# Elucidation of Big Data Analytics in Banking: a Four–stage Delphi Study

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## Abstract

**Purpose:** In today's networked business environment, a huge amount of data is being generated and processed in different industries, which banking is amongst the most important ones. The aim of this study is to understand and prioritize strategic applications, main drivers, and key challenges of implementing big data analytics in banks.

**Methodology:** To take advantage of experts' viewpoints, we designed and implemented a four-round Delphi study. Totally, 25 eligible experts have contributed to this survey in collecting and analyzing the data.

**Findings:** Our results revealed that the most important applications of big data in banks are "fraud detection" and "credit risk analysis". The main drivers to start big data endeavors are "decision-making enhancement" and "new product/service development", and finally the focal challenge threatening the efforts and expected outputs is "information silos and unintegrated data".

**Originality:** In addition to stepping forward in the literature, the findings advance our understanding of the main managerial issues of big data in a dynamic business environment, by proposing effective further actions for both scholars and decision-makers.

**Keywords:** Big data analytics; Big data applications; Business value; Challenges; Banking industry

## 1. Introduction

The notion of big data first was introduced by Laney (2001) as the vast volumes of highly diverse data that are created, collected, and processed at high rates. Thereafter, researchers have studied big data through various lenses such as strategic (e.g. Howie, 2013), analytic (e.g. Wamba et al., 2015), or technical (e.g. Gualtieri, 2012) perspectives. Overall, previous research introduces big data as a main competitive advantage fostering innovation in business models, products, and services to leverage business opportunities (e.g. Chen et al., 2012; Davenport and Kudyba, 2016; Davenport et al., 2012; McAfee and Brynjolfsson, 2012; Woerner and Wixom, 2015).

After the financial crisis of 2008, banks and other financial service providers (FSP) have been under severe pressures to increase their stability and enhance the quality of services (Das et al., 2018). New regulations like Payments Service Directive in digital markets (Donnelly, 2016) and Basel III (Allen et al., 2012) force banks to be more transparent and request access to billions of banks customer data. Meanwhile, disruptive technological innovations such as big data, blockchain and Internet of Things have transformed market trajectories. For instance, recently big data analytics (BDA) has enabled other companies such as Alibaba to enter financial services market by using their big data capability to provide new services to their customers (Baesens et al., 2016). Driven by technological advancement and market requirements, banks increasingly consider BDA as an important vehicle to make fundamental changes in their business strategies (Bhimani, 2015). According to the IDC institute's report in 2016, the banking sector has invested $20.8 billion on big data, indicating that banks are one of the dominant consumers of big data applications. However, actualizing BDA value requires considering various factors (Côrte-Real et al., 2019) for aligning BDA capabilities with a strategic value system (Verma and Bhattacharyya, 2017) to improve decision quality and gain new business insights.

While practitioners have reported various big data use cases, less systematic attempts have been undertaken to uncover big data main applications and issues in the banking industry. To address this gap, the current study aims at conducting a Delphi study to explore and examine the most important big data applications, challenges, and drivers in the banking industry from experts' viewpoints. To deepen our theorization about how banks can exploit big data benefits, our study intends to answer these questions:

1) What are the important (i) applications, (ii) drivers, as well as (iii) challenges related to BDA in banks?
2) How are these applications, drivers and challenges ranked in order of importance?
3) What is the consensus level regarding the relative importance of identified applications, drivers and challenges?

Although its applications have flourished over the recent years, big data related research is still considered in its early stages and under-studied; thus scholarly effort to identify its strategic applications, main drivers and critical challenges is a step in the right direction. There is also a need to rank the identified items based on their importance to help practitioners and researchers for further concentration on the most significant ones. The contribution of this research is also originated from the suggestions of other researchers to identify the challenges and the effects of big data in the organizations (George et al., 2014; 2015; Srivastava and Gopalkrishnan, 2015) by using a tested technique for capturing and refining domain experts' opinion.

## 2. Background

Gaining competitive advantage in a highly dynamic environment entails gathering, manipulating, and analyzing large volumes of structured and unstructured data (Davenport and Harris, 2007). FSP companies such as banks use big data for asset management and market analysis, wherein a huge amount of stock exchange, banking, and online/offline transactions' data are flowing. While, previously IT departments mainly focused on acquiring, storing, and updating data as well as ensuring the security in banks, technology management teams are now expanding the scope their expertise and activities into a wider portfolio of technologies. Currently, IT teams use BDA to gain new insights for several objectives such as attracting customers, growing market share, providing better customer service and managing risk (Hoppermann and Bennett, 2014). Big data as "the next frontier for innovation" (Shollo and Galliers, 2016) has a great capacity to contribute toward bank's business value by improving their business process (Loebbecke and Picot, 2015; Popovič et al., 2018) or enhance customer experience and satisfaction (Chau and Xu, 2012; Chen et al., 2012). However, to fully realize the BDA value, several data, process and management challenges need to be addressed (Sivarajah et al., 2107) to take the advantages of this disruptive technology.

### 2.1 BDA Applications in Banking Industry

According to PwC (2013), banks primarily use big data for better customer support, risk assessment, decision-making support, evaluation and assessment of new opportunities for profitability, investment in new markets, reduction of the time required to enter the market, and investment in blockchain projects. Because of competition forces, banks now have to deal with manifold demanding customers who expect ongoing communications and transacting in new and varied ways anywhere, anytime (Turner et al., 2012). To meet customers' increasing demands, banks need BDA to deliver more value at the entire customer journey via accessing and analyzing large amounts of data. By using BDA, banks executive managers, operational

supervisors, and customer service teams are able to predict market movements, forecast sells, and provide their customers with better and superior services. With the proliferation of mobile Internet technologies and cloud computing, businesses, especially FSPs are facing different types of risks, including financial risks in various forms and intensity levels. Using BDA allows banks to establish efficient risk management systems, make more conscious decisions, and improve corporate governance (Chen et al., 2012).

## 2.2 BDA Drivers in Banking Industry

Companies collect and analyze big data to gain various insights about their businesses and market environment, make better decisions (Özemre and Kabadurmus, 2020), and choose more effective strategic initiatives. Baesens et al. (2016) state that BDA has dramatically changed businesses, in particular FSPs. However, according to Cavanillas et al. (2016) companies are still unclear about BDA value generation. How businesses can create value through collecting and analyzing big data and what is its return on investment are major questions that many managers struggle to find the correct answer. Certainly, the benefits that organizations consider them as value depend on their strategic goals in adopting and using big data (Ghoshal et al., 2014).

