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A Critical System Heuristics Approach to Boundary Judgements

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Benefits from Big Data Analytics Projects: A Critical System Heuristics Approach to Boundary Judgements

Research Paper

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Abstract

Big data analytics (BDA) has strategic value for many large organisations. However, obtaining evident benefits from BDA projects requires complex orchestration across organisational boundaries and entities. The requisite ability to distinguish a potential BDA benefit in its' organisational context has nevertheless received limited research attention. Against this backdrop, we report a case study of benefit conceptualization in a BDA project at a large wind turbine manufacturer (Vestas). Using critical systems heuristics, a framework of systems' stakeholders, stakes, and stakeholding issues, we analyse how the stakeholders in Vestas make boundary judgements for the BDA benefits they plan to realize. This analysis shows how a BDA benefit is a complex system involving negotiations on how a benefit ought to become evident in the organization. We discuss the implications of this finding for how BDA projects can make their boundary judgements for planned benefits explicit and defensible.

Keywords: Big data analytics benefits, critical system heuristics, boundary judgements, value creation, case study.

1 Introduction

Big data analytics (BDA) has the potential to create significant competitive advantages for organizations by enabling benefits such as product innovation, service innovation, organisational agility and many more (Grover et al., 2018; Mikalef et al., 2020). Realizing benefits from BDA is, however, a challenge for many organizations (Jensen et al., 2019; Sivarajah et al., 2017), and studies have stressed the need to understand how, when and why BDA can act as a valuable resource (Abbasi et al., 2016; Agarwal & Dhar, 2014; Corte Real et al., 2014; LaValle et al., 2011). A complex BDA output is not in itself a benefit (Sharma et al., 2014). Instead, it is an information statement to be perceived and consumed by a potential user (Abbasi et al., 2016).

The ultimate success of a BDA project lies in realizing the benefits it aimed at achieving in creating a strategic advantage (Grover et al., 2018). However, benefits does not materialize from the technical implementation solely (Marchand and Peppard 2013; Ransbotham et al. 2016). Going from the output as the technology has been implemented to a benefit is a transformational dilemma. BDA is an intangible product of multiple data from various sources, in various forms, that may be interpreted very differently depending on who the receivers are. These varying interpretations can cause conflicts in what the value of the BDA essentially is and how it can be realized as a benefit in the organization.

Transforming a BDA output into a benefit is a systemic problem containing systems of conflicts due to organization-wide stakeholder interactions that dilute what a benefit can be taken to be. To make the benefits from BDA projects more evident and delimited for organizational actors, we propose attending to these actors' boundary judgements. To address this, we report on a case study of a complex

BDA project in the wind turbine manufacturer Vestas Wind Systems A/S (Vestas) to address the research question:

How can a big data analytics project make boundary judgements for the benefits they plan to realize?

In answering this research question, we first present the related research on BDA benefits and the systems thinking of critical system heuristics (Ulrich, 1987; Ulrich and Reynolds, 2020). Next, we present our research method and case context leading to the analysis and final discussion and conclusion of our case study.

2 Related research

2.1 Big Data Analytics Benefits

BDA may provide economic and societal benefits for public and private organizations (Günther et al., 2017; Loebbecke and Picot, 2015; Mikalef et al., 2020; Sodenkamp et al., 2015; vom Brocke et al., 2014). Organizations investing in BDA should perform better financially (Grover et al., 2018; McAfee and Brynjolfsson, 2012; Müller et al., 2018) and gain strategic advantages in terms of innovative products, services and new business opportunities (Davenport et al., 2012; Davenport and Kudyba, 2016; McAfee and Brynjolfsson, 2012; Seddon et al., 2017). While BDA may provide an organisation with many benefits, simply assuming that implementing BDA is enough to realize benefits is naïve (Asadi Someh and Shanks, 2015). This problem is evident in many BDA project failures (Asay, 2017; White, 2019) and the numerous challenges of realizing BDA benefits (Berntsson et al., 2020; Jensen et al., 2019).

Organizational actors' sensemaking is essential for the success of BDA (Côrte-Real et al., 2019). Pre-existing frames of reference carried by analysts, users and business managers influence the logic applied to the data elements and the narrative in constructing action repertoires (Lycett, 2013). Recent studies thus call for investigating the human component as it is up to humans to interpret the BDA outcomes and make decisions (Mikalef et al., 2020). In creating benefits from BDA, the human actors in this are often subject to several forces that potentially can inhibit or sway their decision-making and judgements processes in interpreting the analytical output (Sharma et al., 2014). Similar results are noted by (Janssen et al., 2017), who indicate that BDA will provide little benefits if the human actors are not able to interpret the desired decisions from it. Nevertheless, the interdependencies or restrictions that big data creates for analytics and human interpretation are rarely empirically researched (Mikalef et al., 2020).

