Measuring of benefits from big data analytics projects: An action research study

Abstract

BDA projects are expected to provide organizations with several benefits once the project closes. Nevertheless, a large amount of BDA projects are unsuccessful as benefits did not materialize as expected. Organization can manage the expected benefits by measuring these, yet very few organizations actually measure on benefits post project development, and little has been written about BDA benefits measurements that extends beyond those typically identified in the project business case. This study examines how we should establish measures for BDA benefits in the context of a large wind turbine manufacturer investing in BDA to improve their practices when defining BDA benefits measures. We present lessons learned from our action research, that were found useful in establishing BDA benefit measurements. There are three lessons on (1) change, (2) specification of who, and (3) explicitness in establishing a useful BDA benefit measure. We contribute to BDA benefits realization in proposing the lessons to establish BDA benefits measurements. Finally, we discuss the lessons and contributions related to research on BDA value creation and benefits management.

Keywords: big data analytics benefits, measuring of benefits, big data analytics projects, benefits management

1. Introduction

Since its introduction nearly 20 years ago, big data analytics (BDA) has gained significant momentum both within the research and practice community (Ranjan and Foropon, 2021). According to Chen et al., (2012) BDA can be described as a specific application for managing, prioritizing, and analyzing big data for business purposes and is expected to enable several value propositions pertaining to individuals, organizations and society as a whole (Günther et al., 2017; Grover et al., 2018; Mikalef, Pappas et al., 2020). The value aspect of BDA is concerned about the extent to which it generates economic value or other types of benefits through extraction and transformation (Fosso Wamba et al., 2015). Yet, despite the potential value propositions stemming from BDA projects, organizations succeeding with these are still

scarce (Grover et al., 2020). The current literature on BDA has in general been dominated by the technical solutions (Chen et al., 2012; Baesens et al., 2016; Lau et al., 2016; Günther et al., 2017) and few empirical studies exist that assess the business value of BDA with robust measures and also measuring the improvement (Trieu, 2017; Müller et al., 2018).

The challenge of measuring benefits from BDA projects is prevalent throughout BDA research (Grover et al., 2018). Essentially the process of measurement is the means by which practitioners can obtain knowledge about what they are interested in (Ferris, 2006). Traditionally, the theory of measurement has been concerned with the nature of scales of measurement, the relations that these have to the phenomenon they are trying to measure and what one can assert about the current state of the phenomenon from the measures obtained about its current state (Ferris, 2006). In this study we adopt the view on measurement by Churchman (presented in Ferris, 2006) that measurement, or measuring, is essentially about obtaining understanding of the observed so that one can attain a measure of control over the observed with the purpose to provide a basis for decisions. In this study, the observed refers to BDA benefits that is expected to materialize post BDA project development and we apply the term benefits as we consider this to both entail tangible and intangible gains, whereas only talking about BDA value tends to lead the discourse toward financial gains such as return on investment.

We contribute to the calls for research on measuring BDA benefits (Mikalef, Pappas et al., 2017; Chiang et al., 2018; Grover et al., 2018) with an action research study (Mckay and Marshall, 2001) conducted together with a large wind turbine manufacturer, Vestas Wind Systems A/S (Vestas), in which BDA plays a significant strategic role in creating a competitive advantage. The aim of our study was to establish lessons for BDA benefit measurement, and we thus set out to answer the research question:

"How can we measure benefits of big data analytics?"

Emphasizing the collaborative nature of action research, we as researchers together with the practitioners, engage in change to improve the current benefits measure practices in Vestas.

The remainder of this paper has the following structure. First we review and contextualize our study in related research on measuring benefits for BDA. Second, we present how to measure benefits from benefits management as our theoretical framework. We utilize the theoretical framing with a BDA project in Vestas, *Plant design.* We then present the action research approach to address our research question. Finally, we present our research iterations and the

lessons extracted from these. The paper ends with discussing our findings and concluding on these.

2. Related research

We based the theoretical framing of the action research study on the BDA benefits measurement and benefits management literature. The literature on how to establish benefits measures for BDA projects, is very scarce. Instead we looked into the literature on performance measures for BDA and benefits measurement from IS that, in combination with benefits measurement from benefits management, formed the theoretical basis of our study.

2.1 BDA benefits measurement

The concept of BDA benefits measurement lacks clarity as a research field of BDA. How to measure value, frays into many lines of focus that takes various directions making the discussion on this topic fuzzy (Côrte-Real et al., 2019). The concept of value, or benefits, has multiple dimensions that makes it difficult to work with in practice (Schryen, 2013), which also is reflected as to how measures of BDA benefits are established. In the following, we present the literature on BDA benefits measurement according to what we know from performance measurement on BDA, both as a technology and as a process, and how to measure on intangible benefits from BDA projects once the project has closed down. Finally, we present literature on how to measure benefits based on benefits management.

The success of a BDA project depends on several factors to be managed including technology, process and people (Ali et al., 2019). In measuring the value of BDA, the term performance measurement is often applied and is described as the process of quantifying efficiency and effectiveness of an action or process (Neely et al., 1995). It is important to be precise and distinguish to what element of BDA we refer to when talking about BDA benefits measurement. In general we found a difference in establishing measures from BDA as a *process*, which is the process that turn big data (BD) into analytics, the *BDA technology*, which is the technology used for storing, analyzing and deploying BDA analytics solutions, the *BD* itself in terms of data quality etc., and finally, *BDA value* that refers to the expected financial gains of implementing BDA successfully in an organization. Moreover, we found a difference in establishing measures at either the BDA project level and BDA outcomes, in which the latter somehow refers to benefits. Very little has been written about BDA benefits measurement

from a project level, whereas several studies are concerned with what is referred to as performance measurement (Müller et al., 2018). In the following we will try to make sense of this.

According to Lai and Leu (2019) organizations ought to invest in performance measurement for their BDA projects as this may lower the failure rate that has been notoriously high for these and the value that is expected to be achieved in the organization.

When establishing performance measures for BDA projects, we may begin by distinguishing between measures on BD and BDA. First BD is typically described by the "three Vs": volume, velocity and variety (McAfee and Brynjolfsson, 2012; Akter et al., 2016). As the concept of BD matured, several scholars have included other aspects of BD in trying to conceptualize it adding further five V's to it: veracity, value, variability and visualization (Seddon and Currie, 2017). Despite being described as a process that includes several factors in addition to the BD, existing performance evaluation studies has focused on comparing the various BD technologies such as Hadoop, Spark and Flink (Veiga et al., 2016; 2019). To mention a few, measures pertaining BD typically come on the form of assessing data quality, speed of computation, data extraction, data integration (Hu et al., 2014; Larson and Chang, 2016). Yet, these measures are limited to the BD technology and lacks the users' role as well as the business context in assessing performance (Erevelles et al., 2016; Mikalef, Pappas, et al., 2017; Mirarab et al., 2019).

