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Embedding Service Logic into Business Model Design: The Case of Predictive Maintenance for industry 4.0

Completed Research Paper

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Abstract

Diffusion of new technology can be approached as a good marriage between business model innovation and technological innovation. With maturing and converging technological innovations ranging from Internet-of-Things, Artificial Intelligence, Blockchain to digital platforms comes a fundamental shift in how companies can do business and what can be offered. They enable greenfield services (i.e. services not pre-existing), including servitization of existing products to compete. Whilst businesses are experimenting with services for emerging domains like industry 4.0, research embedding service logic in business model design for delivering and diffusing greenfield services is nascent. Using a Design Science approach, this paper contributes a method (SL-BMD) for designing service logic embedded business models that forefronts how to incorporate the customer's perspective. We instantiate and evaluate SL-BMD by charting the experimental journey of a Predictive Maintenance offering for manufacturing settings, and highlight implementation considerations for SL-BMD and the experimental case chosen.

Keywords: Service Logic, Business Models, Service Innovation, Predictive Maintenance, Design Science, Industry 4.0, greenfield service, experimentation

Introduction

Despite the clamor for technological innovation in advanced societies, it is often business model innovation tied to technological innovation that yields value to the innovator and society at large. Though business model research (Osterwalder and Pigneur, 2010) is just decades old, pioneering examples of business model innovation stretch back centuries. James Watt famously stimulated the industrial revolution by offering

horse faring customers' free steam engines in return for receiving a third of potential savings (Hofmann et al., 2012). Business literature is also awash with cases of innovators failing to commercialize technological innovation only to see imitators profiting from them, such as Kodak's competitors commercializing its digital-camera innovation, thereby making Kodak's core business model redundant (Lucas and Goh, 2009).

Traditionally, the value creation logic underlying business models emphasized performing activities inside firms and occupying positions in the value chain, adding value by processing inputs and passing on outputs to nodes in the chain (Porter, 1985), without customer interference. This is rooted in a goods dominant logic, where value is understood as embedded in the units of output, and outputs are the fundamental units of exchange. Here, the customer's role is largely seen as utilizing products as defined by the supplier. More recently, there's been a marked turn in the narrative of the customer's role in value creation. Open Innovation as a paradigm shift extends information & knowledge acquisition and flows beyond traditional boundaries of firms. 'This approach places external ideas and paths to market on the same level of importance as internal ideas and paths to market' (Lee et al., 2010). Related to this shift, Service Dominant Logic (Vargo and Lusch, 2004) and Service Logic (Grönroos, 2006) reposition customers to the forefront of value creation. These alternate views underline concepts such as value co-creation and value-in-use respectively. The latter, Service Logic, suggests value can only be created when customers put in use or experience the offering, understood through Value-in-Use; *'a cognitive customer assessment of the service, including functional and emotional dimensions'* (Sandstrom et al., 2008). Despite this turn towards service logic, literature integrating service logic into business model design is nascent, with further research needed on *how* to integrate co-creation and the customers perspective in business model design (see table 1. below).

The turn towards service logic is particularly acute in relation to a plethora of maturing and converging disruptive technology innovations from Artificial Intelligence (AI), Internet of Things (IoT), Distributed Ledger Technology (DLT), Virtual Reality (VR) to digital platforms. Combining service logic with such trends creates prevailing conditions for greenfield services, i.e., *services not pre-existing, and where the market is untested, or unaware and/or not ready for such services*. Such services pose a completely different set of diffusion challenges not adequately addressed in business model design literature, as they enable new value propositions in emerging and experimental domains such as with industry 4.0 (Lee et al., 2019). New digital innovation's such as, Automated Service Interaction (McLoughlin et al., 2020), Mobility as A Service platforms and Predictive Maintenance (PdM) exemplify such greenfield services. The latter, PdM, concerns *intelligent condition monitoring and forecasting of an artifact's maintenance needs* (Passlick et al., 2021). Further to being an exemplar of greenfield services, PdM also supports servitization of products in areas like manufacturing (Keller et al., 2019, p.3) making PdM also an enabler of certain greenfield services. Our study contributes how to approach business model innovation of such services. Our objective is to *devise a method to embed service logic into business model design for greenfield services*.

Using a Design Science Research (DSR) approach (Hevner et al., 2004), we address this objective by designing the Service Logic embedded Business Model Design (SL-BMD) method. This IS artifact details four consecutive stages; 1) 'Identify target market segments', 2) 'Understand customers' 'Value-in-Use', 3) 'Derive Value Clusters' and 4) 'Build Business Models for each Value Cluster'. SL-BMD is instantiated and evaluated in an Industrial IoT setting using the experimental case of a large Hardware Technology Multinational's Predictive Maintenance offering. We show how instantiating SL-BMD for this greenfield service results in a linked portfolio of service oriented business models supporting the core value proposition; 'machine uptime' for the pharmaceutical and food & beverage industry. Each business model variant reflects either 'OEM', 'Intellectual Property', 'Outcome' or 'Safety' driven Value Cluster approaches to service delivery, with each Value Cluster reflecting a *customer group perceiving value-in-use similarly*.

The major IS research contribution is to propose a methodological approach to inform the experimentation process of greenfield services, so as to hasten their diffusion and adoption. We show *how* to integrate the customer's perspective into business model design via a process centering on generating Value Clusters, and discuss the challenging nature in ascertaining a practical level of variations. Further, we contribute implementation knowledge for PdM service adoption by charting the experimental journey toward a linked portfolio of business models needed to satisfy two key manufacturing contexts. Evaluating SL-BMD, we find selecting the right customer representatives and the composition of company participants as critical to outcome validity. We propose a further SL-BMD stage to 'Assess Business Models', and call for future research on how to; support assessing service orientated business model feasibility, as well as clustering value-in-use data. IS digital tools and conceptual guidance could offer avenues for further research.

The paper is structured according to the DSR schema by Gregor and Hevner (2013, p. 349). Firstly, literature overviews key business model and service logic concepts and research. We then position and show the studies rationale by overviewing literature integrating service logic and business model design innovation. The Method section outlines our DSR strategy, and we describe the greenfield service (i.e. Predictive Maintenance and Industrial IoT) and company case. The Artifact section describes each step of the artefact and instantiates it by applying SL-BMD to the experimental case along each step. The evaluation section addresses the outcomes and utility of SL-BMD. Finally, we conclude on the paper's findings.

