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Do outcome-based contracts exist? The investigation of Power-by-the-hour and similar result-oriented cases

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Abstract

Outcome-based contracts (OBCs) are claimed to be the new business model for manufacturers. They have attracted a lot of research that identifies two types of OBCs: outcomes based on availability (aOBCs) and outcomes based on economic results (eOBCs). The first involve the sale of the availability of a product whereas in the second the customer purchases the functional result of the product. This characterisation is identical to the distinction between the use-oriented and result-oriented Product-Service System type. However, there are studies that seem to challenge the prevalence and even the existence of eOBCs in practice. We have set out to investigate whether eOBCs exist. This was done by addressing the following research question: what are the differences between aOBCs and eOBCs? The study employed research design that consists of three steps: identification, selection, and analysis of OBC cases as reported in journal articles. In relation to the case studies identified, our preliminary analysis suggested that all the case studies in the literature are of the aOBC type. The only case identified as the possible case of eOBC, and subsequently selected for further analysis, is that of Power-by-the-hour (PBTH) by Rolls-Royce. The analysis of PBTH was conducted from the Remote Monitoring Technology perspective. Our key contributions are: (1) a new theoretical perspective on OBCs, (2) the articulation of differences between OBC types and of what constitutes an outcome, and (3) doubt in the existence of eOBCs in practice.

Keywords: Outcome-based contracts, servitization, Product-Service System, remote monitoring technology, power-by-the-hour

Research paper

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1. Introduction

Outcome-based contracts (OBCs) have received increased attention in servitization research (e.g. Ng et al. 2009; Ng and Nudurupati, 2010; Ng et al. 2013; Böhm et al. 2016; Batista et al. 2017; Visnjic et al. 2017; Hou and Neely 2018; Visnjic et al. 2018). Some (Ng et al. 2013; Visnjic et al. 2017) argue that an OBC is the most advanced form of servitization, which is defined as a process of creating value by adding services to products (Vandermerwe and Rada, 1988). Other phenomena closely related to OBC include: functional products (e.g. Alonso-Rasgado et al. 2004), solutions offerings (e.g. Nordin and Kowalkowski, 2010), Performance-Based Contracts (e.g. Hypko et al. 2010a; Kleemann and Essig, 2013; Selviaridis and Wynstra, 2015; Essig et al. 2016; Liinamaa et al. 2016), Performance Based Logistics (e.g. Randall et al. 2011; Holmbom et al. 2014), result-oriented Product-Service Systems (e.g. Baines et al. 2007; Van Ostaeyen et al. 2013), and advanced services (e.g. Baines and Lightfoot, 2014; Baines et al. 2017; Ziaee Bigdeli et al. 2018). Common to all is a supposed transformation of manufacturing organizations from selling products to selling results from products. For example, Baines et al. (2017) define the concept of advanced services as services whose outcome is focused on capabilities delivered by a product's performance. However, some studies seem to challenge the prevalence and even the existence of such value propositions in practice.

Sharma et al. (2002) argue that more than 60 percent of the largest US Fortune 100 firms claim to offer solutions. Day (2004) challenged this by saying that this may just be (p. 18) “merely a fashionable statement of intent” rather than evidence that they were in fact doing so to any significant extent. Some support for this is found in Hypko et al. (2010b) who says that machinery and equipment manufacturers are still reluctant to provide Performance-Based Contracts (PBCs) extensively. Lim et al. (2012) analysed 181 cases of Product-Service Systems (PSSs) and found that the product-oriented PSS type is far more prevalent than the other two types (use-oriented and result-oriented). Holmbom et al. (2014) reviewed more than a hundred research papers to investigate the benefits and drawbacks of Performance Based Logistics (PBL). They found that many studies base their conclusions on preconceived opinions rather than facts, which also applies to performance contracting in general. This is similar to Böhm et al. (2016) who argue that there is a dearth of empirical work on OBC in practice and that the existing empirical evidence is at best inconclusive. Mahut et al. (2017) review literature on PSS with a specific emphasis on the automotive industry. Similar to Lim et al. (2012), their analysis reveals that automotive services are mainly of a product-oriented PSS type. Finally, the recent exploratory survey of European manufacturers operating in automation, machinery, and transportation sectors by Adrodegari et al. (2018), which investigates their service orientation, found that their revenues are still dominated by product sales with services contributing less than 20%.

Moreover, the services involved are mainly repair and spare parts provision with more advanced services, such as pay-per-x service contracts, having a negligible contribution.

Motivated by such conflicting accounts this paper set out to investigate whether services based on selling outcomes exist. The rest of the paper is structured as follows. Section 2 presents a review of the literature on OBCs and other related phenomena. The aim is to establish what is known about these phenomena and to inform more precise research question. Section 3 explains the research design developed to address the research question while section 4 introduces findings from an analysis of the case of Power-by-the-hour by Rolls-Royce. Before we conclude, in section 5 we discuss the study's key contributions, while in section 6 we explore their implications for research and practice.