Instead, some studies focus on assessing the performance of BDA as a process (Ali et al., 2019). Chen et al., (2012) categorized BDA as a field related to that of business intelligence & analytics in relation to data mining and statistical analysis. (Côrte-real *et al.*, 2017, p. 380) describe BDA as *"a new generation of technologies of architectures, designed to economically extract value from very large volumes of a wide variety of data, by enabling high velocity capture, discovery and/or analysis"*. BD is injected in the BDA process of collecting, cleaning, analyzing and deploying solutions, to produce insights that should be exploited by the users into their context. Several studies propose measures to manage the performance of BDA as a process (Veiga et al., 2016, 2019; Ji-fan Ren et al., 2017; Lai and Leu, 2019). Typically measures pertaining the BDA process are categorized in terms of 1) efficiency, 2) flexibility, 3) effectiveness and 4) performance contributing factors. Yet for BDA, time-related measures such as cycle time, latency, speed and response time are still dominating for assessing the performance and impact that BDA may have on an organization, which again refers to the performance of BDA as a technology (Lavalle et al., 2011; Kwon et al., 2014; Ali et al., 2019). Assessing the performance of BDA as a process and measuring this are often found to be easier

than to measure the effects, or what could be described as benefits, of BDA (Gibson and Arnott, 2005).

2.2 Intangible benefits measures

Despite having an extensive list on how to measure performance from BD and BDA, very little guidance is provided for establishing measures pertaining to the benefits of BDA. Benefits are "*an outcome whose nature and value are considered advantageous to an organization*" (Thorp, 1998 cited in Bennington & Baccarini, 2004 p. 21). Emphasis should be placed on *outcome.* Thus measurements for BDA benefits, must focus on the outcomes of what the BD and BDA jointly produces to an organization. Establishing measures solely for BD or BDA as a process or technology may thus be insufficient. Typical outcome measures for BDA projects are stated in financial terms such as return-on-investment, increased sales or improved contribution margin to justify the up-front investment of the BDA technology (Gibson et al., 2004; Gibson and Arnott, 2005; Wamba et al., 2017). Yet, these measurements take very little account of the intangible nature of BDA and the intangible benefits it may provide.

In establishing measures for BDA benefits, several studies point to the need of establishing measures for the intangible benefits (Gibson et al., 2004; Trieu, 2017). Examples of intangible benefits may be improved work processes, greater business knowledge or more effective decision making and tend to reflect a strategic nature (Irani and Love, 2002). These intangible benefits can often be difficult and even impossible to quantify, yet they often contain overlooked sources of value regarding the use of BDA.

Over time different studies have proposed methods or frameworks that can, or partly, deal with intangible benefits. As example, the balanced Scorecard of Kaplan and Norton (Kaplan and Norton, 1996), the Performance Pyramid (Lynch and Cross, 1995), Kanji's business scorecard (Kanji and E Sá, 2002), and the Extended Process Model (Markus and Soh, 1995; Marshall et al., 2004). Each of the methods or frameworks has their own pros and cons in defining how to measure on benefits. Yet, as successful BDA implementation often result in organizational changes to structure, processes and use of technologies (Mirarab et al., 2019), a method for measure the potential benefits must take this into consideration as well in order to show how benefits are made explicit and materialize (Vries et al., 2016). To this, we may turn to Benefits Management (Ward and Daniel, 2012).

2.3 Benefits measurement from benefits management

Stemming from the need to improve on the success of IS/IT projects, benefits management is defined as "The process of organizing and managing such that the potential benefits arising from the use of IS/IT are actually realized" (Ward and Daniel, 2012, p. 8). The approach is based on a life-cycle process and a set of linked steps that guides the identification, scoping, justification, planning and implementation of IS/IT projects to realize benefits. One of these steps explicitly deals with establishing evident measures for benefits and where the benefits will occur in the organization. In establishing measures, the benefits management approach asks questions concerning if and how the benefits can be measured, quantified and if a financial value can be associated with it? Defining an evident measure of a benefit will often improve the clarity or precision about what was meant by a particular benefit. As example, a benefit may have been defined as "faster response time to customer", but when considering how this might be measured it could become apparent that the faster response time could actually become faster for various reasons. Thus, the benefit measure needs to be attributable to the improvement directly associated with the specific BDA investment in question. In the benefits management approach, the continuous emphasis on the relationship between change and benefits, and the need to be explicit about benefit measurement are some of the main differences from more traditional approaches when looking into the value perspective of IS/IT projects.

In their study Daniel et al. (2007) propose a method as to how to determine the explicit value of a benefit from IT investments. Benefits are distributed into four different classifications of measurement being 1) observable, 2) measurable, 3) quantifiable and 4) financial benefits. The degree of explicitness increases as the benefit moves towards being financial. All benefits are essentially observable until evidence of knowledge and value is determined about the benefit (Daniel, Peppard and Ward, 2007).

Although there has been a substantial amount of research on benefits management (Waring, Casey and Robson, 2018), there is still disagreement if benefits realization practices, such as benefits management, essentially improve an organization's ability to realize benefits (Daniel et al., 2007; Badewi and Shehab, 2016). Few empirical studies on how benefits management works in practice still prevails (Doherty, 2014; Frisk et al., 2015). Moreover, a majority of existing benefits management frameworks explicate benefits as formulated to support pre-determined project outputs (Chih and Zwikael, 2015). The emphasis on getting projects approved often result in inflated formulated benefits underrating both costs and complexity (Lin and Pervan, 2003). The high level of complexity in establishing benefits measures calls

for a broader view and rigorous investigation into how a good measure for BDA benefits realization can be established. Benefits management, however, may serve as a reasonable means as to define measures for benefits and was thus applied in this research.

3. Research approach

The research was structured as a two-year action research effort (Mathiassen, 2002) as part of the case project, Plant Design. The research was organized with three researchers with among these an industrial PhD student and close collaboration with 20 practitioners involved in the case project. Action research is a popular method in the information systems research community as it links theory and practice in a cyclic process for situations in which improvement is needed (Davison et al, 2012). It creates a synthesis with specific knowledge that then provides actors in the situation, the capability to act and general knowledge that is useful in similar situations (Baskerville and Wood-Harper, 2016). As an action research approach, collaborative practice research (CPR) makes it possible to adopt different research initiatives and methodologies as the problem-solving in the client organization evolves over time (Mathiassen, 2002). In our case we choose to adopt CPR as an action research approach for the reasons of; first, in order to respond to the problematic situation and needs pertaining benefits measurement in Vestas. Second, to present solid and relevant general outcomes of our research in addressing the complexities in establishing measurements for BDA benefits (Mikalef, Pappas, et al., 2017).