Literature

Business Models

The business model (BM) concept has proliferated in business strategy and increasingly information systems research since the late 1990s. It encapsulates the value creation logic of firms such as key interrelated elements of value creation and capture (Osterwalder and Pigneur, 2010), in relation to its strategy and environmental conditions. To date, a myriad of BM definitions and approaches exist. For example, Amit and Zott (2001) define a BM as the content, structure and governance of transactions designed to create value by exploiting business opportunities, whilst Osterwalder and Pigneur (2010) refer to a 'conceptual tool containing set of elements and their relationships for expressing the business logic' of a firm. Despite a myriad of proposed BM definitions and related models, 9 central elements appear common across several models, matrices etc., proposed: Value proposition, key resources & activities, customer segment, revenue stream, cost structure, customer channel, customer relationship, and partners (Wirtz et al., 2016). Importantly, these elements correspond closely to the Business Model Canvas (BMC) (Osterwalder and Pigneur, 2010) with authors such as Demil and Lecocq (2010), emphasizing the dynamic nature of BM development in terms of dynamic interactions between and within core model elements, and deliberately internally and externally induced changes from issues as cost or revenue revision. Thus, analysis of a firms' BM development gives us a dynamic sense of firms. I.e., a dynamic perspective is key to identifying a firm's *journey towards* establishing a sustainable competitive advantage.

There are two widely accepted views guiding good BM design for achieving sustainable competitive advantage. An industry positioning view proposes a truly differentiated position within an industry that can be defended (Porter, 1991). The dynamic capability view argues competitive advantage requires developing competencies hard to replicate (Teece, 2007). Here, McGrath (2010) argues that BM innovation for competitive advantage can neither be strictly categorized as a positioning approach or dynamic capability approach. Both these views focus on the conditions for competitive advantage but do not elaborate on the journey towards it (McGrath, 2010). Also, in the increasingly dynamic setting of technology based businesses, it is impossible to visualize the constraints that eventually prove to be competitively important at the time decisions pertaining to BM innovation must be made. In such cases, experimentation is the preferred strategists' tool of choice than analysis, where early experiments often shape the future BM trajectory (McGrath, 2010). Thus, *experimentation* as a vital activity in BM development is argued as crucial for diffusion and scaling offerings, with the complimentary role of conceiving value and organizing for value creation in a dynamic process of BM development *requiring* further research (Chesbrough, 2010).

Service Logic

Service logic is broadly seen from two literature perspectives: 1) service as a market offering and 2) service as a value logic (Fiel, 2012). Early literature on 1) service as a market offering focused on delineating services from products. Zeithaml et al. (1985)'s defined 4 characteristics differentiating services from products; Intangibility, Heterogeneity (or non-standardization), Inseparability (of production and consumption), and Perishability (or exclusion from inventory). Other early literature congruent with this definition concentrated on the intangible nature of services. Lately, there is emphasis on the interactive and relational nature of service provision. For example, Grönroos (2006) defined a service as 'a process consisting of a series of more or less intangible activities, that normally takes place in interactions between the customer and service employees and/or physical resources/goods and/or service provider systems, that provide solutions to customer problems'. This increased attention to the customer's role in service provision flows into the second perspective, 2) service as a value logic which places customers at the center of value creation. The torch bearers of this paradigm are Service Logic (Grönroos, 2006) and Service Dominant

Logic (Vargo and Lusch, 2004). Despite important differences, they broadly concur on the foundational premises of value. Some of which are that; the customer is co-creator of value, enterprises cannot deliver value but only offer value propositions, and services are the fundamental basis for value exchange.

Finally, with increased interest in service orientated business models, there is a renewed research interest to address topics like service innovation and service orientated business model design. The realization that the goods-dominated, “inside-out” value chain paradigm making way to a knowledge intensive, resource integrating, collaborative, value network paradigm, along with the increasingly permeable and fuzzy boundaries of organizations; forms the basis for recent studies in this domain (Ojasalo and Ojasalo, 2015).

Service Logic and Business Model Design

The business model literature focuses heavily on rent extraction, whilst service design literature places an overwhelming emphasis on co-creation. In addressing this dichotomy lies a mutually beneficial relation between buyers and sellers (Normann and Ramírez, 1998). As shown below, research integrating service logic in business model design is nascent, Furthermore, few studies specifically tackle greenfield services.

Author	Year	Design	Limitation
Bouwman et al	2008	STOF model	How to incorporate customer’s perspective
Heikkilä, Heikkilä and Tinnilä	2008	SCOF Model	How to incorporate customer’s perspective
El Sawy et al	2013	VISOR framework	Limited focus on co-creation
Zolnowski et al.	2014	Service Business Model Canvas	Rooted in Goods-Dominant logic (see Turetken and Grefen et al. 2017)
Ojasalo & Ojasalo	2015	Service Logic Business Model Canvas	How to fully integrate value-in-use in relation to the ‘customers view’ in BMC
Turetken and Grefen	2017	Service Dominant Business Model Radar	How to derive and operationalize value-in-use
Table 1. Prior Work integrating Service Logic in Business Model Design			

Most relevant to this study, Ojasalo & Ojasalo (2015) introduce the Service Logic Business Model Canvas, whilst Turetken and Grefen (2017) propose the Service Dominant Business Model Radar (SDBM/R). Whilst the former introduces ‘customer view’ questions into business model elements, there is limited attention to fully integrating Value-in-Use. For SDBM/R, it particularly focuses on the value network aspect of service innovation, but could benefit from complementary work focusing on elaborating how to unpack and organize value-in-use for similar customer groups in a way that informs SDBM/R.

As is evident, there is recent interest in integrating business model and service logic literature. However, prior works tend to highlight the customer’s role without sufficiently delineating *how* to incorporate their perspective, or offer limited guidance on operationalizing Value-In-Use’. Moreover, methods suitable for transitioning product to service offerings and/or deriving BM portfolios, are needed. Finally, prevailing conditions of a greenfield service, where the market is untested, unaware and/or not ready pose different diffusion challenges thus far not sufficiently addressed. This study addresses existing limitations by designing a method to embed service logic into business model design for greenfield services.

Method

The utility orientated nature of Design Science Research (DSR) makes it particularly suitable for addressing our objective (Hevner et al., 2004). In their seminal work, Hevner et al. (2004) state, “utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.” Thus, utility is seen as a fundamental design characteristic along with quality and efficacy (Gill and Hevner, 2011). DSR creates and evaluates IT/IS artefacts intended to solve organizational problems (Hevner et al., 2004). March and Smith (1995) suggest application of DSR yields output of four kinds; Constructs, Models, Methods and Instantiations, with this present study focusing on method. Our research entails a Level 1 DSR

contribution, i.e., “situated implementation of artifact” in a context where limited and less mature knowledge is available (Gregor and Hevner, 2013, p. 342).

