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A note on big data analytics capability development in supply chain

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ABSTRACT

Big data analytics (BDA) are gaining importance in all aspects of business management. This is driven by both the presence of large-scale data and management's desire to root decisions in data. Extant research demonstrates that supply chain and operations management functions are among the biggest sources and users of data in the company. Therefore, their decision-making processes would benefit from increased use of BDA technologies. However, there is still a lack of understanding of what determines a company's ability to build BDA capability to gain a competitive advantage. In this study, we attempt to answer this fundamental question by identifying the factors that assist a company in or inhibit it from building its BDA capability and maximizing its gains through BDA technologies. We base our findings on a qualitative analysis of data collected from field visits, interviews with senior management, and secondary resources. We find that, in addition to technical capacity, competitive landscape and intra-firm power dynamics play an important role in building BDA capability and using BDA technologies.

1. Introduction

Big data (BD), which consists of high-volume, high-velocity, and high-variety data assets [1], has virtually become accessible to all businesses. Tremendous amounts of real-time or almost real-time data are continuously produced and made available in multiple forms and from various sources, like social media applications, shopping portals, search engines, sensors, smart applications, and internet of things (IoT). Using such data by applying analytics offers promising opportunities for gaining insights in various domains and business sectors, as shown by Chen et al. [2] in their seminal paper "Business Intelligence and Analytics: From Big Data to Big Impact." This gave rise to the concept of big data analytics (BDA), which consists of applying advanced analytics (e.g., data mining, machine learning, social network analysis, data visualization) to BD. BD and BDA have routinely been touted as key drivers of corporate and supply chain performance. For instance, McAfee et al. [3] claimed that BD has the potential to radically change the practice of management. Wamba et al. [4] showed that using BD and analytics can improve operational performance by allowing real-time decision making for resource allocation and coordination. Ghasemaghaei and Calic [5] provided evidence of enhanced data quality and diagnosticity and, by consequence, better decision-making due to BD. Côrte-Real et al. [6] demonstrated that BDA allows the implementation of effective knowledge management for enhanced organizational agility and performance.

The same claims about the effectiveness of using BD and BDA at the corporate level also hold for supply chain management (SCM). For instance, Wang et al. suggested the use of BD for a more efficient and robust design of distribution networks. In the same vein, Chae [7] proposed a framework for using BDA tools to extract intelligence from Twitter data and suggested to use this framework for demand management, new product development and supply chain risk management. Li et al. [8] showed that studying Website behavior data by using BDA allows for better demand management and enhances supply chain performance. Shao et al. [9] proposed a BDA-based approach for identifying and categorizing nexus suppliers.

Despite the potential of BDA in supporting decision making on the corporate and SCM level, there is still a lack of understanding of how companies build their BDA capability in practice and overcome the related organizational challenges, as rightfully pointed out by Papadopoulos et al. [10] and Sena et al. [11]. This brings us to our current study, through which we intend to understand the mechanisms that companies use in building their supply chain-related BDA capability. Specifically, our work aims to answer the following research question: *What factors determine a company's capacity to build BDA capability for managing its supply chain?*

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To answer this question, we use an inductive approach based on the exploratory research mechanism. The inductive approach is particularly appropriate to our purpose given the novelty of the concept of BDA capability and the lack of knowledge regarding its related issues. We base our analysis in the French and Indian economies. France's developed logistics network makes it one of the leading manufacturing destinations in the world. India has a rapidly developing economy, with a strong focus on emerging technologies like BD and analytics. This analysis enables us to gain insights from diverse perspectives and evaluate whether the differences in economic terms translate to differences in implications for supply chain's BDA capability.

As indicated by our literature review, substantial research has happened in the field of supply chain and operations on the identification of BDA capabilities of companies. However, the specific area of what factors impact the development of such capabilities has rarely been studied. Our exploratory study identifies those critical attributes that help companies develop those capabilities and convert them to competitive advantage. Through our study context of France and India, we also find that enhanced global interconnectedness has led to similar issues in supply chain departments' BDA capability development exercise.

Our analysis, based on interview data of over a dozen senior supply chain managers, indicates that a multitude of factors affect the capability of a company to implement and use BDA for SCM. Most significant of these are resource availability in terms of both human and monetary resources and competitive landscape. Our work enhances the understanding of companies' BDA capability development and presents testable propositions that define how a company's internal and external factors contribute to such development in new technology usage.

2. Background

2.1. BDA in SCM

The expression “big data” invokes the size of the data. However, the high volume of data sets is not the only distinguishing characteristic of BD. Actually, literature reviews on this concept (see [12,13] for detailed reviews) point out that in addition to the high volume, BD definitions commonly refer to the high velocity at which data is created and transmitted and the high variety of data types and sources (Web sources, business processes, sensors, and tags). Drawing on these characteristics, McAfee et al. [3] claimed that companies could radically improve their performance and gain competitive advantage through exploiting BD. In this perspective, the concept of BDA is proposed as a means to analyze BD and capture its maximum business value.

