

Impact of Big Data Technologies on Value Creation

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Abstract—This paper identifies and describes five types of value creation enabled by Big Data technologies. This was determined after performing a qualitative content analysis of publications from industry and academics. The five types are: (1) Optimization of Operations, (2) Enrichment of Operations, (3) Enhancement of Customer Experience, (4) Innovation of Business Model, (5) Creation of Knowledge and Insights. This differentiated perspective of Big Data-based value creation provides practitioners a better basis for decision-making where to focus investments in Big Data technologies. Furthermore, this paper contributes to the academic community and provides the impetus for the comprehensive analysis of Big Data-based value creation.

Keywords- Big Data technologies, Data-driven Business Model, Value Creation

I. INTRODUCTION

Globalization and increased competition forces organizations to constantly innovate and reduce costs to remain globally successful in competition. Emerging technologies, such as Big Data technologies, create new opportunities for organizations to optimize business processes or to generate new growth opportunities. Empirical studies have shown that the use of Big Data technologies affects profitability and the competitiveness of firms significantly [1], [2]. Consequently, the exploitation of Big Data sources is becoming a key way for organizations to outperform their competition [3]. Big Data has the potential to fulfill a paradigm shift from a product-centric to a more and more data-centric business model, which means that a substantial amount of revenue is generated through data-related services. Many use cases were published by vendors and research firms to underpin the importance of Big Data technologies with regard to value creation. However, the questions how exactly Big Data generate new sources of value is still unanswered both in academic and industry publications. Several management research scholars have consequently encouraged to investigate if and how Big Data generate new sources of value [4], [5]. This paper address this research gap and identifies and describes different types of Big Data-based value creation by conducting a qualitative content analysis of industry and academic publications. Building on these thoughts

we propose the following research question: *What types of Big Data-based value creation exists and how is value creation measured?* The identification of different types of value creation provide practitioners a better basis for decision making, especially where to focus initial investments in Big Data technologies. Furthermore, the systematization of Big Data-based value creation forms the basis for future research, since each type of value creation may require different management approaches. This paper is structured as follows. Section 2 focuses on the theoretical background, section 3 introduces the methods being used and section 4 presents the results. Finally, section 5 concludes with a summary and outlook.

II. THEORETICAL BACKGROUND

The term Big Data was first mentioned in a scientific publication in the 1970s, but has come in the focus of interest in the mid-2000 [6]. There exists several definitions of Big Data, however a widely accepted definition is the 3V model by Gartner [7] defining Big Data by its three characteristics:

- High-Volume of data
- High-Variety of data
- High-Velocity of data

This problem-centric definition however lacks a clear distinction between high and low values for the three dimension [5]. Moreover, several authors have proposed further dimensions, such as veracity or value [8]. Veracity refer to the reliability and uncertainty of data which is partly due to issues with data quality. The value dimension of Big Data refers to the information asset, implying that Big Data lends value to the organization [5]. Dapp and Heine [9, p. 6] for instance state that “Big Data can become a factor in production and competitiveness that will open up new possibilities for value creation”.

Traditional database systems based on relational databases have reached their performance limits for the processing of Big Data. A new data management approach, generally referred to as NoSQL (not only SQL), has been introduced for being able to efficiently process Big Data. So called NoSQL databases,

such as HDFS, Casandra or MongoDB, are commonly associated with Big Data technologies [10]. The underlying principle of these databases is to divide data that are too big to fit into a computer’s main memory. These data sets are then divided into small subsets and processed concurrently. This approach is commonly known as MapReduce and is the basis to achieve the fast processing of Big Data [11]. The ability to efficiently process large amount of unstructured and semi-structured data has created the opportunity to integrate more internal and external data into business process that were previously not exploited due to lack of technological possibilities.

Value creation is a broadly discussed concept in business literature and there is still no agreement among scholars what value creation is and the process by which value is created [12]. The traditional view of value creation refers to the profit (revenue minus cost) that an organization captures during a certain financial period. In corporate finance for instance, value creation could be determined by the Economic Value Added (EVA). This economic measurement equals the net operating profit of a firm minus its weighted average costs of capital.