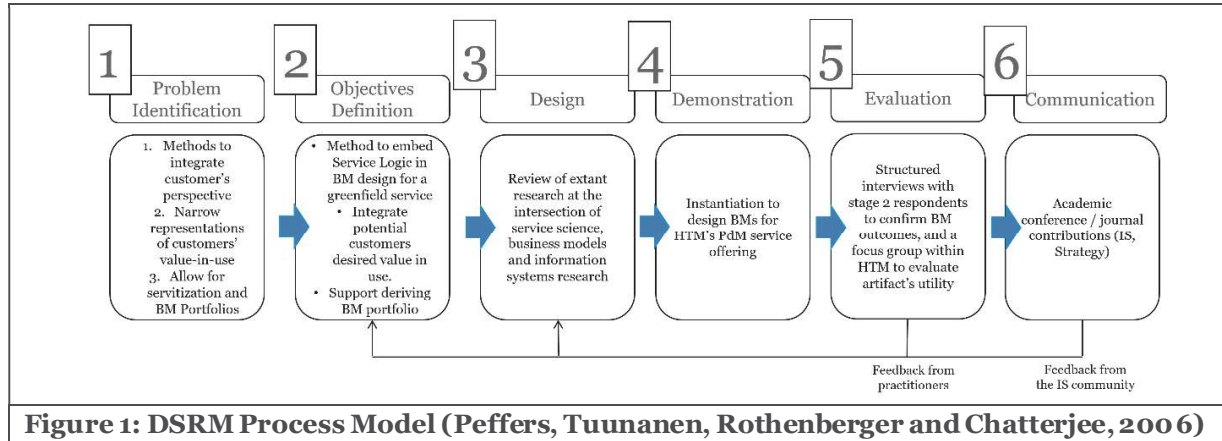


Figure 1: DSRM Process Model (Peffer, Tuunanen, Rothenberger and Chatterjee, 2006)

Figure 1 summarizes how the DSR Methodology Process Model (Peffer et al., 2006) is contextualized in this research. Furthermore, Table 2. overviews our operationalization of Hevner et al's. (2004) seven guiding principles for high-quality DSR, such that evaluation is accomplished (McLaren et al., 2011). The method's design steps described in the Artifact section include careful justification using prior theory, and evaluation of the artifact from the case.

Principle	Operationalization in this study
Design as an Artifact	Design of SL-BMD method to address the gap identified in the extant literature.
Problem Relevance	The first two sections of this paper outline the relevance cycle with regard to specifying the domain problem, opportunity and potential.
Design Evaluation	We used Venable et al. (2016) to design a suitable evaluation process consisting of naturalistic, ex-post techniques that specifically involve focus group and case study.
Research Contribution	SL-BMD aims to contribute to emerging literature at the intersection of Service Science and business models, as well as literature on experimentation and living labs.
Research Rigor	SL-BMD is theory ingrained from integrating service logic and business model design theories, thus manifesting theory in a “socially recognizable form” (Orlikowski and Iacono, 2001). Evaluation drew on Venable et al's. (2016)'s framework.
Design as a Search Process	As explained in the artefact section below, the SL-BMD Method was the result of heuristics creating iterations of understanding the solution and application domains.
Communication	The 2-pronged communication strategy includes publication in IS conferences for feedback from the research community and understanding the views of practitioners.

Table 2. DSR Guidelines (Hevner, March, Park and Ram, 2004, p. 83)

Evaluation Strategy

Seminal works in the application of DSR have emphasized the importance of evaluation. Broadly, the evaluation strategy comprises of two dimensions – the evaluation setting and the temporal aspect of evaluation. Temporally, a DSR artefact can be evaluated Ex-ante or Ex-post while the setting can be naturalistic or artificial. In this study, we adopt an Ex-post, naturalistic strategy to evaluate the SL-BMD method using a greenfield service case. Various stakeholders associated with the case are further involved in evaluating the artefact. Whilst a qualitative engagement comprising presentation and feedback with potential customers of the greenfield service evaluated the outcomes of the artefact's instantiation, a focus

group comprising potential users of the artefact evaluated its utility. McLaren et al. (2011) followed a similar DSR evaluation strategy. The greenfield service case used in the process is the experimental design of a Predictive Maintenance (PdM) focused sensing-as-a-service solution. The industrial IoT context provided a unique setting for the artefact. The case context is described in detail in subsequent subsections.

Case Environment

Company Setting - Hardware Tech Multinational

Hardware Tech Multinational (HTM) is the pseudo name for a large multinational technology company with multi-billion dollar revenue annually. They've predominantly delivered a product based business for a host of solutions such as semi-conductors, sensors and integrated circuits. Drawing from their vast tacit knowledge on manufacturing environments, they have a range of Integrated Circuit (IC) offerings found in many of the instruments and control systems in manufacturing plants. Over the years, these have been sold by a very strong distribution network comprising of direct and indirect channels.

More recently, HTM began investigating new ways of capturing value, not only through selling ICs and sensors etc., but also, through service innovation leveraging emerging capabilities in IoT, big data and AI. With a fast pace of innovation at the semiconductor level, coupled with new digital technologies, HTM begun exploring value adding solutions by leveraging their traditional strengths with new capabilities. This foray potentially represents a shift in how they operate, when compared with existing product sales. It necessitates introducing new and amending existing value creation processes. In addition, their exploration into PdM focused sensor-as-a-service, which aims to separate ownership from use, is a new paradigm for customers mostly used to purchasing sensors-as-a-product, thus posing different challenges (Rifkin, 2015).

One of the paper's authors engaged in a research collaboration with HTM in 2018 and 2019 to contribute towards business model and service innovation for their experimental industrial IoT and PdM solution. Thus, representing a greenfield case environment for instantiating SL-BMD. As discussed below, the PdM space is evolving without established paths to high rates of adoption and sustainable competitive advantage. Identifying the right business models involves answering a host of questions such as what model should a firm adopt to embed itself into existing ecosystems' of OEMs? The right revenue model? Should it attempt to commercialize on its own or via licensing its Intellectual Property? (Teece, 2012).

Greenfield Service - Predictive Maintenance and Industrial IoT

Internet of Things (IoT) is a paradigm concerned with devices connecting and exchanging data over internet infrastructure. IDC forecasts 55 billion IoT devices by 2025 (IDC, 2021), with rapid growth largely fueled by new business models. Broadly, IoT combines three major aspects – comprehensive perception (sensors), reliable transmitting (communication) and intelligent processing (analytics) (Xu et al., 2012). Together, they can transform a primitive but indispensable service - maintenance of industrial systems. The approach to maintenance in life cycle management has evolved from being reactive (breakdown maintenance) to preventive (planned maintenance) to predictive (condition monitoring) (Mobley, 2002). The latter, Predictive Maintenance (PdM) refers to *'the automated and intelligent scheduling of maintenance activities based on continuous analysis of system's operating conditions'* (Mobley, 2002), and involves monitoring and forecasting of an artifact's maintenance needs (Passlick et al., 2021).