3.1 The action research cycle

Action research is a cognitive process depending on the social interactions between those that observe and those in their surroundings (Baskerville and Wood-Harper, 1998). In practice, the essence of action research is a two-stage process in a simple form. The first part, being the diagnostic stage, involves an analysis of the social situation. In this stage, the researchers formulate hypothesis concerning the nature of the research domain. The second stage then involves change experiments and the effects from these are studied (Baskerville and Wood-Harper, 1998). CPR encompass a detailed process model and offers a research methodology serving as a general frame for our research design and activities for us to understand current BDA benefit measurement practices and how to improve on these in Vestas. Table 1operationalize the dual research interests from the researchers and Vestas. The research cycle portrays how this study combines theory and practice as follows:

- Research theme: As a general area of interest this study investigated BDA benefits measurements and in particular how these are, or can become, useful for an organization investing in BDA projects.
- Research framework (F): Theory about benefits management and measurement framed this study.
- Research methodology (M): The study was based on CPR with several iterations as outlined in table 1.
- Problematic situation (A): The study addressed BDA benefits measurement challenges in Vestas that has been evident for a long period. The challenges to this unfolded in greater detail as the researchers and practitioners jointly worked to improve Vestas' capability related to BDA benefits measurement.
- Reflection based on F and M: The researchers would continuously debrief while engaging with A to accumulate and share experience.
- Findings: Upon several iterations, the researchers would eventually exit from A and review the results and experiences from A to identify and document contributions to research.

3.2 Data collection

The premise style of the research is practical and not theoretical as we investigated how practitioners involved with BDA projects define benefit measures to these. Our inference style is thus inductive and not deductive as the arguments we present are based on data and evidence from the problem-solving activities.

Given our research question, we were seeking a contribution to problem-solving lessons that should be useful for practitioners when defining and assessing BDA benefit measurements. The researchers spend a considerable amount of time in collecting and analyzing data for the study in relation to the CPR criterion of documentation (Iversen, Mathiassen and Nielsen, 2004; Nielsen, 2007). The criterion is met by explicating data in relation to the change process, the representation of context and temporal nature of the change. To fulfil the criteria, we used several data collecting techniques:

- In depth qualitative interviews both in the diagnosis stage and after the iterations (Patton, 2002).
- Audio recordings of workshops between researchers and practitioners.

- Project documentation collected by one of the researchers as an inside-action researcher.
- Debrief meetings between the researchers on a weekly basis following the interventions (Spall, 1998).

We then integrated the analysis of all the collected data in the CPR process and through the ongoing debrief meetings. We had continuous feedback in collaboration with Vestas as results were presented. Feedback was also collected as the researchers implemented the successful changes in the organization.

3.3 Research practice – The Plant design project

In 2019, Vestas conducted a study in collaboration with the researchers identifying various challenges in relation to realizing benefits from BDA. Several challenges in relation to measuring BDA benefits were found as well (Jensen et al, 2019). Essentially, establishing benefits measurements was not applied consequently that often led to confusion about the exact impact of the BDA project that pointed to the challenges of not establishing consistency and measurability. Moreover, challenges of not measuring the change following the BDA project or establishing baselines of the performance prior to the BDA development became evident. Finally, a challenged related to typically only defining benefits measures from business cases and BDA project gate material as financial was identified. Financial measures of BDA benefits are by no means obsolete, yet the challenges emerged in not establishing benefits from understanding affected activities resulting from the BDA project.

Based on the central challenges on how to establish measures for BDA benefits, the study that we report from here focus on how to establish measures for these. Together with the practitioners, the central problem of establishing BDA benefits measurements was identified as a key concern and the appreciation of this particular challenge was the first step in the action research process. Table 1 outlines the research cycles and iterations.

Improvement activities for Vestas' BDA benefits measure practices were initiated specifically following a complex BDA project, Plant Design. As researchers, we considered the issues of 1) how benefits management and specific attention to measurement practices work in organizations (Doherty, 2014; Frisk et al., 2015), 2) how practitioners should take action in formulating BDA benefits measures (Mikalef, Augustin Framnes, et al., 2017), and 3) a majority of benefits management frameworks explicates benefits as formulated to support pre-determined project outputs (Chih and Zwikael, 2015).

We adapted benefits measurement practices from benefits management (Ward and Daniel, 2012).

	First iteration	Second iteration	Third iteration	Closing
1. Appreciate problem situation	Part of PhD study research collaboration (ECIS2019)			
2. Study literature and select approach	Study BDA benefits realization and benefits measurement			
3. Apply approach	Development of benefits measures established in Plant Design project. Participants: Researchers, Plant design project manager, Plant design technical managers, Plant design project owner, Product owner and Senior financial specialist.	Elaborate benefits measures in Plant Design project reflecting organizational change resulting from BDA. Participants: Researchers, Plant design project manager, Plant design technical managers, Plant design project owner, Product owner, Senior financial specialist, Global development sales manager and Global head of Siting.	Further development of benefits established in Plant Design project presented varying degree of explicitness of benefits measures that can move between being purely observable to financial. Participants: Researchers, Plant design project manager, Plant design technical managers, Plant design project owner, Product owner, Senior financial specialist, Global development sales manager, Global head of Siting, Product strategy chief specialist, Senior functional lead modelling and analytics.	Final closing. Participants: Researchers, Plant design project manager, Plant design technical managers, Plant design project owner, Product owner, Senior financial specialist, Portfolio manager, Global head of Siting, Siting specialist.
4. Assess usefulness and redesign approach	Benefits measurements ought to be established for organizational change resulting from BDA. + Assessing BDA benefits measures is useful for the practitioners. + Establishing measures for BDA benefits makes the benefits more concrete. + Establishing BDA benefit measures in a document is useful. - BDA benefits measures established from business case are not sufficient for measuring success of the benefits. - BDA benefits manifest from organizational change and measures should portray this.	The further elaboration of benefits measures revealed ownership of the benefits measurements should be distributed and that ownership can be scattered reflecting different types of metrics. + Establishing BDA benefits measures for the organizational change is useful for the practitioners. + BDA benefits cross departmental boundaries and require several measures for control. + BDA benefits measures stretch beyond assessing BDA technology performance. - BDA benefits measures evolve as ownership is established but can cause conflict in establishing measures. - Making BDA benefits measures financially explicit is difficult.	The continued development of benefits measures from BDA revealed how the degree of explicitness cannot stand alone as a measurement, is negotiable and will change over time in the BDA project. + BDA benefits measures become more concrete as organizational change and more actors become involved. + BDA benefits measures are multidimensional. - BDA benefits measure financial explicitness cannot be established alone. It is dependent upon the organizational actors involved. - BDA benefits measure financial explicitness will change as the BDA benefits become more concrete.	Assessment of lessons learned and approach for BDA measurement
5. Exit				Action part closed
6. Elicit research results				Result and lesson elicitation. Implement lessons in case organization.

Table 1: Action research cycles and iterations

4. Findings

In this section we present our three interventions (cf. table 1) in Vestas with the Plant design project to improve their benefits measurement practices.