The concept of a benefit is subjective and co-determined by actors' interactions (Barile et al., 2012). Benefits depend on the time, place and those involved in defining it, but current organizational instruments and procedures do not provide sufficient support for this view (Iandolo et al., 2018). We need to better understand how analytics leads to benefits in order to move beyond the early stage of maturity and lack of empirical investigation in the BDA research literature (Abbasi et al., 2016; Conboy et al., 2020). BDA provide an information statement to be consumed in a given setting before it can be materialised as a benefit (Abbasi et al., 2016; Sharma et al., 2014). Information can be consumed multiple times and in different settings, which makes the benefits realization complex.

Moreover, organisations consist of a plurality of voices and social dynamics that shape how organisations and individuals act. In projects responsible for the implementation, semi-autonomous members must interact at many levels of organizational hierarchy and silos with diverse practices of "this is how we do things" (Svejvig and Andersen, 2015). For these reasons, defining benefits from BDA projects is a complex task that may be inhibited by what we know about organizational boundaries (Eisenhardt, 2005), cognitive limitations (Simon, 1955), and cultural differences (Wenger, 1988). Consequently, a BDA benefit depends on the organisational setting for processing a BDA output into meaningful comprehensions (Gandomi and Haider, 2015).

Initial studies suggest that realizing benefits from BDA requires for an organisation’s different entities to be aligned (Jensen et al., 2021; Jensen et al., 2023). This includes the alignment of strategic plans, experts and tools (Akter et al., 2016; Ghasemaghaei et al., 2018; Larson and Chang, 2016; Wamba et al., 2017). There has been a tendency to focus on the technology challenges pertaining to BDA (de Camargo Fiorini et al., 2018; Mikalef et al., 2020; Sivarajah et al., 2017). However, resource allocation and orchestration processes must be better understood for BDA benefits realization (Gupta and George, 2016; Mikalef et al., 2018; Sharma et al., 2014). Generating BDA benefits involves a multifaceted relationship between data, analytical tools and sensemaking that can be seen as a complex system involving multiple actors (Armenia and Loia, 2021). In understanding BDA benefits as wholes, relationships, dependencies, and patterns, we propose attending to the boundary judgements made by the actors involved in the BDA benefits realization. To this, we apply boundary judgements stemming from Critical System Heuristics (Ulrich, 1996).

2.2 Critical systems heuristics

“The systems approach begins when first you see the world through the eyes of another.”

(Churchman, 1968/79, p. 231)

Critical systems heuristics provides a conceptual framework for critical practice and awareness (Ulrich, 1987) in which problem solvers aim to intervene in problematic social situations to improve them (Ulrich, 1983), which has been useful in IS/IT contexts (Duboz et al., 2018; Venter and Goede, 2017). Critical systems heuristics considers human intervention and broader organisational aspects pertaining to both social complex and technical issues by including the “Involved” and the “Affected”. The involved group could include professionals and decision makers in a system’s design, whereas the affected group are those that receive the system and are affected by it.

Critical systems heuristics brought in the notion of boundary judgements through multiple stakeholder viewpoints for analysing facts and values underlying such a decision-making process. Boundary critique enables problem solvers to deal with boundary judgements and make sense of situations by understanding assumptions and appreciating the bigger picture (Ulrich, 2010; Ulrich and Reynolds, 2020). This critical analysis aims to determine what is relevant, who should assist to determine it, and how to handle conflicting views among relevant stakeholders. Critical systems heuristics offers a checklist of boundary questions to be asked in an “is” and “ought” analysis of the what, who and how of a system, c.f. Table 1.

Sources of influence	Boundary judgements informing a system of interest (S)			
	<i>Social roles (Stakeholders)</i>	<i>Specific concerns (Stakes)</i>	<i>Key problems (Stakeholding issues)</i>	
Sources of motivation	<i>1. Beneficiary</i> Who ought to be/is the intended beneficiary of the system (S)?	<i>2. Purpose</i> What ought to be/is the purpose of S?	<i>3. Measure of improvement</i> What ought to be/is S's measure of success?	The Involved
Sources of control	<i>4. Decision maker</i> Who ought to be/is in control of the conditions of success of S?	<i>5. Resources</i> What conditions of success ought to be/are under the control of S?	<i>6. Decision environment</i> What conditions of success ought to be/are outside the control of the decision maker?	
Sources of knowledge	<i>7. Expert</i> Who ought to be/is providing relevant knowledge and skills for S?	<i>8. Expertise</i> What ought to be/are relevant-knowledge and skills for S?	<i>9. Guarantor</i> What ought to be/are regarded as assurances of successful implementation?	
Sources of legitimacy	<i>10. Witness</i> Who ought to be/is representing the interests of those negatively affected by but not involved with S?	<i>11. Emancipation</i> What ought to be/are the opportunities for the interests of those negatively affected to have expression and freedom from the worldview of S?	<i>12. Worldview</i> What space ought to be/is available for reconciling differing worldviews regarding Among those involved and affected?	The affected