While there are some promising narrow scope BDA use cases, even with significant capital returns, many banks are not be able to scale them up, thus BDA impacts on increasing the overall profit or cost reduction remain trivial. As a result, many senior bank managers still do not consider BDA as a promising mean to make fundamental changes or so-called "disruptive" technology, rather seeing it as a sideline to other traditional activities (Garg et al., 2017). However, massive amounts of internal and external data and technology advancement from one side, and competitive and market pressures from the other side increasingly drive banks to apply BDA to achieve their goals.

## 2.3 BDA Challenges in Banking Industry

Although most of the academic and industrial reports have pointed to the BDA benefits, implementing BDA projects have serious challenges. According to Gartner's report, due to the lack of required skills, technical infrastructure, unsupportive senior executives, and inappropriate organizational culture, around 60%of BDA initiatives fail to be successful (Goasduff, 2015). Further, many BDA projects are not initiated because of high infrastructure costs crucial for supporting daily big data collection. Thus, lots of data, especially data beyond organizations' boundaries, are not recorded or stored and, in the case of being stored, are not used or analyzed appropriately. In fact, one of the major BDA challenges is processing and analyzing huge amounts of data to extract useful information and knowledge (Abinaya, 2015). To generate value from big data, organizations need to establish appropriate information foundations supporting rapidly growing data volume, data diversity, and high rate of data production. Nearly half of the companies that execute BDA, even with appropriate technical infrastructure, are facing unintegrated data challenges (Turner et al., 2012). BDA requires accurate data management, including governance of data sources, content quality, access and security, data compatibility, and user training (Shaw, 2013). Therefore, despite appreciating BDA importance, these challenges push banks back to benefit from the massive amount of their structured and unstructured data.

# 3. Research Methodology

Given the exploratory nature of this research and the limitation of related previous studies, listening to experts from both business and academic backgrounds is a sensible approach to identify and examine key underlying factors (Barnes and Mattsson, 2016). To achieve the research objectives, we followed modified version of the Delphi method (Schmidt, 1997), because prior studies have shown its applicability in accomplishing comparable objectives (Barnes and Mattsson, 2016; Lang et al., 2018). The Delphi method is applied when the research problem can benefit from subjective judgments on a collective basis (Linestone and Turoff, 1975), and to avoid negative effects of interpersonal biases, strong personalities, defensive attitudes and unproductive disagreements (Linstone and Turoff, 2002). We opted to use this method to explore big data applications, challenges and drivers and their relative importance in banking industry, as an under-studied area, drawing on the collective experience of our expert panel (Schmidt, 1997). As such, this research design is an appropriate method for exploratory theory building (Akkermans et al., 2003; Melnyk et al., 2009), which has repeatedly been used to investigate important phenomena in IT domain. Delphi studies inherently secure the construct validity, as the results of the preceding rounds are sent back to the experts for further assessment (Okoli and Pawlowski, 2004). For ensuring the internal validity, we followed content analysis and survey techniques, and for achieving reliability, we outlined each step of the Delphi process and described how the single rounds build on each other (see Fig 1).

## 3.1 Panel Selection

In this study, we define an expert as "an individual who has acquired knowledge in a specific domain (e.g. big data) gradually through a period of learning and experience" (Okoli et al., 2010, p.9). To obtain valid and robust results, we invited professionals with significant work experience and knowledge in the field of big data in the banking industry. We checked and reviewed professional communities' members on big data in LinkedIn, searched banks with BDA projects and approached their project managers and IT specialists, and also looked for academic researchers with relevant publications to participate in this study. For choosing the appropriate panel members, a Knowledge Resource Nomination Worksheet was prepared to categorize panelists' disciplinary background and/or skills. Participants with less than five years of related experience were excluded. Totally, 45 experts fitting our selection criteria were invited, of whom 28 accepted to participate in the first round of the study. However, only 25 participants either filled their questionnaires completely or accepted to participate in the semi-structured interviews. In the second round 24, in the third round 23 and in the last round 21 experts participated.

## 3.2 Data Collection and Analysis Method

Brainstorming and semi-structured interviews enabled us to develop a deep understanding of the identified items and reasoning behind the participants' individual rankings. We collected data from April 2018 to November 2018 in four stages according to Schmidt et al. (2001), including a preparation phase and four subsequent Delphi rounds (Fig. 1). During the preparation stage, we did the planning and configuring our expert panel. In the first round, brainstorming was performed to identify as many applications, drivers and challenges as possible. After interviewing, all answers were compiled and inserted into a single Word-document; totally 17,400 words. Then, we analyzed and synthesized the gathered information with Strauss and Corbin's (1990) method and applied open and axial coding to identify all relevant applications, drivers and challenges. To ensure consistent coding, all authors independently conducted content analyses to identify a list of keywords, coded interview transcripts and discussed any conflicting results until reaching consensus (Gioia et al., 2013).

After completing the content analysis, a final list of 21 unranked BDA applications, 15 drivers, and 27 challenges in banking were developed.

Second round focused on narrowing down the list of items to a manageable set. In this phase, the panel experts were presented a randomized list for three questions. The Likert-scale was used as an appropriate evaluation method, which allowed identifying items that are rated as most important. We asked the experts to rate the importance of the items on a 7-point Likert scale ranging from *extremely important* (7) to *not important at all* (1), with the possibility for providing additional comments. A brief description of each item was provided to reassure all experts had the same understanding. After the ratings were consolidated, based on Hsu and Sandford (2007) suggestion, the items with mean value more than neutral that 70% of respondents rated them positively were selected.

In the third round, each panel member received a list of final items in random-order from the previous round and asked them to rank the items in order of importance. To measure the degree of consensus among the panel experts, Kendall's coefficient of concordance (Kendall's W) was used. Kendall's coefficient of concordance ranges from 0 to 1, indicating the degree of consensus reached by the panel (Schmidt, 1997). In the last round, experts were provided the list of items with mean ranked and their previous ranking from the previous phase, as a controlled feedback (Schmidt et al., 2001). After this round, the study was stopped because a good level consensus was reached. During the entire Delphi study, we tried to ensure the anonymity of the respondents. Fig 1 represents the structure of the Delphi process and the summary of each stage in our study.