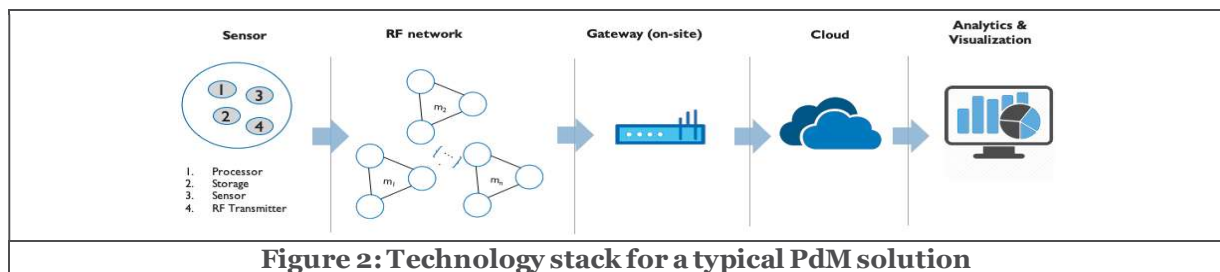


Figure 2: Technology stack for a typical PdM solution

PdM has emerged as one of the most compelling applications of IoT within Industry 4.0 (Lee et al., 2019). While not a fundamentally new concept, PdM is experiencing something of a renaissance, driven largely by

advances in sensors, connectivity, and AI analytics. It represents an opportunity for operators to improve asset uptime and decrease costs throughout operations, as well as for vendors to sell new PdM related products and services. Contemporary PdM programs boast a number of tangible and quantifiable benefits, including; reduced downtime as assets and production lines experience fewer operational disruptions due to proactive maintenance programs, improved equipment lifetime by timely ongoing maintenance of expensive legacy assets, process quality by better predicting breakdowns before they occur and finally, increased personnel efficiency to save time and effort for maintenance. As well as potentially value adding to sensor-as-a-service solutions, PdM supports and enhances servitization of products and services that IoT sensors are embedded within (Keller et al., 2019), such as with the Rolls Royce jet engine (Lee et al., 2019).

Like any nascent industry, the PdM space is very volatile with a mix of high-performing start-ups continuing to raise larger funding rounds and industrial majors making acquisitions to grow inorganically. Moreover, a multitude of business models are currently in play (Passlick et al., 2021). While some players prefer to deliver an end-to-end service, others are focused on being specialists (Figure 2). Further, the use of indirect channels such as Original Equipment Manufacturers (OEMs) and Insurance service providers to reach end users is seen as a strategy to drive up adoption. Also, to reduce upfront investment costs and attract skeptical customers, PdM platform providers are experimenting with new service offerings such as revenue sharing models, freemium, subscription oriented models and/or outcome oriented pricing strategies.

Artefact: The SL-BMD Method

This section introduces the IS artefact, SL-BMD (Figure 3), a methodological approach for embedding service logic in business model design. A prerequisite for applying SL-BMD is an existing technological innovation and its core intended use. We describe below four stages; 1) 'Identify target market segments', 2) 'Understand Customer's Value-in-Use', 3) 'Derive Value Clusters' and 4) 'Build Business Models for each Value Cluster'. As a result of evaluating the artifact's utility in the later Evaluation section, we propose an additional step in future studies, 5) 'Assess Business Models'. Whilst SL-BMD allows for iterations between different stages, iteration between stages 1 and 2 is particularly encouraged. The sequence, number and approach taken within each stage resulted from reviewing and synthesizing together literature and theory at the intersection of service logic and business model research suitable for greenfield service innovation.

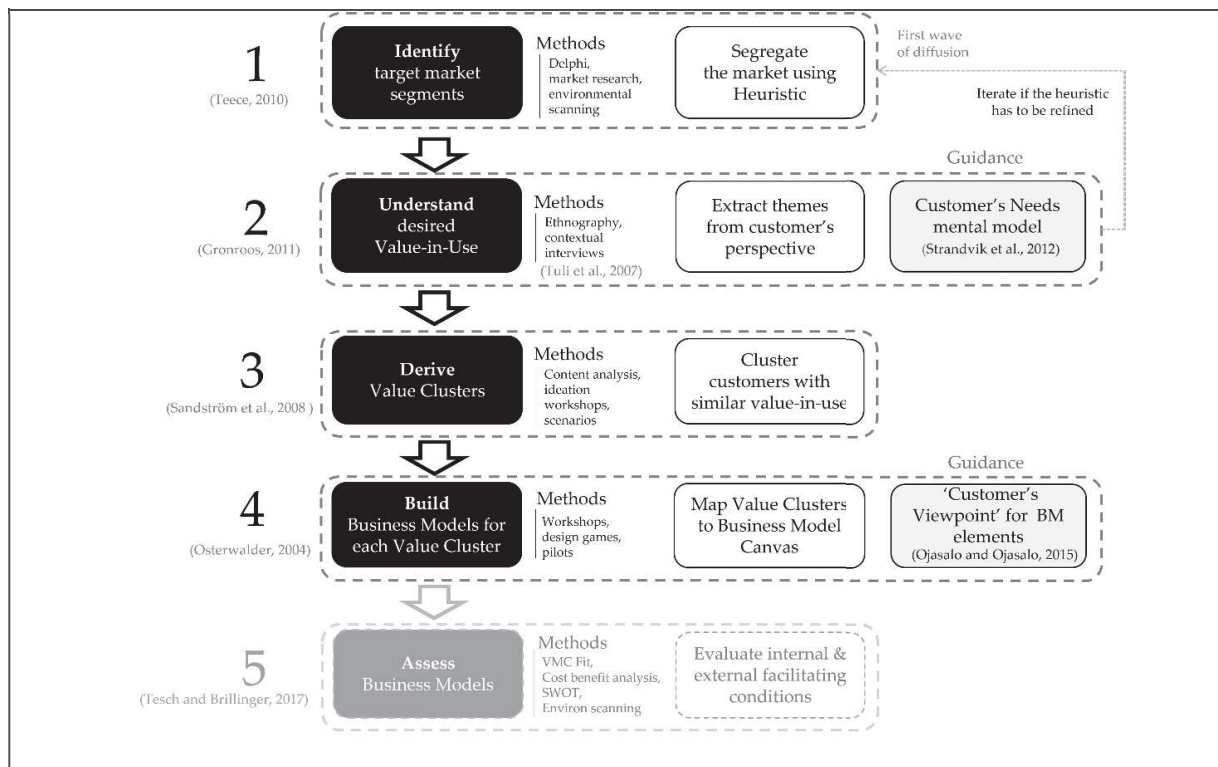


Figure 3: Service Logic-Business Model Design Method (SL-BMD)
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In subsections below, we first describe and then instantiate each of the 4 design stages of the method using the experimental case of Hardware Technology Multinational's (HTM) Predictive Maintenance focused sensing-as-a-service solution. Data collection took place in 2018 and 2019 to instantiate the artifact and involved 26 participants consisting of; 13 semi-structured interviews with target customers, 10 focus-group participants comprising of HTM Staff and 1 workshop involving authors from this paper. Details of these activities as well as the methods are discussed within relevant sub-sections below.

Step 1: Identify Target Market Segments

Description: The journey towards an effective business model design started by identifying target market segments for the first adoption wave (Teece, 2010) and the major customer benefit/value derived (heuristic). In the case where a company has designed a new technological artefact to exploit as a service, or wishes to transition from a product to a service offering, there is the need to understand the target market. As such, Teece (2010) argues that it is 'vital to identify the markets to be targeted and understand the benefit/value the customer would derive from consuming the product/service'. Thus, the first stage of our method is to identify target market segments and the major benefit/value (heuristic) of the artefact for those market segments, by using techniques such as market research, environmental scanning tool etc.