4.1 Iteration one

4.1.1 The problematic situation – Establishing BDA benefits measures

In 2020 the modelling and analytics module initiated a project to improve the Vestas siting universe tool, the capabilities and the data included in the tool to improve Vestas' siting capability. The project was named *Plant design* and was an extensive upgrade of the Vestas Siting Universe.

The Plant design project aim was to provide a BDA system that the siting engineers and technical sales management team would use for identifying optimal power plant configurations. A power plant is a composition of turbines. Vestas Siting Universe was used by technical sales management to provide optimizations of deal opportunities in sales negotiations. However, Vestas Siting Universe was actually not providing this functionality optimally causing the technical sales management organization to propose sub-optimal sales offerings to Vestas' customers. The Vestas Siting Universe platform had essentially been outgrown over time and from new technologies (turbines etc.) that have been verified to generate substantial Levelized Cost of Energy improvements. The new technological offerings that a power plant could contain, had proven too demanding for the platform to handle in the analytics phase. Additionally, the process for sales project analysis contains large manual components which is not favorable in being able to react quickly to customer requests. Thus from Vestas Siting Universe, the technical sales teams was not able to identify the full potential of the power plant and hence missed out on significant sales value. Plant design was then initiated to solve these challenges. By enabling techno-economics plant product configuration, it was expected that Vestas could generate 3% more value adding plant configurations measured on Levelized Cost of Energy, contribution margin and/or Annual Energy Production indicating a sales value of more than 400mEUR in 2019 numbers. However, in order to achieve this the Plant design system had to be able to integrate and communicate with commercial tools in Vestas, established automated siting process performance baselines used for consistency comparisons, validation and improvements of siting components such as wind flow, long term corrections etc.

The project complexity was large due to a significant technical debt in the existing siting and technical sales platform which in addition to developing the new technical solutions in Plant design, a lot of maintenance was required for these former systems. Consequently, a strong transition plan was needed migrating from the old systems to the Plant design technical solutions. This also entailed a benefits realization plan to ensure that the Plant design project would achieve the value propositions it promised to deliver once the technical solutions was in place. However, establishing benefits measures was not a practice that was well integrated in Vestas in relation to BDA projects, as Plant design, and measures were often based on financial metrics as a necessity from establishing a business case.

"It's a general challenge for us that we simply don't know how to capture value from these type of projects" (Specialist, Wind Resource Assessment)

Due to the significant investment in terms of technology and development hours spend in the organization, Vestas wanted to ensure that the Plant design project would become a success. In former BDA projects, Vestas did not establish BDA benefits measures explicitly but would instead monitor the success of the BDA project in terms of cost, hours spend and technical delivery. Yet for future BDA projects, Vestas wanted to move to post project development to monitor the success of the BDA projects both in terms of technical and organizational delivery. To this, Vestas regarded establishing the right benefits measures as crucial. Thus, Vestas engaged with the researchers with the aim of improving its practice in establishing BDA benefits measures following Plant design project. The Plant design project manager highlighted the task:

"In Plant design we now have the task to look at benefits and how to measure on these. This has been a continuous and well-known challenge in these type of projects" (Project Manager, Plant design)

The researchers engaged with the plant design project team in the autumn of 2020. At that point the Plant design project had already gotten approval for its business case by management and was slowly moving into the next project development stage of developing the technical solutions. The output of plant design was a system for BDA analytics in defining future turbine power plants combining various types of data and complex analytical models. Despite the project's large potential in providing Vestas, as an organization, with a competitive advantage,

the Plant design project team have had a difficult time in actually getting the business case approved by management. The business case had to be based on financial defined benefits and measures, which however was difficult for the project team to define due to the intangible nature of the project output. Examples of the expected benefits were to increase the contribution margin for Vestas with X % and to increase sales by Y %. Consequently, the project team was skeptical towards how actually to prove the benefits promised in the plant design business case once the plant design project would shut down as the technology had been implemented.

"We've tried in the past, on some (analytics) projects to measure on benefits over time based on the business case, but that is not something we have been good at" (Project Manager, Plant design)

The senior members of the plant design project team, engaged with the researchers to improve their current practices in establishing measures for the benefits they expected that the analytical output from plant design would provide.

4.1.2 The first intervention – A better understanding of BDA benefit measures

Based on how to measure benefits from benefits management (cf. section 2) the researchers initiated a workshop with the plant design senior project team members. These included the project owner, the project manager, the senior technical managers, product owner and senior financial specialist. In the workshop, the researchers and the included practitioners would go through each of the benefits identified in the plant design business case and ask in-depth questions to each of these. The questions were based on the applied research framework, benefits management, (F) stemming from and were formulated as 1) How should we measure the impact of the benefit? 2) How will we know if the benefit is successful? and 3) Is this the best measure for the benefit? Previous benefits and potential measures of these in the plant design project were mainly formulated in financial terms, yet there was a willingness amongst the participants to expand on their understanding on how to measure benefits:

"People would like to measure on benefits, but there are many opinions about it and there is not as such a clear strategy on how to do it" (Project Manager, Plant design)

The researchers designed a BDA benefits profile measure document, that would include information about the type of benefit and how it should be measured in order to write down the details from the workshop and providing a means for the coming interventions.

4.1.3 The first evaluation – BDA business case measures are not enough

During the first intervention, the researchers and the project team members managed to go through each of the benefits identified in the original business case for the plant design project. The researchers evaluated explicitly on the intervention in establishing BDA benefits measures that were considered useful for the participants.

In the workshop it quickly became evident that asking the above questions to each of the business case benefits, expanded on the participants understanding of what was meant by a benefit and that the benefits, in their current form, would not be sufficient in validating the success of plant design as a system. The benefits and established measures were defined with the aim of a high level of financial explicitness from the business case. However, this was problematic as it was difficult for the participants to agree on how to measure on these, what data to use, and who ought to hold ownership of the benefits. Moreover, the benefits and their measures were simply too generic formulated and needed to become more specific towards the benefits delivered by Plant design. To increase the degree of explicitness, it became apparent how the degree of explicitness begins with understanding the change or affect that the BDA, in this study the Plant design project, would have on the business. As stated by the Senior specialist for service products:

"The impact of being wrong in the analytics outcome based on the business needs of a particular analysis, is what determine what it should be measured on" (Senior Specialist, Service Products)

The original business case was composed of 5 benefits, which after the first intervention had expanded to 13 different benefits measures. Thus, the main experience from the first iteration was that the questions asked by the researchers and the proposed benefits profile measure document was useful for the project team. However, in contrast to the original 5 benefits and the measures defined to these in the business case, the measures identified from the first intervention also included measures pertaining to the change in the organization that plant design would require. Establishing measures for monitoring the change or affects in the business would then contribute to increasing the level of explicitness of the benefit, as the changes are a means for understanding how the benefit may be financial attributable. As example, measuring risk for the business based on the outcome of BDA:

"Connecting the risk in the business as a metric" (Senior Specialist, Service Products)

This view was further supported by the financial business analyst that in her daily work was trying to establish measurements to BDA projects impact. She was involved with the financial data that the Plant design project would integrate. She explained:

"Metrics (for BDA) depend on the process they are linked to" (Financial Business Analyst, Modelling & Analytics)

We then expanded on how to conceptualize measures for the benefits which lead to the first lesson. As measures from the first iteration now extended into the change that will occur resulting from the BDA implementation, we ended up with more than one measurement per benefit as each benefit had an affect across departments in the organization.

