tremendous increase of smartphones and sensors led on a significant increase of data generation and a growing need of real-time analysis and instant decision making.
- Veracity refers to the data uncertainty and the level of reliability correlated with some type of data.

The combination of these characteristics defines big data and provide organizations a competitive advantage in the digital economy. Nowadays, data are in every sector (agriculture, health, energy and infrastructure, economics and insurance, sports, food and transportation) and every world economy. DDI's economic value expecting to be enormous in the following years and it has the capacity to introduce: new products and/or services, new and better processes in the production, more efficient marketing, improved organization management, more efficient R&D and better supply chain management.

There is evidence that data-driven approach has a positive impact in enterprises' performance (Brynjolfsson, 2011; Davenport & Harris, 2007; Lavalle, 2010; Bakhshi et al., 2014). However, a significant obstacle to adopting data-driven approach through big data analytics is the high level of technical skills required to use and exploit these systems. People with specific skills and expertise in statistics, analysis and machine learning are required in order to get valuable insights from big data.

The scope of this study is to present evidence about the significance of big data in data-driven innovation orientation of businesses and its impact on enterprises' performance.

State of the art

Innovation, knowledge creation, effective knowledge management and the development of internal technological capabilities enhancing the creation of sustainable competitive advantage that is translated to superior market position. A firm's performance is positively correlated with the development of internal capabilities such as technology and a continuous development and innovation strategy. Innovation, improvement of internal technological capabilities and firm's knowledge accumulation result in enterprises becoming more competitive in domestic and international markets (Maranto-Vargas & Gómez-Tagle, 2007). Many empirical studies have focused on the relationship between innovation and firm performance. The bulk of the studies have concluded that innovation drives positively firms' performance in terms of market share, production efficiency and growth, revenues (Van Auken, 2008). Thornhill (2006) using data from Canadian manufacturing firms found that innovation have a positive correlation with firm performance (in terms of revenue growth). Madrid-Guijarro et al. (2013) examined enterprises innovation (product, process, management) using a data sample of Spanish manufacturing enterprises during two periods: during the current economic downturn and a period of economic growth.

It is observed growing attention to big data and data-driven approach from academics and professionals, since the analysis of "big data" leads on valuable knowledge, promotion of innovative activity transforming economy of countries (OECD, 2015). The insights by leveraging big data provide a competitive advantage in enterprise through new ways of productivity, growth, innovation and consumer surplus (Manyika et al., 2011). As big data becomes a key determinant in generating added value in enterprises, there is need of data analytics capacity in order to release full potential of DDI. According to Cebr (2012) the economic benefits of big data in UK private and public sector businesses will increase from £25.1 billion in 2011 to £216 billion in 2017, while data-driven innovation will lead to £24,1 billion contribution to UK economy during 2012-2017. Empirical evidence related to the impact of data-driven approach and its impact to enterprises performance are scarce and limited mainly in research for multinational companies.

The exploitation of big data provides enterprises in several industry sectors, not only ICT firms (Tambe, 2014) added value through the improvement in resources (physical and human) supervision and allocation, reduction of waste, greater transparency and facilitation of new insights. The increased use of digital services and Internet has transformed all the sectors in the economy. Through data-driven innovation, almost all the sectors including retail, manufacturing and agriculture has become more service-centred, adopting the term "servicification" (Lodefalk, 2013).

Big data is considered a driver for better decision making and better profitability in enterprises (Waller and Fawcett, 2013). According to a recent European survey by Microsoft (2016)[1] using a data sample of 6000 European small and medium enterprises (SMEs), it is found that data

[1] Microsoft Europe, 2016, "Go bigger with big data", Available at: http://news.microsoft.com/europe

provides a competitive advantage to businesses that evaluate and use data insights for growth and competitiveness. Brynjolfsson et al. (2011) examine how adoption of data-driven decision making induces firm performance using a dataset of 179 large publicly traded firms and concluded that adoption of data-driven decision making approach provide 5-6% higher performance (in terms of productivity) to firms. In addition, these firms present better performance in asset utilisation, return on equity and market value.
The analysis and exploitation of data can provide significant added value to enterprises through data driven innovation in several sections of enterprise (manufacturing production, resources allocation, customers' preferences, business development etc.). Big data has the ability similar to IT to bring significant cost reductions, delivery time, enhanced R&D and new/improved products or services. However, little evidence exists on return on investment for big data applications in enterprises, showing promising issues (Davenport & Dyché, 2013).