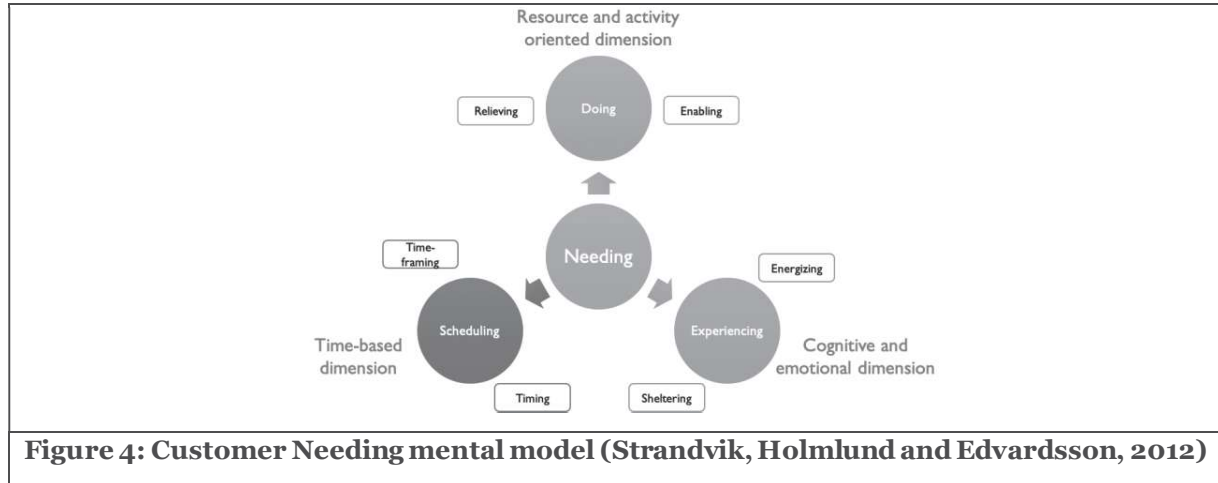
Instantiation: This was identified by HTM commissioning a market research study. The first heuristic identified was the potential impact of downtime. The higher the impact the more likely a potential customer would see value in a service such as this. Then again, many industries with very high downtime costs have already instrumented fool proof condition monitoring systems into their industrial machinery. Both semiconductor and aviation industries (despite being impacted by potential downtimes) have industrial processes heavily instrumented for fault tolerance. After scouring industries for high downtime costs and low to moderate process instrumentation, the Pharmaceutical and Food & Beverage industries were identified and targeted for the first wave of diffusion. However, during step 2, another driver for PdM emerged out of interactions with potential customers. To mitigate potential outages, some organizations have incorporated redundancies in their production facilities such as having backup production lines. Despite this, they see value in PdM for health and safety. Health and Safety emerged as a key theme from multiple customer interactions. The heuristic for identifying target markets was then updated. Iterations such as this are key to ensure robustness in design of the final business models.

Step 2: Understand Customer's Value-in-Use

Description: The scope of what and how value is created can be understood as co-controlled by both sellers and buyers (Normann and Ramírez, 1998), each understood as resource integrators. Gronroos (2011) argue customers perception of value should be the starting point for discussing the value proposition, whilst Tuli et al. (2007) report there is often a fundamental mismatch between suppliers' and buyers' idea of the offering. Customers tend to look at offerings with respect to their existing setups in a more *holistic* manner. Thus, step 2 is to more deeply understand the needs and perceptions of value for the target market segments identified and update major benefits/values if needed. To do so, we draw on Sandström et al., (2008)'s definition of Value-in-Use as a *customer's cognitive assessment of service offerings including functional and emotional dimensions*, with firm's needing to group customers experiencing a similar value-in-use. We suggest guidance from a conceptual tool such as Strandvik et al., (2012)'s Customer Needing mental model as it is specifically designed for unpacking, analyzing and organizing a prospective customer's desired value-in-use. Complimentary approaches in future studies could include integrating 'customer profile' concepts elaborated in the Value Proposition Canvas (VMC) work by Osterwalder et al. (2015).

The Customer Needing (Figure 4) mental model encapsulates the holistic picture of customer's strategies, priorities, decisions and their impact on fulfilment of specific tasks. It's operationalized along three dimensions containing six functions, which together represent the desired value-in-use: The '*Doing*' dimension, a resource and activity oriented aspect of the model, has 'Relieving' and 'Enabling' functions (definitions of the functions further below, e.g. 'Relieving'). The '*Experiencing*' dimension, a cognitive and

emotional aspect, has ‘Energizing’ and ‘Sheltering’ functions. The ‘Scheduling’ dimension, a time-based dimension, contains ‘Time-framing’ and ‘Timing’ functions.



Instantiation: By conducting 13 semi-structured interviews, the maintenance needs of potential customers was gathered, as well as customer’s evaluation of the perceived value-in-use in their work in relation to predictive maintenance. These semi-structured interviews with knowledgeable and experienced managers form the primary source of empirical data. The decision to rely on semi-structured interviews suits the exploratory nature of this study which can be traced further back to the greenfield nature of PdM services. It allows structured data collection though still following the principle of openness, where the investigator serves as an inquiry and interpretation instrument (Yin, 2009). The interview guide, informed by service design literature (Tuli et al., 2007), included dimensions and functions of Customer Needing (Strandvik et al., 2012). It also served as the first thematic schema in analysis.

Table 3 provides profiles of respondents for these interviews. All are from either Pharmaceutical or Food and Beverages (F&B) industries and are directly associated with the maintenance function within their organization. All interviews were either audiotaped and transcribed or recorded in the form of notes at the request of a few interviewees. First, data was organized by content coding according to the key concepts of the study. These included the business model elements and Customer Needing (Strandvik et al., 2012). Data was analyzed by theme-based categorization (Braun and Clarke, 2006). Themes also emerged from the data. MAXQDA software was used to organize and categorize data.

Seq	Role	Location	Firm	Method of Documentation
1	Head of Operations	Europe	F&B 1	Notes
2	Maintenance Manager	Oceania	Pharma 1	Audio taped & transcribed
3	General Manager – Operations	Europe	Pharma 1	Audio taped & transcribed
4	Senior Manager – Maintenance	Europe	Pharma 2	Notes
5	Site lead TPM	Europe	Pharma 3	Audio taped & transcribed
6	Equipment/maintenance manager	Europe	Pharma 4	Notes
7	Maintenance Manager	Asia	Pharma 5	Audio taped & transcribed
8	Deputy General Manager - Operations	Asia	Pharma 6	Audio taped & transcribed
9	Vice President - Operations	Asia	Pharma 7	Audio taped & transcribed

10	Global Automation Director	Europe	F&B 2	Notes
11	Maintenance Manager	Europe	F&B 3	Notes
12	Vice President - Operations	Europe	F&B 4	Notes
13	Operations Manager	Europe	F&B 5	Audio taped & transcribed
Table 3. Respondents' profiles.				