2. Outcome-based contracts: literature review

2.1 Terminology and definitions

The first thing that one notices is the number and diversity of terms used to describe this phenomenon. In addition to OBC (e.g. Ng et al. 2009; Ng and Nudurupati, 2010; Ng et al. 2013; Böhm et al. 2016; Batista et al. 2017; Visnjic et al. 2017; Hou and Neely 2018; Visnjic et al. 2018) and PBC (e.g. Kim et al. 2007; Kim et al. 2010; Hypko et al. 2010a, 2010b; Guajardo et al. 2012; Kleemann and Essig, 2013; Selviaridis and Wynstra, 2015; Essig et al. 2016; Liinamaa et al. 2016), which are the most widely used terms, other closely related terms include: functional products (Alonso-Rasgado et al. 2004), solutions offerings (Nordin and Kowalkowski, 2010), integrated industrial product-service offerings (Priya Datta and Roy, 2011), PBL (Randall et al. 2011; Holmbom et al. 2014), result-oriented PSS (Van Ostaeyen et al. 2013), and advanced services (Ziaee Bigdeli et al. 2018). Many authors use several terms at the same time, implying similarity between them. For example, Kim et al. (2007) and Guajardo et al. (2012) say that PBC is often referred to as 'power-by-the-hour' (PBTH) or PBL. Ng et al. (2009) and Ng and Nudurupati (2010) describe PBC as a narrower version of OBC and say that the latter is also called PBL. Ng et al. (2013) view PBTH to be identical to OBC. Hypko et al. (2010a; 2010b) argue that PBC is known as OBC, PBL, and PBTH. In addition to these terms, they also use functional products (Hypko et al. 2010a) and solutions provision (Hypko et al. 2010b). Some use PBC, OBC, PBTH, and availability contracting interchangeably (e.g. Selviaridis and Wynstra, 2015; Essig et al. 2016). Similar is observed in other studies (e.g. Priya Datta and Roy, 2011; Liinamaa et al. 2016; Hou and Neely, 2018). The lack of consistent terminology however, is not new but has been reported earlier (see Hypko et al. 2010a; 2010b). Table 1 attempts to capture the multiple definitions that exist in the literature of what is essentially the same phenomenon.

Insert Table 1 here

In common to all is an idea that the customer is purchasing a performance, result, output, and/or an outcome. However, what these terms mean is not clear. They are vaguely described with a number of terms, such as: 'functional performance' (Alonso-Rasgado et al. 2004), 'performance outcome' (Kim et al. 2007), 'performance' (Hypko et al. 2010a; Selviaridis and Wynstra, 2015; Liinamaa et al. 2016), 'service outcome' (Kim et al. 2010), 'realized outcome' (Guajardo et al. 2012), 'desired outcome' (Kleeman and Essig, 2013), 'business outcome' (Böhm et al. 2016), 'business result' (Essig et al. 2016), 'required outcomes' (Batista et al. 2017), 'outcomes of the solutions' (Hou and Neely, 2018) and 'specific outcomes' (Visnjic et al. 2017; 2018). The only definitions that offer more specific guidance are those by Ng et al. (2009), Ng and Nudurupati (2010), Priya Datta and Roy (2011), Ng et al. (2013), Van Ostaeyen et al. (2013), and Holmbom et al. (2014). These definitions suggest that in OBC the customer purchases the functional result of the product. However, what the functional result involves is not entirely clear. For example, Kim et al. (2010) say that the role of performance specification has not been adequately explored in PBC literature while Nordin and Kowalkowski (2010) found that the term solution leaves considerable room for different interpretations and conceptualisations. They found conflicting views about what constitutes a solutions offering. Van Ostaeyen et al. (2013) argue that the concepts 'functional performance' and 'functional result' are nowhere explicitly defined in the PSS literature. They continue that although orientation toward the provision of 'function' is an essential characteristic of PSS, the notion is not systematically treated in the PSS literature. This is similar to Essig et al. (2016) and Hou and Neely (2018). The former found that the majority of literature fails to explicitly define 'outputs' and 'outcomes' and their differences. Hou and Neely (2018) concur by saying that the definition of OBC still lacks clarity.

2.2 Types and features

Although lacking clarity and precision, the literature recognises that OBC is not a monolithic concept but characterised by differences. Namely, four typologies of OBC/PBC are identified. The first, by Kim et al. (2010), argues that the majority of PBCs fall into two categories: a contract based on cumulative downtimes, and a contract based on the sample-average of downtime. In essence, what they refer to is a product's availability. The other three typologies are by Hypko et al. (2010a; 2010b), Selviaridis and Wynstra (2015), and Böhm et al. (2016). What is in common to all these typologies can be summarised in a distinction proposed by Böhm et al. (2016). The distinction is between outcomes based on availability (aOBCs) and outcomes based on economic results (eOBCs). As such, all three typologies are identical to the distinction between the use-oriented and result-oriented PSS types from the widely used categorization of PSS. Thus, Baines et al. (2007) define use-oriented PSS as

involving the sale of the use or availability of a product whereas in a result-oriented PSS a result or capability is sold instead of a product. This is identical to typologies proposed by Hypko et al. (2010a; 2010b), Selviaridis and Wynstra (2015), and Böhm et al. (2016). For example, Hypko et al. (2010a; 2010b) distinguishes between performance providers who provide machinery or the equipment's availability, and providers that take over the operation task and provide the machinery or the equipment's output. This is identical to Selviaridis and Wynstra (2015) who make a distinction between outputs and outcomes. The former are defined as the direct results of the service activity, usually quantified in monetary terms, whereas the latter are defined as the value derived by the customer from a given service or product. To explain the difference they give an example of a machine where the output of a maintenance activity may be the uptime of a machine, while the outcome may be the actual production of that machine (e.g. tonnes excavated). Böhm et al. (2016) say that even though previous research acknowledges different OBC/PBC types, researchers have not yet investigated their differential outcomes.

Also, there seems to be a convergence of ideas on what characterises a typical OBC. Thus, the literature suggests that an OBC is typically found in the context of a capital-intensive (Alonso-Rasgado et al. 2004; Kim et al. 2007; Hypko et al. 2010a; 2010b; Holmbom et al. 2014), complex engineering product (Kim et al. 2007; Kim et al. 2010; Hypko et al. 2010a; Ng and Nudurupati, 2010; Randall et al. 2011; Guajardo et al. 2012; Holmbom et al. 2014; Essig et al. 2016; Visnjic et al. 2017; Hou and Neely, 2018) with long life cycle (Alonso-Rasgado et al. 2004; Guajardo et al. 2012; Kleeman and Essig, 2013). Such a product would require a considerable effort to maintain (Kleeman and Essig, 2013) and the consequences of its breakdown would be severe and may bring high-impact disruption to its customers (Kim et al. 2010; Guajardo et al. 2012). These features are in agreement with the trend toward selling OBCs and other closely related value propositions (PBC, PBL, etc.), which is especially apparent in the defence (Kim et al. 2007; Kim et al. 2010; Hypko et al. 2010a; Holmbom et al. 2014; Böhm et al. 2016; Liinamaa et al. 2016) and aerospace (Alonso-Rasgado et al. 2004; Kim et al. 2007; Kim et al. 2010; Hypko et al. 2010a; Randall et al. 2011; Guajardo et al. 2012; Holmbom et al. 2014; Böhm et al. 2016; Liinamaa et al. 2016) sectors. Other sectors where OBCs are found include medical equipment (Alonso-Rasgado et al. 2004; Kim et al. 2010; Randall et al. 2011; Guajardo et al. 2012; Böhm et al. 2016), transportation (Hypko et al. 2010a; Randall et al. 2011; Liinamaa et al. 2016), and machinery and equipment, such as engines (Guajardo et al. 2012), elevators and machine tools (Hypko et al. 2010a).