BDA is defined by Russom et al. [14] as the application of advanced analytics techniques on BD. Although rooted in established disciplines like mathematics, statistics, and computer science, BDA involves a new generation of technologies and techniques that allow for capturing the maximum value from BD through improved scalability, flexibility in knowledge discovery, and speed of computing. Readers are referred to Chen and Zhang [15] and Gandomi and Haider [16] for detailed descriptions of the technologies and techniques that are usually used in BDA. Readers can also refer to Choi et al. [17] for a focused discussion of the techniques used for BDA-based decision making in operations and SCM.

Research on the use of BDA in SCM is pioneered by Waller and Fawcett [18], who show the relevance of applying advanced analytics on BD related to supply chain activities to improve the supply chain design and competitiveness. For a comprehensive overview of this literature, the reader is referred to the reviews done by Choi et al. [17] and Guha and Kumar [19]. In what follows, we discuss significant contributions of this research and highlight the related areas of application and use of BDA in SCM.

One of the traditional problems in SCM is the design of distribution networks. In this perspective, Wang et al. [20] formulated and validated a model that uses massive amounts of data generated by distribution operations to determine the optimal number of distribution centers and assign customers to these centers. Another important decision area in SCM is inventory management. In this regard, Choi [21] modeled the influence of social media comments in the BD environment on the retailer's inventory decisions. Choi [21] analyzed the impact of such comments on the value of quick response programs in the fashion industry. BDA also found applications in sustainable SCM. For instance, Kaur and Singh [22] suggested a heuristic model that leverages BD and real-time analysis for optimizing carbon emissions related to procurement and transportation activities. Badiezadeh et al. [23] developed a network data envelopment analysis model that uses BD for assessing sustainability in supply chains. In port operations, Maldonado et al. [24] used BDA to predict dwell times of containers in ports and propose heuristic algorithms for stacking the containers based on the predicted dwell times.

2.2. BDA capability

Despite the great potential of BDA for supporting decision-making on the corporate and SC level, academic research on the prerequisites and enablers of BDA usage in companies is still scarce. The article by Schoenherr and Speir-Pero [25] is one of the earliest works on this topic. Based on the results from a large-scale survey among SCM professionals, the authors show that using BDA in companies is mostly motivated by the encouragement of senior management and the individual conviction regarding the usefulness of BDA techniques. Kache and Seuring [26] studied the implications of BDA capability on decision making and revealed the multiple benefits that could potentially be obtained from this on the corporate and SC level. Benefits include a better understanding of customer behavior, higher supply chain transparency and visibility, and higher operational efficiency. In a more theoretically motivated contribution, Gunasekaran et al. [10] drew on a resource-based view to suggest and validate a conceptual framework according to which supply chain and organizational performance is positively correlated with the assimilation of BD and predictive analytics, which is positively related to connectivity and information sharing under the mediation effect of management commitment. Adopting the same theoretical approach, but with a larger perspective, both Akter et al. [27] and Wamba et al. [28] suggested that BDA capability is composed of management capability, technology capability, and talent capability.

The works mentioned above help in elucidating the concept of BDA capability and confirm its positive impact on corporate and supply chain performance. However, in line with a recent claim by Sena et al. [11], we notice a need for widening the theoretical perspective adopted in this domain. Drawing on the above discussion and given the novelty of the concept of BDA capability, we think that an inductive approach allows for a better understanding of the multiple issues related to building such capability and grasping the benefit of BDA.

In conclusion of this literature review, we can say that while existing research reveals that acquiring and using BDA capability is associated with highly valuable opportunities at the corporate and supply chain level, knowledge of how companies develop their BDA capability is still lacking. In this work we intend to fill this gap using an inductive qualitative approach.

3. Research method

We have used key informant interview and thematic analysis as a method of choice [29,30]. Qualitative methods have been considered to be the most preferred approach for researchers exploring new phenomena and theorizing new constructs [31,32]. In the specific context of this paper, we find that extant research has not been able to identify the factors related to the success of BDA capability development in

SCM. Hence, we have chosen the qualitative research method to dive into the field and get a theoretical understanding of these topics on which future empirical validation, based on large scale data, may be performed.

3.1. Design of study and data collection

We followed a semi-structured open-ended interview format for maximum information elicitation in our research design. This allowed us to develop a theory for the research setting with limited bias and high empirical testability. We aimed to collect data from firms based in locations with contrasting characteristics to be able to gather maximum insights about BDA capability development in diverse environments.

