Design Drivers: A critical enabler to meditate value over the NPD process within *Internet of Things*

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Abstract: With the emergence of Internet of Things (IoT) as a new source of 'big' data, businesses face new opportunities as well as emergent challenges. Recent research claims digital technology can enable new kinds of development processes that are distinctive from their counterparts in 20th century. However, although academics and practitioners often critically debate the IoT, minimal attention has been focused on New Product Development (NPD) processes; arguably, one of the most critical marketing planning and implementation process activities undertaken within the organisation. Thus, this paper aims to contribute to a new understanding of IoT NPD processes. To achieve this aim, a comprehensive literature review was undertaken on traditional NPD design processes and reviewed against, a featured case study, IoT NPD processes. The relevance of IoT NPD against the characteristics of existing NPD processes, are subsequently reviewed and critically debated. Finally, NPD processes and the meaning of design within an IoT context is reframed. Finally, this paper summarizes how NPD processes and the role of design could be improved and proposes a set of guidelines with an accompanying conceptual framework for IoT NPD processes.
Keywords: New Product Development Processes for IoT, Internet of Things, IoT development risks, Value creation for IoT, Design for Io

Introduction

Over the last few decades, a compelling wave of innovation based on digital technology has emerged with the invention of World Wide Web (WWW). The internet, an open and distributed network by which people can communicate and share information, has become a vital platform. In recent years, it has become possible for almost any physical object has been connected to the internet and transformed into an IoT device. As such, it is estimated that 30 billion devices around the world will be connected to the Internet by 2020 (IEEE Spectrum, 2016). The emergence of IoT as a new source of 'big' data, whereby people enter new relationships with objects and businesses are increasingly reshaping business models and strategies. In industry, the IoT is regarded as a fertile field for commercial enterprises, it has been forecast that one in every six businesses would be engaged in the roll out of an IoT-based product (Burkitt, 2014).

There are vital opportunities for new innovation (Lasi et al., 2014; Radziwon et al., 2014; Xu, 2012; Yoo, 2013) by amalgamating sensors, actuators, and cloud computing with non-digital products and services (Yoo, 2010). In this regard, it is estimated that the total global impact of IoT technologies could generate anywhere from $2.7 trillion to $ 14.4 trillion in value by 2025 (McKinsey, 2013). However, it has been revealed that most businesses are adopting the IoT only to a limited extent, at the proof-of-concept stage (McKinsey, 2017) and nearly three-quarters of IoT device implementations are failing

(Cisco, 2017). Reichert (2017) argued that one of the significant reasons challenging the early IoT initiators is the lack of experience in IoT development. This is because digital technology radically changes traditional ways of business activities such as: how to operate supply chain (Gartner, 2014); how to develop products and services (Henfridsson et al, 2014; Yoo et al, 2012); and how to create meaningful value (Hui, 2014).

The continual development of new products and innovation are widely accepted as a requirement for companies' sustainable growth. Consequently, the subject of innovation, New Product Development (NPD), development risks and risk management has gained a considerable amount of attention from academics and practitioners over decades and has increased in the last ten years (Machado, 2013; Susterova et al., 2012; Smith and Merritt, 2002; Thauser, 2017; Teller et al, 2014). However, despite growing popularity and opportunities of developing IoT products and services, there has been little attention focused on NPD processes for IoT; arguably one of the most critical marketing planning and implementation process activities undertaken within the organisation in the future. As software is becoming increasingly embedded within a variety of design artefacts, it is imperative that emerging perspectives in order to both feed and draw insight from the broader design discourse. Scholars from marketing and design (Ng & Wakenshaw, 2017; Speed and Maxwell, 2015) argue that it is time to reframe conventional NPD processes to satisfy current needs and potential commercial opportunities in the era of IoT.

Methodology

This study explores how IoT products and services, which aim to increase organisational value, should be developed, and as such to contribute to a comprehensive understanding of NPD for IoT. In order to achieve these aims, the following research questions were proposed for critical discussion: (1) How are the conventional NPD processes and value creation different to its counterpart in IoT context? (2a) How are IoT products and services actually being developed and (2b) what are the risks inherent over the duration of the NPD process? (3) How should design be reframed as a critical enabler to mediate value over IoT NPD process? This research study was conducted using a strongly qualitative research methods approach, including an extensive examination of current literature and a single in-depth case study.

