Application of Blockchain in the Wind Industry

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Abstract. The PhD-project explores the value of blockchain for the wind industry and explores how it may improve its inter- and intra-organizational business processes. Specifically a supply chain-based use case is explored and intended to be developed through the UnWind-project. Topics considered include the technological maturity of blockchain, the characteristics of the wind industry's collaborative supply chain activities and how the blockchain may be adopted by the wind industry. The research will follow the development of a use case in the UnWind-project, in which both the architectural design of the blockchain solution and the implications on the business model of the implicated organizations' business models are considered. Finally, the UnWind use case is intended to be evaluated in relation to technology adoption theory, while contributing new empirical knowledge to elaborate on said theory.

Keywords: Blockchain, wind industry, business process management.

1 Introduction and context of the project

The purpose of the research is to uncover the potential blockchain technology may have on the wind industry, focusing on upstream supply chain activities associated with the wind turbine generator (WTG) including activities on manufacturing, operation and service. The broad perspective is taken because it is the transactions, transformation and information flow associated with WTG-components and their associated business processes that is of interest in the context of blockchain technology. In other words, the interest of the project is on the processes where there is a flow of information, whether it is intra-organizational or inter-organizational.

The term *wind industry* is used as a way to refer to the supply and value chains that in unison make the WTG and ensures its continued operation. As such, the *wind industry* include original equipment manufacturers (OEM), multiple tiers of suppliers, maintenance and service organizations as well as non-profit organizations whose focus is on improving the competitiveness of the general industry.

Blockchain facilitates transactions and store the history of said transactions digitally as a ledger, except the ledger stored on the blockchain is distributed and immutable (Martinez *et al.*, 2019). Being distributed means that all members of the blockchain has a copy of the it at all times, meaning no centralized authority is in charge of it (Kamble, Gunasekaran and Arha, 2019). Instead of trusting a third party, the members

of the blockchain ensure the validity of transactions through a consensus mechanism in which members involved in a transaction agree to the updated ledger being valid (Francisco and Swanson, 2018). It is this consensus mechanism and the distributed nature along with cryptography that makes blockchain immutable (Min, 2019).

Aspects such as transparency, immutability, trust etc. in the wind supply chain will be affected by and influence the path to implement blockchain in the industry's business processes (van Hoek, 2019). Affected aspects associated with introducing blockchain are analyzed in a case study based on primary data from industry stakeholders and secondary data from literature will provide insight from other industries' experience on implementing supply chain-based blockchain solutions (Hughes *et al.*, 2019)

The PhD is tied to the UnWind-project, which is a project funded by the Danish Industrial Foundation seeking to unveil the potential of blockchain in the Danish wind industry (The Danish Industry Foundation, 2020). The project seeks to develop a use case (henceforth UnWind use case) for the wind industry supply chain, including at least three tiers, i.e. a focal company and one or more first and second tier suppliers.

1.1   Relation to BPM

As blockchain is still a new way (Wang *et al.*, 2019) of sharing transactional data amongst organizations it is still unclear how the technology will impact business process management (BPM) in organizations and this is what the PhD-research seeks to uncover. Management of data in future organizations and industries, may well be changed fundamentally where blockchain is implemented (Kamble, Gunasekaran and Arha, 2019) and as such the PhD-research contributes to the management implications of BPM (Treiblmaier, 2018). The PhD-research will follow and help develop the UnWind use case in the wind industry supply chain and as such, it will contribute to BPM-research in regards to the engineering of new systems.

1.2   Overall research design

The PhD-research is based on developing a blockchain use case for the wind industry and takes inspiration from design research (Peffers *et al.*, 2007) and can be considered a developing case study (Ketokivi and Choi, 2014). The case study is explored and developed with a mixed methods approach, primarily based on qualitative data from interviews and workshops. Primary data is mostly obtained from the wind industry, while secondary data acquired through literature reviews provides most of the data on the blockchain. The research design is explained in further detail in the work packages (WP) in the following section.

2   Description of research, methods and research questions

The PhD-research has the purpose of answering the research question: "*What value does blockchain have for the wind industry*?" To answer the main research question, a series of sub questions are answered. An ongoing task of the PhD is to follow the blockchain technology through its development in terms of technological capabili-

ties and industry adoption in- and outside the wind industry in order to keep of with best adoption practices. Furthermore, collaboration with the industry is a continuous task as it provides the research with empirical data and is accomplished through the association with the UnWind-project and the connections made possible by the PhD-candidate's association with the Centre for Energy Technologies (Aarhus University, 2020). The following sections explains the process in the PhD and the sub-questions (SQ) intended to be answered along the way.