Table 1: The boundary categories and questions of critical systems heuristics. Adopted from (Ulrich, 1996, p. 44)

Critical systems heuristics then considers four categories to describe the normative content of systems. From table 1 these are the sources of influence being 1) sources of motivation, 2) sources of control, 3) sources of knowledge and 4) sources of legitimacy (Ulrich, 1996). The 12 boundary questions make explicit the everyday judgements on which we rely to understand situations and to design systems for improving them. As a starting point, the boundary questions contribute to gaining an analytical focus to understand situations – as example, BDA benefit creation. In both the analytical and practical focus, the aim is to enable a reflective practice in a way that goes beyond the mainly psychological-introspective understanding of the concept both for the people considered as involved in the system but also those considered uninvolved. Thus, critical systems heuristics allows an emancipatory focus that permits people to make their own authentic boundary judgements, being involved or not.

3 Research approach

We aim to investigate boundary judgement for a BDA benefit and its realiation using a case study approach since it is a valuable method for studying contemporary practice-based problems (Benbasat et al., 1987). Our research design is qualitative with inductive reasoning due to: 1) the lack of prior research on BDA value considering boundary judgements, and 2) the novelty of the topic. We selected a revelatory case study design (Yin, 2009) as our phenomenon of interest in understanding BDA benefits is inherently complex and organizational situated. Our case, the Plant Design project and the AEP bias and uncertainty benefit, is a highly business critical and complex project in Vestas involving multiple data sources and actors. Vestas is a Danish wind turbine manufacturer and service provider with a little over 26,000 employees located around the globe. For several years, the company has used big data to strengthen its competitive advantage and offer various products supported by big data. In 2020, Vestas began a journey to improve its siting capability in building wind turbine power plants. The location of a wind farm influences the power generated from the turbines and the impact on the power grid. It builds the economic business case for the customer; making the assessment of the potential site for wind farms is crucial. Data for siting is key and works as important decision drivers. Vestas has, since January 2000, built its climate library with hour-by-hour data to predict the performance of potential wind farms. It is a unique global climate library that includes data from more than 38.000 turbines online in the system, more than 61.000 turbines installed, historical data from previous projects and more than 10.000 meteorological masts installed. Thus, the Vestas climate library provides the siting engineers with mesoscale models that covers the entire globe with more than 100 climate variables to apply for analysis. In addition, Vestas had implemented a big data solution that reduced the geographic grid area by 90% to increase accuracy in estimating a potential site. Vestas began its siting improvement journey by investing significantly in the project Plant Design. The project was expected to run for a couple of years, aimed at delivering a digital platform for designing, configuring, and optimizing a power plant layout and, through that, delivering for various value measures. Amongst these value measures were the ‘AEP bias and uncertainty’ benefit.

The project was initiated for the technical sales management in Vestas, to identify the full potential of renewable hybrid sales offerings. The current technical optimization was sub-optimal from the existing technologies not being fully utilized due to the current platform’s inadequacies. Moreover, there was a lack of integration of financial parameters. Further, as the market conditions and demands for renewables constantly change, the current platform was not sufficiently agile in keeping up with the changing requirements. From this development work, the project intended to deliver various benefits both internal and external to Vestas. Among these were improvements in the customers business cases by being able to provide the most competitive product offerings, reduce response time on sales leads, reduce resources spend in technical sales, improved contributions margins in sales projects and more accurate computational outputs combining various data sources such as financial data. The ‘AEP bias and uncertainty’ was a computational output that lowered the uncertainty in AEP predictions for a future

power plant and doing so with less bias between actual and predicted AEP. So, the ‘AEP bias and uncertainty’ output is a computational improvement with the potential to become important information and knowledge that Vestas should turn into a benefit. Yet, at the time of the project, very little attention had been given to how this would happen. Simply providing the improved computational output would not ensure benefits achievement as well.

In this study, we collected data from multiple sources. The advantage of using multiple sources of evidence is the development of “converging lines of inquiry”, which is a process of triangulation that increases the precision of the empirical research (Yin, 2009). Moreover, as generalizability (Maxwell, 1992) is challenging for particularly case studies (Yin, 2009), we addresses this from linking the findings in the study to existing generalizable theory (Urgugart et al., 2010). Thus, to enhance conclusion validity from the study, we took the following actions (Yin, 2009): 1) All three researchers were involved in the interpretation of the transcribed interviews and notes hereto, 2) conclusions were based on a clear audit trail from initial data collection and 3) the findings were presents to the management and project teams in the case.