2.3 Benefits and the essence

An OBC brings a number of benefits to its customers. Ng and Nudurupati (2010) found that an OBC brings efficiency improvements to customers because they no longer directly manage or even own inventory. Randall et al. (2011) argue that PBL promises to reduce the life cycle cost and improve system performance. These findings are supported by a literature review on PBC research by Selviaridis and Wynstra (2015). The review finds that the key benefits of PBC include: increased efficiency, improved accountability, innovation, budget flexibility, and value for money. Although bringing a number of benefits to customers, OBC is a high-risk strategy for the supplier. Thus, Ng and Nudurupati (2010) say that OBC poses risks to service providers, which is similar to Selviaridis and Wynstra (2015) who claim that PBC entails both increased risk and rewards for the supplier. Others have found that in PBCs, OBCs, and advanced services respectively, risks are considerable (see Kleeman and Essig, 2013; Hou and Neely, 2018; Ziaee Bigdeli et al. 2018). This, however, is because the transfer of risk is the key value proposition behind OBC. Namely, the literature suggests that the essence of OBC is the transfer of risk from the customer to the service provider as outlined by the paper quotes shown in Table 2. The key risks identified are those related to the delivery of output (Kim et al. 2010), performance (Ng and Nudurupati, 2010; Priya Datta and Roy, 2011; Selviaridis and Wynstra, 2015; Visnjic et al. 2017), and/or outcomes (Ng et al. 2013; Visnjic et al. 2018). However, what these risks involve is not that clear. This should not be surprising considering that what is meant by performance, result, output, and/or an outcome is also not clear from the literature (see section 2.1).

Insert Table 2 here

In relation to OBC/PBC typologies introduced above, the literature recognises some fundamental differences in terms of the risks involved. Thus, it seems that eOBCs carry far more risk for the supplier than aOBCs. For example, Selviaridis and Wynstra (2015) found that risk transfer is significant when purely outcome-based contracts are deployed. This is also recognised by Hypko et al. (2010a) and Böhm et al. (2016). The former say that the more the payment is based on the contribution to the customer's economic result, the higher the risk for the performance provider. This is almost identical to Böhm et al. (2016) who found from their empirical investigations that although eOBCs accompany more benefits for sellers at the same time they also involve more risks. However, although the literature acknowledges that different OBC/PBC types carry different risks, it provides no information about those risks and their differences. In this respect we could mention Hypko et al. (2010a) who say that future research could deal with issues on which PBC type is optimal.

This section concludes by presenting findings on what the literature recognises as key risk mitigation strategies. Improving product reliability and maintainability, where the latter is supported with IT, are recognised as the most important risk mitigation strategies in OBCs. This is understandable considering that in OBC the customer purchases the functional result of the product (see section 2.1). Thus, Alonso-Rasgado et al. (2004) argue that reliability is a key design parameter for the delivery of functional products. Interestingly, and counter to our intuition, Kim et al. (2010) found that implementing PBC may be least efficient when the equipment is most reliable. Meaning that, in addition to reliability, maintainability is another crucial risk mitigation strategy in the delivery of OBCs. This is corroborated in a review of literature on PBC research by Hypko et al. (2010a) who identified that in almost all of the publications analyzed, management of maintenance activities, which aims to ensure the goods' availability, is always inherent to PBC. A similar result was found by Kim et al. (2007) and Guajarado et al. (2012). The former recognised that in addition to reliability, in the long run suppliers of PBC may find it in their interest to invest in more efficient repair and logistics capabilities. This resonates with Guajarado et al. (2012) who found that, in PBCs delivered in the defence sector, achieving a high level of product reliability together with availability and maintainability are the three essential elements of enabling mission capability. It should not be surprising then that IT is recognised as another essential risk mitigation strategy. Namely, Alonso-Rasgado et al. (2004) argue that provision of functional products must include monitoring of quantitative performance measures that determine whether the level of functional provision reaches, or exceeds, the levels specified in the contractual agreement. This is in agreement with Böhm et al. (2016) and Visnjic et al. (2017). The former found that eOBCs demand not only in-depth knowledge about the product itself but also of the product's performance in the customer's processes. Visnjic et al. (2017) argue that by providing the necessary information to manage cost and risk, as well as ensuring efficient customization processes, information technology is becoming an ever-more important enabler for OBCs.

2.4 Research gaps and question

The literature review found that a number of terms are used to discuss and describe OBC and other related phenomena such as: PBC, PBL, functional products, solutions offerings, integrated industrial product-service offerings, result-oriented PSS, and advanced services. As a result, there are multiple definitions of what in essence is the same idea, i.e. purchasing the functional result of the product. However, the meaning of functional result or functional performance is not defined. Also, the literature recognises that there are two types of OBCs, i.e. outcomes based on: (1) availability (aOBCs), and (2) economic results (eOBCs). This characterisation is identical to the distinction between the use-oriented and the result-oriented PSS type from the PSS research. But even though research has acknowledged different OBC types, researchers have not yet investigated their differences.

Furthermore, because the key idea of OBC involves purchasing the functional result of the product, transfer of risk is seen as a key value proposition behind an OBC. In relation to this, the literature recognises that there are fundamental differences between the risks involved in two OBC types. It seems that eOBCs carry far more risk for the supplier than aOBCs. However, their key differences are still not clear.