France has a well-developed manufacturing industry and is a world leader in production and export of automobiles, aircrafts, defense products, etc. [33]. The country has also been rapidly expanding and developing its capability in the field of artificial intelligence (AI) [34]. On the other hand, India is the world's fastest growing developing economy. For over two decades, its growth has mainly stemmed from its information technology industry, which is considered one of the best in the world [35]. It has also recently shown a push toward developing more manufacturing and logistics sectors [36].

We conducted a total of 14 interviews across the two countries-India and France. The sample was chosen to be composed of a heterogeneous set and the sample size with the depth of interviews is appropriate and comparable to similar studies [37]. Key informant interviews are methodologically different from standard practices of qualitative interviews as the key informants are individuals with higher than usual access to detailed information about the phenomenon being studied [38,39]. As such, a smaller number of key informants is generally sufficient in achieving theoretical saturation [39]. Hence, given the choice of our method and standardized practice of supply chain in most large global companies, 14 key informants are considered a sufficient sample size for the choice of data collection method employed in this paper.

In the case of our research, we used 14 key informants who represent senior-most positions in the supply chain division of the firm. Hence, they represent not just personal experience of the issue but a firm-level perspective. As such, our data represents 14 firms. Additionally, the data gathering exercise was done in a semi-structured format to gather information about diverse perspectives on a topic so complex that a structured interview or survey would not have gathered the same. We also used third-party information sources like newspaper articles, Bloomberg supply chain reports, and French and Indian supply chain association newsletters to cross validate some claims (that could be publicly validated) and ensure the consistency and reliability of our dataset.

Interviewees were selected based on the following criteria adapted from past qualitative informant interview practices [40]. First, they should have substantial experience in the field of SCM, operations management, or distribution management. Second, they should be in a senior managerial position in their respective fields and leading supply chain division or procurement teams. Third, they should have significant interface with technology products used in the management of their division and planning processes. Fourth, they should belong to medium- to large-size firms so that secondary information for data triangulation could be acquired, as and when required. Finally, there should be willingness to share information about organizational issues and factors in decision making and willingness to be contacted to follow up on required information.

The interviewees were approached through multiple channels. We relied on our personal network and the Brittany Chamber of Commerce (CCI-Bretagne) to connect with relevant individuals who were willing to share the information. Interviews were organized in either a comfortable setting in our university designated for executives visiting us for other professional work or (mostly) at their own offices. The interviews were spread across time and geography. In terms of order of interviews, we first conducted the interviews in France and then in India. Since, the themes that were emerging from Indian data were similar to the data collected from French interviewees, we needed a smaller sample from India as compared to France. The global nature of firms and integrated supply chains meant that apart from one aspect, the availability of technical talent, in all other aspects the responses were similar across the two geographies.

After each interview, we used the snowball method to gather information about potential future informants who fit our criteria [41,42]. All participants were promised anonymity to ensure maximum information could be gathered. Interviews were conducted in a semi-structured manner. A broad list of thematic questions along which the interview would be conducted was prepared beforehand by the researchers for internal control. The interview was free flowing as the researchers attempted to ensure that the interviewees discussed all the broad questions that the initial interview protocol had envisioned. The participants were asked to describe the extent of adoption of BDA tools and technologies and the issues they faced in its adoption, if any. Participants freely described their experiences. Follow-up questions were asked only if clarification on a certain aspect was required or if some information was of acute interest and the researchers wanted more information on some points. We also collected information through secondary sources like news reports, articles, e-mails, or other materials shared by informants to triangulate and corroborate the information shared by informants. Table 1 provides a list of participants in the exercise. The participants belonged to an array of industries and firm sizes to cover for diversity and technical practices prevalent in industry. It needs to be stated that we have provided as much information about the interviewees as possible as per qualitative research

Table 1
Details of interviews.

Sl. No.	Location	Gender	Firm Size (No. of employees)	Industry	Experience	Interview Length (in minutes)
1	France	Male	> 1000	Large Vehicle Manufacturing	12	38
2	France	Male	100–500	Dairy	15	40
3	France	Male	500–1000	Electrical Products	22	48
4	France	Male	0–100	Supply Chain Consulting	18	44
5	France	Male	0–100	Supply Chain Consulting	16	60
6	France	Female	> 1000	Heating and Ventilation	19	45
7	France	Male	> 1000	Passenger Auto	21	44
8	France	Male	0–100	Food Products	24	42
9	France	Male	> 1000	Medical Products	18	44
10	France	Male	> 1000	Product Packaging	18	42
11	India	Male	> 1000	Retail	14	52
12	India	Male	> 1000	Electrical Products	13	50
13	India	Female	500–1000	Electrical Products	10	49
14	India	Female	> 1000	Auto Manufacturing	11	65