4.2 Iteration two

Following iteration one, the plant design project team continued to work and develop on the benefits measured using the benefits measure template provided by the researchers during the first intervention. Measures pertaining to the change in the organization were established from iteration one.

4.2.1 The *new* problematic situation – Deliberation on the who

However, in continuing the work in defining benefits measures from iteration one, the measured that had been identified were still not sufficient in actually measuring the success of the plant design output once the project would have implemented the technical solution. From iteration one, the lessons learned was that benefits measured should also be established from the change that would take place in the organization. For plant design, the change in the organization involved the global siting department that would have to adopt the system and use it in their daily work and the modelling & analytics module that would have to maintain the technical solution. However, change also involved the sales organization that would use the analytical output from plant design in negotiating sales contracts. Moreover, change was evident in the product organization that stated how the improved analytical output from plant design, would enable them to develop new digital product offerings. Thus it appeared that in engaging with the change that plant design would impose in the organization, expanded the types of benefit measures needed as change was needed from several departments in Vestas that required different types of measures.

4.2.2 The second intervention – who to involve?

We began the second intervention with the practitioners a little wiser from the first iteration, but now with a new challenge. We continued to use the benefits measure document from iteration one and expanded on the content of this. The content now also included measures at information needed for the change that Plant design would require in order to realize benefits. Expanding the content and gaining a better understanding of the change measures, also expanded on the plant design project team's understanding of who then was affected by the change or had an important role in actually making the change happen. This meant that the plant design project team needed to include departments, that they not previously had engaged with before in defining benefits measures for the plant design project. This included the global development and product organization. The researchers now expanded the second intervention to include representatives from each of these departments as well. The Plant design project manager elaborated on both the opportunities but also challenges, including more people in determining the benefits measure, would entail:

"We are losing a lot of value (from not anchoring the benefits in the organization). Without this anchoring of who to involve and when, means that we have to go out and involve at least 20 people in each project, which all can have different opinions about the benefits that can bring the scope of the project in jeopardy" (Project Manager, Plant design).

In the subsequent sessions the researchers together with the plant design project team and the newly included representatives, would further analyze each benefit from the first intervention and expand on the measures to each of these. As example, a benefit concerning the efficiency improvement in producing siting reports now included measures about how the additional hours from being more efficient, would be used for other value adding activities. This stretched overall several sessions, in which the newly included representatives from global development and the product organization, would add their requirements towards the Plant design project, in realizing the potential benefits. However, suddenly expanding on the who in defining benefits measures caused several challenges for the plant design project. The members of the plant design project were mainly concerned with developing the technical solution for the project and meeting the requirements that originally was defined for the project. They were concerned with the who that had been defined at the outset of the project and the benefits that these saw as important. This caused friction as the who expanded and now included the global development and product department. That resulted in misunderstood areas of responsibility as

to what the plant design project should be accountable for and what e.g. The product department should do. As example, several parallel meetings were held between the plant design project team and the representative from the product department. There were no formal structures in place as to how these should engage at a stage of a project in which the scope was already defined. Yet this engagement was necessary, as the product department were found to have an important role in achieving some of the benefits that the plant design had based its business case on and the measures established in this.

4.2.3 The second evaluation – getting those affected to the table

After the second intervention, the researchers evaluated the approach applied until now specifically assessing the benefits measure document that had been used. Expanding the benefits measures to the change needed in the organization was found successful, but also expanded on who essentially was responsible for the change and what benefits measures they found necessary. The Senior siting specialist explained how there previously had been a tendency to focus too narrowly on the same benefits metrics limited to each department. He elaborated how reaching a potential benefit is a collaboration between different departments in terms of value engineering, and hence, the benefit measure must be a representation of this.

Defining the who and establishing measures extra-BDA project was crucial as benefits would not be realized from the BDA technical implementation solely. In addition to system improvement benefits such as automatization and reduction of compute time and costs, catering for dynamic markets and tender condition was a crucial benefit that would materialize what was described as value engineering:

"I believe that it is very difficult to have any benefits from software… you tend to look at the automatizing aspect of it as a benefit, but really how much can you make automatic (in analytics). Can you actually make automatic an optimizations routine with millions variables to consider?" (Specialist, Wind Resource Assessment)

As example:

" You have a strong automatization compute machine in the background and what you then can focus on instead is "what-if" scenarios of projects that are in your pipeline for calculations. Then you play with different parameters to see what it can give the external customer on their business case" (Specialist, Wind Resource Assessment)

Essentially measures had to be established pertaining to the who and the process they engaged in applying the BDA output in their daily work. The who can involve BDA system users,

beneficiaries and benefit owners. Meaning that the measurements should reflect the mechanisms that enable benefits realization. The Senior specialist, Service products elaborated on this:

"I'm trying to imagine this… so if we improve our estimates, which reduce uncertainty, then we can price it accordingly or incrementally. But the question is really if that is the mechanism" (Senior Specialist, Service products)

Clearly, finding the mechanism that fosters a financial measure demands more than only the financial metric itself. He concluded:

"We need to make the business improvement from the analytics attributable to the system and analytics enabling this improvement" (Senior Specialist, Service products)

At the outset of the plant design project, the who was defined in terms of the users of the plant design system. These were the global siting department and the technical sales. Measures of benefits to these were mainly related to the performance of the system and came in the form of speed of computation, automatization and ease of use compared to the system to be replaced, VSU. These were not concerned with users of the improved analytical output stemming from plant design. In addition to improving the system performance itself, plant design would also produce BDA that had a higher level of accuracy and lower bias in its predictive models. Thus in evaluating the second intervention, we learned that there are different types of who for establishing BDA benefits and that these may evolve over time as the project matures.

4.3 Iteration three

We began the third iteration by appreciating what we had learned from the first two iterations that in order to measure on BDA benefits we need to pay attention to the change in the organization that the BDA technology will have and moreover that users and beneficiaries may evolve as the BDA project matures. Each of these are important contributors in establishing BDA benefits measures.

4.3.1 The continued problematic situation – we want financial measures

The plant design project continued to work together with both the global development and the product organization in defining benefits and furthermore how to measure on these. Despite not having any formal guidelines as to how these departments should work together with the project team, they slowly managed to conceptualize what was the responsibility split between the plant design project during the project development stages and once the plant design technology was developed fully and implemented. Both the global development and the product organization were interested in the analytical output stemming from plant design and thus defined benefits measures that reflected this. These benefits measures were defined in financial terms such as increased sales and improved contribution margin for Vestas. Prior engaging with the global development and the product organization, the plant design project team was challenged when trying to define the necessary measures for the financial benefits that they had identified in the business case.