| **Phase 1:**<br><br>**Brainstorming (n=25)** | • Open questions for gathering ideas about the big data applications, drivers and challenges in banking industry. The experts were asked to provide a list of items based on their experience.<br>• The items were aggregated applying content analysis by the researchers to make a consolidate list with the interrater agreement for Applications= 95% for Drivers 100% and for Challenges= 97%<br>• At the end of this phase we reached 21 items in applications, 15 items for drivers, and 27 for challenges |
|---|---|

| **Phase 2:**<br>**Narrowing down (n= 24)** | • Experts were asked to give a Likert based rating for the items on each question based on the consolidated list from the previous stage.<br>• Lists reduced based on the ranking criteria of mean>=5 and more than 70% of respondents rated them positively<br>• Final lists contained nine items for applications six items for drivers and eighteen items for challenges |
|---|---|

| **Phase 3:**<br>**First ranking (n= 23)** | • Respondents were presented with the random lists for each question based on the final items from phase 2.<br>• Experts ranked the items with providing justifications/ reasons.<br>• Items were ranked based on the calculated mean. |
|---|---|

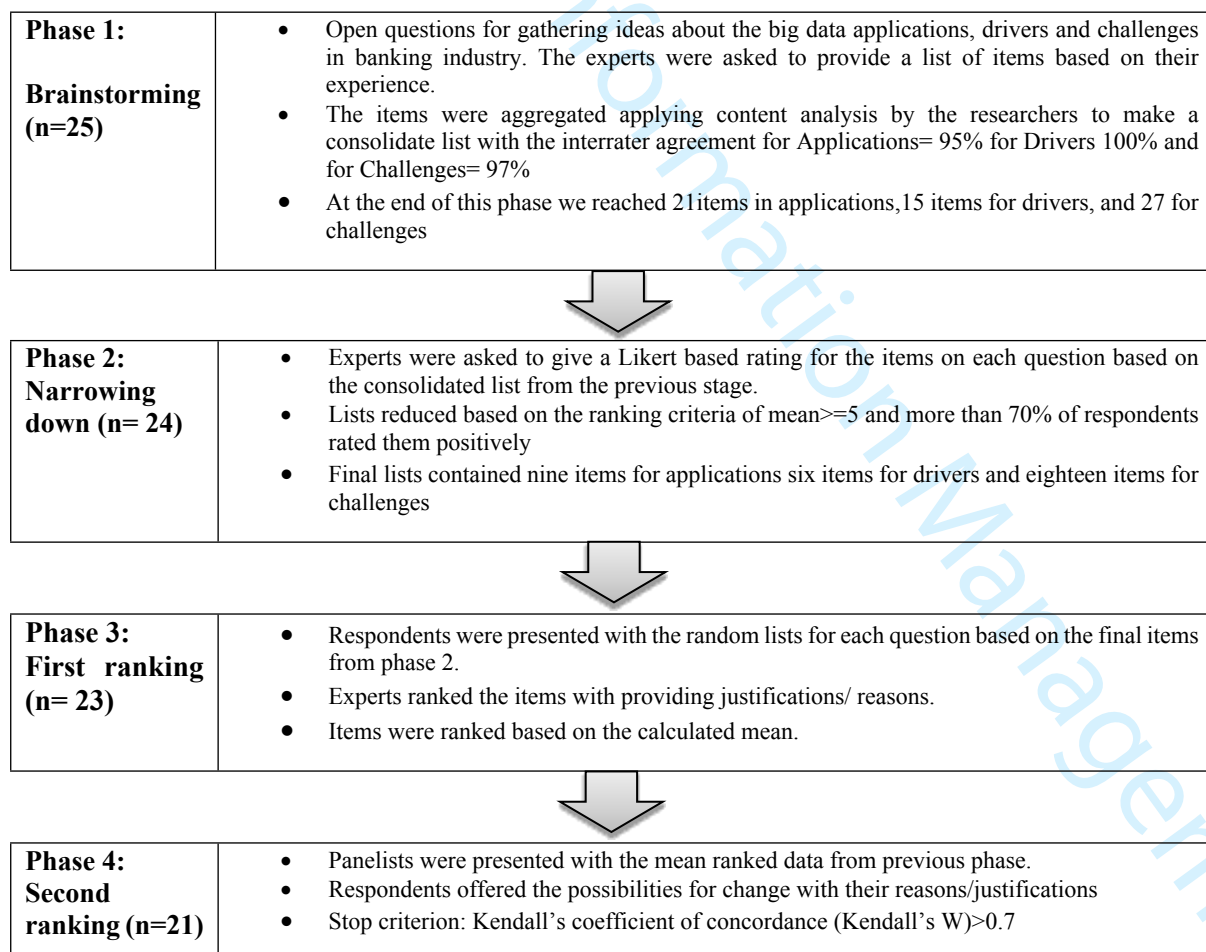| **Phase 4:**<br>**Second ranking (n=21)** | • Panelists were presented with the mean ranked data from previous phase.<br>• Respondents offered the possibilities for change with their reasons/justifications<br>• Stop criterion: Kendall's coefficient of concordance (Kendall's W)>0.7 |
|---|---|

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**Fig 1: The logic of Delphi process in this study**

# 4. Results

The first round was based on the three open questions: What are the main BDA applications in the banking industry? What are the main BDA drivers in the banking industry? What are the main BDA challenges in the banking industry? This round is a critical breakthrough in the process of Delphi study, and we included an open-ended call for viewpoints and ideas from our panelists (Okoli and Pawlowski 2004) to discuss a set of wide and unregulated questions. The unranked big data applications, drivers and challenges derived from the content analysis are listed in Tables (1-3). The data we collected from experts revealed (1) some general items that are identical in different sectors including banking, (2) unique items to the banking industry that are more "context-specific" and less-discussed in the extant literature.

In the second phase, the panelists selected nine important applications, six drivers and 18 challenges out of whole lists, using Likert-scale for ranking (Tables 1-3). The criteria for cut off is set to reduce the list based on the ranking criteria of mean>=5, and more than 70% of respondents rated the items positively (more than 4).