practices to enable independent interpretation of our results. This research (being exploratory in nature) only concerns itself with the top-level question of BDA capability development at a generic level. It does not delve deeper into the gender- and firm size-based nuances. If those nuances were brought out during the free-flowing interview, they have been reported. In interest of qualitative interpretability, we have provided detailed information about the respondents. However, the interviews only dealt with the aspect of their firm's BDA capability and their firm's preparedness or response. The variety of interviewees and their backgrounds led to interesting and diverging viewpoints. While most executives felt the need for these technologies, many of them were unaware of the existence of these technologies in their current practices because they were packaged and bundled in ready-to-use software like SAP and ORACLE. The diverging opinion talked about the needless investment in this field for small and medium enterprises.

Interviews were recorded and transcribed using Nvivo software to analyze and code the data. Interviews lasted 38 to 65 min, averaging 47 min. Table 1 provides a snapshot of the interviewees. The names of interviewees and their firms have been hidden for anonymity purposes. The table shows that all respondents were at the senior level of their firm and had 10 to 24 years of experience. Typically, the respondents ranged between 33 and 50 years of age. A majority of the respondents were male (three female respondents). The lack of female respondents signifies the lack of female representation in these positions in supply chain divisions of firms.

3.2. Data coding

The researchers moved between interviewing and data interpretation. Further needs of data were determined from the emerging theoretical insights in data analysis. Fig. 1 shows the complete process of coding from collected data. The process of interviewing and transcribing and coding was ongoing. More data was collected based on the theoretical saturation than the previously collected data provided. We stopped data collection when theoretical saturation was reached. The process took place between June 2017 and April 2018. The final transcription and coding were performed between February 2018 and April 2018. The focus on data, firm, and analytics, as well as its use by managers, was the theme of all interviews conducted during the process.

4. Findings

In this section, we build on the data collected and develop insights based on the analysis of this data. We present the results as a set of propositions that we develop from the codes and analysis of data collected by the researchers.

4.1. A model for BDA capability development in SCM

Table 2 depicts the results of our theoretical coding and analysis described in section 3. It shows the final set of thematic codes that we obtained from the transcribed data and their various second order dimensions. The core category of thematic codes represents the top-level variables or actionable variables that can be acted upon by management. The sub-category codes that were developed using NVivo help us perform a deep dive into the constituents of the core theme to develop our propositions.

4.1.1. Data management and use of advanced software packages

In terms of technical readiness for developing BDA capability, an important dimension that emerged in our analysis of data was management of data. Kwon, Lee, and Shin [43] also found that quality of data is a critical aspect of success of BDA projects. In our research, data management was repeatedly pointed out by SCM executives as one of the most significant factors affecting capability build up in BDA technologies.

We also found evidence of companies without a good data management principle struggling to develop capabilities in the field of BDA. In one of the companies, we found that the efforts to integrate advanced analytics tools did not lead to the desired results due to lack of organized data. Traditional issues with data (i.e., missing data, wrong data, etc.) plagued the firms and led to a situation where the investment was turning sour in this field. The head of the supply chain division at a medium-sized firm out of Paris had the following to say about the importance of data management:

> *There is no analytics without data. Data needs to be secured and stored properly. Realizing this, we have created a special team to look at places where data can be gathered and how that data can be stored. Since the start of that program, the quality of our analysis has considerably improved, and we have made significant cost reductions owing to better planning.*

Ten of the managers interviewed for the study stressed the need for the role of data manager and the field of data management in general. There was near unanimity that the core capabilities of BDA could be fruitful only with active data management. As many as five firms appointed a data manager or equivalent in supply chain/logistics divisions. Three were actively considering an appointment. One executive mentioned:

> *Data is central to the big data world. Earlier, we did not have data. Now we need to make sure that we always have all the right information properly stored and accounted for. You never know what may be required by the strategy team to plan.*

Storing and better management of data was an important theme in some respect for all the interviewees. Companies wanted large data warehouses to store their data and ensure the quality of data. This led to an increase in the importance of data management. Many companies hired exclusive data managers as a chief person entrusted with ensuring the proper storage and generation of quality data. Such endeavors ensured that companies were ready for any requirements for further mining of data. A manager in France noted:

> *We realized the importance of storing quality data a few years ago. At that time, we did not have the institutional mandate or need for advanced analytics. Yet data was necessary. I created a data management team and hired a data manager. The quality and volume of data that we captured rose manyfold. This led to us having a much better view of our processes. A few years down the line, very recently, we felt the need to do some deep mining to overhaul our processes and provide better capabilities to marketing teams to understand the production process. We hired an analytics team. We could swiftly move and provide those capabilities as we had a good data center.*

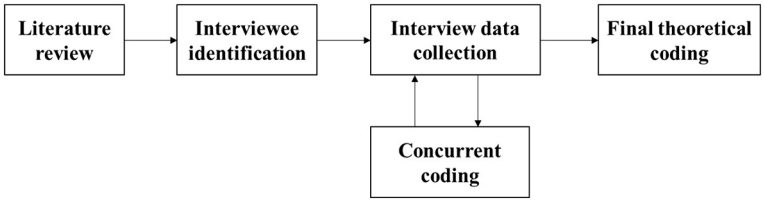

Fig. 1. Representation of the research method and its constituent steps.