The above is translated into the following two research gaps. First, it is still unclear what constitutes an outcome. And second, researchers have not yet investigated differences between OBC types. On the basis of these two gaps this paper aims to explore the following research question: what are the differences between aOBCs and eOBCs? By addressing this question we are hoping to learn more about what constitutes an outcome and whether eOBCs exist.

3. Research design

To investigate the differences between aOBCs and eOBCs we decided to study secondary data found in journal articles. We employed a research design that consists of three steps. The activities in each of these steps are described below.

3.1 Identify OBC cases

The first step involved identification of OBC cases for potential analysis. As a guide we used findings from the literature review that identified a number of terms used to describe this phenomenon. Thus, in addition to OBC and PBC case studies we also considered studies from other closely related phenomena. Table 3 gives an overview of all the case studies identified. In relation to OBC and PBC we considered case studies by Ng et al. (2009), Hypko et al. (2010a), Ng and Nudurupati (2010), Priya Datta and Roy (2011), Kleemann and Essig (2013), Ng et al. (2013), Liinamaa et al. (2016), Batista et al. (2017), Visnjic et al. (2017), and Hou and Neely (2018). For result-oriented PSS and advanced services we considered studies by Lim et al. (2012) and Ziaee Bigdeli et al. (2018) respectively. The only criterion we followed was that a study needs to provide some information on the cases investigated. Although information on the case of PBTH by Rolls-Royce (RR) is scattered over many publications, we also decided to include it. This is because the case of PBTH: (1) is one of the most widely discussed cases of OBC/PBC in the literature (Baines et al. 2007; Neely 2008; Baines et al. 2009; Johnstone et al. 2009; Ng et al. 2009; Nordin and Kowalkowski 2010; Ng et al. 2013; Smith 2013; Gaiardelli et al. 2014; Parida et al. 2014; Barrett et al. 2015; Ostrom et al. 2015; Porter and Heppelmann 2015; Selviaridis and Wynstra 2015; Wünderlich et al. 2015; Böhm et al. 2016; Essig et al. 2016), (2) is universally recognized as being devised by the company that pioneered the PBC concept (Guajardo et al. 2012), and (3) epitomizes the OBC strategy (Visnjic et al. 2017).

Insert Table 3 here

3.2 Select OBC cases

A case was selected for further analysis if it meets the following three criteria: (1) the customer is purchasing the functional result of the product, (2) it involves a capital-intensive, complex engineering product with a long life cycle, which requires considerable effort to maintain and where consequences of its breakdown are severe and may bring high-impact disruptions to their customers, and (3) there is sufficient information to conduct the analysis. The first two criteria have been informed by findings from the literature review on OBC definition and its key features respectively. The third criterion aims to ensure the availability of information necessary for the analysis. By this we mean that a case study description is sufficient to unequivocally characterise it as either aOBC or eOBC.

Preliminary analysis of the cases from Table 3 led to the following findings. Because they fail to meet the third criterion we excluded cases by Lim et al. (2012), Hou and Neely (2018), and Ziaee Bigdeli et al. (2018). We then applied the first and the second criteria to the remaining cases. Most of the case studies are from aerospace and defence industry sectors (Ng et al. 2009; Ng and Nudurupati, 2010; Priya Datta and Roy, 2011; Kleemann and Essig, 2013; Ng et al. 2013; Batista et al. 2017; Visnjic et al. 2017), which are followed by transportation (Visnjic et al. 2017), and machinery and equipment (Hypko et al. 2010a; Kleemann and Essig, 2013; Liinamaa et al. 2016; Visnjic et al. 2017) sectors. This means that all these cases meet the second criterion. The cases were then analysed by applying the distinction identified in the literature review, between aOBCs and eOBCs. The aim was to establish which of the remaining cases meet the first criterion, thus making it a case of eOBC. The analysis revealed that almost all the case studies in the literature (Ng et al. 2009; Hypko et al. 2010a; Ng and Nudurupati, 2010; Priya Datta and Roy, 2011; Kleemann and Essig, 2013; Ng et al. 2013; Liinamaa et al. 2016; Batista et al. 2017; Visnjic et al. 2017) are of the aOBC type. This follows from the analysis of case study descriptions provided by the authors that make an explicit link between an OBC case and the aOBC type (see Table 3). The only cases left are that of PBTH by RR and of capital equipment by Kleemann and Essig (2013). In the case of the former, the situation is a rather confusing. Namely, there are accounts that clearly define the case of PBTH as an eOBC type (Baines et al. 2007; Neely 2008; Ng et al. 2009; Ng et al. 2013; Gaiardelli et al. 2014; Barrett et al. 2015; Ostrom et al. 2015; Wünderlich et al. 2015). These accounts view it as the case in which RR customers pay for and get in return the result of the product, i.e. the power or thrust from the jet engine (Table 4). Yet there are accounts (Baines et al. 2009; Johnstone et al. 2009; Nordin and Kowalkowski 2010; Smith 2013; Parida et al. 2014; Porter and Heppelmann 2015; Selviaridis and Wynstra 2015; Böhm et al. 2016; Essig et al. 2016) that suggest that PBTH is an aOBC type (Table 5). In relation to the case of capital equipment by

Kleemann and Essig (2013), the information provided by the authors is not sufficient to establish whether the case is of either aOBC or eOBC type. Therefore, the case of PBTH by RR was identified as the case on which the differences between aOBCs and eOBCs will be explored further.

Insert Table 4 here

Insert Table 5 here

3.3 Analyse OBC cases

The analysis of PBTH was conducted from the Remote Monitoring Technology (RMT) perspective. We first give reasons why taking the RMT perspective is justified for the investigation of OBCs and then explain how the perspective was applied to answer the research question.