The concept of value creation experienced a renaissance with the elaborations of Porter [13] in his book *Competitive Advantage*. Porter [13, p. 38] defines the ultimate value a company creates by the “amount buyers are willing to pay for its product or service”. From this follows that the economic value does not equal the market price for a certain price or product nor the profit of an organization.

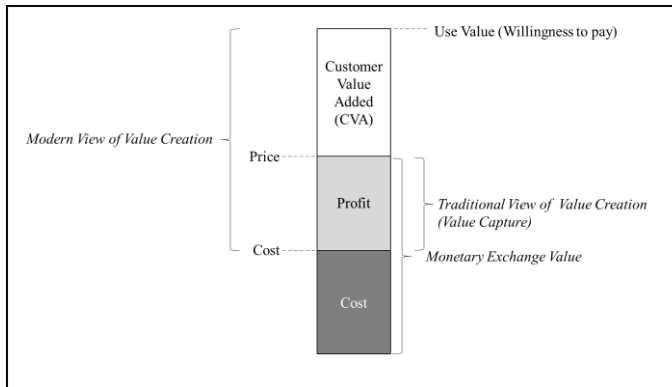


Figure 1. Exemplary Illustration of Value Creation

The traditional view refers to value creation from an organization’s perspective and is thus the profit or the value that an organization is able to capture from the monetary exchange value (Figure 1). The modern view refers to value creation from a consumer’s stance [14]. The consumer’s use value refers to the subjectively perceived value due to the specific qualities of the product [15]. This implies that a company may create more value with its products and services than it charges its customers for it. Colloquially, this customer value added is also referred to as good value for money by consumers. Porter further adds that a firm is competitive when it either perform value activities more efficiently (lower costs) or in a unique way that justify higher prices (differentiation). The

difficulty in the concept of value creation lies with the several levels of analysis or sources of value creation (e.g. individuals, organizations, society) that are often not clearly stated by authors; furthermore another difficulty is that value creation refers both to the content and process of new value creation [12]. The process perspective investigates how value is generated, whereas the content perspective focuses on the question where value resides. Several theoretical frameworks, such as value chain analysis (cost efficiency or differentiation as source of value creation) [16], transaction cost economics (transaction efficiency as source of value creation) [17] or Schumpetrian innovation theory (innovation as source of value creation) [18] have been suggested to explain and determine sources of value creation. In publications by practitioners, value creation have often been measured by (1) competitive advantage, (2) increased customer loyalty, (3) increased revenue or (4) economically viable environmental benefits [19]. In this paper, we define value creation from an organization’s economic perspective. Thus, value is either created through cost efficiencies within the organization and/or through additional revenue streams. For a comprehensive analysis we also consider indirect effects of value creation on profit. A higher use value for instance may prevent consumers from switching to competitors and thus sustain an organization’s revenue stream.

III. DATA COLLECTION AND ANALYTICAL APPROACH

Publications were collected based on a systematic literature search of literature content (Table I). We included both publications from practitioners and scholars. Our further review, however, excluded publications with a strong advertising character.

TABLE I. OVERVIEW OF SYSTEMATIC LITERATURE SEARCH

Step	Description
Step 1	Screening of relevant academic and practical literature to identify appropriate search terms: Big Data, Big Data and Value Creation, Data-based value creation, Business Model Innovation and Big Data, Big Data use cases
Step 2	Data collection by keyword search in EBSCOhost Business Source Complete, Google Scholar, IEEE Xplore and WWW: Over 55,000 publications
Step 3	Limiters in title, keywords, abstract to identify relevant publications: 54 relevant publications/ White Papers
Step 4	Full text screening of relevant publications and selection of final publications: 32 publications reviewed

For the analysis of the material we conducted a qualitative content analysis using the software tool MAXQDA 11. Content analysis is a method for the analysis of written or verbal communication with the purpose to make replicable and interferences from texts [20]. Several techniques and frameworks have been suggested for the rigorous analysis of large data sets to identify pattern and themes. This study uses the procedure proposed by Mayring [21] using an inductive category development approach (see Figure 2).