Lavalle et al. (2010) in their empirical research with a data sample of 3000 enterprises across more than 30 industries and 100 countries, found that top-performing enterprises apply analytics to guide daily operations and future strategies twice than lower performers. McAfee & Brynjolfsson (2012) examined the performance of data-driven companies and whether big data intelligently improves business performance. Conducting interviews with 330 executives of North American companies and combining them with companies' financial performance, found that top performers in the use of data-driven decision making have 5% higher production and 6% higher profitability than their rivals.

Bakhshi & Mateos-Garcia (2012) in their empirical study for 500 UK businesses from various industries operating on-line, divided data sample into two categories: data-driven decision making enterprises and experience-driven enterprises. They found that data-driven companies present higher level of innovativeness launching new products and services and making disruptive changes to their business processes. Despite to the activity of UK enterprises to internet economy, exploitation of data is in early stage. Findings of the study suggest that use and exploitation of online data can impact positively enterprises. In 2014, The Economist Intelligence Unit (EIU) conducted a survey with 174 enterprises executives examining data-driven decision making and its perspectives. It is found that data respaced the decision making approach about marketing, pricing and operations more than half of the enterprises including large enterprises such as P&G, Hilton Hotels. Additionally, the research provides the insights of data in decision-making capabilities. A recent survey conducted by IDC (2015) examined how enterprises exploit Big Data and analytics through 1810 interviews. Using a maturity model taking in account: people, process, technology, data and intent, the organizational maturity of enterprises is evaluated. The most mature in Big Data, "Big Data Innovators" are innovation-driven and are more likely to investigate and adopt technology-based transformation.

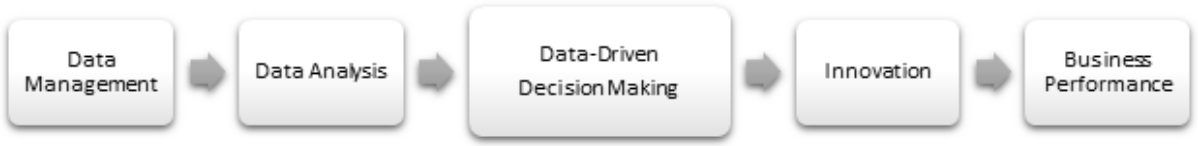
According to Deighton and Johnson (2013) properly exploitation of data provides cost reduction and increase of efficiency in enterprises' marketing. It is found that reliable use of data has transformed the way of interaction with customers and decrease that cost as much as 11% of all the revenues of American enterprises, since they ensure that the expenditures they make have valuable interactions with customers.

Approach

In order to model the benefits of big data to enterprises, a firm-level model will be designed to measure the impact of big data exploitation to enterprises innovation performance and performance. In that context, big data processes of leveraging big data are divides into 2 phases: data management and data analysis. The first is related with the processes and technologies for data generation, storage, mining and preparation for analysis, while the second refers to the methods and techniques to analyze and get valuable insights from big data (Gandomi & Haider, 2014).

More specifically sub-phases of big data processes, are:

- Data management
  - Data Acquisition and Recording
  - Extraction, Cleaning and Annotation
  - Integration, aggregation and representation
- Data analytics
  - Modelling and Analysis
  - Interpretation



Data analysis will provide valuable information and knowledge that can be exploited for decision-making. Therefore, data are widely considered as a driver of better decision making and improved profitability (Waller & Fawcett, 2013). The knowledge arising from the analysis of data will lead on decisions that increase innovativeness of enterprises that contribute to increased business performance. The benefits of big data exploitation contribute to enterprises performance in terms of economic variables such as financial performance, innovative activity and performance (Brynjolfsson et al., 2011; Lavalle et al., 2010; Davenport & Dyché, 2013).

Conclusion

In the data-driven era transformed by the rapidly large streams of data generated through information and communication technologies (ICT) and Internet of Things (IoT), enterprises have the opportunity to gain sustainable competitive advantage against their rivals through innovation arising from data-driven approach.

Data-driven innovation (DDI) relies on the context of knowledge-based capital (KBC) associated with digital information, innovative capacity and economic aspects (OECD, 2015). The insights by leveraging big data provide a competitive advantage in enterprise through new ways of productivity, growth, innovation and consumer surplus. The knowledge originates from big data processes provides the decision makers the capability to innovate and increase their performance gaining a competitive advantage against rivals. Therefore, big data is characterized as a major resource for enterprises to obtain new knowledge, present added value and foster new products, processes and markets. Further research is needed in results of big data exploitation in SMEs and the returns of investments in data-driven processes.

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