Three reasons are offered. First, RMT is widely recognised as one of the key enablers of servitization (e.g. Oliva and Kallenberg, 2003; Alonso-Rasgado et al. 2004; Johnstone et al. 2009; Ulaga and Reinartz, 2011; Grubic, 2014; Grubic and Peppard, 2016; Cenamor et al. 2017; Gebauer et al. 2017; Rymaszewska et al. 2017; Grubic and Jennions, 2018). The key principle behind RMT involves enriching physical products with digital components (Novales et al. 2016) that enable real-time monitoring, acquisition, and communication of data on various aspects of the product's performance in service (Grubic, 2014). This phenomenon is known under many names, such as: smart services (Allmendinger and Lombreglia, 2005; Wünderlich et al. 2015), remote diagnostics (Brax and Jonsson, 2009), smart technology (Ostrom et al. 2015), remote maintenance services (Paluch, 2014), smart products (Porter and Heppelmann, 2015), digitized products (Novales et al. 2016), and digitalization (Cenamor et al. 2017). At RR the term used to depict the phenomenon is Engine Health Management (Waters, 2009), but here we have followed Grubic (2014) by using the more generic term RMT.

Second, the key purpose of RMT is to mitigate the risks of a product failure or breakdown that may lead to a loss of service (Smith, 2013; Reim et al. 2016). By collecting and analysing data on various aspects of the product's performance in the field, RMT aims to reduce those risks. A survey of UK manufacturers (Grubic et al. 2011) showed that the main factors driving manufacturers to develop and adopt diagnostic and prognostic technology are improving: product performance, availability, and maintenance efficiency and effectiveness. This is also supported by findings from the literature review where improving product's reliability and maintainability, supported by IT, is recognised as the most important risk mitigation strategies in OBCs (see section 2.3).

The last reason for adopting the RMT perspective for the investigation of OBCs is related to the concept of availability. The concept has been adopted by servitization researchers for the formulation of servitized offerings, and originates in the discipline of reliability and maintainability engineering

(Alonso-Rasgado et al. 2004; Settanni et al. 2017). This discipline is fundamental to RMT in the way that it provides a theoretical foundation for diagnostics and prognostics which form the basis for the development and application of RMT. Therefore, investigating an OBC case from the way the availability concept has been defined and understood in reliability and maintainability engineering, and made operational in RMT diagnostics and prognostics, seems reasonable.

All three reasons provide a clear and sound logic for the choice of the RMT perspective for investigation of OBCs. Next we explain how the perspective was applied.

The method we applied to investigate differences between aOBCs and eOBCs is *reductio ad absurdum*, which is one of the most widely used deductive methods in philosophy and mathematics. However, the use of the method is not restricted to these domains only. *Reductio ad absurdum* can be applied in almost any argument or proof. For example, Konrad (1982) employs it to investigate whether the actions of business managers can be judged by the same moral standards as the actions of everyone else whereas Abbasi et al. (2012) use it to eliminate the myth that there is or should be an easy way to commercialize new technologies. Regardless of context, in *reductio ad absurdum* one seeks to prove the falsity of a proposition within the system (Fauconnier and Turner, 2003). That is, given a hypothesis A, the way to falsify A is to show that A has consequences that either conflict with empirical findings or lead to absurd or impossible results. The existence of such consequences is then taken as evidence that A must be false. In our case, the hypothesis is that PBTH is an eOBC as it is understood in the literature. We then proceed by employing a number of studies that belong to three areas of research behind the three reasons explained earlier. The areas are: (1) RMT and servitization (Grubic and Peppard, 2016; Grubic and Jennions, 2018), (2) diagnostic and prognostic science (Waters, 2009; Jardine et al. 2006), and (3) reliability and maintainability engineering (Knezevic, 1987; Ebeling, 1997; Saranga and Knezevic, 2000). By employing these studies we attempt to show that, from the RMT perspective, the hypothesis that PBTH is an eOBC is impossible, thus taking this as evidence that the hypothesis must be false and that PBTH is better understood as an aOBC.

4. Power-by-the-hour: a view from the RMT perspective

According to the literature, in eOBC the customer purchases the functional result of the product. In terms of the famous case by Levitt, with eOBC the customer is paying only for a hole in a wall. We start by deducing that eOBC subsumes guarantees for the product availability as well as for its performance or capability. Namely, an aOBC only guarantees that the product will be available for use, not that it will necessarily be capable of delivering the functional result. Taking the case of the electric drill, an aOBC would make it available for use for an agreed percentage of time, say 95%. The contract

would not guarantee that the drill had enough power to drill a hole of a given size, to a given quality, in an appropriate time. So the equipment may be available but not 100% capable of delivering the service. This is a subtle, but very important, distinction between an aOBC and an eOBC.

That there is a difference between the two is clear from an in-depth case study of an original equipment manufacturer of durable capital equipment reported by Smith et al. (2014). The manufacturer expanded its offerings with availability and outcome value propositions. The existence of differences between the two is hinted in the following interview excerpt by one of the interviewees (p. 253): "[Capability contracts] includes a lot more than any of the [repair contracts] or [availability contracts] do. It takes a lot more of the risks from the customer; it takes on a lot more things that the customer is used to do." To understand what 'a lot more' means for the delivery of eOBC, we start our investigation with an analogy between eOBC and Overall Equipment Effectiveness (OEE) from Total Productive Maintenance (TPM) as proposed by Grubic and Jennions (2018). OEE is determined by multiplying three components that characterize the overall equipment effectiveness: availability, performance, and quality. Taking the example of the electric drill again, availability represents the percentage of scheduled time the drill is available to operate, performance represents the speed at which the drill runs as a percentage of its designed speed, and quality represents the 'good' holes drilled as a percentage of the total holes drilled. Equating eOBC with OEE would mean that the former is about delivering the product of all three components, not just availability. Therefore, eOBC subsumes aOBC. To deliver an eOBC a manufacturer would need to provide guarantees not only for the availability component but for the performance and quality components as well. However, the state-of-the-art RMT is not able to support this. To explain this point it is necessary to delve deeper into the challenges behind producing diagnostic and prognostic knowledge from RMT data.

