Big Data Analytics and Product-Service System – Advance and Accelerate Implementation

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Abstract

Digital transformation with its emerging rich data pools as well as developments like cyber-physical systems and the Internet of Things, are presenting opportunities for business model and product-service system (PSS) innovations from Big Data Analytics (BDA). For this qualitative research, semi-structured interviews with 16 top-level managers were conducted, testing existing theoretical linkages, while gaining additional insight. This research we demonstrate that not only PSS innovation is driven by BDA, but that Big Data itself can be the product of the new models, this way creating a feedback loop for continuous innovation in the company.

Keywords: Big Data Analytics, Product-Service System, Supply Chain Management

Introduction

The amount of data sensed, created and communicated, by and about individuals, things and their interactions. is constantly increasing (Boyd and Crawford, 2012; Manyika et al., 2011). The combination of data science, predictive analytics and Big Data presents opportunities that possess great the potential for supply chain design and management (Waller and Fawcett, 2013). ‚Big Data Analytics can drive new business model as well as product innovation in companies, promising higher performance, faster decision making and competitive advantage (Laney, 2001; Manyika et al., 2011).

Product-service systems bringing companies closer to their customer and are creating a competitive advantage for the company innovating. Independently, from if they area product, use or result orientated, does the inclusion of service components allow for new insight in the customers' use of the product, the value of product characteristics and customers' operating environment in general. To collect, analyse and apply this newly created data has the potential to drive another loop of innovation for the company. (Roy et al., 2009)

By connecting opportunities from BDA to characteristics of PSS, followed by an assessment of thru engaging practitioners, we are pursuing the research questions:

- **How can the adoption of Big Data Analytics advance and accelerate the implementation of Product-Service System?**

A series of semi-structured expert interviews was conducted. 16 top-level managers from different industries were interviewed. The aspects raised in the interviews were analysed using qualitative content analysis and set in the context to drivers for competitive advantage from both, PSS and BDA found within the existing research.

Current Research

Big Data Analytics consists of two distinct technical concepts of Big Data and predictive Analytics (Waller and Fawcett, 2013). Big Data, as one part of Big Data Analytics, is often characterised by an increase in volume, a broad variety of this data and the velocity of the generation of data, which are commonly referred to as the three Vs.

While Data is an important ingredient, performance improvements and competitive advantage are the result of analytics. Therefore, "Advanced analytics is likely to become a decisive competitive asset in many industries and a core element in companies' efforts to improve performance." (Barton and Court, 2012). Analytics seeks to transform data from "patterns with no meaning" into Information as "data with meaning" (Aamodt and Nygård, 1995). The SAS Institute Inc has defined Big Data Analytics as "[…[the process of examining big data to uncover hidden patterns, unknown correlations and other useful information that can be used to make better decisions.", which provides an argument for adding "veracity" and "value" to the lists of Big Data Analytics' Vs . (Fosso Wamba et al., 2015)

Veracity is referring to data consistency and trustworthiness of the predictions. Trustworthiness requires confidence in data origin, methods of collection and processing, as well as security measures protecting the data and infrastructure. Additionally to the more technical aspects the quality of Big Data Analytics, Mai (2013), argued that "information quality is context-dependent, and can only be assessed and understood from within specific situations and circumstances".

Value links to the benefit that can be achieved through the exploitation of the obtained information. Big Data Analytics in the supply chain can improve the chain's efficiency, enable customer segmentation as well as vendor-managed inventory to optimize the supply chain (Manyika et al. 2011). The adaption of predictive analysis of Big Data is positively related to a firm's operational and supply chain performance and information technology enables sharing capacities which increase the supply chain's flexibility and competitive performance." (Jin et al., 2014; Gunasekaran et al., 2016). Similar Wu et al. (2006) argue that sophisticated information technology has the potential to facilitate the development of unique, difficult to replicate capabilities, which are able to lead to competitive advantage. Besides performance improvements in the company or supply chain, companies may gain competitive advantage from the captured Big Data through sale of the data or insight directly. Additionally, combining Big Data Analytics with servitization of new or existing product-service systems can result in increased competitiveness (Opresnik and Taisch, 2015). Ultimately, "The ability to manage and exploit knowl-edge will be the main source of competitive advantage for the manufacturing industry of the future" (Berawi and Woodhead, 2005).