The data collection was carried out from November 2020 until August 2021 by an industrial PhD student that had access to this interesting case of a complex BDA benefit through participant observation at 33 project meetings. This amounted to a total of 51 hours combined with weekly research debriefing meetings (Spall, 1998) with the two other authors of the paper. In addition, several documents from the Plan design project were collected. These documents included the business case justification of the project as an investment, minutes of meetings, stage gate presentation material, project design specifications of the BDA technology to be developed, cost and hour allocation material and documentation in relation to the specific assignments and tasks concerning the agile development that the project used.

Eight in-depth interviews with the stakeholdes involved and affected (Ulrich, 1996) by the Plant project and AEP bias and uncertainty benefit realization served as primary source of data. The informants were individuals that could account for the motivations and challenges for the AEP bias and uncertainty benefit and the project output for it. Their organisational levels ranged from the Plant Design project level to the strategic level for the AEP bias and uncertainty benefit (see table 2).

Participant	Functional area	Role in case project Plant Design
1: Design Owner	Engineering, Modelling & Analytics	Technical solution specialist, management level. Responsible for the technical solutions developed within functional area.
2. Project Manager	Project management	Project management responsible for delivering on agreed deliverables within time, budget and scope for the Plant Design project.
3. Senior functional lead	Modelling & Analytics, senior functional leads	Technical solution specialist for the Plant design project. Involved directly in project work. Reports to the Design owner.
4. Sales Manager	Sales	Sales representative. Defining requirements from sales.
5. Chief Specialist	Product Value engineering	Defining potential products that could be developed from the improvement in AEP bias/Uncertainty
6. Head of Siting	Global Siting	Representing the siting department and the requirements specific from them towards the Plant design project.
7. Senior Financial Specialist	Finance	Financial expert supporting the Plant design project in developing the business case for the potential benefits in collaboration with the chief specialist and the Sales manager.

8. Senior Specialist	Product development	Defining market requirements towards product development from AEP bias/Uncertainty benefit in the plant design project.
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Table 2: Interview participants

The informants (cf. Table 2) were chosen to collect rich and thick data for analysis (Gerring, 2011; Gibbert and Ruigrok, 2010; Onwuegbuzie et al., 2010), and the questions were tailored to the case context (Ulrich and Reynolds, 2020). All the interviews were transcribed based on audio recordings that resulted in 130 pages of transcript. The data was analysed with directed content analysis (Hsieh and Shannon, 2005; Assarroudi et al., 2018), which begins by identifying key variables or concepts from existing theory as initial coding categories (Potter and Levine-Donnerstein, 1999). From critical systems heuristics, the analytical categories were given through the 12 boundary questions. We then pursued stepwise coding that consisted of open, axial and selective coding. We did so to elaborate on the boundary judgements from the participants on the AEP benefit. Asking the twelve boundary questions fulfils the analytical purpose of critical systems heuristics to reveal how decisions about what is relevant to a system being made. The boundary questions are considered in two modes: an ideal model (what “should” be), and a descriptive mode (what “is”). Differences between “is” and “ought” answers point to unresolved issues.

4 Analysis

From our analysis, we report the system of dealing with ‘AEP bias and uncertainty’ benefit, which is derived from the improvement in the computational output, i.e., to reduce the bias by X% with a certainty of Y%. The computational output is not necessarily a benefit. Thus, we treat the computational output and the potential benefits as separate systems yet dependent upon each other. We make the following distinctions:

System 1 (S1): ‘AEP bias and uncertainty’ output. This system is involved in improving the computational output of the ‘AEP bias and uncertainty’ by reducing the bias between forecasted AEP and actual AEP with X%, e.g., having a more accurate prediction. The improvement in uncertainty is then that the more accurate prediction now involves less uncertainty in the computation.

System 2 (S2): ‘AEP bias and uncertainty’ benefit. This system is about transforming the output from system 1 to a benefit in the organization; in this case Vestas (Figure 1).