Each interview represents a narrative of the maintenance function within their organizations. While some respondents spoke about the friction between top management and personnel responsible for maintenance and operations, some talked about the implications of macro industry factors on their strategies for maintenance. To represent each narrative, Strandvik et al., (2012)'s Customer Needing mental model has been adopted, because it is designed for Value-in-Use in an industrial service setting, as is our case.

Doing is the dimension that refers to the resources and activities that buying decisions normally concern. The Goods-dominant logic places an overwhelming focus on this dimension alone. Relieving, as described by Strandvik et al. (2012), is the value-in-use realized by being relieved of performing tasks or carrying liabilities in current or future business activities. Maintenance is often seen as a non-value adding function within organizations. It is therefore considered ripe for outsourcing by top management in many instances. While very few respondents raised concerns such as loss of control, vendor's credibility in IP (Intellectual Property) sensitive areas etc., there was an overwhelming consensus on the potential of this service to relieve. However, there were differences in the nature of tasks respondents wanted to be relieved of.

"I would like someone with the brand recognition of HTM to come in, convince the top management about the virtues of predictive maintenance.... Beyond that we would only like to be informed if our machines need maintenance." Respondent #2

Enabling is the function that focuses on filling a void in the buyer's setup by getting additional resources, competence or capabilities from sellers to enhance their performance. For example, the case seen in the anecdote below is of a major Irish food and beverage organization. The spare parts needed to service plant machinery are procured from all over the globe and often have lead times between 6 months to 1 year. To mitigate this uncertainty, they either enter into costly maintenance contracts or 'over stock' based on the cost-benefit analysis for each machine. They are on the lookout for an external service provider, who would be able to optimize the spare parts inventory management by monitoring the condition of a machine on continuous basis and accurately predicting the remaining life of a spare part.

"We have been struggling to manage our spares' inventory from cost and availability perspectives. For availability, we either over stock or enter into costly maintenance contracts with the OEMs. If this service can enable me optimize the whole spares inventory management, I am keen." Respondent #10

Energizing is a cognitive function realized by sourcing inspiration and motivation to perform activities from the seller in current and future business. Maintenance in many industrial setups is still done in a reactionary mode. Even a preventative approach, where maintenance is in fixed time periods, is very inefficient. It either leads to over or under servicing as historical patterns are prioritized over present machine conditions while arriving at service schedules. Some interviewees have been actively trying to champion a push towards PdM approaches in their organization but have often faced resistance from various sources. They are looking for an external service provider to come in and energize their push towards PdM.

"Top management sees maintenance as a necessary evil. They are often averse to major investments. I have been trying to move the site away from preventative and reactive maintenance and focus on predictive... As I see it, the challenge is two-fold – technical and cultural. Technical challenge is to identify deterioration in devices with long life expectancy and a lot of sub components. Cultural challenge is to convince the top management and the folks in operations." Respondent #5

Sheltering is a cognitive function realized by being able to control risks and unwanted fluctuations in current or future business. By nature, maintenance is responsible to control operational risks. Downtime costs are a direct consequence of operational risks, but during interviews it became increasingly evident that potential buyers see health and safety concerns as an important value proposition. Sheltering is the function

capturing such concerns. Moreover, it is sometimes seen as a cognitive equivalent of the Doing dimension. Interview 2 is an example where Sheltering is seen with Enabling rather than Doing.

“We operate in a heavily regulated environment, unscheduled failure causes enormous wasted effort, to investigate the root cause, potential product recall, product rejection, increased QA etc. If a provider can free us from these fears and give us peace of mind, we would be gladly on-board.” Respondent #6

Time-framing is the function realized by adaptation to expected time frame and pattern of development. There was a concern amongst respondents about making any serious capital investment when the PdM technology is still immature. It is therefore vital for the service provider to consider business models that are light on upfront capital investments to alleviate such fears.

“Sometimes it goes beyond what is on offer today. We do not want to make huge investments, purchase the sensors, gateways etc. only to see a new piece of sensor technology make the whole setup obsolete. We would like to be as hands-off at an operational level and in control at a strategic level.” Respondent #12

Finally, Timing is concerned with purchase decisions fueled by certain isolated incidents. Changes in the management, new regulatory controls, accidents are few such incidents that could activate new strategic priorities for the buyers.

“Our drive towards predictive maintenance is not cost driven, but safety driven. We have had a few major accidents in our plant that could not be avoided by existing preventive and corrective maintenance approaches. Our internal reviews recommended PdM for some equipment.” Respondent #7

Step 3: Derive Value Clusters

Description: Adopting Sandström et al., (2008) Value-in-Use definition, we noted companies need to group similar customers experiencing a similar value-in-use. We thus propose the concept of ‘Value Cluster’ in this study, defined as *a group of customers that perceive the value-in-use similarly*. The third stage generates Value Clusters based on data from the second stage. The mental model representations of respondents described in step 2 served as a basis for this exercise. A workshop comprising relevant stakeholders suitable for this kind of activity is a particularly applicable method.

Instantiation: The mental models were analyzed in a workshop lasting approx. 2.5 hrs, and involved 10 participants primarily comprising of managers responsible for different functions associated with the experimental case of PdM offering at HTM. The designations of the participants include General Manager, Systems Application Engineer, Technical Lead, Senior Software Technologist, Corporate Strategy amongst others. Inclusion criteria from the pool of potential candidates was to ensure accountability, diversity, expertise and/or experience around the issue. One of the paper’s authors took an active part in the workshop by leading and enhancing the discussion between the other participants.

The workshop was supported with contextual data and notes to facilitate deep analysis, control bias, and harvest reliable data. Thematic coding and analysis from step 2 was presented along with mental model representations. The dimensions of mental models were used as the primary basis to group customers into Value Clusters. Other attributes considered for clustering included additional interview themes. Technical specifications of the solution were also included. A challenge we discovered through this process was on reaching a manageable level of variations. On one extreme is creating a separate cluster for every slight variation to maximize the aggregate value-in-use. However, this is offset by the increased cost of delivering countless variations. Striking a right balance between these was one of the key challenges. The analysis has resulted in demarcating 4 value clusters. The following summaries the findings from the workshop:

OEM driven cluster: One of the salient respondent’s views primarily from the food & beverage industry was their inclination to limit the number of 3rd party service providers they engage with. It was also noticeable that most are already in relatively long-term service contracts with OEMs. Contrary to other clusters, where different maintenance activities are potentially done by different vendors, firms in this cluster perceive the cognitive overhead of managing multiple vendors as a key deterrent to outsourcing. The workshop participants agreed that the route to customers is by collaborating with the OEMs. This can be done by implanting HTMs’ technology into machines either at the time of manufacturing or by retro-fitting brownfield machinery and then monitoring these machines remotely. Accordingly, the revenue model would be tuned to suit this mode of value delivery. The sensor usage which subsequently is dependent on

the machine usage forms the basis for pricing. The OEM would be front-facing, while HTM operates in the background. Such an arrangement means close OEM relationships to develop a better understanding of machines, critical for efficient analytical models. OEMs can also save costs related to warranty claims, improve succeeding design by aptly tracking use of products and earn a cut from the maintenance contracts.