Kache and Seuring (2017) stated that the highest impact of big data analytics might be within the area of innovation and product design. They noted that the use of data from sources such as point of sale, sensors or customers and suppliers cannot only drive product or process innovation but also become products themselves. Furthermore, can the access to new data sources and new insights, acquired through the application of Big Data Analytics, enable companies to develop new business opportunities. Competitive advantage can be gained through the creation of new business models driven by this availability of previously unavailable knowledge (Kache and Seuring, 2017).

Similar to Big Data Analytics, have product-service systems (PSS), as systems of products, services, supporting networks and infrastructure, aiming to satisfy customer needs, the potential to increase competitiveness as well as environmental sustainability, above the level which traditional, product- or service-only, business models can achieve.

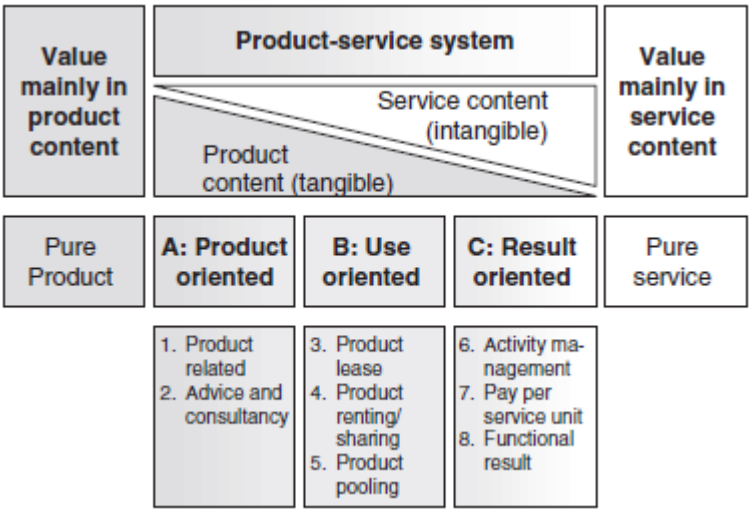

Figure 1 - Main and subcategories of PSS (Tukker, 2004)

PSS can be grouped in three main categories. Product orientated PSS add services to an existing product. Models are focussed on products sales, with additional services like maintenance contracts or consultancy services added. While the service component has the potential of creating a higher profit margin, the closer interaction with the customers, allows the gathering data of the product in the use scenario, mainly relating to its durability and functionality. Furthermore, can valuable information regarding the customers operations be gathered. (Roy et al., 2009)

Secondly, use orientated PSS often intensify the use of the products., through sharing or pooling models, inseparably combine product and service. These models have been evaluated regarding their economic value in terms of customer value, costs and risk premium,, capital needs as well as value chain and client relations issues. (Tukker, 2004; Opresnik and Taisch, 2015). In the use orientated model information about customer habits, working modes and product deterioration and failures, can be collected and trigger ongoing improvements of product and service (Roy et al., 2009).

Result orientated systems are promising customers unit or outcome-based charging models, often without the application of specific products. The result-oriented model implies that the supplier has a better knowledge of how to use maintain the PSS in the most efficient way Taking over the responsibility for uncertainties that cannot be controlled by the provider will lead to high risk premiums being included in the price of the PSS. However, being in full control of the processes relating to the PSS allows the provider to gather and analyse comprehensive sets of information enabling a high speed of innovation and better comprehension of uncertainties.(Roy et al., 2009; Tukker, 2004)

The loop between Big Data Analytics and servitization is shown in Figure 2. Selling raw data or insight does not necessarily break the loop as the data could still be applied to internal product-service models as well. Furthermore, the newly exploited information does not require to flow into the originating product-service system but can be applied in different existing or newly created models.