Table 2
Category of codes with sample quotes.

Core Category	Sub-Category (in NVivo)	Sample Quote
Competitive Advantage	Competition	Competition is growing in the field. Increased data analysis helps the firm and the customers.
	Better Performance	Analytics capabilities provide multiple benefits to perform a better analysis and find avenues to reduce cost and increase efficiency.
	Advantage	Analytics invariably provides advantages over traditional estimation and planning methods. It also provides a better understanding of the market situation.
Data Management and Use of Analytics Packages	Data Processes	In the beginning, data was not collected from all sources. After adopting analytics tools, more data required additional coding and storage. Suppliers were given tablets to digitally record data at each point.
	Big Data (BD)	Suppliers, in particular, get a lot of data. This is difficult because many existing solutions like SAP Oracle are expensive. Smaller software may not be efficient in understanding the large amount of data.
	Data Manager	A data manager was appointed as head of data services. This streamlined the data capture from multiple sources and enabled a single point of contact to gather and requisition correct data.
	Quality Software	SAP's enterprise resource planning software is cutting edge. It has enabled us to move to a BDA domain because they often integrate these tools. There was no need to purchase additional software.
Human Resources	Access to Skilled Employees	Location is a disadvantage. Many firms in Paris can easily employ the best technology resources capable of using BDA tools. Others struggle, which limits the capability to enhance in this domain.
	Retraining Needs	The existing workforce must be retrained to utilize this software because they still work with Excel. This becomes a roadblock in adopting new technologies.
Organizational Politics	Top Management Focus	It is difficult to convince top management about the need to invest in dedicated software for other divisions. Management suggested that divisions continue using the SAP ERP package.
	Functional Leadership	The previous head of supply chain could not convince top management about the requirement for Tableau. This forced the division to work with SAP, which placed limitations on BD. However, new leadership invested in Tableau for the division.
Global Integration	Central Planning	A centralized plan exists for all the software and technology needs. This ensures that the entire company is on the same page.
	Analytics Strategy	It is a goal to be at the forefront of technology. The competition is severe. Good analytics will keep industry leaders at the top of the chain.
Environmental Determinism	Future of Technology	An issue with the adoption of analytics solutions is which software to adopt. The technology is changing so fast. It is difficult to know how to stand ahead of the curve while losing minimum money.
	Competitive Pressure	Many times, competition leads to change in business practices because no one wants to be left behind the curve.

While there is limited debate on the utility of BDA technologies in any domain of business management, the development and usage of such technologies have proven to be a challenge [19]. The SCM function is not an exception. Enabling the development and utilization of these technologies in SCM had its own set of issues [12]. Adding to the complexity, these technologies, as well as the software and terms used in the domain, are evolving fast. Given these facts, it is not surprising that we found a relative lack of technological awareness among the top SCM executives. Our initial interviews suggested that many top executives did not believe they had any sort of analytics capabilities. Most of these executives had heard of the terms and technologies, including BD and analytics, but few were aware of potential uses in SCM or the benefits/ongoing uses of such technologies. One of the early interviewees said:

> *I have been in industry for a long time. We use our traditional ERP systems to manage inventory and production. I have not had the need to look for other technologies for forecasting or planning. I have heard about analytics technologies and packages. We do not yet use these packages. We probably will in the future.*

These sentiments displayed a lack of awareness about the capabilities of advanced enterprise resource planning (ERP) packages like SAP and Oracle that come with built-in systems for forecasting and use advanced analytics techniques to enable high-quality planning. On being prodded about these issues, one of the managers responded:

> *Oh, yes. We use the latest version of SAP. I do not know the specifics of what those packages do. It is done by the tech or inventory team of my department. But over the past few years, the quality of interface and projection has improved. I can now see better projections and better dashboards … I am not sure whether they do analytics at their back. They probably do. In that case, we probably use analytics in our business.*

It was clear that for supply chain divisions that use the latest and integrated ERP packages, the readiness for use of analytics and BD technologies was reached. The transition was easier because of the technologies being available in a user-friendly format packaged with the core software that they have been using for decades.