In the first step, we specify the unit of analysis. Choosing a smaller unit of analysis (e.g. words or sentences) usually impacts reliability positively and support automated analysis of

data, however sentence-spanning ideas cannot be captured [22]. Therefore, we chose the ‘theme’ as suggested by Kassirjian [23] as unit of analysis and only coded one category within one sentence to stabilize reliability measures.

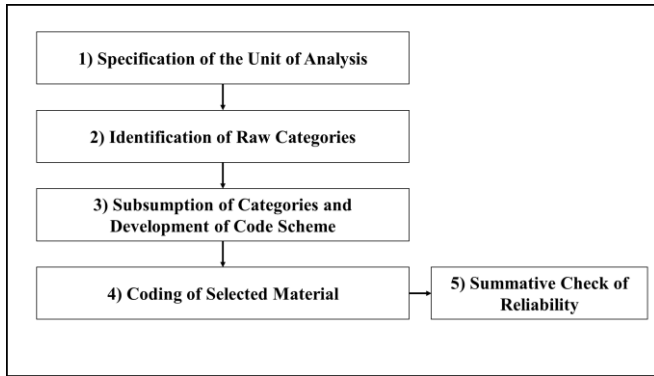


Figure 2. Content Analysis based on Mayring [21]

In the second step, coder 1 reviewed the material and inductively derived raw categories from the material. Raw categories were built if insights are found in the reviewed publication with regard to value creation. Specifically, we focused on how value creation is measured (value creating attributes) and what types of value creation exist. In the third step, similar raw categories were clustered to similar types. For instance the raw category ‘optimization of marketing processes’ and the category ‘optimization of sales processes’ were merged to the category ‘optimization of operations’. In the next step, a coding scheme was derived with a clear definition for every category (including anchor example). In the fourth step coder 1 has coded the material on basis of the coding scheme. After that process, coder 2 has independently coded the material and intercoder reliability lies above the recommended threshold (intercoder reliability > 0.85). After final working through the material, we identified five main types of value creation with three value creating attributes. Value creating attributes are measurements (e.g. cost reduction) to determine and quantify value creation. We use the term value creation types for similar clusters in the material.

IV. RESULTS

The qualitative content analysis has revealed five types of value creation based on Big Data technologies: Type 1 Optimization of Operations, Type 2 Enrichment of Operations, Type 3 Enhancement of Customer Experience, Type 4 Innovation of Business Model, Type 5 Creation of Knowledge and Insights (Table III).

TABLE II. MEASUREMENT OF BIG DATA-BASED VALUE CREATION

Value Creating Attributes	Summary
Lower costs	Big Data applications reduce cost
Higher revenue	Big Data applications generate additional revenue
Higher customer loyalty	Big Data applications increase the loyalty of customers

In the publications reviewed, practitioners have used the value creating attributes lower costs, higher revenue and higher customer loyalty to measure the value-added of investments in Big Data technologies (Table II).

TABLE III. TYPES OF BIG DATA-BASED VALUE CREATION

Type	Summary
1 Optimization of Operations	Focus on the optimization of business processes
2 Enrichment of Operations	Focus on the expansion of existing businesses
3 Enhancement of Customer Experience	Focus on the improvement of customer use value
4 Innovation of Business Models	Focus on the development of new business opportunities
5 Creation of Knowledge and Insights	Focus on the creation of insights for tactic and strategic decisions

The following section describes each type:

Type 1 Optimization of Operations: Big Data technologies are used to optimize parts of existing business processes to increase resource efficiency. New algorithms and database systems enable innovative use cases. This includes, but is not limited to:

- Algorithmic trading
- Automated product pricing based on current buying patterns
- Distribution and inventory optimization
- Optimization of resource allocation and scheduling

Many different use cases have been presented in the examined material to optimize existing operations. For example, telecommunication providers use predictive analytics to anticipate network utilization ahead of the demand curve to optimize resource allocation in the network [24]. However, use cases are not limited to a certain industry or activity within the organization. Rather, optimization of operations can be applied to almost every activity within the organization (logistics, marketing, production etc.).