Books, articles, academic text and white papers were selected for a comprehensive literature review through searching electronic databases such as ProQuest Business Premium, Springer Journals Archive, Wiley Online Library Journals, and Google Scholar. Search terms used, included 1) "NPD", "Innovation process", "software development", "design and development process", "linear value creation" and "role of design" 2) "IoT development", "digital innovation", "digital artefact", "value constellation" and "digital economy" 3) "development risks", "IoT development risks", and "IoT risks". These are then supported by a manual investigation of abstracts and articles published in select journals- Journal of Product Innovation Management, Journal of Information Technology, European Journal of Innovation Management and Journal of Association for Information Systems. Each text was critically examined for their relevance to the primary question(s) of the main research study.

A case study was selected as it is argued as one of the best means of investigating a contemporary phenomenon within a bounded system (a single case) (Yin, 2009; Stake, 1995, 2005) or multiple bounded systems (cases) (Yin, 2009; Eisenhardt, 1989; Stake, 1995). Although this research only includes a single case study, as it is the early stage of current research, the overall research programme will contain a multiple case studies to generalise and validate the findings (Eisenhardt and Graebner, 2007). Bounded system can be any special unit such as a program or an activity (Creswell, 1998). As the object of investigation was NPD process for IoT, the unit of analysis for the case studies bounded as the whole journey of IoT products and services development rather than a company which is common in business studies (Mills and Durepos, 2013).

The case study involved a semi-structured interview and document reviews, such as public marketing material and presentations. Multiple sources of data were used to ensure a thick description and increase the trustworthiness of findings (Grandy, 2010; Stake, 1994). The case for the research was selected relying on purposeful sampling (Merriam, 2009) rather than random sampling. Considering the research aims, accessibility and resources, the case needed to satisfy the following criteria were considered: a) the geographical location of case was limited to the UK; b) the project should aim at developing a new IoT products and services. A small number of leading industry white papers on IoT case studies leading the industry were reviewed to develop the list of possible case studies and further internet searching was conducted to contact the company.

In order to select appropriate participants, job roles were considered rather the job titles, such as: 1) those who are in charge of managing the development process; 2) those who are involved strategic decision making over the process; 3) and/or those who hold the authority to drive IoT development project. The interview was conducted at the interviewee's office over 90 minutes in February 2019. The interview was transcribed by the researcher and analysed using qualitative content analysis method (Zhang & Wildemuth, 2009) which enables the researcher to focus not only on the explicit text itself, but the experts' intention or contextual meanings around the text. At the level of analysis, findings from the literature review and single case study were analysed to critically understand NPD processes for IoT products and services.

Conventional NPD processes and design

Conventional NPD processes

NPD is a complex business activity, which aims to transform customers' requirements into organizational value through products and/or services in the market. Over the half a century, NPD processes have been constantly refined by the practitioners and researchers (Best, 2006). A number of different NPD models for physical products have been developed within manufacturing economies, then in the late 20th century the models started to be modified and developed specifically for service and software development. This research study explored conventional NPD processes and it identified that whether developing physical product, software, or service, the process begins from identifying the latent needs for delivering the product(s). However, depending on the characteristics of the objects (physical, digital or service), there are specific ways of designing and developing new products.

The majority of the development processes for traditional products represent conventional sequential approaches, often referred to as 'a stage gate system (Cooper, 1990)', 'over the wall process (Trott, 2012),' and 'parallel processing models (Takeuchi and Nanoka, 1986)', but also there are a few models with different representations of NPD, such as 'Unger and Eppinger's spiral model (2009)', and 'a cyclical innovation model (Berkhout et al, 2010). As the economic paradigm has transformed from good-dominant logic to service-dominant logic, and emerging digital technologies disrupt existing NPD processes, new approaches toward service and software development appear and affect physical products development which are 'service design process (Johnson et al, 2000)', 'V-model (Forsberg and Mooz, 1991)', 'agile development method (Beck et al, 2001)', 'double design process (Design Council, 2007)', and 'open innovation (Chesbrough, 2004)'.