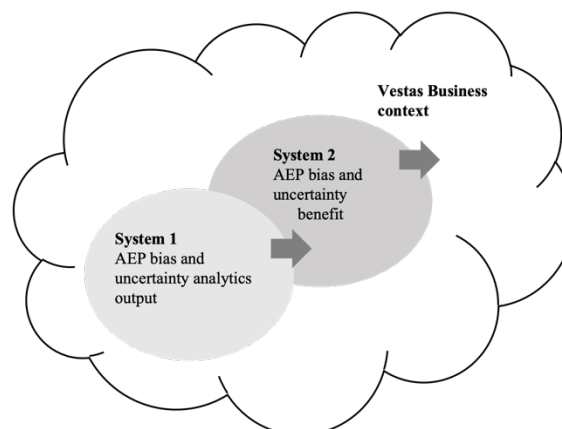


Figure 1: Systems of interest

The system of realizing a benefit (S2) from the ‘AEP bias and uncertainty’ output (S1) is made up of an ensemble of departments, information to be consumed, internal and external customers and financial

institutions. Thus, any attempt to establish this system involves collaboration and partnerships among various stakeholders. We will explicate these by dividing our analysis based on the three boundary categories developed by (Ulrich, 1983) being: 1) Social roles (Stakeholders), 2) Specific concerns (Stakes) and 3) Key problems (Stakeholding issues), cf. section 3.

4.1 Social roles (Stakeholders)

A **beneficiary** is someone who experience an improvement from a particular system. At the outset of the Plant Design Project, the ‘AEP bias and uncertainty’ output (S1) should help the siting engineers improve the quality of their siting reports. However, the Siting Department was essentially a beneficiary limited to S1. For S2, it was sought to convert the ‘AEP bias and uncertainty’ output into a monetary benefit. In this conversion, the Product Value Engineering Department wanted a warranty product to mitigate AEP production risks for Vestas’ customers, and the Global Development Department wanted to help its sales managers sell a wind turbine park at a higher price per MW. Thus, the S2 beneficiaries were spread throughout various functions and departments in Vestas and not from a single department, the Siting Department, in isolation.

The **decision maker** is someone who ought to be or is in control of the conditions of success for a system. The decision maker of S2 was the project manager, who had the mandate to scope which parts of the organization the Plant Design Project project engaged with. The design owner in the Modelling and Analytics Module also acted as a decision maker that had previously worked with a benefit focus in other projects and thus was a strong contributor in including the S2 in the Plant Design Project. Yet, both of these decision makers tended to focus on the technology and technical requirements of the ‘AEP bias and Uncertainty’ output, S1. To realize the potential benefit, S2, the decision making needed to move from those engaged with the technical development to those representing the business demands. The design owner elaborated:

“There are some important principles in separating the analytical part and the decision maker rights. We are currently missing the decision architecture” (Design owner, Modelling and Analytics Module).

The **expert** acts as a source of knowledge and skills provider for the system. As S1 and S2 depend on each other, an expert must know about both systems, but nobody meets this requirement. Instead, the experts were either focused on S1 and S2 separately. Again, the design owner acted as the central source of knowledge for S2 based on previous experience working with BDA benefits. The senior functional lead, an expert for technical development in S1, had also worked with a benefit focus, but not to the same extent as the design owner. The senior financial specialist had no experience working with a benefit focus before the Plant Design Project and thus struggled to define a benefit from the ‘AEP bias and uncertainty’ output. His expertise was crucial in formulating monetary benefits. However, he did not collaborate with experts on what the benefit from the improvement in the ‘AEP bias and uncertainty’ output could be beside the computational improvement. Essentially, these experts in S2 had not been included in S1, despite the need for their business demand input to the business case calculations. As these experts had not been identified at the beginning of the project, their collaboration was very limited.

Finally, the **witness** is someone who ought to be or is representing the interests of those negatively affected by, but not involved with the system. Taking responsibility for representing and identifying the witnesses was not a standard practice in Vestas. The Plant Design Project reached out within the organization to identify potential cases where the improvement in ‘AEP bias and uncertainty’ output might be harmful. Yet no witness was defined to which the chief specialist described the issue stemming from these projects’ overrepresentation of S1 experts with few S2 stakeholders (which the Chief specialist calls generalists) that contribute to changing the mindset of those deeply involved with the technical development:

“We need more generalists and I hope that is the purpose with our new Product Strategy Department, but we also need to make people in the module departments to think differently about this (AEP bias and uncertainty benefit realization)” (Chief specialist, Plant value engineering)

4.2 Specific concerns (Stakes)

The **purpose** is concerned with the reason and motive of the system in question. The purposes of S2 were scattered and unclear, with no clear boundaries. The purposes ranged from being purely driven by computational improvement, to being able to offer new innovative digital products – such as warranty products, to external customers. The ought-to-be purpose of the benefit defined by the chief specialist was: *“to bring down the financial costs for our customers”* (Chief specialist, Plant value engineering).