> *The quality of our analysis and forecast had been improving over the years. We have always used the latest ERP package. We have invested a lot of resources for the same. In recent years, we have also moved to the creation of large data nodes and used software like Tableau to make dashboards using these large data sources.*

It has always been difficult for companies to jump to self-developed packages and open source software. However, use of such software enables quick transition to analytics and BD technologies as the learning curve is smaller for firms. Often, they do not realize that they are using advanced techniques. The analysis developed above leads to our first proposition:

Proposition 1. *BDA capability development is significantly enhanced in companies that adopt a dedicated approach to data management and use advanced software packages*.

4.1.2. Skilled human resources and training for analytics

Another factor that has been found to be instrumental for technology capability development at the corporate level is the presence of skilled resources [44]. Bharadwaj [44] found that the lack of skilled resources can be detrimental to firms in their technology planning and capability enhancement. For evolving technologies, skilled resources are neither easily acquired nor developed. [45]. The lack of skilled resource availability can impede quick capability building in companies.

During our data collection, we interviewed executives from companies based in different regions, including large and small cities like Paris, Bangalore, and Pune. These locations provided a contrast of opportunities for companies. Extant research in the field of skill and capability building has highlighted the importance of skilled resource

availability in a large congregation of industries [46]. Places like Paris and Bangalore are central locations of the employment market. Talent from all walks of life in the nation moves to these cities to explore and advance their career. This eases the scouting of new talent in analytics and BD technologies. This task is more difficult for companies based in smaller cities. One manager based out of a firm in a smaller city specified:

> *We realize that we need to develop analytics and big data capabilities. However, even if we were able to convince our top management for the need, where are the skilled people? We are a specialized firm. We need people who can use analytics and interpret the large data for our industrial needs. Such a skill set is difficult to find in this part of the nation. I could get one or two people but running a team and looking for replacements is very difficult. If I were based out of Paris, it would be different as all kinds of talent is available there. Therefore, I use the projections that my software provides.*

Training of existing employees is also a challenge. It is a challenge to store all (at each point) in large dedicated data structures tuned for BDA. A manager retorted:

> *I want and have established data centers but data is not easily available. Employees have been trained to produce the maximum amount of product. Storing more data and making entries at each point in the assembly line can slow the process. I need to train employees for this, but it is increasingly difficult as I need more money from my management after investing in these technologies.*

Our analysis leads us to the following second proposition:

Proposition 2. *BDA capability development is significantly enhanced in companies based out of regions with a favorable human resource environment* (*or high concentration of skilled employees*) *and with training programs on BDA*.

4.1.3. Intra-organizational power dynamics

Pfeffer and Salancik [47], described decision making as a political negotiation process. Given this viewpoint from extant research, it is easy to imagine that resource allocation and capacity development would be more difficult for firm divisions with less representation and clout in the top decision-making body of the company. The supply chain function is underrepresented in the top management hierarchy that has traditionally been dominated by finance and marketing professionals [48].

This leads to another conundrum in which it is difficult to acquire the resources for providing the BDA technologies and capabilities to the supply chain function. Many of the supply chain division heads proclaimed that it was simply impossible to get top management to agree to higher investments in technology for procurement and inventory management. Most of the time, they moved to better projection capabilities due to these capabilities being available as a part of established packages. They noted that analytics are first made available to marketing and finance departments and then to their department. The Finance department often wanted the latest ERP packages, which is why the firm had the latest ERP packages. At one firm, a manager said:

> *I am on very good terms with top management. I have made them aware of the importance of our department. Hence, we get whatever we want. I ask for resources and I get it. This might not be true for other organizations.*

A general manager of operations at a French firm stated that the organizational dynamics were such that to ensure that he was not credited with inordinate success in revamping the operations division, his rivals in the firm ensured blocking of funds in the new proposal of developing a BDA center in the company. Such instances are substantiated by the role of intra-organizational politics in decision making as established in the literature. The technology development effort is one instantiation of such practices. This leads us to our third proposition:

Proposition 3. BDA capability development is significantly enhanced in companies with organizational politics suitably aligned or the presence of supply chain division heads in an organizational decision-making body.

4.1.4. Global connectedness

Another aspect that pushes firms toward the use of such technologies is global connectedness. As Wu et al. [49] found in their research, the necessity to reach more stakeholders is one of the earliest levers for digitization in organizations. Companies with a requirement to efficiently connect and disperse information to internal or external stakeholders will utilize more advanced technological capabilities for both analysis and dispersal of information.