Existing NPD models remain continuously evolving, supported by emergent trends of increasing significance of NPD activities, such as: a) NPD process runs simultaneously b) a cross-functional approach; c) external network interactions; d) iterative and incremental approach. These factors not only serve to progress NPD processes, they also to widen the designer's horizon and working methods in the design process (Jacobs & Cooper, 2018). However, conventional models are regarded as obsolete in order to create value for the IoT products and services. This is mainly because they do not reflect the characteristics of digital technologies, the role of data, and specific ways of developing digital artefacts. Therefore, the attention of this discussion focuses on more details of development risks, and NPD process for IoT products and services.

Emergent NPD processes for IoT- a case study in agri-tech

Although UK dairy exports are growing and the long-term outlook for the industry is positive, UK Farmers have faced financial challenges caused by low milk prices. An IoT system targeting dairy industry has been developed in order to satisfy the increasing world-wide demand for good quality animal products in combination with responsible farming, such as reduction of environmental impact, diminishing resource use and increasing animals' welfare. It combines real-time sensor data gathered from neck collars with GPS, machine learning technologies and cloud-based services to create more value in the dairy chain. The neck mounted collar monitors animal's fertility and health through by detecting its eating behaviour, heat expression, and rumination 24/7. Once real time data is analyzed, meaningful information is transmitted wirelessly to the farmers' devices to support decision-making and service provisioning.

The new development process for this IoT system is identified and illustrated by an interviewee who led the development as a co-founder, Director and CTO of the start-up company. The NPD process has continued over a 13 year period- and continues still- from initiating the IoT solution to a global company providing products and services to the dairy industry, comprising multiple cycles of design and development phases. Each discrete stage of activities within the NPD process were critically examined (Figure. 01).