**Table 1. Primary perspective about BDA applications in banking**

| Item | Score | | | | | | | 5,6 & 7 % | mean |
|------|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | |
| Fraud detection | 0 | 0 | 0 | 1 | 3 | 7 | 13 | 96% | 6.3 |
| Credit risk analysis | 0 | 0 | 1 | 1 | 3 | 8 | 11 | 92% | 6.1 |
| Customer 360 | 0 | 0 | 1 | 2 | 4 | 8 | 9 | 88% | 5.9 |
| Customers segmentation | 0 | 0 | 1 | 3 | 4 | 11 | 5 | 83% | 5.7 |
| Designing new business models & new products and service development | 0 | 1 | 3 | 2 | 3 | 6 | 9 | 75% | 5.5 |
| Increasing loyalty and decreasing customer attrition | 0 | 1 | 1 | 4 | 4 | 6 | 8 | 75% | 5.5 |
| Customer recommender systems | 0 | 1 | 3 | 4 | 3 | 6 | 7 | 67% | 5.3 |
| Increasing efficiency and reducing costs | 0 | 2 | 2 | 3 | 5 | 6 | 6 | 71% | 5.2 |
| Customers sentiment analysis | 1 | 1 | 3 | 2 | 7 | 4 | 6 | 71% | 5 |
| Customer churn prediction | 0 | 2 | 4 | 2 | 8 | 5 | 3 | 67% | 4.8 |
| Customer channel journey | 0 | 2 | 3 | 6 | 7 | 3 | 3 | 54% | 4.6 |
| Operation optimization | 1 | 2 | 2 | 5 | 8 | 4 | 2 | 58% | 4.5 |
| Cross-selling/up-selling | 0 | 3 | 3 | 7 | 6 | 5 | 0 | 46% | 4.3 |
| Customer acquisition | 2 | 2 | 2 | 7 | 5 | 4 | 2 | 46% | 4.3 |
| Business process analytics | 1 | 1 | 2 | 12 | 6 | 1 | 1 | 33% | 4.2 |
| Anomaly detection | 0 | 3 | 4 | 7 | 8 | 2 | 0 | 42% | 4.1 |
| Designing new product and services | 1 | 3 | 6 | 8 | 3 | 3 | 0 | 25% | 3.8 |
| Customers satisfaction | 2 | 2 | 7 | 6 | 5 | 1 | 1 | 29% | 3.7 |
| Marketing analytics | 1 | 6 | 5 | 5 | 5 | 2 | 0 | 29% | 3.5 |
| Designing innovative reward models | 4 | 3 | 5 | 8 | 2 | 0 | 2 | 17% | 3.4 |
| Customer profiling and knowledge | 3 | 6 | 5 | 3 | 4 | 2 | 1 | 29% | 3.4 |

**Table 2. Primary perspective about BDA drivers in banking**

| Item | Score | | | | | | | 5,6 &7 % | mean |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | |
| Decision making improvement | 0 | 0 | 0 | 0 | 3 | 6 | 15 | 100% | **6.5** |
| Customers intimacy | 0 | 0 | 0 | 1 | 3 | 7 | 13 | 96% | **6.3** |
| Providing new products and services | 0 | 0 | 0 | 2 | 4 | 9 | 9 | 92% | **6** |
| Survival | 0 | 0 | 0 | 3 | 6 | 7 | 8 | 88% | **5.8** |
| Creation of competitive advantage | 0 | 1 | 2 | 3 | 2 | 4 | 12 | 75% | **5.8** |
| Achieving operational excellence | 0 | 0 | 3 | 3 | 3 | 7 | 8 | 75% | **5.6** |
| Enhance customer experience | 1 | 3 | 4 | 1 | 5 | 5 | 5 | 63% | **4.7** |
| Data driven decision making | 0 | 2 | 5 | 4 | 7 | 4 | 2 | 54% | **4.5** |
| Combining the product and services | 1 | 3 | 4 | 4 | 7 | 2 | 3 | 50% | **4.3** |
| Designing business models | 0 | 4 | 7 | 3 | 4 | 2 | 4 | 42% | **4.2** |
| Regulatory compliance | 2 | 2 | 5 | 5 | 4 | 3 | 3 | 42% | **4.2** |
| Proactive customer care | 0 | 3 | 6 | 7 | 7 | 1 | 0 | 33% | **3.9** |
| Informing strategic direction | 3 | 2 | 4 | 5 | 7 | 3 | 0 | 42% | **3.8** |
| Faster time to market | 2 | 2 | 5 | 7 | 6 | 2 | 0 | 33% | **3.8** |
| Following the first movers | 2 | 3 | 4 | 7 | 5 | 3 | 0 | 33% | **3.8** |

**Table 3. Primary perspectives about challenges in applying BDA in banks**

| Item | Score | | | | | | | 5,6 &7 % | mean |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | |
| Information silos and data integrity | 0 | 0 | 6.6 | 0 | 1 | 7 | 16 | 100% | **6.6** |
| Lack of technical and skilled workforce | 0 | 0 | 6.4 | 0 | 4 | 6 | 14 | 100% | **6.4** |
| Privacy concerns | 0 | 0 | 6.3 | 0 | 4 | 9 | 12 | 100% | **6.3** |
| Security concerns | 0 | 0 | 6.3 | 0 | 2 | 12 | 10 | 100% | **6.3** |
| High implementation cost | 0 | 0 | 6.2 | 2 | 3 | 8 | 12 | 92% | **6.2** |
| Poor data quality | 0 | 0 | 6 | 1 | 4 | 8 | 10 | 92% | **6** |
| Immaturity of real time big data processing technologies | 0 | 0 | 6 | 2 | 1 | 11 | 9 | 88% | **6** |
| Lack of Top management support | 0 | 1 | 5.8 | 0 | 7 | 7 | 8 | 92% | **5.8** |
| Unsupportive organizational culture | 0 | 1 | 5.7 | 1 | 6 | 8 | 7 | 88% | **5.7** |
| Incompatibility of internal policies | 0 | 1 | 5.6 | 0 | 9 | 7 | 6 | 92% | **5.6** |
| Inappropriate organizational structures | 0 | 0 | 5.6 | 2 | 10 | 4 | 7 | 88% | **5.6** |
| Difficulty in integrating current infrastructure with big data technologies | 0 | 1 | 5.6 | 1 | 9 | 4 | 8 | 88% | **5.6** |
| Dominance of legacy systems in the bank sector | 0 | 0 | 5.5 | 6 | 4 | 7 | 6 | 71% | **5.5** |
| Lack of comprehensive big data commercial solutions | 0 | 0 | 5.4 | 3 | 8 | 6 | 5 | 79% | **5.4** |
| Inaccessibility of appropriate infrastructures | 1 | 0 | 5.4 | 3 | 7 | 6 | 6 | 79% | **5.4** |
| Difficulty in embedding big data in current bank processes | 0 | 0 | 5.3 | 6 | 7 | 6 | 4 | 71% | **5.3** |
| Lack of operational/strategic data sharing between different units | 0 | 1 | 5.2 | 5 | 7 | 7 | 4 | 72% | **5.2** |
| Week Data governance | 0 | 1 | 5.2 | 3 | 5 | 7 | 5 | 71% | **5.2** |
| Inappropriate business cases | 1 | 1 | 5.2 | 1 | 4 | 6 | 7 | 71% | **5.2** |
| Unfitted solutions with the organisation complexity and variability and institutional context | 1 | 1 | 4.8 | 2 | 7 | 6 | 3 | 67% | **4.8** |
| Legal and Regulatory issues | 0 | 2 | 4.7 | 6 | 6 | 3 | 4 | 54% | **4.7** |
| Limited scalability | 0 | 2 | 4.5 | 7 | 6 | 4 | 2 | 50% | **4.5** |
| Data heterogeneity | 1 | 1 | 4.4 | 6 | 4 | 5 | 2 | 46% | **4.4** |
| Poor data accessibility | 2 | 2 | 4.1 | 7 | 6 | 3 | 1 | 42% | **4.1** |
| Time taken to analyze large datasets (Processing Time) | 3 | 5 | 3.5 | 6 | 4 | 2 | 1 | 29% | **3.5** |
| Need to a lot of storage | 4 | 7 | 3.4 | 3 | 3 | 5 | 0 | 33% | **3.4** |
| Unreliability of big data technologies | 4 | 6 | 3.3 | 3 | 3 | 4 | 0 | 29% | **3.3** |