During our data collection exercise, we found that a company that was using Excel sheets for recordkeeping and analysis moved to Microsoft's PowerBI software to enhance their relationships with their stakeholders. While the company faced the need to adopt new technologies (i.e., Tableau, Power BI, SAS), they were reluctant to make the required investment as the top management did not feel a strong need. However, after the company acquired three new international partners, the need for data sharing and precise forecasting was felt more deeply. Therefore, the enhanced analytics package and training were arranged. The head of operations stated:

> *We would have moved to one of the latest analytics software soon anyway. However, the need to be more aligned with global standards of reporting was felt much more strongly after the new collaborations. This led us to start use of Power BI in our operations division sooner.*

One executive insisted that as she moved from a smaller to a larger firm, she realized the importance of better planning. Hence, she identified the need for using precise analytics algorithms and large-scale data mining.

> *At my previous firm, we could manage even if the projections were a bit off mark. Now we needed to be very precise. The chain was connected across countries and it was very costly to make mistakes as the time taken to supply the materials and create products for other nation markets was very long. We used high-quality analytics technologies and even had a team to use R to provide better analytics capabilities using the software.*

This leads to our fourth proposition:

Proposition 4. *BDA capability development is significantly enhanced in firms with a higher global integration in their supply chain.*

4.1.5. External landscape and analytics capabilities

One of the biggest externalities that leads to major investments in technology enhancement or capability development in companies is competitive pressure [50]. Firms' growth and capability development is placed within the realms of the competitive environment [50]. We found the same to be true in our analysis of capability development in BDA for SCM. Some companies moved to BDA technologies to stay competitive and remain attractive for their clients. This was especially true in those cases where companies faced increased competition as their competitors adopted these technologies.

> *My clients wanted data aggregation and Hadoop-based data systems to store production and planning data for two years. They required this for quality control purposes. At that time, we had not established big data centers in our firm. However, our competitor had. This firm was a long-term client of our company and we did not want to lose that firm as we knew our competition already had these capabilities. We quickly upgraded and hired a big data analytics team to satisfy our client. This*

enabled us to get one more contract that was earlier on the edge.

During our study, we found that multiple companies moved to advanced analytics techniques when they saw a threat of competition wooing their clients with the use of such tools and technologies. A manager at a mid-sized French firm lamented:

I was trying to convince management for months of the need to invest in the new analytics visualization tool. However, the final approval came only after the competing firms started setting up their own analytics teams dedicated to planning and procurement. We could have taken a major step ahead if we had done it earlier. However, you do not always get what you want. Such is the nature of business.

Beyond the competitive landscape, other external factors play a significant role in decisions leading to the development of new capabilities, as well as the advantages that can accrue from those capabilities. The respondents pointed out that external environmental determinism impacted not only BDA capabilities but how much benefit they could theoretically get from the use of such technologies. One of the respondents stated:

I do not believe that big data is the solution for all problems in today's age. Yes, they are important. However, you have to look for other things, too. How much data is available? How much are your suppliers willing to work with those data that determines your ability to benefit from them and also use these technologies?

Based on our analysis of data and theories about the use of technology in the face of an external environment, we reach our fifth proposition.

Proposition 5. BDA capability development is significantly enhanced in companies within an external environment composed of clients, regulations, and competition being favorably disposed.

The propositions presented in the previous sections are based on the common themes in the codes and represent the dominant view of the data. Based on these propositions, we suggest the model presented in Fig. 2 for building BDAC for SCM. Our model posits that the different constructs we identified through our analysis determine the capacity of the firm to build BDA capability and gain competitive advantage. In this model, we used competitive advantage as being perceived and not actual as we have used the interview respondents' claims about capabilities' competitive effects. We have not done any independent analysis of the true extent of the competitive advantage that the technology grants. Nevertheless, the framework drawn from theory and data presents an insight into the complex factors that determine the growth of capabilities and advantage due to BDA.

5. Conclusion

The rise in awareness and use of BDA technologies follows the rise in technologies that enable the capture and storage of large-scale data. As such, managers are striving to build BDA capability in their respective business units. Research in the domain of BDA capability development and use in SCM demonstrates the potential benefits and competitive advantage that BDA may contribute in SCM. However, extant research does not show what factors affect the capability of a firm to use BDA and build BDA capability. Using an exploratory method, we extend the debate and research in this domain and propose a model for BDA capability development in which both internal and external factors play essential roles in determining the speed and success of BDA capability development in SCM.

5.1. Contribution to research

This paper extends our understanding of the factors driving BDA capability for managing the supply chain. Through our exploratory analysis, we find organizational factors that determine BDA capability development. BDA users in SCM are not immune from the organizational structure and objectives. Their individual micro-adoption is contingent on the macro goals and adoption by the firm, particularly for technologies that require a major shift in strategy and financial investment. We identify factors, including resource alignment, environmental determinism, and organizational politics, that are the contingencies that drive and enhance building BDA capability for SCM. Our paper extends the discussion in the domain from the constituents of BDA capability to factors that affect BDA capability development. Identification of these factors enables the development of empirical studies to identify the relative importance of these factors.