Over 70 % of the analyzed publications have measured this type of value creation by reduced costs. Figure 3 illustrates how lower costs may impact an organization’s value creation. In scenario A1 both the customer and the organization benefit from reduced cost, because the price is lowered. Thus, both profit and customer value added (CVA) is increased. The CVA is the difference between the willingness to pay (perceived use value) and the actual price. In scenario A2 the reduced costs are not passed onto consumers and consequently only the organization benefits from optimized operations. In the third scenario the cost benefits are completely passed onto clients.

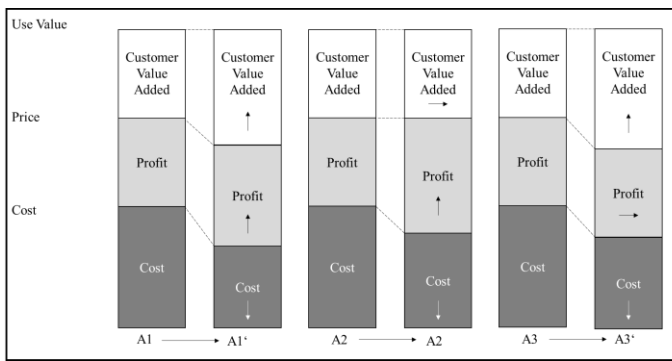


Figure 3. Optimization of Operations

Type 2 Enrichment of Operations: Big Data technologies are used to leverage additional revenue streams from existing operations [25]. This includes, but is not limited to:

- Sale of customer/product/marketing data to other organizations
- Additional services based on available data (e.g. log data)

A representative example of this type of value creation, is the service TomTom Live which uses the movement data of TomTom’s navigation devices. Customers can buy an additional service to get real-time information about traffic and construction sites.

Figure 4 illustrates how enriched operations impact value creation. In scenario B1 the sales of data to external parties lead to additional revenue streams and consequently additional profit. This is also referred to as monetization of data by many authors [25]. Scenario B2 illustrates how an additional service for an existing offer may impact both profit and customer value added.

Over 70 % of publications reviewed have measured this type of value creation by additional revenue streams. Some authors have pointed out the increased customer loyalty due to the innovative and unique offer.

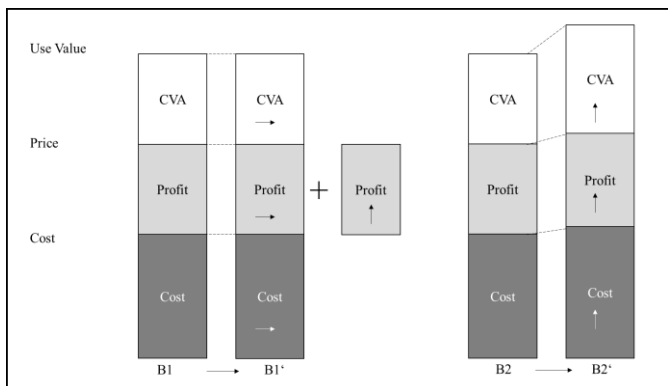


Figure 4. Enrichment of Operations

Type 3 Enhancement of Customer Experience: Due to increased competition, firms are forced to differentiate their products from competitors to prevent customers from

switching over to them. Big Data technologies can be used to increase customer value, more specifically the subjectively perceived use value by embedding analytical features in products. Manufacturers for instance have built cars that analyze driving behaviors and patterns and automatically suggest optimal routes. Furthermore, Big Data analytics can be used to differentiate and personalize services. This includes, but is not limited to:

- Personalization based on customer behaviors
- Personalization based on social media
- Personalization based on ancillary sales
- Personalization based on location
- Personalization based on schedule disruptions

Davenport [26, p. 17] has illustrated some examples for the above mentioned use cases. Automated messages like “We are sorry we missed you this week on the Dallas-Chicago flight after twelve straight weeks of enjoying your company” or “We are sorry to observe that you are likely to miss your flight. Would you like a seat in first class on the next one at 3:15 PM?” contribute to a unique and personalized service offer [26].