An overview of the key analytical findings related to the ranking of items is presented in Tables 4-6. The items in each table are sorted in descending order according to the panel experts aggregated rankings with their average rank in each round, Kendall's W value for iterations in rounds 3 and 4, and the final ranking of the items.

**Table 4. Ranked BDA application in banks**

| Rank | Application | Round 3 Rank Mean | Round 4 Rank Mean |
|---|---|---|---|

| | | Round 3 | Round 4 |
|---|---|---|---|
| 1 | Fraud detection | 1.94 | 1.72 |
| 2 | Credit risk analysis | 2.33 | 2.17 |
| 3 | Customer 360 | 2.50 | 2.50 |
| 4 | Customers segmentation | 4.06 | 3.89 |
| 5 | Designing new business models & new products and service development | 4.83 | 4.94 |
| 6 | Increasing loyalty and decreasing customer attrition | 6.50 | 6.56 |
| 7 | Customer recommender systems | 7.33 | 7.33 |
| 8 | Increasing efficiency and reducing costs | 7.61 | 7.78 |
| 9 | Customers sentiment analysis | 7.78 | 8.00 |
| | Kendall's W | 0.63 | 0.78 |

Based on the aggregated experts' ranking of all items in rounds 3-4, among BDA applications, "fraud detection" received the highest and "credit risk analysis" received the second highest ranks. After that, "customer 360" and "customer segmentation" attracted the highest attention amongst the panelists.

**Table 5. Ranked BDA drivers in banks**

| Rank | Driver | Round 3 Rank Mean | Round 4 Rank Mean |
|---|---|---|---|
| 1 | Decision-making improvement | 1.50 | 1.33 |
| 2 | Customers intimacy | 2.39 | 2.28 |
| 3 | Creation of competitive advantage | 2.94 | 3.00 |
| 4 | Survival | 4.00 | 4.00 |
| 5 | Providing new products and services | 4.67 | 4.78 |
| 6 | Achieving operational excellence | 5.50 | 5.50 |
| | Kendall's W | 0.68 | 0.81 |

Based on the experts' consensus, "decision-making improvement" along with the "customer intimacy" were evaluated as the most salient drivers for BDA in banks. The "creation of competitive advantage" was recognized as the third most important driver.

**Table 6. Ranked BDA challenges in banks**

| Rank | Issue | Round 3 Rank Mean | Round 4 Rank Mean |
|---|---|---|---|
| 1 | Information silos and disintegrate data | 2.17 | 1.8 |
| 2 | lack of technical and skilled workforce | 2.72 | 1.9 |
| 3 | Privacy concerns | 3.44 | 2.5 |
| 4 | Security concerns | 3.78 | 3.3 |
| 5 | High implementation cost | 6.33 | 4.2 |
| 6 | Poor data quality | 7.83 | 5.6 |
| 7 | Immaturity of real-time big data processing technologies | 8.28 | 6.8 |
| 8 | Lack of top management support | 8.94 | 7.1 |
| 9 | Unsupportive organizational culture | 9.06 | 8.8 |
| 10 | Incompatibility of internal policies | 10.33 | 8.9 |
| 11 | Inappropriate organizational structures | 10.67 | 12 |
| 12 | Difficulty in integrating current infrastructure with big data technologies | 13.28 | 13 |
| 13 | Dominance of legacy systems in the bank sector | 13.39 | 13 |
| 14 | Lack of comprehensive big data commercial solutions | 15.94 | 14 |
| 15 | Inaccessibility of appropriate infrastructures | 16.00 | 15 |
| 16 | Difficulty in embedding big data in current bank processes | 16.06 | 15 |
| 17 | Lack of operational/strategic data sharing between different units | 16.89 | 16 |
| 18 | Inappropriate business cases | 17.06 | 17 |
| | Kendall's W | 0.57 | 0.72 |

Found from panel rankings, "lack of data integrity due to the information silos" was detected as the most important issue. "Lack of skilled experts", including data scientists, was rated as the second most significant obstacle to the banks' progress towards BDA. "Privacy" and "security" were ranked at the third and fourth levels of importance because many senior bank managers are worried about such issues. Many participants pointed out that slightest inadvertent or deliberate mistake in unauthorized use of customer data can seriously damage banks' reputation. "High costs" of acquiring essential technologies and "data quality" are other important challenges.

## 5. Discussion and Implications

Through the four-round Delphi method, we identified nine BDA important applications, six strategic drivers, and 18 challenges hindering successfully implementing BDA in banks (RQ1). We also ranked these items according to the experts' opinions (RQ2) to expose their importance in the banking context, based on the calculated level of consensus (RQ3), which is more than 0.7 for in the last round.

Two primary BDA applications highlighted by our experts are "fraud detection" and "credit risk analysis", which are extremely important to banks due to the possibility of losing of billions of annual banks incomes (Bhattacharyya et al., 2011). Fraud and risk detection is not only important for the bank's competitive advantage but also is a key factor for bank long-term sustainability (Cordella et al., 2018). Additionally, obligations and principles of Basel III for managing credit risks (Baesens et al., 2016) require banks to convert their simple credit risk management model to more advanced frameworks for credit risk management, market risk management, and operational risk management, which are enabled by BDA capabilities. Previously, banks evaluated just a portion of transactions for fraud detection, therefore, some fraudulent activities were not detected, led to inaccurate positive conclusions. Using BDA has enabled banks to process huge datasets for fraud detection and to minimize the operational risks (West and Bhattacharya, 2016). We categorized these two related applications under a single application classification labeled: ***fraud and risk analytics*** (Fig 2).