The business case was needed in order to obtain funding for the financial investment by management. Quite often this is a tedious process going back and forth between evaluating and improving the business case until management approval is obtained. In the plant design project, the business case was established on the foundation of three value drivers being 1) volume opportunity, which meant an increase in sales projects that included an optimization of the technical solution, 2) Increase in profits through value engineering of the technical solution and 3) Improving the prediction accuracy on relation to AEP (Annual Energy production). As example, improving the technical solution could mean to adjust the tip height of the turbines selected for designing the power plant. It could also mean to adjust the type of tower.

The metrics for the three value drivers were presented in percentages e.g. volume in sales would increase by X % of sales and profits would increase by Y %through value engineering. The latter percentage increase in profit would then be translated into a financial figure that would depend on the amount of projects being analyzed and would with the support of the Plant design system. Three of the interviewees mentioned the financial metric as an adequate measure of BDA benefits success. As example:

"*It must be (a measure of success) that we will have a higher price on our products by improving our AEP accuracy" (Chief Specialist, Plant value engineering).*

The chief specialist continued to elaborate that the high price would be achieved by de-risking the business case for the external customers. Hence applying risk as a metric of performance:

"…since we have an improved accuracy, the customers can have a cheaper financing from the banks. Then both the customers and Vestas will earn higher profits" (Chief Specialist, Plant value engineering)

Establishing a financial metric for benefits evaluation, was further supported by the Modelling and Analytics module design owner. To this he added that the financial improvement essentials was the end goal:

"It's of course the end goal, so that we have secured a higher business case certainty for both the customer and vestas" (Design Owner, Modelling and Analytics)

The steps from which the analytical output from Plant design, would materialize financially was not explicit before the global development and the product organization could put it into their context. Yet, in collaborating with the global development and product organization, the road as to which a benefit may materialize in financial terms, became evident.

4.3.2 The third intervention – a progression towards explicitness

We began the third intervention by applying the benefits template document used and developed further from the former iterations. We used it jointly with the plant design project team and now also included the global development and product organization. Especially the product organization became involved as they saw a significant financial potential from the plant design analytical output.

Having a financial metric as the end goal, was further supported by the product manager that initially contributed to developing the business case for the Plant design project. He elaborated on the improvement in financial metrics pertaining to increase in sales price and CM (contribution margin)

"It would be amazing if we directly could measure and improvement by implementing Plant Design, in our sales price and CM" (Product owner, Product Performance & Warranties)

He added that naturally the financial metric would be of the most interest to Vestas, yet also what would be the most difficult to be in control of. As BDA product an intangible outcome

and may be regarded as an intangible product supporting decision making for many organizational actors, isolating the exact events that leads to an increase in financial performance from BDA, may be difficult. If not impossible unless BDA is isolated as in asset management defining it as a product in itself. The latter was supported by a Specialist in wind resource assessment from the Siting development department. He elaborated on the LCOE (Levelized cost of energy):

"we cannot simply either just measure on LCOE… I'm sure we will reach a good LCOE regardless if we have Plant design or not" (Specialist, Wind Resource Assessment)

The LCOE is a metric widely used within renewable energy. It measures the lifetime costs divided by energy production of a power plant. It consists of investment expenditures in a given year, operations and maintenance expenses, fuel expenditures, electricity generation, discount rate and the expected lifetime of the system. As stated by the wind resource specialist, he expects that Vestas would reach an improvement in LCOE regardless of implementing the Plant Design project, thus making it difficult to state a direct relationship between applying LCOE as a metric for benefits realization from the Plant design project. The LCOE metric is made up of various parameters that are difficult to control or keep direct track off based in a system use.

The product organization thus continued to define a product concept based on the analytical output from plant design. They defined a digital product offering that would enable Vestas to offer a new type of warranty to the external customers. The researchers were present at several of these interventions and would continuously focus on establishing measures to the benefits. During these sessions, the researchers were able to document each benefit and the measure to this in greater details by continuously focus on the type of benefit, the change it was dependent upon and who the benefit engaged in the organization and at what time these were involved. The aim was essentially to reach the highest possible level of explicitness for a benefit, which means that it could be expressed in financial terms with sufficient evidence showing how the target value of the benefit was achieved.

As we progressed through the documentation, it made it easier for the plant design project team, the global development, and the product organization to conceptualize the benefits and their measures.

4.3.3 The third evaluation – BDA benefit measures as a dynamic concept

Applying our learnings from iteration two in iteration three, we saw the emergence of an understanding towards BDA benefit measures as much more dynamic and subject to change in reaching a high degree of explicitness. Moreover, that the degree of explicitness is negotiable depending on benefit ownership and may moreover change over time as the BDA project matures. The practitioners found the engagement with the researchers very useful, and they emphasized the benefit of having reached an understanding of how to define benefits measures and the means as to how explicitness could be reached to each of these.

This was found to be a significant concern amongst the interviewees, the element of being able to control the exact financial improvement, whether being a price increase, LCOE or CM improvement, pertaining to the use of the Plant design system.

Essentially the participants and the iterations portrayed how metrics with a high degree of financial explicitness was what was mostly sought after. Presenting business cases in terms of financial metrics has been a long standing practice for BDA projects in Vestas, yet also what caused significant challenges later in the project when trying to realize the benefits for which financial metrics were attached. As example, one interviewee identified measures for data traceability and analytical trust-ability as key for BDA projects success. Yet these types of metrics were seldom presented in the work with establishing a business case for BDA project.

"metrics as traceability and trust ability are key (for analytics)" (Specialist, Wind Resource Assessment)

4.4 Closing

We closed the action research process together with the participating practitioners and the Plant Design project team when these had assessed the lessons' usefulness in a BDA benefit measurement context. The Modelling & Analytics program manager elaborated:

"This (approach) is really good and clearly a step in the right direction" (Program Manager, Modelling & Analytics module)

The practitioners agreed to continue defining BDA benefits measures given the lessons. Further, they involved the Finance department to acknowledge the learnings based in this action research. The Finance department had an important role in supporting benefits

monitoring post BDA project development. The Finance business partner outlined how the method contributed to establishing both a long-and short-term focus on benefits and how to measure on these:

"I think that this (the method) makes it more simple for us to focus on both short-term and long-term benefits, where the long-term benefits might be dependent upon other departments in the organization" (Business Partner, Finance)

The researchers provided guides and templates for the practitioners to continue the work with BDA benefits measures across other BDA projects. Finally, the Product Manager described how the method in defining BDA benefits contributes for the product organization:

"I think it makes sense" …It also provides input to the product organization and a function as mine in the way that it becomes clear what needs to be done in order for the long-term benefits to materialize" (Product owner, Product Performance & Warranties)

5. Lessons Learned

In the following we present the lessons from our analysis and research iterations based on our initial research question "How can we measure on benefits from BDA?".