IP (Intellectual Property) driven cluster: There was a sense of unease amongst some interviewees about the potential intrusion a PdM system might necessitate. To deliver this service in a hands-off manner from the customer's perspective, they would have to divulge information (layouts etc.) about machines and agree to transfer data to the cloud beyond the firm's boundaries. Barring firms in this cluster, others do not find this particularly disagreeable. However, pharmaceutical firms that operate in IP sensitive environments see this as an adoption challenge. On the product to service continuum, these firms prefer to operate closer to the product extreme where ownership is not separated from usage. The solution for addressing the concerns is to develop standalone systems in which the technology stack resides within the organization's boundaries, or leverage edge computing. Beyond that, servicing is limited to providing on-site assistance to install updates to hardware/software components of the PdM system. The revenue model would be a mix of upfront asset sale revenue and a continuous subscription revenue stream. Naturally, needed technical capabilities would be different as the customer would expect a greater level of autonomy.

Outcome driven cluster: The common theme found is the relatively higher degree of skepticism of PdM. Some also expressed concerns about vendor lock-in when a newer, shinier piece of sensor technology emerges. This cluster broadly resembles the late majority and laggard cohorts in the diffusion of innovation (Rogers, 1962). Workshop participants opined a model light on upfront investments can propel adoption by lessening fears of lock-in. Revenue models like freemium, revenue sharing and value-based pricing are low on upfront costs. Freemium models offer free pilots to potential customers and once convinced, a different pricing structure can be agreed. Revenue sharing is an outcome orientated approach. However, the importance of the maintenance function and downtime threats generally dictates the customer's willingness to agree to this pricing structure. 'Value based' is again an outcome driven pricing mechanism. Value is linked to how valuable the assets being monitored and the cost impact of unexpected downtime or failure (i.e., mission-critical equipment are costlier). Although quantifying value agreeable to both service provider and customer is a challenge. Beyond that, offering the service with minimal upfront costs would have an adverse impact on the working capital management for the service provider.

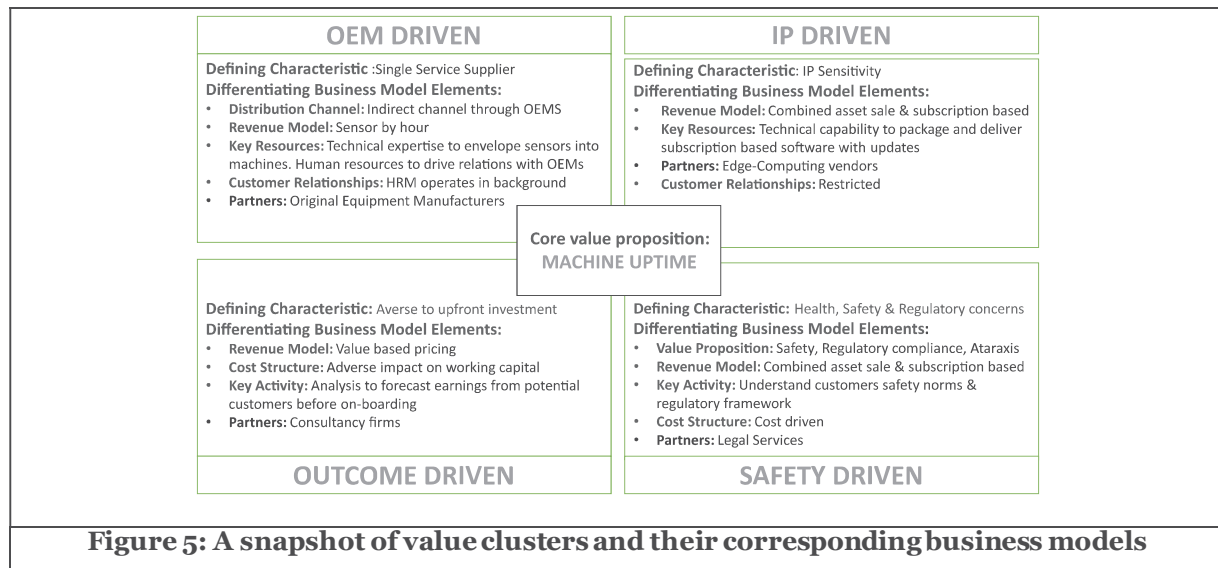
Safety driven cluster: The defining characteristic lies in increased safety. The cluster primarily comprises bulk drug manufacturers and food & beverage manufacturers. Bulk drugs, also known as Active Pharmaceutical Ingredients (APIs), are the sub-components of a final drug. Unlike final drug manufacturers where a machine breakdown essentially means discarding entire batches, APIs at any intermediary stage have fairly long shelf lives. This enables servicing of faulty machines and resuming production without significant losses. They are often equipped with backup production lines. However, a combination of regulatory requirements and self-imposed employee safety standards drive adoption. For example, faulty industrial sized centrifuge machines containing a rapidly rotating container, are extremely dangerous to personnel. The value offering on top of the core value proposition is increased safety, regulatory compliance, and peace of mind. This means service provider must have a good understanding of regulatory frameworks and design the solution appropriately. The propensity to pay for this service is limited as it is not seen to be directly impacting the bottom-line.

Step 4: Build Business Models

Description: Ojasalo and Ojasalo (2015) proposed a modified version of the Business Model Canvas (BMC) (Osterwalder and Pigneur, 2010), taking into account the principles of service logic by considering the 'customers' viewpoint' across its 9 elements. Consistent with the approach to 'customer viewpoint' in their work, this stage maps each Value Cluster generated onto the BMC, in order to arrive at a portfolio of linked Business Models, needed to deliver the solution to all target customers. To do so, each BMC should be considered in terms of *the implications for BMC elements needed to realize a value cluster*. 'Customer view' questions from Ojasalo and Ojasalo's (2015) work or can offer additional methodological guidance.

Instantiation: A workshop organized with the paper authors mapped resulting Value Clusters to the BMC. Whilst participants were all familiar with the BMC, one of the paper's authors familiarized other participants with the Service Logic Business Model Canvas (Ojasalo and Ojasalo, 2015). The workshop started by building the business model for the core service offering; with "increased uptime of industrial

machinery” as the core value proposition. One of the paper’s authors then presented resultant Value Cluster’s from stage 3 and made available accompanying contextual data and notes for reference. Using post-its, participants mapped 4 business models according to each cluster. Interestingly, the core value proposition remained “increased machine uptime” for each one of the value clusters, with health and safety now understood as a downstream value proposition according to the safety driven cluster. However, other business model elements vary between clusters. Figure 5 presents highlights from the 4 value clusters aligning to their corresponding key differentiating business model elements. Each of these is a business model built on the core value proposition to deliver the technological innovation (note: a further publication will more deeply illustrate and discuss results from step 4, including interrelations between elements).