The second important category of BDA applications is related to analyzing customer data, which has been referred to as ***customer analytics***. Banks have already realized how utilizing digital technologies could benefit customer acquisition, satisfaction and retention. Although banks' structured data are growing in size and scope on a daily basis, unstructured data can be a richer and more critical source for better understanding of the customer behavior (Sun et al., 2014), contributing to novel and enhanced insights about customers. Typically, banks use a sample of their structured internal data and a small portion of unstructured data to extract information and create insights that enhance customer experience (Vieira and Sehgal, 2018). Previous research also emphasized that less than 50 percent of banks analyze external unstructured customer data such as their social media activities or their online behavior (Coumaros et al., 2014). However, increasing competition mandates a strategic shift of focus from product-orientation to customer-centric and push banks toward the conclusion that customer should be the focal point of their operations, technology, systems, and data analysis. Even the banks' structure and organizing of activities need to be around customers and knowledge discovery should be all around this axis (Michael et al., 2017).

"Customer 360" or simply analyzing customer behavior from different perspectives is ranked as the 3rd important BDA application by experts in this study. According to the IDG report, 78% of companies believe that collecting and analyzing customers' big data make fundamental changes in their business operations over 1 to 3 years (IDG, 2016). A precise and fact-based

customer knowledge such as extracted knowledge from social media (He et al., 2019) enables banks in offering suitable products or services to the most valuable customers at the right time and with the right price. For example, analyzing data from different channels might reflect that customers prefer receiving banking services through high quality of omni-channel banking integration (Hamouda, 2019).

The other important BDA application is recognized as "customer segmentation". Recently, companies with good experience in marketing analytics have begun using advanced big data techniques, such as real-time micro-segmentation of customers, to better target their advertising and sales promotions (Manyika et al., 2011). BDA customer segmentation goes beyond traditional indicators such as age or marital status and classifies customers based on their lifestyle, life stage, behavior type, their interests in social networks, and special events. Precise customer segmentation results in not only higher customers' satisfaction but also improves pricing strategies (Shee et al., 2015). Furthermore, BDA-based customer segmentation can be used to identify loyal and profitable groups as well as clusters that would become more important in the near future.

"Decreasing customer churn" is placed in the 6th rank of importance in big data applications. It is estimated that around 50% of customers across the world have changed their banks or have shown signs of tendency to switch (Businesswire, 2018). Today customers depend on their needs, create short-term and loosely-coupled relations with several banks. Due to the high number of banks and financial institutions, customers' bargaining power has increased which in turn raises customers' expectations. Customers expect to receive responses in real-time and, at the same time, request products and services with full transparency. Thus, banks should have a closer relationship with their customers to retain them for a longer period of time (He et al., 2016). They need to anticipate customer requirements and actively promote their products' position. In fact, by analyzing various indicators and indexes, potential customer churn can be detected, before it gets too late. Big data solutions can effectively help banks to attract more customers, increase their loyalty, and reduce their churn (Prasad and Madhavi, 2012).

"Customer recommender system" enables banks to combine different data indicators, such as past transactions and interactions, demographic data, as well as customer sentiment analysis to provide best offers for cross-selling and upselling to their customers (Gonzalez- Carrasco, 2012). By enhancing customers relationship values, recommender systems increase customers' loyalty (Schafer et al., 2001), and satisfaction (Gallego et al., 2012), and improve their experiences, which finally leads to increased sales and profitability (Pathak et al., 2010). Therefore, this application is ranked as the 7th important one in this study.

For the last application in the customer analytics category, experts stated that "sentiment analysis" is an important BDA application for banks. BDA analyzes people opinions and feelings about products, services, organizations, brands, individuals, and events (Liu, 2012). Companies have learned to apply BDA, not only for automatic decision-making but for online monitoring of their environment (Davenport et al., 2012). Sentimental analysis usually takes place over a period of time to measure the success of a brand or its position against the competing brands (Goswami et al., 2013). Precisely analyzing emotions enables identifying influential customers, whereby targeting these customers, companies can quickly increase product awareness and their brand influence in the customers' mind and society (Neri et al., 2012).

We labeled the third category of BDA applications as *operational analytics*, consisting "designing new business models & offering new products and service" and "increasing efficiency and reducing costs" with ranks 5th and 8th respectively. In the dynamic financial

market, banks have two different options to improve their operations by applying BDA: a) accessing to new data sources and techniques that eventually leads to improved efficiency and effectiveness of the existing processes (Ghoshal et al, 2014), or b) using big data capabilities to innovate business model, deliver novel values to customers, enter new market segments, or develop novel services and products (Woerner and Wixom, 2015). To optimize their current operations, banks use BDA, but they continue to operate in the same way, just more efficiently and effectively. For example, they digitize some parts of their business model or use BDA for identifying and modifying less efficient sectors to create incremental improvements in their business models (Loebbesce and Picot, 2015). Likewise, banks can leverage BDA to innovate their business models that enable them to propose new values, target different customers, or interact with customers in different ways (Günther et al., 2017).

The results of Delphi study also disclosed six main drivers that stimulate banks to invest in big data initiatives as follow:

A) Panel participants asserted that the most important driver that motivates banks to use BDA is to *improve decision-making*. Mostly, accessing useful noiseless data is limited and costly or even data might not exist in an appropriate digital format (McAfee and Brynjolfsson, 2012). By explicitly modeling decisions and the logic behind them, business agility is sharply increased. Endowing with comprehensive analytical techniques, methods and standards for describing, modeling and managing decisions are essential for organization success (Baesens et al., 2016). BDA enables banks to make timely and fact-based decisions by providing useful data and real-time analysis.

B) To expand their market share and increase shareholders' profit, banks simultaneously need to attract new customers and retain their current customers. Delphi experts maintained that banks can employ BDA as a vehicle to achieve greater *customer intimacy*. To this aim, banks must focus on understanding and optimizing their clients' experiences to increase profitability (Schmitt, 2003). Although 80% of bank executors believe that they offer great services to their customers, only 8% of their customers agree with this statement (IBM, 2014). Filling such a great gap requires shifting the focus from product-centric to customer-centric; that is banks put their customers at the center of their operations. Smart banks use BDA to create a 360-degree view of their customers and seek to gather information regarding how their customers use various channels such as mobile banking, online banking, ATMs, physical branches or other channels (Wagle, 2014). More recently, some leading banks have succeeded in delivering seamless integrated multichannel experiences through real-time data collection and analysis. Customers can thus easily navigate from one channel to another without any problem in fulfilling their requests (Garg et al., 2017).

C) Most of the participants in Delphi rounds believe that BDA could be a *source of competitive advantage*. They commented that when banks realize one or more of the BDA drivers, they are more likely to act better than their competitors and consequently, gain competitive advantage. The leading banks know how to use big data to be different. They know how to create unique capabilities and behave differently from their competitors by collecting and analyzing transaction data along with market data, geospatial data, and social data (Bedeley and Iyer, 2014).