1) Benefits require change and change require measurement

The first lesson specifies that BDA benefit measurements should be established as to where the change in the organization will occur. Thus, depicting the difference between before and after the BDA project. Establishing benefit measurements pertaining to the organizational change means that the BDA project participants must spend time in understanding the impact that the BDA project will have on the organization in which the output will be used. In understanding the context of the BDA project in greater detail, it means for the project participants to move from solely focusing on BDA technology measurements towards other types of measurements such as adoption rates, understanding of the analytical output, and implications for decision making, etc. As the project will impose changes in the organization, these changes must be understood and made explicit in order to exercise a certain level of control of the change that are required to realize the BDA benefits and hence how they can be measured.

The lesson became obvious as the benefits identified in the Plant Design Project evolved as it matured. It became gradually apparent where the project would have an impact in the organization. In the beginning of the Plant Design Project, the participants had identified five different benefits already included in the business case. These were predominantly defined in financial terms: 1) scalability, 2) automatization, 3) reduction of resource spend, 4) reduction in response time, and 5) improve the contribution margin by a percentage. Before the participants engaged with the researchers in improving the BDA benefits measurement, the different ways of measuring were established from the project business case and as such were primarily financial and tied to immediate project outcomes. These were found to be insufficient. Essentially the Plant Design Project wanted BDA benefits measurements to have a high degree of explicitness, but they had difficulty in actually explicating measurements. At a first glance the business case measures seemed directly connected to project outcome but in fact they were derivatives of changes that had not been realized yet. On this basis, the first lesson demonstrates that the necessity in establishing measures of the changes in the organization. These measurements must show the difference between previous practices and new practices in which the analytics are used. For example, the project came from a benefit focus on 'automation' to realizing that they would want to 'spend more time with customers' as a measure.

The point is not that financial or quantifiable measurements are inadequate. They are indeed relevant in establishing the project business case; but we cannot rely solely on these types of measurements. The financial business analyst elaborated on this point and explained how a benefit of improving the 'contribution margin' is difficult to pin down as a wind turbine sales project contains many components that each adds value. Further, wind turbine projects may take years to develop from initial sales to the project is sold and the turbines erected. The financial benefits are long in the making and will take considerable time compared to when the analytics were produced.

2) Explicate who you are talking about

The second lesson unfolds the necessity to explicate who is involved in deciding on BDA benefits measurements at a detailed level. The who can quickly involve different groups of people in the organization that may change over time as the BDA project matures. BDA benefit measurements must be established to each of the different types of who, which can be more than simply defining the beneficiaries. A beneficiary can be described as someone who obtains a gain from something. In this study, a beneficiary was someone that would obtain a gain from

the BDA project output, Plant Design. However, there was a discrepancy between the first established BDA benefits measurements in the Plant Design Project and the type of beneficiaries that the project had defined. The beneficiaries were defined as the siting engineers and the technical sales management, and it was difficult to see how these directly would gain from the BDA benefit measurements such as reduction in the resources spend per siting reports as example. Essentially, a BDA project involves multiple actors with different perceptions on what type of benefits the BDA project may bring and how these benefits ought to be measured. The participants in BDA projects are typically part of a formal structure that entails clear descriptions of roles and responsibilities, yet beneficiaries of BDA can be found outside of these formal structures due to the intangible nature of what a BDA project delivers.

The lesson became apparent as we went through the iterations with the Plant Design Project and the project matured. BDA complicates the establishment of "who" for various reasons. First, defining the who in absolute terms is complex as BDA projects delivers an intangible product that is consumable multiple times in multiple settings. From our second iteration we learned how the who of BDA may expand as the BDA project matures. The responsibility of realizing benefits was preferred to be established with the adopting department that defines the who. Yet as the who for BDA projects may evolve over time once benefits are operationalized, so might the measures for BDA benefits. As previously described BDA benefits measurement must not solely be concerned with financial estimates but should in addition be established at the change level in the organization. This change is the responsibility of the adopting department and hence they ought to take the responsibility for the measure as well. To this we found that the latter involves BDA project measures resting outside of the formal project governance, to which little formality was established at the outset of our study. As example, in addition to system improvement benefits such as 'automatization' and 'reduction of compute time and costs', 'catering for dynamic markets and tender condition' was a crucial benefit that would materialize through the process of value engineering. In the Plant Design Project value engineering involved multiple actors. Essentially, measures had to be established pertaining to the who and the process they engaged in applying the BDA output in their daily work in the value engineering process. The who can involve BDA system users, beneficiaries, and benefit owners. Meaning that the measurements should reflect the mechanisms that enable benefits realization

3) The road to explicitness

A BDA benefit measurement is explicit once it is defined in financial terms such as increase in sales, expected return-on-investment etc. These types of measurements are typically what is

sought after in developing the BDA project business case, yet the final lesson describes how the level of explicitness cannot stand alone as a financial measurement. For a BDA project, establishing benefits measurements is dependent on other contextual measurements such as the changes in the organization and the type of who of the benefit. For practitioners wanting to establish financial explicit benefit measurements, the lesson is that these must not stand alone as what is typically found from a business case. Instead, these must be coupled with measurements pertaining to the context post BDA project development. As example, a financial measurement of improving the contribution margin of wind turbine sales projects must be attributed to how the BDA project output improves the factors that affect the contribution margin for the sales manager in negotiating sales projects.

In the Plant Design Project this became obvious from what the project participants described as value engineering. Again, the value engineering aspect of developing a siting report can be described as a process in which the siting engineer works together with the sales managers and possibly also the external customer, in developing the most optimal siting solutions for the sales project. In this process they then negotiate on different parameters such as type of turbine, rotor diameter, tip heights, type of tower etc., which eventually may have an impact on the contribution margin that the project is sold with. Thus, the value engineering process is then crucial in actually achieving the benefit of improving the contribution margin, which was expected from the Plant Design Project. Measurements pertaining the value engineering process in the organizational context, should be established in order to follow how the decisions here affect the financial measurement at a later stage.

6. Discussion

In the following we relate and review our findings from the action research study to our main research question: “How can we measure on benefits from big data analytics?” From our iterations with Vestas, we present three lessons in relation to establishing BDA benefits measurement. At the outset of the study Vestas did not have an explicit practice for measuring benefits of their BDA projects. Instead, measurements were taken directly from the BDA project business case, which, however, was found to be insufficient in measuring the potential BDA benefits. Vestas’ current practice of establishing mainly financial BDA benefits measures did not match their need post project to be able to monitor BDA benefits realization. Thus, alleviating the challenges for Vestas was not simply a question of using existing benefits measure methodologies or BDA measures (cf. section 2).