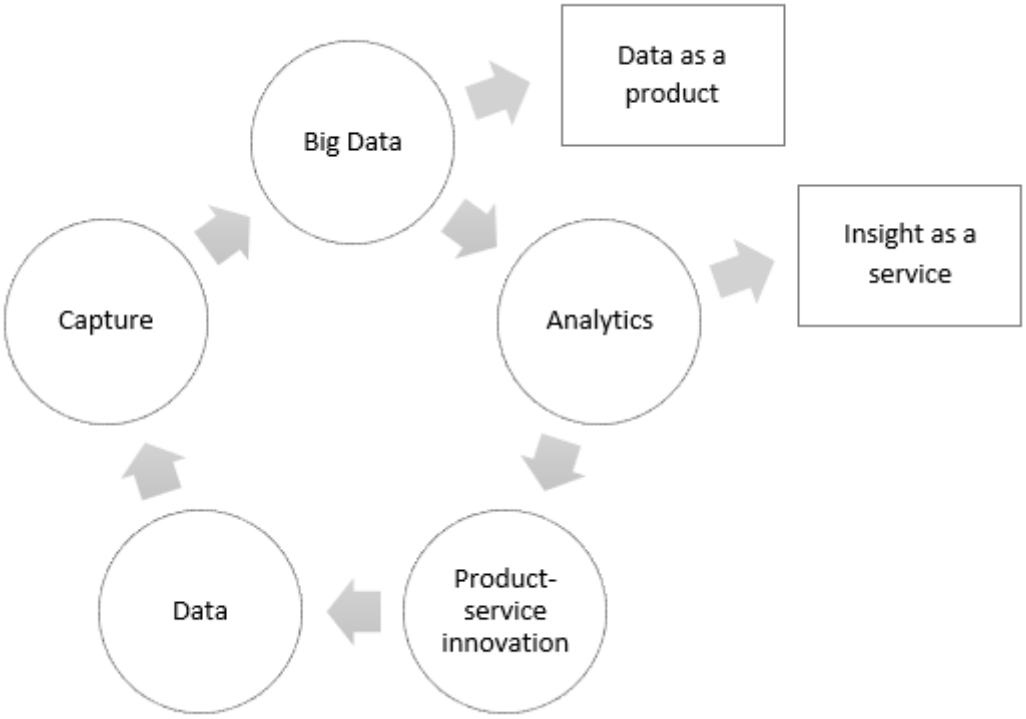

Figure 2- Big data analytics in servitisation (Authors)

While rich data can be a driver of product and business model innovation, highlight several authors relevant barriers for the adoption of big data. Besides infrastructure and resource limitations, data ownership, data governance and privacy are challenges companies will have to face when adopting Big Data Analytics driven innovations (Kache and Seuring, 2017; Manyika et al., 2011; Sivarajah et al., 2017).

Besides positive effects of the adoption of PSS, negative impacts on product value through transitional cost or the loss of perceived, intangible customer value can be the consequence. Specifically, the adoption of result orientated PSS can be hampered by difficult to sufficiently define the result and estimate risk being transferred from the client to the provider (Tukker, 2004).

Methodology

In structured interviews the interviewer has extensive knowledge of the subject and is searching for answers to specific questions in order to determine how strong predefined categories are present. (Leech, 2002, p.665). Conversely, "Unstructured interviews are best used as a source of insight, not for hypothesis testing." (Leech, 2002). For this qualitative research, semi-structured interviews were conducted with the aim of testing the predetermined opportunity and challenge constructs while gaining additional insight from a practitioner's point of view.

The content analysis follows the steps as laid out by Mayring (2014). As it is crucial to focus on reliability and validity during the process rather than at the end of it (Morse et al., 2002) quality criteria were included throughout the research. An interview structure is required to convey rigor in the interview process and crucial for the execution of the interview. Furthermore, does the interview structure encourage completeness in the data collection. (Lillis, 1999; Rabionet, 2011). The developed structure enabled the interviewer to consistently guide the interview along the same path while allowing

sufficient space for a more detailed discussion. This provided the interview partner with the opportunity to discuss his perspective. The interview was structured into three parts. In the introduction interviewer and interviewee got to know each other and exchanged basic information. In the implementation and business process section the interview focussed on understanding the actual situation in the company relating to Big Data Analytics driven innovation. The third section of the interview focussed on a general view on Big Data Analytics implications on products and supply chain. The interview closed with a question on general technology trend with the potential of high business impact.