The use of RMT is motivated by an assumption that the product's performance is at any instant of time related to the condition of its constituent components. Namely, we assume there is functional dependence between the output parameters encompassing the product's performance and the condition of the components that constitute the product. That this assumption is warranted is demonstrated by Knezevic (1987) and Saranga and Knezevic (2000). For example, a change in gas turbine temperature margin may suggest an issue with the turbine. Determining a root cause behind the change in gas turbine temperature is the goal of diagnostics. Prognostics, on the other hand, aims to predict the remaining useful life of the gas turbine. To understand the challenges involved in producing the diagnostic and prognostic knowledge from RMT data, it is crucial to introduce the problem of the *mismatch* between the levels at which data are collected and analysis conducted (Grubic and Peppard, 2016). We need to understand that RMT supports the collection of data on so

called *collective variables*. In the case of the RR gas turbine these would include output parameters encompassing the turbine's performance such as: pressures, temperatures, speeds, fuel flows, and vibration levels (Waters, 2009). The aim of diagnostics then is to determine if there really is a problem, what may have caused it, and where (in the product's hierarchy) in the gas turbine it is located, i.e. what part or component. Diagnostics is generally aimed at finding problems or faults with the individual components of a product and the data used to inform this comes from parameters which are *ontologically* of higher level, hence the mismatch. That is, we are trying to determine the state of a component based on data about the state of the product (whole). This is an indirect approach to diagnostics as it works on collective variables, which can be understood as emerging from the interaction of all the components that constitute the product. Waters (2009) likens this with the medical world where the expert knowledge is used to turn a symptom into a diagnosis. The challenge that the mismatch brings to the delivery of aOBC is exemplified by one of the interviewees in an OBC study by Ng and Nudurupati (2010: 666): "it's hard to tell if 85% availability of the entire weapon system translated to 85% of subcontracted component parts." An even more succinct example for the challenge comes from a general manager in one of the case studies conducted by Grubic and Peppard (2016) to investigate the role of RMT in servitized strategies (p. 168):

"The more skilled the analyser or the service provider if you like it, he has that background to look at a machine and understand how the machine is functioning. That is what we are looking for when we are employing these guys and it is not just their capability in using different types of analysers or software because that is all trainable; you can train guys to do that. But it is very difficult to train them to understand when they look at the gear box for them to be able to visualise what is going on within that gear box which is important. Because when they are analysing the vibration signatures they need to be able to understand how that relates to the asset they are monitoring it from."

Therefore, while RMT supports the collection of data on collective or emergent variables that may tell us something about the overall performance of a product, diagnostics is generally aimed at finding problems or faults with the individual components of the product. Inevitably, this process introduces uncertainties in the diagnostics results, which, by using the medical world again, result from the fact that there are always many more combinations of symptoms than there are diagnoses, so translating symptoms into diagnoses discards information (see p. 107 – 114 in Starbuck, 2006).

Once we have information about the current health or state of the product, achieved by investigating the state of its constituent components, we then use this to determine its predicted health or state moving into the future, i.e. prognostics. The logic behind prognostics, however, progresses in the opposite direction to that involved in diagnostics. Namely, we aim to determine the reliability of the

product based on knowledge about the condition of its components. The meaning of reliability adopted here follows Ebeling (1997) where it is defined as the probability that a component or system will function over some time period. To express reliability of the product through the condition of its components it is necessary to determine the condition of components at any instant of time and also to find a way of describing the mechanisms of their change during the product's operating life (Saranga and Knezevic, 2000). However, the processes of change in condition are random processes, because it is impossible to predetermine how they will develop (Saranga and Knezevic, 2000). Similar to diagnostics above, the randomness Saranga and Knezevic mention inevitably will bring uncertainties in the prognostics results.

As the preceding analysis shows, both diagnostics and prognostics are prone to significant uncertainties. But even if the uncertainties surrounding the production of diagnostics and prognostics knowledge could be resolved, so RMT would be capable of providing information on which it could be acted on with complete certainty, this would still *not* be sufficient to support an eOBC. When the diagnostics and prognostics are extrapolated to the domains of performance and quality, the remaining two components in the OEE/eOBC expression, the situation becomes exponentially more challenging and clearly beyond the reach of state-of-the-art RMT. The RMT required to support true eOBC would need to go beyond prognostics. Namely, the latter aims to determine the remaining useful life of a product and not to foresee how its effectiveness will change. Thus, it may be possible to determine, with some level of certainty, that a particular part in the drill is deteriorating and it may fail in X time units. But diagnostic and prognostic science is still not able to provide information on how much the drill's capability or performance will change due to this (see Jardine et al. 2006). The RMT functionality required to support such analysis would need to provide an integrated view on how the product's availability, performance, and quality change through time. Without this functionality the risks involved in the delivery of an eOBC would far exceed those that surround aOBC. From this we deduce that PBTH is better understood as an aOBC and not an eOBC as advocated in the literature.

Figure 1 summarises the preceding analysis.

Insert Figure 1 here

5. Discussion

This paper aims to address the following research question: what are the differences between aOBCs and eOBCs? By investigating this question we were hoping to learn more about what constitutes an outcome and whether eOBCs exist. We identify three areas where our research makes contributions.

These are: (1) a new theoretical perspective on OBCs, (2) the articulation of differences between OBC types and of what constitutes an outcome, and (3) doubt in the existence of eOBCs in practice.

5.1 RMT - a new theoretical perspective on OBCs

To address the question of differences between OBC types the current paper proposes investigating OBCs through the RMT perspective. This was justified by three reasons. First, RMT is widely perceived as one of the key enablers of servitization. Second, the key purpose of RMT is to mitigate the risks of OBC delivery. Namely, the review of literature recognises that the essence of OBC is the transfer of risks from the customer to the service provider. It also recognises that improving product's reliability and maintainability, especially when supported by IT, are the most important risk mitigation strategies in OBCs. The role of RMT therein is to monitor and collect data on performance and usage of a product in the field to determine its current and predicted condition and health thus reducing the risk of OBC delivery. This brings us to the third reason. The concept of availability, which originates in reliability and maintainability engineering, is fundamental to RMT. This discipline provides a theoretical foundation for diagnostics and prognostics which form the basis for the development and application of RMT.