Instead, we needed a new perspective on BDA benefits measurement. The concept of BDA benefits measurements is not well established as a research topic of BDA. How to measure benefits essentially frays into various lines of focus taking different directions of discussion that altogether makes the topic fuzzy (Côrte-Real et al., 2019). A large proportion of studies have focused on establishing measures in relation to either the BDA technology or as a process (Larson and Chang, 2016) referring to what we know as performance evaluation. However, for BDA measurement this is problematic as it is limited to the technological side of BDA and lacks both the user role and business context in assessing performance (Erevelles et al., 2016; Mikalef, Pappas, et al., 2017; Mirarab et al., 2019). Against this backdrop, we present three lessons as key contributions. We will discuss each of these in what follows.

From our first lesson we expand on the change perspective for realizing BDA benefits in describing how measures pertaining to the change activities in the organization must be established. Typical performance measures for BDA related to the BDA technology itself or the BDA process (Veiga et al., 2016, 2019; Ali et al., 2019). Yet these measures are essentially limited to the BDA technology or process and does not stretch into the remaining of the organization in which the BDA output is used for decision making. The improvement in decision making caused by the better BDA analytics output will hopefully lead to higher sales or better ROI for the company, however it depends on several factors. The BDA technology success and the analytics output are naturally one set of factors, but in particular the change from old practices in the company to the new practices where the analytics output is being utilized. With this finding we thus support the claim by (Mikalef, Pappas, et al., 2017) that BDA benefits measures should be based on context. We expand with our finding on the understanding of context to also include the change of practice that can be brought about due to the BDA project.

With this lesson on measurement, we further suggest that the changed practice must be measured. For benefits management in general this is not new as this can be found in similar ways in (Ward and Daniel, 2012) Yet, BDA research does not so far relate to change of practice let alone measurement of the change. BDA research on the other hand relate only to financial measures, e.g. (Gibson et al., 2004; Gibson and Arnott, 2005; Wamba et al., 2017) but as we have seen that is a view of measurement of benefits that is too narrow and evades crucial issues. E.g., how financial measurement take very little account of the intangible nature of BDA and the potential intangible benefits that the organization can achieve. Research on BDA benefit measurement calls for establishing measure for intangible benefits (Gibson et al., 2004; Trieu,

2017). As example, Müller et al., (2018) call for research to triangulate and extend their findings applying different measurement instruments other than productivity. Benefits that are intangible could as example be greater business knowledge and tend to be of more strategic nature (Irani and Love, 2002). For these type of benefits, financial measures are not completely suitable, as these will not capture how the improvement in e.g. a decision process is stemming from the BDA implementation. As a result, the managers may only see the resulting technology cost and not the real added business value. The Plant design project was an example of this. Essentially the project had identified various financial attributable measures that however did not capture the potential value from how the Plant design project would improve the accuracy of the prediction and the Plant design process as a whole, once the system was implemented in Vestas.

With the second lesson on specification of who, we respond to the call by several studies that BDA measurement needs to extend into the business context in assessing performance as well as to understand the users' role in this (Erevelles et al., 2016; Mikalef, Pappas, et al., 2017; Mirarab et al., 2019). Especially explicating the users in benefits measurement as we present how defining the who can involve different groups of people in the organization. Specifying the who for the benefit measures is important as BDA produces an analytical output, e.g., an information statement in the form of a prediction, which can be interpreted and then acted upon. As this information statement is not restricted to be consumed only once or by a certain group of people, it may benefit different groups of people in the same organization. The beneficiaries are different and must thus be specified to impact how benefits get measured and used. This is novel finding from this study and it replies to the call for explication of users. It also goes beyond that as the same analytics output will be valued in differing ways by different beneficiaries.

The third and final lesson concerning measurement explicitness, describes how the level of explicitness is dependent upon other types of measures. As example, financial measures come with a high degree of explicitness and are tangible in their nature, which makes them more easy to deal with. Thus studies stress that benefits with a high degree of explicitness in financial terms are sought after (Wamba et al., 2017). Our third and final lesson, fundamentally confirms this as well. As the ultimate measure for the Plant design project, the project members wanted measures in the form of increased sales, improved contributions margins etc. However, the road by which explicitness was achieved and the financial benefits could be attributed to the Plant design project, was dependent upon them establishing other types of measurement. Several studies stress that BDA benefits manifest by orchestrating both technology, people and

organization (Mikalef, Pappas, et al., 2017; Ali et al., 2019). We add BDA benefits measurement to the same orchestration and not solely from financial measures. Thus, in evaluating investments in BDA we must understand that these investments are complex and difficult to measure with a high degree of explicitness and anticipation. The measures stretch beyond typical measures we see for BDA when assessing the BDA process as efficient. Instead, we propose that the level of explicitness for a BDA benefit measurement is coupled with other types of measurements (e.g., Lesson one and two). In supporting the claim that BDA benefits realization is a combination of people, process and technologies, and thus the road to achieving a financial improvement from the BDA technology investment is dependent upon various other factors. These factors must be understood and potentially measured to assess the financial impact.

7. Limitations

A limitation of our study concerns the research method of action research. Despite the obvious advantages of action research when engaging in a problematic situation with the aim of change relevant for both the practitioners and researchers, the method also comes with some limitations (Mckay and Marshall, 2001; Avison et al., 2018). First, AR is often criticized for providing "local solutions to local problems" (Hayes, 2011, p. 16). This does not indorse the neutrality and generalizability that is associated with scientific rigor (Mckay and Marshall, 2001). We based our analysis and lessons on the collaboration with a single organization, Vestas. Even though we were involved with a project highly engaged with BDA, extending our lessons to other organizations that face similar challenges would be needed. This would add to the generalization ability of our findings. We report significant contributions from our findings in relation to the value concern of BDA (Mikalef, Pappas, et al., 2017). Yet, there is still limited information on how to measure on BDA benefits and future research ought to investigate how to measure benefits from BDA projects that extends beyond BDA as a technology and a process, and instead into the context in the organization where BDA materialize.

8. Conclusion

In this study we applied action research to study how an organization deeply involved with

BDA, can improve on the way they establish BDA benefit measurements. Our action research led us through several iterations through which we elicited three lessons. The lessons were found as:

- Specification of change
- Specification of who
- Establishing explicitness

The lessons were found useful for the problematic situation Vestas was in, at the outset of the study. The study was based on benefits measurement from benefits management and BDA value measures. These formed our theoretical basis for the iterations in Vestas. Our study provides novel contributions for BDA benefits measurements and point to new directions on benefits realization in BDA projects. Our research highlights the need to establish BDA benefits measures that goes beyond business case financial and technology pertaining measures and we encourage future research in understanding contextual BDA benefits measures.

9. Statements and Declarations

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. The authors have no conflict of interest to declare.

The authors declare that the data supporting the findings in this study are available within the article in form of quotations. The data are not publicly available due to these containing sensitive information from Vestas Wind Systems A/S.

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