This enhanced customer experience increase the use value for a certain product or service (Figure 5). As illustrated in scenario C2, an organization can only capture the created value in terms of profit if competitors do not offer a similar or even better value proposition. Nevertheless, the increased customer experience prevent consumers from switching to competitors and thus indirectly impact profit through sustained revenues.

Over 70% of publications reviewed have measured this type of value creation by increased customer loyalty. However, over 50 % of publications have also mentioned additional revenue streams as advantage.

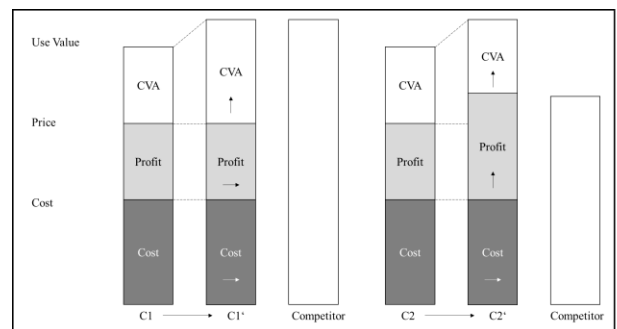


Figure 5. Enhancement of Customer Experience

Type 4 Innovation of Business Model: Big Data technologies can be used to either transform existing business models or to create completely new (data-centric) business model based on Big Data. Although type 4 and type 2 have some commonalities, they differ in terms of their degree of value creation. The value proposition of a data-centric business model is fundamentally based on data which also requires to develop new business activities. Metaphorically speaking, the data has become the actual product. An example can be drawn

from the telecommunication industry. The telecommunication provider Telefónica for instance uses anonymized, aggregated network data for its service SmartSteps which is sold to retailers and market researchers for the tracking of people [27]. Additionally, Telefónica has launched a new, global business division outside its core business for the exploitation of new business opportunities based on Big Data.

Scenario D1 (Figure 6) illustrates this type of value creation; the development of a new business usually requires investments and consequently rise costs. However, additional revenue streams are generated and thus profit is realized as soon revenue exceeds the cost.

Over 70 % of publications reviewed have quantified the advantages of this type of value creation by additional revenues. Roughly 30% of reviewed publications have mentioned increased customer loyalty as an advantage.

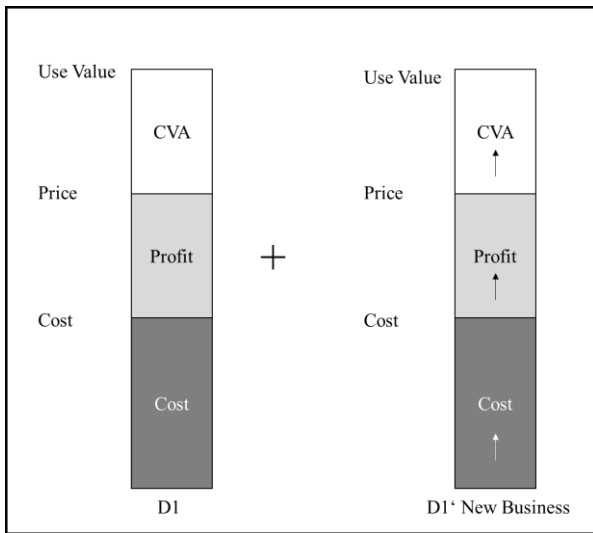


Figure 6. Innovation of Business Model

Type 5 Creation of Knowledge and Insights: Big Data technologies are used to provide more accurate information and insights to decision makers for strategic and tactical decisions. Big Data analytics enable business users to uncover new insights for the adaption of an organization’s business strategy by asking key business questions [28]. This includes, but is not limited to:

- Who are my most valuable customers?
- What are my most important products?
- What are my most successful campaigns?