The sample consists of companies engaged in Big Data Analytics initiatives located in Germany as well as internationally. The target group for the interview partners comprised "upper management level" who had contact with Big Bata Analytics initiatives within their organisation. Due to the novelty of the subject, the number of potential participants was limited. Companies were contacted via Email. The sample participating companies consists of a small number of a wide range of industries. From each organisation, one individual was interviewed.

A total of 16 interviews with companies from different industries (Table 1) were conducted of which one interview was done in person and 15 were done by telephone. A total of 395 audio minutes were recorded with interview durations varying between 19 and 53 minutes. The interview guideline was distributed to the interview partner beforehand. All but one interview was conducted in German. The participants were wide spread across a range of industries. The education and mining sector were included with one interview each and two interviews with car manufacturers were carried out. Additionally, there are four interviews each in logistics, manufacturing and retail trade present.

Table 1 – Participating companies' industry

Industry	Interviewees	% of interviews	BDA and PSS
Agricultural equipment	1	6%	1
Automotive	2	13%	2
Chemical	1	6%	1
Engineering	1	6%	1
Infrastructure	1	6%	1
Logistics	3	19%	1
Other	2	13%	1
Resources	1	6%	1
Retail	4	25%	
Total	16	100%	9

Source: Authors

On, average the revenue of the participating companies amounted to 30 billion Euro in 2015. The largest group with seven of the participating companies report annual revenue of less than 5 billion Euro. The number of employees, as of end 2015 varied greatly between the interviewed organisations. The average number of employees across all companies was 90 thousand, while 38% of the organisations had more than 50 thousand employees.

The coding was done in two rounds. Initially the coding table was walked through top down and the construct codes were assigned to paraphrases. This was followed by a second pass, starting with the constructs, and searching though the paraphrases. The second coding pass was performed across all of the interviews to reduce errors of

omission. One outcome of the second pass was that some material was reassigned from the supply chain construct to the corporate one.

Findings

Except for one, all organisations where either on a corporate or supply chain level engaging in Big Data driven performance improvements. Of the 16 interviews only nine companies (Table 1) described Big Data driven and product-service system related innovations.

Manufacturers focus on end-customers for new business opportunities. Many of these opportunities are further servitization of current product-service systems with the aim of building new, higher value product orientated models. Additionally, some companies working towards offering completely new services based on parts of the current supply chain. Big Data Analytics ultimately enables both directions through insight from Internet of Things. These new service models are rearranging the current supply chain, moving companies closer to their end-customer.

Table 2 – Data value capture

Data Origin	Interviewees
New PSS	4
PSS innovation	5
Raw data	0
Insight	1

Source: Authors

Main focus of the information use (Table 2) the interviewed companies was on the development of product service systems. Product orientated models (Table 3) received most attention, while the potential development of higher value systems was rather vague. However, two of the interviewed organisations were engaging in the development of use and result orientated product service systems. In one case a new business model was opened through the development of a forecasting model. Macro-economic forecast, based on the company's operational data, was made possible through introduction of Big Data Analytics and availability of information technology infrastructure. The company offered the insight gained as result of the analysis, rather than the raw data, to the market.

However, within the interviews the fear of publishing private information, which may result in a loss of competitive advantage, was the reason provided for a restrictive behaviour of organisations towards information sharing. Here most likely lies one of the reason why companies do not use their data or gained insights as products themselves, but rather develop new or enhance existing product-service offerings.

Table 3 - PSS orientation

Target PSS orientation	Interviewees	Interview responses
Product	7	Maintenance and product related services; proactive supply chain (maintenance); Improved customer satisfaction through more granular market segmentation, improved after sales service
Use	1	Machine pooling
Result	1	Light as a service

Source: Authors

Additional, we identified two logistic service providers offering production close to consumption models. Instead of shipping products for their customers, regional factories based on additive manufacturing were established. While this is not strictly Big Data Analytics, the innovation was made possible through the availability of extensive product design data and the corresponding storage and communication infrastructure.