When the purpose was defined at the computational level, it involved S1 and what was needed to achieve the improvement in the computation, which is not a benefit before it is transformed into something that actively contributes to Vestas’ competitive advantage. S1 is concerned with the technical boundaries, whereas S2 extends these to the rest of the organization. The project manager elaborates:

“We are very much a technology driven organization, we lack a focus on our customers and sales activities. We are missing a constructive anchoring of our (data) products and if we had a lifecycle management perspective of these, I think it would have more management attention as the whole budget and value of the product would be managed” (Project manager, Plant Design project)

The **resources** concern what conditions of success that is, or ought to be under the control of the system. The different purposes defined for S2 diluted which resources were needed for S2. As the purpose of S2 was many, this entailed various departments that could be affected both positively or negatively by S2. The Plant Design project struggled in identifying these as it went beyond the responsibilities of the project team. Instead, a focus on a more permanent function post the project development stages was needed that would build a bridge between the technical BDA development and the business:

“We are missing that part right now. We are deeply involved in the technical development in the organization, however, this does not work when we are trying to represent the needs of the business, our customer etc...” (Senior specialist, Product management)

The senior specialist argues S2 ought to include resources that could anchor the benefit from an organizational perspective and sustain it, such as a product strategy department and a financial specialist role that could break down the computational output in S1 to a monetary benefit in S2. To this, the chief specialist added that the needed resources for S2 ought to have a more general profile in bridging the business and technical experts.

Expertise is concerned with what ought to be or is the relevant skills and knowledge of the system. As the ‘AEP bias and uncertainty’ output had not previously undertaken a benefits focus, the expertise needed for establishing S2 was spread throughout Vestas. The technical expertise in developing S1 was in place, a prerequisite for S2, yet, the expertise in bridging S1 and S2 was missing. A strong business anchoring was needed in establishing S2. Expertise between S1 and S2 was equivalent to a separation between a technical focus in S1 and a business focus in S2. Keeping these two separate may work to a certain degree, where the technical department decides on the computational method, data needed, analytics etc., and the business departments decide the product strategy, sales, customer need, etc.

Finally, **emancipation** is concerned with how those potentially negatively affected by the system can raise their concern and be free from the worldviews dominating the system. The responsibility for emancipation was distributed to different levels in Vestas, ranging from project, department and product level. The Design owner elaborated:

“To me, there is only one way to do this, and that is at the product ownership meetings ultimately” (Design owner, Modelling and Analytics Module).

The product ownership meetings included representatives from the organization, such as sales, service, finance, and the different module departments in Vestas. Thus, those potentially negatively affected would be present at these meetings, or those present would be aware of the issues to be addressed in relation to the AEP benefit. However, this was not always the case. Instead, the conflict in opinions regarding the benefit was mostly handled on an ad-hoc basis. Emancipation responsibility at a

departmental level – specifically the Siting department and the technical sales department, meant that these departments were responsible for including potential victims and their opinions when developing a new system. Yet, this was not a formalized practice but based on the individual's knowledge of Vestas. With this scattered distribution of emancipation, there was little consideration of those potentially negatively affected by S2.

4.3 Key problems (stakeholding issues)

The **measure of improvement** is concerned with the system's measure of success. The S1 measure of success was the improvement of the computational output, while the strategic focus on measuring the success of S2 was, according to the project manager, lacking:

“People would like to measure on it [‘AEP bias and uncertainty’ benefit system] ... but there are many opinions about it and it's not like there is a clear strategy for it” (Project manager, Plant design project).

The design owner further elaborated that the current measure of success was established from the computational improvement and thus limited to S1:

“We are not measuring on this today, not systematically...we have a measure for bias and uncertainty but not for the benefits” (Design owner, Modelling and Analytics module)

The ought-to-be measures of system success were many and varied across the actors in S2, e.g., warranty product's improvement of the financing model for external customers or improving the business cases regarding price per MW.

The **decision environment** asks what should be included and what ought to be left out of the system. The S2 decision environment struggled with an unclear cooperation setup when distinguishing between business and technical responsibility and accountability for the requirements. Those representing the business were anchored within the technology department resulting in technology people developing BDA for other technology people prioritizing the computational output improvement and not the business, such as developing new warranty products. The project manager elaborated:

“We suffer from ‘groupthink’ ...the people, we in the Plant Design Project are delivering to, are people that previously have been in the same department as us. They are still technology people despite now sitting in the Product Management department” (Project manager, Plant design project)

Thus, the technical experts restricted their attention to the boundaries of S1, excluding the benefits realization focus of S2.