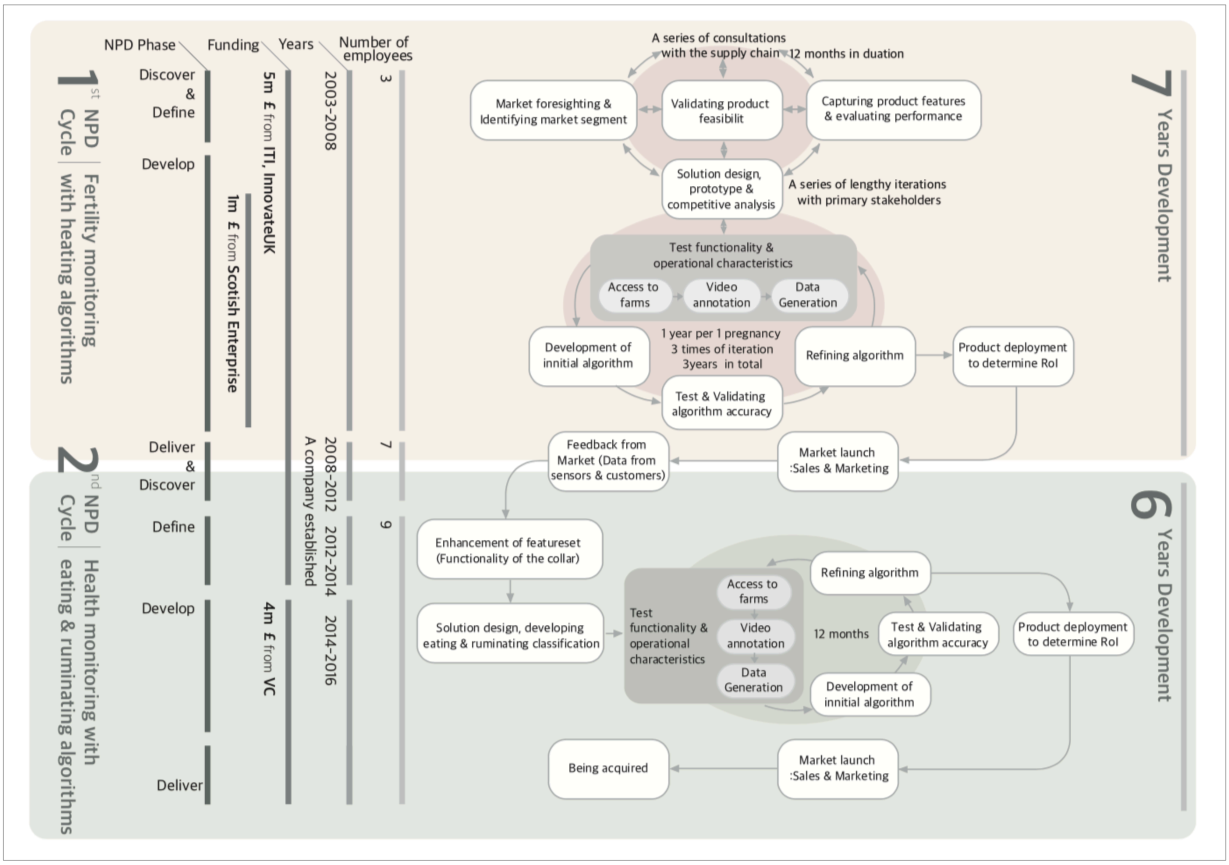

Figure 1: The emergence of value over a thirteen-year period.

1st Cycles of Discover and Define

The ‘Discover and Define’ phases encompass market foresighting and segmentation, validating product feasibility, capturing product features and evaluating performance. This phase was 12 months in duration. The market needs were identified and validated within the market foresighting stage through a series of consultations with the sector supply chain, such as farmers, herdsman, main retailers, logistics, milk recorders, artificial inseminators, nutritionists, animal scientists, and technology providers. All the agriculture segments from crops to chickens were assessed and the appropriate market segment was identified as dairy herd management. Identifying the most appropriate market segment is crucial as it drives nearly all of the business decisions. Once the market was identified, the project team validated the viability of the product through specifying the features embedded within the final product/ service of the solution.

1st Cycle of Develop

The product features and performance requirements were then specified in detail at the solution design stage considering the competitive landscape. Designing and prototyping a solution was achieved through a series of lengthy iterations with primary stakeholders involved from the outsets in the product definition. In the development of the solution and managing the input from industry stakeholders, critical decisions were reached such as; what is the minimum viable feature set of the product?; what is the form factor?; what is the products’ lifetime requirements?; the definition of the deployment process?; and what is the overhead in terms of the maintenance cost?. Subsequently the initial product hardware prototype was developed and evaluated in partnership with dairy farmers who not only to test functionality and operational characteristics of the hardware but also to collect data in order to create and validate a software algorithm that identified accurately the onset of heat (to optimise pregnancies) automatically.

In order to increase the accuracy of the algorithm, the project team incorporated the understanding the farmers' knowledge of the characteristic behaviour animals at or near the onset of ovulation and interpreting data into an actionable event through an alert. It is fundamental to 'listen to your customers' during the entire IoT NPD process but specifically at the stage of understanding current on-farm practices, in turn informing on what and how data should be presented, core to all IoT system.

The team enjoyed a good relationship with a small number of research and commercial farms from the outset of the project, as such; access to the farms was not a significant issue. However, the stages of developing the initial algorithm, testing and validating the accuracy of algorithms, and refining algorithms were time intensive and resource consuming. Primarily this is due to the ovulation cycle of the animal (which is one year); thus, the robust validation of the impact of the solution relies on the collection and analysis of 12 months of data. For the initial product, the period was 36 months as the stages of development, test, and refining algorithms was iterated through a series of many iterations. Moreover, even though the team had the access to on-farm environments and were allowed to deploy the neck-mounted collar on appropriate commercial animals, the annotating of videos for a significant number of animals to gather truthing data against which the algorithms would be compared was both time-consuming and costly. During the stage of algorithm development, there were three internal researchers, but three or four operatives at each of five farms simultaneously became involved to annotate the video over a series of iterations.

Securing funding was also a significant issue in order to ensure that the team generate sufficient on farm data to validate the algorithms. On top of the funding from InnovateUK, they succeeded in securing close to £1m from Scottish Enterprise. The phase of developing, testing, validating and refining algorithm was a long and challenging journey. Apart from time and financial issues, the team encountered a series of development risks such as: the performance of the IoT system; the risk of misunderstanding the appropriate market segment; the risk of not having algorithms(s) which are fit for purpose; and the risk of limited market traction. Thus, the development risks in an IoT NPD process could be more difficult and complex when compared to a traditional NPD process.