The investigation of OBCs from the RMT perspective contributed the following three areas. First, by proposing the use of an RMT perspective we are making a contribution to this largely neglected area of research; the role of RMT in servitization (Grubic, 2014; Grubic and Jennions, 2018). More specifically, the paper extends knowledge on OBCs as published in the literature by linking it to research into RMT as published in the systems engineering literature. This has enabled the second contribution. We make a novel contribution to the theoretical toolbox of OBC research. This research is not only largely undertheorized (see Selviaridis and Wynstra, 2015) but is also characterised by the use of organizational theories such as agency theory, contract theory, transaction cost economics, and information economics (see Hypko et al. 2010b; Selviaridis and Norrman, 2015; Essig et al. 2016). The application of an RMT perspective provides a novel addition to the study of OBCs. Furthermore, we propose a new unit of analysis that has been completely neglected thus far. Namely, Essig et al. (2016) argue that PBC literature can be classified in terms of three main levels of analysis: (1) the supplier, (2) the dyad (supplier-customer), and (3) the supply chain/network. By investigating OBCs from a product level, we propose a new unit of analysis. This brings us to the third area. The application reveals new aspects about OBCs that have not been detected previously by the conventional thinking about the subject. The aspects thus revealed have clear implications for the understanding of the differences between OBC types and of what constitutes an outcome. They also throw a doubt on the existence of eOBCs in practice.

5.2 The articulation of differences between OBC types and of what constitutes an outcome

Common to all definitions of OBC found in the literature are the concepts of performance, result, output, and/or an outcome. More precise definitions, as those found in Ng et al. (2009), Ng and Nudurupati (2010), Priya Datta and Roy (2011), Ng et al. (2013), Van Ostaeyen et al. (2013), and Holmbom et al. (2014), suggest that in OBC the customer purchases the functional result of the product. However, the literature gives no explicit definition for the concepts of 'functional performance' or 'functional result' (Van Ostaeyen et al. 2013). Furthermore, it fails to explicitly define the concept of outcome and of its various types (Böhm et al. 2016; Essig et al. 2016; Hou and Neely, 2018). By taking a product as a unit of analysis and investigating it from the RMT perspective, we have made contributions to these areas of OBC research. From the RMT perspective the value proposition of selling the use of a product with an availability guarantee (aOBC) is fundamentally different to a value proposition that centres on selling and guaranteeing its functional results (eOBC). This means that delivering and guaranteeing a product's availability ought to be clearly differentiated from delivering and guaranteeing its result. This conclusion is derived once an analogy between eOBC and Overall Equipment Effectiveness (OEE), from reliability and maintainability engineering, is adopted. By equating eOBC with OEE it becomes apparent that the former is about delivering not only a product's availability but its performance and quality as well. In this way it is seen that eOBC subsumes aOBC. We hold this to be the key difference between the two OBC types. This also implies what may constitute an outcome. That is, delivery of an eOBC involves a manufacturer providing guarantees not only for the product's availability but for its performance and quality as well. However, delivery of eOBCs, at least from the RMT perspective, is not currently feasible. This is because state-of-the-art RMT cannot provide an integrated view on how the product's availability, performance, and quality change through time. This brings us to the last contribution.

5.3 Doubt in the existence of OBCs based on product's functional results

Investigation of differences between aOBCs and eOBCs was based on case study accounts found in scholarly journal articles. In identifying and selecting the case studies we also used findings from the literature review. This informed us about the features that characterise an OBC. Thus, it is found that an OBC typically involves capital-intensive, complex engineering product with long life cycle, which requires considerable efforts to maintain and where the consequences of its breakdown are severe and may bring high-impact disruption to the customer. In addition to empirical case studies of OBCs we considered case studies from other closely related phenomena (PBC, result-oriented PSS, and advanced services). We have also included the case of PBTH by RR, which is one of the most widely discussed cases of OBC in the literature. The preliminary analysis found that almost all the case studies in the literature (Ng et al. 2009; Hypko et al. 2010a; Ng and Nudurupati, 2010; Priya Datta and Roy,

2011; Kleemann and Essig, 2013; Ng et al. 2013; Liinamaa et al. 2016; Batista et al. 2017; Visnjic et al. 2017) are of the aOBC type. Only two possible case studies of eOBC were found: PBTH by RR, and the case of capital equipment by Kleemann and Essig (2013). Description of the latter, however, is not sufficient to unequivocally establish whether the case is of either aOBC or eOBC type. In general, this was recognised as one of the key problems with the case studies identified in the literature. They provide very little information necessary for more reliable analysis. Similar was also noticed by Hypko et al. (2010a) who said that adequate information on specific PBC cases is either not available or is scattered over many publications. The latter is the case with the PBTH by RR, accounts of which are scattered over a number of publications (Baines et al. 2007; Neely 2008; Baines et al. 2009; Johnstone et al. 2009; Ng et al. 2009; Nordin and Kowalkowski 2010; Ng et al. 2013; Smith 2013; Gaiardelli et al. 2014; Parida et al. 2014; Barrett et al. 2015; Ostrom et al. 2015; Porter and Heppelmann 2015; Selviaridis and Wynstra 2015; Wünderlich et al. 2015; Böhm et al. 2016; Essig et al. 2016). Furthermore, the accounts are rather confusing because half of those describe the case of PBTH as the case of eOBC type (Baines et al. 2007; Neely 2008; Ng et al. 2009; Ng et al. 2013; Gaiardelli et al. 2014; Barrett et al. 2015; Ostrom et al. 2015; Wünderlich et al. 2015) while the other half describe it as the case of aOBC type (Baines et al. 2009; Johnstone et al. 2009; Nordin and Kowalkowski 2010; Smith 2013; Parida et al. 2014; Porter and Heppelmann 2015; Selviaridis and Wynstra 2015; Böhm et al. 2016; Essig et al. 2016). The application of an RMT perspective on this case followed the deductive method of *reductio ad absurdum* that attempts to falsify a hypothesis by demonstrating that the hypothesis has consequences that either conflict with empirical findings or lead to absurd or impossible results. By showing the latter we put forward evidence that the hypothesis 'PBTH is an eOBC' must be false (Figure 1) and that the case is of an aOBC type as all the other case studies found in the literature. Therefore, our analysis throws a doubt in the existence of eOBCs in practice, thus providing support for other studies (Day 2004; Holmbom et al. 2014; Mahut et al. 2017; Adrodegari et al. 2018) that have made similar propositions.