Furthermore, new data sets and analytical approaches allow a differentiated analysis for management. The most valuable customer for example has traditionally been calculated by the customer with the highest revenue. However, the most valuable customer could also be determined by taking the social network of customers into account. A consumer in a central position of a social network may influence the buying decisions of many others and consequently should deserve a firm’s full attention.

Many publications have emphasized the positive effect of Big Data analytics on decision making, however, most of them are concerned with the (automated) optimization of operational decision (Type 1). Although only a few papers have distinguished between operational and strategic decisions and its implications on value creation, we have kept it as a separate dimension since the value creating attributes differ and are hard to quantify. Operational decision-making usually directly impacts costs and consequently deliver a positive, measurable value to the firm. On the contrary, the measurement of value creation from new knowledge and insights is complex since it only impacts profitability with a certain time-lag.

Table IV summarize the value creating attributes and its mapping to the identified types of value creation. Value creating attributes are measures of value creation that have been used in the articles to determine the added value of investments in Big Data technologies. Except from type 4 (creation of knowledge), every type has at least one predominant value creating attribute. Type 1 (optimization of operations) focuses on the reduction of costs. Type 2 (enrichment of operations) and type 5 (innovation of business model) predominantly focuses on the exploitation of additional revenue streams. Type 3 focuses on the enhancement of customer loyalty. Type 4 only indirectly effects the value creating attributes, since there often is a big time lag between creation of knowledge and its usage in business processes and strategy.

TABLE IV. MAPPING OF VALUE CREATION ATTRIBUTE TO TYPES

Value Creating Attributes	Types				
	Optimization of Operations (1)	Enrichment of Operations (2)	Enhancement of Customer Experience (3)	Innovation of Business Models (4)	Creation of Knowledge and Insights (5)
Cost (-)	●	○	○	○	●
Revenue (+)	○	●	●	●	●
Customer Loyalty (+)	○	●	●	●	●

- Over 70 %
- Between 10 % and 70 %
- Less than 10 %

V. SUMMARY AND FUTURE RESEARCH

Many practitioners and research firms have published whitepapers that analyze the potential of Big Data technologies. We have derived five main types of Big Data-based value creation: (1) Optimization of Operations, (2) Enrichment of Operations, (3) Enhancement of Customer Experience, (4) Innovation of Business Model, (5) Creation of Knowledge and Insights. The publications reviewed have measured value creation based on reduced costs, higher revenue streams or increased customer loyalty. From a firm’s perspective and traditional value creation research, Type 1, Type 2 and Type 4 represent value creation in a narrower sense, since they have a direct impact on an organization’s

profit. In a broader sense, the enhancement of customer experience contributes to an organization's value creation, as it increases the subjectively perceived use value due to a unique experience and may lower the rate of customer fluctuation. The exploitation of created knowledge and insights is an exceptional type of value creation, since created knowledge is intangible whereas insights only create a monetary value when used in business processes.

Empirical studies have shown that the majority of firms start their first Big Data initiatives with the optimization of their operations, because relevant business questions are known and improved efficiency can easily be measured [29][30]. The enrichment of operations, however, is more complex and require many skill sets. The innovation and transformation of business models is probably the most supreme type of value creation and mainly data- and analytic-driven organizations have been able to successfully align their business model using Big Data. Consequently, organizations that have little or no experience with regard to Big Data technologies should start with small projects and focus on Type 1 (Optimization of Operations). Organizations with analytical experience should consider to leverage the skills to extent existing business (Type 2) or even develop new business opportunities (Type 4).

Many factors influence the ability of organizations to successfully create and capture value with Big Data technologies. In a highly competitive environment for instance, it might be possible that an organization may not be able to charge its customers for Big Data-based services. Furthermore, many internal factors, such as management support, capabilities etc. influence the successful exploitation of Big Data [25]. However, very little research has been conducted so far to determine the key success factors of Big Data implementations.

This research paper has laid the foundations for future research. Future research should for example determine the success factors and drivers of value creation for each type of value creation. It is very important to distinguish between the different types of value creation, since it can be assumed that success factors differ between the different value creation types.

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