The **guarantor** asks what ought to be, or is, regarded as assurances of successful implementation. The first assurance of success for the project manager was at the business case level, where a strong business case with a positive return-on-investment would act as an assurance of success. Yet, accepting the business case as the assurance of success for S2 would mean that the business case should include the potential benefits arising from improving the computational output ‘AEP bias and uncertainty’. The senior specialist from the Product Management department explained how the assurance of success for S2 was driven from a bottom-up perspective where projects, such as Plant Design, would have to prove the benefit of the project to justify the project being developed. Proving for the management that a benefit is realized without the needed changes in the organization is a difficult orchestration between forecasting and assuming certain conditions – if not an almost impossible task:

“It's bottom-up driven at the moment. We must go out and prove its (the project) worth first and from that then justify the investment in it...” (Senior Specialist, Product management)

This justification resulted in tension between S1 at the Plant Design project level and the business departments where the sustaining changes needed for S2 had to be implemented. The business departments are responsible for sustaining the changes needed for benefits realization in S2. At the Plant Design project level, these sustained changes were not part of the scope, and the project struggled to settle this with the Product strategy, Sales, and Service departments that needed to realize the benefit.

The Plant Design project did consider the enabling changes needed for S2, and the anchoring and acceptance of transforming them to sustained changes were missing.

Finally, **the worldview** deals with the space that ought to be, or is, available for reconciling differing worldviews regarding the system in question, among those involved and affected. The normative content developed in S1 can only be justified through the voluntary consent of all those that might be affected by the consequences. Hence, there can be roles and departments affected in S2, be they involved in S1 or not, which ought to be regarded as part of the context. Yet, these actors' clashes in worldview fostered systems of silos instead of systems of cooperation. In S1, very little concern was given to the potential victims of S2. The chief specialist highlighted the challenge:

"We have a very traditional way of treating these things (BDA projects). We have Sales, Product Management, Product strategy, the Module departments etc. It's a long chain, and we are simply used to just chasing requirements. What we do is push these requirements towards each other but not the understanding...I think it's a disaster that it's an engineer like myself who must explain Product strategy and Service how I think they should do business" (Chief specialist, Plant value engineering)

The different departments and functions had their own idea of how the two systems should interact, with an expectation that the potential victims and their say in the development of S2 would automatically be included. Often it was expected that the potential victims of a system would speak their concerns – though without necessarily knowing they are supposed to be concerned. In defining the boundaries between S1 and S2, we are dealing with a computational output that may be consumed by multiple actors in various settings and with different purposes. Asking for the people involved in S1 to settle on all these unknown factors appeared as essentially out-of-scope at the Plant Design project level.

5 Discussion

Realizing evident benefits from BDA projects is a complex organizational effort. Research on BDA benefits realization offers valuable insights into what benefits BDA may provide to an organization (Günther et al., 2017; Loebbecke and Picot, 2015; Mikalef et al., 2020), but few studies provide a detailed account of how these benefits become evident. Our case study of a complex BDA benefit in Vestas, addresses this research gap by answering the question: How can a big data analytics project make boundary judgements for the benefits they plan to realize? Our case study unfolds the boundary categories of 1) social roles, 2) specific concerns, and 3) key problems. The following discusses how these boundary categories contribute to research on BDA benefits realization.

First, we found that making a BDA benefit evident can require different social roles in an organization, beyond the boundaries of the BDA project (c.f. section 5.1). This finding corroborates the importance of understanding the human component (Mikalef et al., 2020) in BDA benefits realization. Empirical studies on BDA benefits realization may assume a direct relationship between BDA capabilities and performance outcomes for the organization (Wamba et al., 2017). Yet, our case study shows how manifesting a BDA analytical output as a benefit can involve many beneficiaries and potential victims with varying interpretations of what it is, as individuals or co-determined by their interactions or in lack of such interactions. We thus corroborate (Barile et al., 2012) that the concept of a benefit may be co-determined by actor's interactions and how these negotiate the boundaries around it. BDA benefits entail a dilemma in establishing boundaries among the perceived systems involved in benefits realization, i.e., the project (1) and benefit (2) system. Actors in these systems, e.g. the project manager or the data scientist, can have different social roles in these highly related but very different systems. Thus, an expert in one system– e.g., in providing the analytical output from Big Data, may instead act as a witness in another system that is concerned about the benefits realization from the analytical output. This finding contributes to the call for assessing the human component in BDA benefits realization by making explicit the system considerations of social roles with the needed resources for an organization to orchestrate BDA benefits realization. The underlying assumption that the necessary resources are orchestrated and mobilized effectively has yet been largely ignored by BDA research (Mikalef et al., 2020), with "most studies adopting the logic that just because some key resources are in place, they are

orchestrated and leveraged efficiently” (p. 4). From our analysis of social roles at Vestas, a world-leading organization in using BDA for sustainable energy production, we show how this assumption is highly problematic for BDA benefits realization. Our case had the needed resources for BDA benefit realization, yet with critical systems heuristics we showed how the successful orchestration of these resources were missing. We thus propose researchers and practitioners alike attend to the different social roles in the boundary judgements for a BDA benefit that both involves intra and extra BDA project roles.