One may challenge such a conclusion by saying that our analysis is based only on a handful of case studies, thus suggesting that the sample is not sufficiently large to make such generalisation. However, the conclusion is not based on statistical but on analytical generalisability, which involves generalising theories and not enumerating frequencies (Yin, 2003). By analysing the case of PBTH by RR, we not only show that this is the case of aOBC but that delivery of eOBCs is not currently feasible. This conclusion is derived from the application of an RMT perspective whose theoretical foundations are diagnostic and prognostic science, and reliability and maintainability engineering. As such, the conclusion is applicable to contexts where those theories apply, that of complex engineering products,

which are typical of OBCs. Because of this we argue that our findings have analytical generalisability, thus providing credibility for doubt in the existence of eOBCs in practice.

6. Implications for research and practice

6.1 Implications for research

This study questions our understanding of OBCs; more precisely, it questions the existence of eOBCs in practice. Viewed from the RMT perspective, the existence in practice of contracts of this kind is very dubious. From this we can derive the following questions that invite further study:

- If cases of eOBC do not exist, then what does this say about servitization research which purports that manufacturers are shifting their strategies from selling products to selling results from products? Could manufacturers, compared to servitization researchers, mean something else by 'outcome' and should we revise our terminology and understanding accordingly? What could this mean for servitization research? Would we then need to re-examine the nature of servitization and of the value-in-use concept that supposedly underpins it?

6.2 Implications for practice

Industry, at least capital-intensive, complex engineering product manufacturers, should proceed with caution when considering the provision of value propositions that focus on delivery of results from their products, i.e. eOBCs. This is contrary to some studies (Böhm et al. 2016), which claim that eOBCs should be the preferred option. eOBCs ought to be clearly delineated from the aOBCs as they imply exponentially greater risks and call for development of a different set of business capabilities. Delivery of such value propositions, at least from the state-of-the-art RMT perspective, appears currently not to be possible. The prognostic and diagnostic functionalities of RMT are not yet able to provide the information necessary to support these value propositions. Such information entails provision of an integrated view on how the product's availability, performance, and quality, is likely to change through time. Without this information the risks involved are likely to be too great for most companies.

7. Conclusion

Outcome-based contracts (OBCs) and other closely related phenomena (Performance-Based Contracts, Performance Based Logistics, solutions offerings, advanced services, and result-oriented Product-Service Systems) have received increased attention in servitization research. This research identifies two types of OBCs: outcomes based on availability (aOBCs) and outcomes based on economic results (eOBCs). aOBCs involve the sale of the availability of a product whereas in eOBCs the

customer purchases the functional result of the product. A review of the literature identifies several outstanding research gaps, including: lack of guidance on what constitutes an outcome, functional result and/or functional performance, and a complete neglect for OBC types and their differences. What further obscures understanding are accounts that seem to challenge the prevalence and even the existence of eOBCs in practice. On the basis of these gaps this paper explores the following research question: what are the differences between aOBCs and eOBCs? By addressing this question we were hoping to learn more about what constitutes an outcome and whether eOBCs exist.

To address the research question we devised a design consisting of three steps: identification, selection, and analysis of OBC cases from the research literature. All three steps were informed and guided by the findings from the literature review. The first two steps revealed that almost all the case studies are aOBC type. Only the case of 'Power-by-the-hour' (PBTH) by Rolls-Royce (RR) suggested that this may be eOBC. In relation to the case studies found in the literature, we also found that their accounts provide very little information necessary for more reliable analysis. The information is either not available or is scattered over many publications, a finding also true for the PBTH case. Nevertheless, the analysis of this case was conducted from the Remote Monitoring Technology (RMT) perspective. This was justified by three reasons: (1) RMT is widely perceived as one of the key enablers of servitization, (2) the key purpose of RMT is to mitigate the risks of OBC delivery, and (3) reliability and maintainability engineering, which was identified in the literature as the most important risk mitigation strategy in OBCs, provides a theoretical foundation for diagnostics and prognostics that form the basis for the development and application of RMT.

Our research makes contributions in three areas. First, by proposing an RMT perspective for the study of OBCs we offer a new theoretical perspective. Considering that OBC research is dominated by perspectives from organizational studies (agency theory, contract theory, and transaction cost economics, etc.), which completely neglect the product as a unit of analysis, we make a novel contribution to the theoretical toolbox of OBC research. This brings us to the second area. By taking a product as a unit of analysis and investigating it from the RMT perspective, we have made contributions to the areas regarding the differences between OBC types and what constitutes an outcome. From the RMT perspective, selling the use of a product with an availability guarantee (aOBC) is fundamentally different to selling and guaranteeing its functional results (eOBC). That is, aOBC ought to be clearly differentiated from eOBC because the latter subsumes aOBC. This is the key difference between the two OBC types. From this we propose that what constitutes an eOBC involves a manufacturer providing guarantees not only for the product's availability but for its performance and quality as well. Moreover, in the case of PBTH by RR, we show that delivery of eOBCs, at least from

the RMT perspective, is not currently feasible. This brings us to the final contribution. Our analysis throws a doubt in the existence of eOBCs in practice, mainly because state-of-the-art RMT cannot provide an integrated view on how the product's availability, performance, and quality change through time. This conclusion is not only based on analysis of OBC case studies found in the literature. It is also derived from the application of RMT perspective whose theoretical foundations are diagnostic and prognostic science, along with reliability and maintainability engineering. Thus, the conclusion is applicable to contexts where those theories apply, that of complex engineering products, which are typical of OBCs. Because of this our doubt in the existence of eOBCs in practice should be given further credibility.

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