Table 4 - Data origin

Data Origin	Interviewees	Interview responses
Internal	9	Own smart vehicles as data source, machine sensor-based ground analysis; customer behaviour monitoring to increase retention rate; machine sensors for predictive maintenance; predict fleet behaviour; GPS data
External	3	Social data for product launch, weather data

Source: Authors

The servitization is driven by data captured by the companies themselves. As shown in Table 4, do all companies use internally generated data for their product-service development. External data included in their innovations is limited to basic public pools of information.

Table 5 - Barriers

Barriers	Interview responses
IT capabilities and infrastructure	Lack of human and information technology resources; focus on, legacy system consolidation
Information management	Lack of sensor and interface documentation, quality concerns, complexity of and impact on existing environments prevent inclusion of data
Governance and compliance	Need for agreement to access and use client data within the Internet of Things
Data Security	Heterogeneous landscape of legacy systems challenges companies to identify security risks; fear loss of private information; impact on data quality through attacks

Source: Authors

Several challenges were raised within the interviews conducted. Table 5. lists the main barriers that interviewees highlighted. Practitioners were specifically aware of challenges relating to IT capabilities and infrastructure. These challenges were a subject in more than 30% of the interviews. IT capabilities and infrastructure and limited information management are hampering companies' ability to identify, collect and store valuable data. While there are serious barriers for the adoption of BDA, PSS can provide the business case for investment. Many of the barriers have to be addressed only once. As soon as IT infrastructure is available, a legal framework has been developed or information management provides a clear view on interfaces and data pools the capabilities can be to the benefit of multiple innovation initiatives.

Discussion

Semi-structured interviews proved to be a good approach to engage with a diverse group of interviewees. While allowing for open discussion and spaces for participant to talk about their focus, the interview structure ensured a systematic walk through the themes required. Furthermore, having the flexibility in the execution, allowed tailoring the interview for time constraints of the participants.

The spread of participants revealed the differences in expectations regarding Big Bata Analytics and product-service systems between industries and provides insight into impulses for future research. However, the total number of interviews conducted was small and the results are only a snapshot of a limited number of practitioners. This study does not differentiate the degree to which the initiatives reported were being ultimately realised. As the study indicates, many aspects were recognised during the interviews, but several were far from being implemented or having currently any impact.

There are several areas within this study where reliability and validity as criteria for quality in qualitative content analysis, remain a concern. Even so that a range of efforts, like multiple coding iterations, were implemented by the authors to ensure validity, the sample size is small.

Conclusion

This study contributes by revealing how Big Data Analytics enables innovation and the development of product-service systems, by enhancing and reorganising existing models. Additionally, a further contribution of this research lies not as much in the confirmation previous research, but rather in exposing of differences in focus of practitioners. This holds specifically true for the attitude towards information sharing through data-as-a-product approaches.

BDA is a driver for innovation in products and business models and can be an enabler for PSS based differentiation strategies. Furthermore, products-service systems are not only enabled by big data analytics, but can be the source of valuable data, which in turn be the source of further innovation and revenue. Therefore, their interconnection must be considered when creating new, or innovating existing product-service systems.

While much of the observed development is focused on incremental innovation in product orientated models, step changes are possible, independent of current information technology infrastructure or business model. Companies can and do engage in BDA implementations outside the existing company's legacy infrastructure and innovate their offerings from pure product to a result orientated PSS.

This study informs researchers about possible lenses on industry or customer specific implications of Big Data Analytics adoption and servitization. Additionally, this research highlights the conflict regarding gain and loss of competitive advantage as a specific area for future research.

From a managerial perspective, this research encourages organisations to gain clear understanding of the privacy requirements of unique data. Companies need to be able to answer the questions on how much income can be generated from the raw data versus the value of the competitive advantage perceived to be at risk.

The interview data provides only a small number of examples of BDA related PSS developments. Furthermore, some interviewees could provide only information within their area of responsibility. Industry specific research might be of interest as it could provide more comprehensive insight. Similarly, the research to change in environmental, social and economic product value, when transitioning to PSS models, is fragmented.

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