Second, regarding specific concerns (stakes), our case study shows that a BDA benefit can become evident in different ways, levels and contexts in an organization as resources and expertise for the benefit align. While previous studies also suggest that realizing benefits from BDA requires an organisation’s different entities to be aligned (Akter et al., 2016; Ghasemaghaei et al., 2018; Wamba et al., 2017), the technology challenges tend to take precedence (de Camargo Fiorini et al., 2018; Mikalef et al., 2020; Sivarajah et al., 2017). We add that purpose, resources, expertise, and emancipation should be assessed for complex benefits (cf. section 5.2) to address the call for better understanding BDA resource allocation and orchestration processes (Gupta and George, 2016; Mikalef et al., 2018; Sharma et al., 2014). As BDA provides an information statement that can be consumed in multiple settings in an organization, it can have different purposes, which will affect what resources and expertise is needed and makes its benefits, as put by (Iandolo et al., 2018), multidimensional. In judging a BDA benefit, considering the potential victims of the BDA benefit is important, as these might inhibit the actual use of the BDA output if their concerns are not attended to. An evident BDA benefit entails that an organization meets the requirements of the two systems in their specific context, providing the needed resources.

Finally, our case study shows key problems (stakeholding issues) in relation to measure of improvement, decision environment, guarantor, and worldview for making a BDA benefit evident to the stakeholders. We extend previous research on BDA challenges (Berntsson Svensson and Taghavianfar, 2020; Jensen et al., 2019) by unfolding how specifying and making boundary judgement for a single benefit can entail substantial struggles, even for an organization with a long track record of BDA investments and capabilities. While we know the measure of improvement must move towards the organizational setting post BDA project development (Larson and Chang, 2016). Our study shows how a BDA benefit’s measure of success can go beyond the boundaries of the BDA project and into the organizational setting. This post-project measurement is vital as few empirical studies exist with robust measures of BDA impact and improvement (Jensen et al., 23; Müller et al., 2018). We also extend our understanding of BDA benefits realization challenges (Jensen et al., 2019) by unfolding the decision environment’s technical and economic parties’ engagement in an ongoing negotiation. This situation adds to the complexity of assigning a guarantor and dealing with clashes in worldviews concerning the BDA benefit spanning departmental boundaries. Nevertheless, these clashes of worldviews are both a challenge, and an opportunity as different perceptions and ideas can be instrumental for benefits realization.

While many organizations are keen to pursue the strategic advantages BDA may entail, they struggle to obtain the expected benefits. The practical implications of our study are that organizations should attend to the orchestration of BDA technologies and benefits as two separate yet highly interdependent systems. Organizations should make boundary judgements for the expected BDA benefits’ motivation, control, knowledge, and legitimacy. At the outset of a BDA project, those involved must make explicit the motivations for the specific BDA benefit, how to control its emergence, what knowledge is needed, and how to create legitimacy for the benefit in the broader context.

Our case study does not come without its limitations. As we have investigated a specifically complex type of BDA benefit in an organization with a high degree of knowledge within BDA, transferring our case to another research setting may be difficult. However, we encourage future research to extend our research to other domains and cases in order to gain an even deeper understanding of how BDA benefits become evident. Although this study demonstrates the importance of attending to the boundaries of a BDA benefit, one must not automatically assume that attending to the boundaries leads to benefit realization.

Future research on BDA benefits can be directed from the conclusions drawn to each of the boundary categories, such as how to exercise control from both a technical and organizational perspective of the benefit. We also suggest that future research attends to the concerns around boundaries between benefits in a portfolio. Moreover, we need reearch on how multiple projects contributing to a single benefit, can make boundary judgements in this context. As a starting point for such future research, our case study shows the usefulness of critical systems heuristics for understanding these boundary judgments.

6 Conclusion

The ability to distinguish a potential BDA benefit in its' organizational context has been given limited research attention. To deepen our understanding of the individual benefits from BDA projects, we report a case study of a complex benefit in an organization, Vestas, that uses BDA extensively in the context of sustainable energy production. In this study, we analyse the social roles, specific concerns and key problems to contribute novel insights on the boundary conditions for a BDA benefit. For the social roles, we show that making a BDA benefit evident is co-determined by actors' interactions as beneficiaries, decision makers, experts, and witnesses. Their specific concerns for a BDA benefit involve orchestrating stakeholders' different purposes, resources, expertise, and emancipation. The key problem for evident BDA benefits is that the measure of improvement, decision environment, guarantor and worldview extends beyond the BDA project into its organizational context. Our case study shows how these boundary conditions are central for a BDA project in contributing to benefits evident to stakeholders in a complex organizational setting.

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