2.1 SQ1: What is the maturity of existing blockchain use cases?

Assessing the maturity of blockchain use cases is essential to understand the current state of the technology (Lacity, 2018), so that the right approach is taken when exploring the value in the wind industry. The technology readiness level (TRL) model is used to assess the maturity of existing use cases described in literature (Moni *et al.*, 2019). The method used for finding the use cases in literature is a systematic literature review (Tranfield, Denyer and Smart, 2003). The theoretical contribution of this is theory testing of the TRL-model on blockchain technology and more significantly, a proposed framework for dividing blockchain use cases in terms of the business processes the technology supports. The latter is important, as the PhD-candidate has found no framework covering this in current research. The lack of a framework complicates dissemination of blockchain's potential (Angelis and Ribeiro da Silva, 2019) to those unfamiliar with it, slowing down industry adoption academic research.

2.2 SQ2: What characterize the wind industry supply chain?

SQ2 focus on the wind industry, in which the characteristics of the industry's supply chain are analyzed, specifically how supply chain innovation progress amongst supply chain members and intends to add empirical findings to the current theory (Jajja *et al.*, 2019). Specifically former technological innovations on the WTG achieved through the collaborative efforts of supply chain partners are used as cases to understand how the wind industry made these innovations (Houman Andersen, Drejer and Gjerding, 2017). The concept of coopetition (i.e. collaboration between competitors) is explored in terms of its potential for blockchain (Raza-Ullah, Bengtsson and Kock, 2014). The findings of SQ2 intends to provide knowledge on how to communicate the findings of SQ1. It also seeks to provide knowledge on how supply chain collaboration have occurred in the past in the wind industry.

2.3 SQ3: What is the present awareness of blockchain in the wind industry?

SQ3 intends to be answered using the use cases identified in SQ1 as way to communicate what blockchain *can* do and through that understand which of the characteristics of the cases the wind industry knows and find valuable. Another aspect sought to be understood in the context of SQ3 is how blockchain will affect trust and governance in the wind supply chain. This is essential as blockchain promises to transform these dimensions when implemented (Seidel, 2018; Zachariadis, Hileman and Scott,

2019). At the same time, trust and governance provide a bridge for communication, as these terms are better known in the industry, while blockchain is assumed not to be.

A mixed-methods approach is used for gathering data on the understanding and interest in various aspects of blockchain in the wind industry. Qualitative, unstructured and semi-structured interviews as well workshops are carried out to acquire insight on the best direction to continue the blockchain research in. Following this, quantitative data is gathered through a survey with the purpose of identifying patterns on the findings in the qualitative part. The theoretical contribution is an elaboration on blockchain's impact on trust and governance in supply chain management, while the practical contribution is the identification of industry partners for the UnWind use case.

2.4   SQ4: What blockchain architecture is ideal for a wind industry use case?

SQ4 explores architectural considerations on blockchain (Lu, 2018) particularly for the UnWind use case. Architectural considerations include determining the proper blockchain platform, consensus and validation mechanisms, rules for joining and governing the blockchain etc. The architectural choices will in large be influenced by the UnWind use case partner organizations who will be interviewed and worked with through café seminars and other interactive means. As the UnWind use case is intended to be in operation by the end of the PhD an aspect explored is how the blockchain will interact with other IT-systems (ERP etc.) in organizations involved. The contribution of this will be empirical evidence, intended to elaborate on research focused on general blockchain adoption models (Pedersen, Risius and Beck, 2019).

2.5   SQ5: How does implementation of a supply chain-based blockchain solution affect the business model of the implicated organizations?

SQ5 focus on the business aspects centered on the changes that will occur in the business model. Particular focus will be on the added costs and value for supply chain-based blockchain solutions including the effect on inter- and intra-organizational business processes. The analysis will be based on the UnWind use case providing empirical findings of the realized change in a business model transformed by blockchain, expanding on research done on blockchain's impact on business models (Hald and Kinra, 2019). This will provide deeper understanding on both the monetary and non-monetary value and cost of implementing blockchain.

2.6   Current state of the PhD-project

Once the above questions are answered it is expected the UnWind use case is in operation and can be used as a specific example of the value blockchain can bring to the wind industry. The UnWind use case can be used as a holistically insightful case study from which it is intended best practices can be drawn with the intend of aiding future blockchain adoption and expand upon technology adoption theory (Venkatesh, Thong and Xu, 2012) in a blockchain-specific context. The PhD-research has currently completed SQ1, while SQ2 is finishing up and SQ3 has begun.

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