5.2. Contribution to practice

In this paper, we have brought focus to the underlying factors that drive a company's BDA capability development. Through this research, we have extended the existing discourse on BDA by exploring beyond

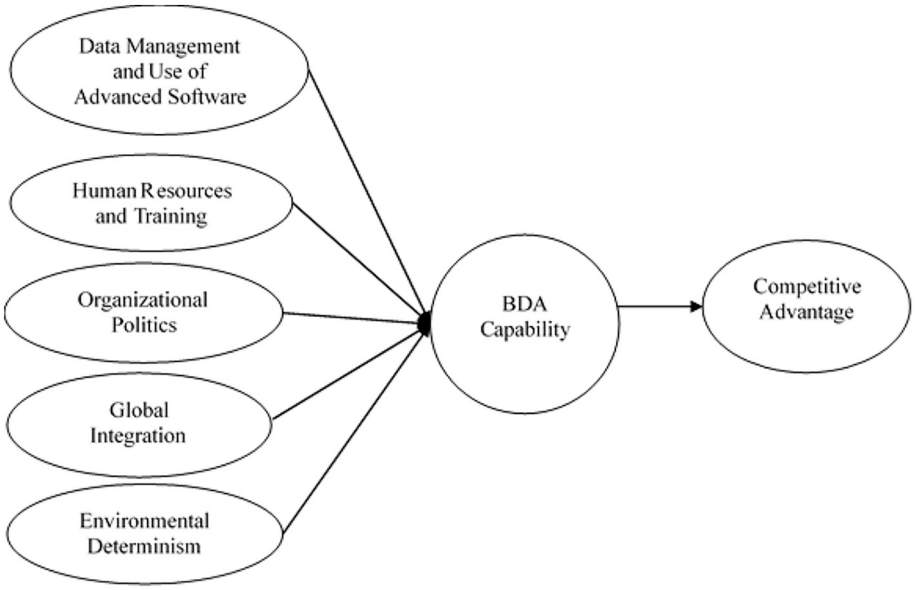

Fig. 2. Model for building BDA capability for SCM and the contribution of BDA to competitive advantage.

the potential benefits of these technologies. Numerous research studies, as well as practitioner articles, have established the potential that BDA has in SCM. Studies also point out potential issues and challenges in implementation. Our study collects data from supply chain professionals to identify factors that lead to capability development in this growing technological field.

Managers can also identify the factors that will be critical within their firm's context for further development of their BDA capability. As depicted in our study, many factors may seem underwhelming. However, they play a pivotal role in ensuring a company's BDA capability development for SCM. These include intra-organizational power dynamics and level of global integration of the supply chain. With careful planning, supply chain managers can ensure success of their divisions and sustained competitiveness in the era of BDA.

5.3. Limitation and future work

This study has its share of limitations that must be considered while interpreting the results and implications. First, the field of data collection is based out of France and India. The study does not cover many geographical locations at the heart of the BDA revolution, including the United States and China. Further studies are required in those geographic locations to generalize and confirm the results of this study.

Second, being an exploratory study, this work develops certain propositions and frameworks. These are based on researcher interpretations of the data and the situations in which such data was collected. As in any semi-structured interview setting, the role of the interviewer is limited to eliciting the interviewee toward the broad topics of discussion and, hence, the role of theoretical saturation [40]. As stated, we conducted the interviews and transcription and coding sequentially. Hence, we were able to follow the similarity of patterns in the interviews and data. Since the similarity of patterns emerged without our intervention of structured questionnaires and surveys, we can reliably assume that the findings are robust and generalizable [40]. In terms of generalizability, we need to discuss the fact that methodological research in the field has made distinctions between theoretical and statistical generalization [31]. This paper does not claim statistical generalizability of our findings. However, the robust data collection exercise, quality of informants, and theory-driven findings support the assertion that our results are theoretically grounded and could be empirically validated in future studies. While due care was taken to ensure that the authors analyzed the data without any bias, unintended bias may occur. Further analysis, research and large-scale data based statistical studies would be required to confirm the results of our work.

The third limitation of this work is the nature of the study. We performed a cross-sectional study in which we collected data from multiple firms and managers on the state of BDA capability development and issues. This methodology allowed us to cast a wide net. It was suitable for a first exploratory study. Such a research design was appropriate to collect all the factors that may affect a firm. Some of these factors may be more relevant to some firms as compared to others. To study capability development more closely, a longitudinal case study may be employed as a follow-up study.

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