Evaluation

Evaluation of the Outcomes

One of the key objectives of the method is to enrich understanding of potential customers’ Value-in-Use to in turn enhance the attractiveness of the service offering. The four Business Model (BM) variations of the PdM solution represent the outcome of an instantiation of SL-BMD and aims to achieve this. Respondents from table 3 were again contacted, and presented with the business model variant relevant to them from SL-BMD, in order to elicit feedback. This mode of qualitative evaluation was prescribed by Venable et al. (2016) and has proven valuable in IS studies such as, McLaren et al. (2011).

“The [safety driven] business models focus on the importance of the supplier considering our safety and regulatory requirements built through design, is something we see as valuable to us.” Respondent #7

The prevailing sentiment on BM variants amongst respondents was mostly positive. However, some discontent stemmed from not seeing all contextual factors reflected in their BM variant. Given the costs involved in delivering each variant means service provider must perform a delicate balancing act.

Evaluation of the Artefact’s Utility

As stated in the method section, we formed a focus group comprising 6 HTM participants including strategists, marketing and sales personnel. Participants had 10+ years of experience in their respective roles. Facilitated by the first 3 authors, we evaluated SL-BMD’s utility, beginning with one of the paper’s authors presenting various model stages to participants. Participants provided in-depth thoughts on these stages with a focus on potential implementation challenges. There was a consensus on the rich potential of SL-BMD to represent customer’s perspective, in turn allowing a better customer segregation. Overall, respondents found SL-BMD provides a good basis for strategists to identify the right business models for

their technological innovations and might be superior to industry based or firm size-based customer segregation. During evaluation, it was reported that SL-BMD felt intuitive and easy to apply. Strategists could use SL-BMD without prior expert knowledge on business models and service logic;

"It's a nice structure, it's all very logical, I actually sent it on to another team, having a structure or a framework where you are thinking about it from different angles is useful" (participant 3)

However, several issues were identified by participants that should be integrated into any further use of SL-BMD. Some participants discussed the validity of data captured from customers;

"It is not always apparent who is making the decisions, so you think you are talking to a person making decisions, but often not the case" (Participant 3)

Future selection criteria for stage 2, should consider including two key aspects for each customer: A) identifying and including a participant with direct knowledge of maintenance within the company. And, B), identifying and including a decision maker, and those who can assess total cost of ownership.

Secondly, there was some confusion concerning the appropriate stage or maturity of technological innovation should SL-BMD be implemented at, with the conclusion that the experimentation process could integrate SL-BMD at various stages to ascertain the viability of further pursuing development, as well as informing the journey or path of experimentation.

The focus group also opined that the fuzzy nature of stage 3 can pose an implementation challenge. The transition from value-in-use mental models in stage 2 to value clusters in stage 3 is a subjective exercise hence is prone to user biases. There was an expectation in the group for methodological guidance;

"How you decide which way to go?... how do you consider elements worth considering" (Participant 4)

However, we conveyed that rigidity could constrain the method's ability to imbibe the contextual knowledge of different instantiations. Moreover, the importance of having the right composition of participants for this exercise cannot be overstated. However, future research or iterations could investigate how participants arrive at a manageable or appropriate number of cluster variations, and how to support this activity.

There were also views that question prompts should be derived to mediate the mapping of clusters onto each business model canvas for the workshop participants. For example;

'In light of existing or future resources and capabilities, eliminate unworkable variations' (Participant 1)

However, the authors believe that these aspects should happen after step 4, given step 3 is concerned with how BM elements satisfy each value cluster. Furthermore, some participant's discussed two aspects that would need to be considered after step 4, which largely relate to some cost-benefit analysis of resulting business models, and how they compare to current or future competitor's offerings;

"The competitive element, did the current or potential competitors come into it. Also, how do we compare?, what's the buy-in for us?" (Participant 3)

Future research should investigate implementation guidance for an additional step to 'Assess Business Models' from step 4 of SL-BMD. In addition to assessing proposed BM's 'fit' (Osterwalder et al., 2015) with customer data, assessing fit with a focal firm's; a) resources and capabilities, b) competitive landscape and c) strategic visions & objectives is needed. These touch on the industry positioning (Porter, 1991) and dynamic capability (Teece, 2010) views of achieving competitive advantage. Recently, Tesch and Brillinger (2017) overviewed existing techniques to evaluate business models, whilst Gilsing et al. (2020) propose guiding questions for evaluating the structural validity, feasibility, viability, and robustness of Turetken and Grefen's (2017) SDBM/R. However, their work does not cover competitive landscape or resources and capabilities, with further work needed to develop IS support tools that cover both internal and external facilitating conditions.

Conclusion

Using a DSR approach, this paper contributes to IS research a methodological artefact incorporating how to imbibe service logic into business model design for greenfield services during experimentation. SL-BMD comprises 4 stages from identifying potential customers, understanding desired Value-in-Use to designing business models, with a fifth stage suggested for future studies to 'Assess Business Models'. SL-BMD

categorize potential customers based on similarity of Value-In-Use i.e., Value Clusters, instead of the often used industry oriented or firm size-based classifications. This enables companies to better incorporate customers' value-in-use into service design. For practitioners, the paper offers a *useful* and intuitive approach for experimenting with and furthering their service innovation, aided by a compelling example.

We instantiated the artefact using the experimental case of Predictive Maintenance (PdM) for industrial machines. PdM's proposed core value proposition was found to be 'machine uptime' for the industrial IoT sensing-as-a-service solution. We collaborated with HTM to use this context to demonstrate and evaluate SL-BMD. Initial market research pointed us towards Pharmaceutical and Food and Beverage industries for the first wave of diffusion. From interviews with potential customers, we ascertained their Value-in-Use is diverse. We used mental models to represent each customer's perspective in relation to a PdM based service. Clustering customer groups with similar desired Value-in-Use resulted in 4 service offerings under the core value proposition of machine uptime. These are 'OEM', 'IP', 'Outcome' and 'Safety' driven variants.

The artefact was then evaluated in a naturalistic, ex-post manner through qualitative focus groups and engagements resulting in additional considerations, such as participant recruitment and composition for SL-BMD instantiation, as well as an additional stage, 'Assess Business Models' for future studies. The case provided a unique and novel setting to demonstrate and evaluate SL-BMD. The PdM service is new to a market used to more reactionary approaches towards maintenance. For HTM this represents a move from product based to service orientated mode of value delivery. Therefore, SL-BMD in the continuum of DSR contribution types, is a Level 1 type 'situated implementation of artefact' (Gregor and Hevner, 2013). Therein lies a study limitation. Despite the study being consistent with a Level 1 contribution type, we acknowledge the need to extend the application of the method beyond the PdM context. The research team is currently working on applying the method for the design of MaaS business models for Autonomous Vehicles.

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