D) To prevent abusing big data resulting from electronic transactions and to create transparency and accuracy in financial records, regularities have expected banks not only

provide accurate and comprehensive reports but also give access to billions of raw data of their customers' records. Hence, banks must change their information systems, and in this way the main driver for applying BDA is *survival*. Investigating more than 50 financial institutions divulged that the main motivation for investing on credit risk analytics is not for gaining competitive advantage or creating added value, rather is the pressure imposed by regularities to embrace Basel guidelines (Moges et al., 2015).

E) Nowadays, big data is known as one of the factors that help companies *deliver new products and services*, or even as an empowering force or stimulus for creating new business models (Davenport et al., 2012; Davenport and Kudyba, 2016; McAfee and Brynjolfsson, 2012). Similarly, banks consider BDA as an opportunity to make fundamental changes to their business strategies (Bhimani, 2015), and a possibility to differentiate their value proposition. It is predicted that big data as a game-changer would jeopardize traditional dominant actors and force them to struggle for keeping themselves in the process of market change, especially in the Internet financial domain (Yan et al., 2015).

F) Panel experts in accordance with literature believe that one of the motivations in implementing BDA is to *achieve operational excellence* (Chae et al., 2014). Monitoring and evaluating organizational processes in real-time, optimizing supply chain flows, determining optimal prices for products and services, improving customer services, and reducing quality problems and mistakes are among the results attained by well-deployed BDA (Davenport et al., 2012; Chen et al., 2012; Giannakis, and Louis, 2016; McAfee and Brynjolfsson, 2012; Kiron et al., 2014).

In addition, this study identifies the main challenges that impede successfully implementing BDA in banks. BDA challenges can be considered in three broad categories: data-related challenges, organizational challenges, and technological challenges (see Fig 2).

Panel experts introduced several *data-related challenges*, including information silos, security, privacy, poor data quality, and lack of operational/strategic data sharing between units. Data compatibility issue is one of the major problems in collecting and processing big data. According to Capgemini (2014), 57% of bank executives considered their multiple information silos as the biggest obstacle for integrating data and big data success (Coumaros et al., 2014). Data lake is a special solution to overcome information silos by bringing the entire bank's data under one roof to access, analyze, and put to use without any restrictions (Hai et al, 2016). Exploiting customer data always raises privacy issues. Issues related to data ownership and the extent to which banks are allowed to use this data to identify different aspects of customers are controversial subjects. By discovering hidden connections between seemingly irrelevant data sectors, BDA reveals sensitive personal information. Research shows that many bank managers are cautious about using BDA due to the privacy issue (Coumaros, et. al., 2014). Although data quality concern is not a new issue, the huge volume of generated data, the fast velocity of arriving data, and the large variety of heterogeneous data from different sources increase its importance (Saha and Srivastava, 2014).

Lack of technical and skilled workforce, high implementation cost and lack of top management support are amongst the most important *organizational challenges* that

could prevent realizing BDA capacities in banks. Given that BDA is in its nascent stage, one of the factors that constraints its usage is the shortage of skilled professionals, especially in the field of machine learning and statistics (Kshetri, 2014; Katal et al., 2013). Panel experts maintain that the presence of business analysts and bank managers with critical insights and analytical competence is also crucial to fully utilize BDA. Lack of data culture is another major obstacle for using big data in banks (Audzeyeva and Hudson, 2016) because most middle managers of banks are against sharing data and strongly dependent on the intuition derived from their past experiences and common practices (Galbraith, 2014; McAfee and Brynjolfsson, 2012). Although culture may not change overnight (Barton and Court, 2010), but bank executives need to understand the importance of data-oriented mindset and data-driven decision-making for creating value from BDA.

Finally, several issues are categorized under *technological challenges*. Although the technologies required for handling large volumes of data, high growth velocity, and high data variety have become available in recent years (McAfee and Brynjolfsson, 2012), our participants argue that many failures of big data projects are owed to the difference between the financial industry business needs and BDA capabilities. Applying BDA in banks is largely dependent on the analysis of data flows in real-time, yet a vast majority of big data technologies function based on the offline batch process analytics. However, recent technology advancement, such as Apache Spark engine, has largely addressed this problem. Another challenge is the banks' dependency on their legacy systems. Panel experts stated that BDA requires its own infrastructures compatible with required applications, whereas banks have invested a lot on their legacy systems. Bank managers thus are concerned about adopting BDA as they cannot easily set aside their current systems or ignore the huge amounts of money they have already invested.

### 5.1 Theoretical Contribution

This study extends the big data literature by exploring and examining BDA applications, drivers and challenges in the banking industry. Through the four-round Delphi study, we provided an overarching portrait of BDA in banks. Our study contributed to the literature in three ways. First, by gathering domain experts' knowledge and synthesizing their viewpoints we identified nine main applications, six important drivers and 18 significant challenges of BDA in the banking industry. Second, this study uncovers the agreed importance of each item from the experts' standpoint. Finally, we followed a Delphi process to integrate both practitioners and academics judgments in a single framework, while maintaining the reliability and validity of process and findings. Fig 2 represents the ranked items from different categories across three dimensions: big data applications, drivers and challenges. The drivers' arrows sizing is in accordance with their rank from panelists' viewpoint. BDA applications are presented in three identical categories including fraud & risk analytics, customer analytics and operation analytics, with the agreed ranks indicated by numbers in front of each application. Finally, the challenges banks are facing in deploying BDA are listed in three categories including data-related, organizational and technological, with their final ranks from panelists' point of view.
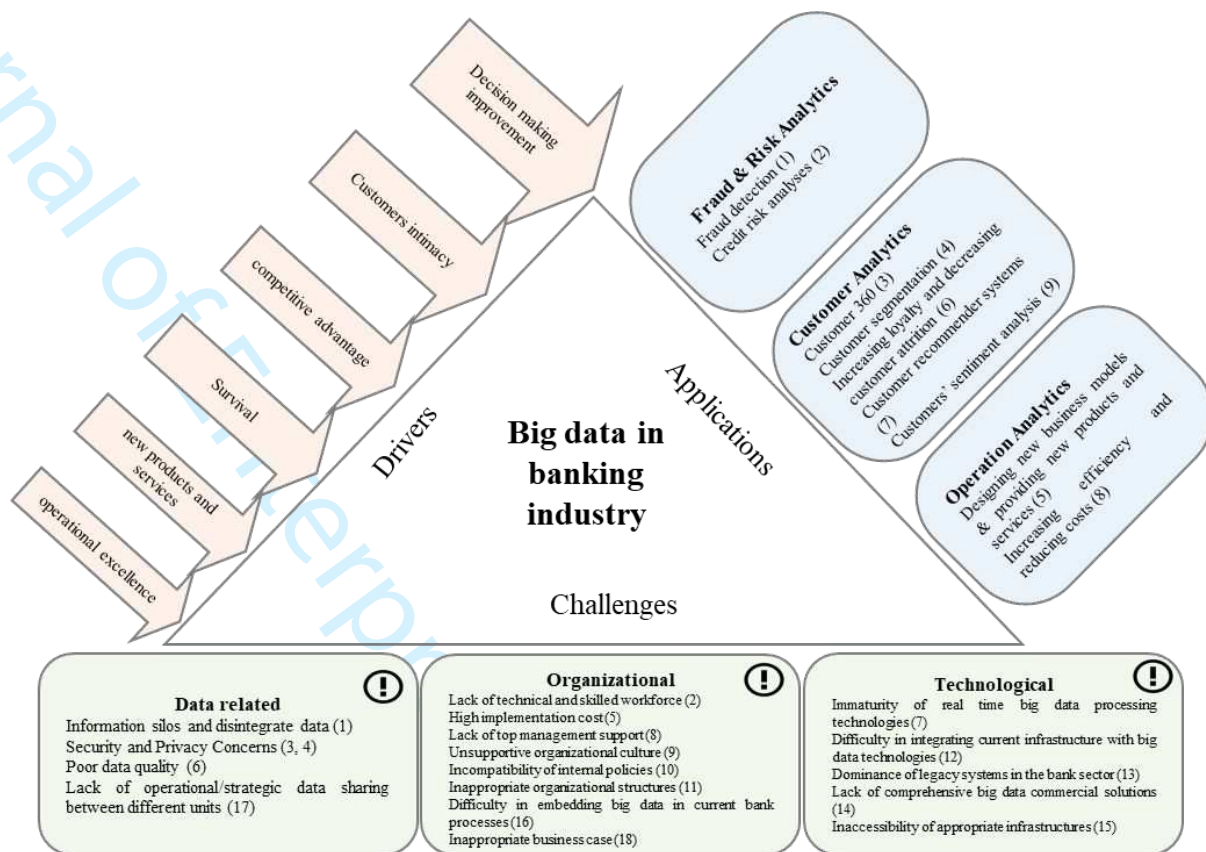
**Fig 2: Big data applications, drivers and challenges in banking industry**

## 5.2 Managerial Implications

The pragmatic insights into a comprehensive and relevant list of applications, drivers and challenges of BDA would guide banking practitioners toward gaining value from BDA. The themes emerging from Delphi study and the consensus that has been achieved reflect key drivers motivate BDA, its main applications, and finally, the main challenges impede BDA implementation. Often, firms view and tackle BDA as a pure IT departmental issue, but our findings highlight that BDA is far from just a technical issue. Our results pinpoint that banks need to strategically think about the main reasons for investing in this technology. Based on our findings, the most important reason for banks to invest in BDA is improving decision-making. However, creating valuable insight is not obtained just by mechanical applications of analytical tools in big data (Sharma et al., 2014). A recent study by the McKinsey and Company (2018), conducted in more than 20 European, Middle East, and African banks, shows that many banks need to align their analytical priorities with business goals and embed analytics in their decision-making processes and business workflows (Fernandez et al., 2018). Furthermore, providing new products and services and creating strong relationships with the customers are other salient drivers for using BDA.

Our findings show that banks should consider potential BDA applications to take benefit from massive amounts of internal and external data. Proper applications in different categories (risk and fraud, customer or operational analytics) can be selected to help banks in achieving their objectives. The results indicate that applying BDA for fraud

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detection, modeling and managing risks, 360-degree customer, designing new business models, and providing new services and products have higher priority for banks. The analysis of customers' sentiment, reducing their churn, offering complementary and alternative products, increasing efficiency, and customer segmentation are other important applications of big data in the banking industry.

Moreover, understanding the main BDA challenges help banks' managers to prepare the foundations for deploying a successful BDA. Gaining strategic value from BDA necessitates the provision of appropriate technical infrastructures. The information silos and unintegrated data, besides the lack of skilled experts in the big data domain are the two major obstacles of deploying BDA in banks. Privacy, security, and data quality issues, the costly implementation, and real-time processing technologies limitations are other significant challenges that hinder effective implementation of BDA in the banking industry. Furthermore, the BDA journey is impossible without the top management awareness, support, and their commitment.

## 6. Conclusion

Many scholars stress that big data is a new yet powerful source of competitive advantage. Banks, similar to other businesses, consider this source as the new oil – a weapon that will differentiate the winners from the losers (McIntyre, 2018). We conducted a Delphi study to synthesis the frame of knowledge from expert domain viewpoint about essential applications, drivers and challenges of applying BDA in the banking industry. Compared to surveys or case studies, this study benefits from a method that does not constrain the results to a fixed set of experience and represents a wider perspective. Hence, we used open questions as a starting point to compile as much as possible set of items.

While recently some pioneer banks have started to use BDA or implemented some of it specific applications such as customer analysis, market monitoring and risk modeling, there is still a huge capacity in this market to utilize big financial data and create business value. Through analyzing BDA applications, drivers and challenges, this research has provided a better understanding of how banks can leverage BDA as a mean of transforming their businesses to generate higher business value. Based on our results, banks can boost their business value through BDA applications on risk and fraud detection, enhancing customer experience or improving internal operations.

The main limitation of this study is using the Delphi technique that reflects the involved respondents' knowledge about the subject. However, the rich data resulting from our analysis in combination with the Delphi ranking provide a conceptual framework for future research and contribute toward the literature. We also explained the research process to ensure the validity and reliability of the study, and the results are justified with extant literature in the discussion segment. As our study was concentrated on the banking industry, researchers can investigate similar questions in other data-intensive industries such as healthcare, tourism, and insurance. Developing a roadmap that encompasses various organizational, managerial and technical aspects of implementing the BDA could be a future research. Since number of banks have implemented some specific BDA solutions, examining the results of these initiatives and identifying the factors affecting the success of using BDA and scrutinizing the rewarding business outcomes can be suitable for further studies. Researchers also can consider evaluating the interrelationships between the explored items in each category. Quantification of the BDA applications, drivers and challenges, by carefully adopting system dynamics, fuzzy analytical hierarchy process (FAHP) or fuzzy analytical process (FANP) is recommended. Furthermore,

statistical analysis of the effects of identified elements on BDA can be a fruitful study in the future.

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