1st Cycle of Deliver and Discover

In order to commercialise the IoT product, the Return of Investment (RoI) of the system had to be accurately validated. As discussed earlier, the natural cycles is one pregnancy per year which means that RoI takes the similar amount of time to capture. The pace of development was another associated risk since validating RoI and algorithm were challenging; whereas the actual feature set and algorithm development definition was quicker. At the stage of market launch, a commercial company who had a partnership with the team progressed the sales and marketing strategy. The start-up company focussed primarily on the IoT system development from analysing the market through to delivering the collars to the farm, the market attraction was a major challenge. The dairy farming sector have followed many years of standard practices which are difficult to change quickly.

2nd Cycle of NPD process

While commercialising the IoT product, the project team received market feedback and collected data which enabled them to identify farmers' latent needs in monitoring animal's health. The team identified that monitoring health is achievable indirectly from the muscle movement of the animal to derive accurate measurements of the time spent rumination and eating with the same hardware. After understanding how the veterinary doctors and farmers judge when the animal is unwell, they accessed the farm environment to record the muscle movement and made efforts to develop and refine the algorithm for a further 12 months. The value of the IoT system is to provide automatic indication of the animals eating behaviour, heat expression, and rumination to the farmers, which would then support their decision making on the optimum intervention. Finally, the company developed the IoT system which has subsequently been acquired by an established business in 2016.

Discussion

Reframing NPD process for IoT through reflecting challenges and opportunities

From the case study, it was identified that approaches towards IoT NPD process seems to be similar to a generic NPD process. In addition, the fundamentals of IoT business success are not much different to its counterpart of traditional business success such as: listening to the customers to understand and articulate their requirements; capturing the understanding of users' behaviour and fusing it into the right solution within the right business purpose; having a good relationship with lead partners and stakeholders. However, several factors, the characteristics of digital technologies (Yoo et al., 2012), the dimensions of big data (McAfee & Brynjolfsson, 2012), the properties of digital artefacts (Yoo, 2010), and the dimensions of digital innovation (Yoo et al., 2012) allow a distinctive approach to existing NPD activities and development risks.

The difference in approach towards NPD for IoT products and services proves to that it is not linear but continuous and emergent process (Jacobs & Cooper, 2018) which indicates that value propositions are able to keep evolving for enhanced customer experiences. Over the first and second cycles of the NPD process, the value of the IoT system was evolved from only proposing fertility monitoring to proposing animals' health monitoring. Flexibly adding new sets of value to the same IoT system is desirable but it also means that design of IoT products and services are unable to be fixed which increases the time and/or cost for project completion (Gil and Tether, 2011). The rapid pace of digital technology development (Yoo et al, 2010) also results in keeping design fluid.

Further, real-time data on customers' experience enables the spatial and temporal division between discovering, defining, developing, delivering, and consuming offerings to coincide. Over the 1st cycle of the delivering stage, while farmers were using the fertility monitoring service, health monitoring service, the new offering, was being discovered and developed simultaneously. Unlike developing hardware or software products, developing digitized artifacts increases risks and complexity of development activities due to their multifaceted architectural and abstraction layers. Hence, the multitude of stakeholders and the two different production (hardware and software) process should be carefully curated in terms of creating value for IoT.

Development risks over the IoT NPD process is more vulnerable compared to its counterpart in the conventional NPD process. Because it takes longer, to test feasibility of IoT system as sufficient data is collected and the accuracy of algorithm is therefore validated. While the importance of iteration of processes has long been regarded as significant factors in NPD process, the iteration within each phase of the process becomes even more of a design imperative. Thus, the business should cultivate the ability to manage the fluidity and the uncertainty of their own NPD process.

Design contribution to create value in the context of IoT

Creating value for a new and yet to be explored technology, such as IoT, is a compelling challenge for businesses and designers who contribute to adding value to digitized artefacts. Due to their continuous connection to the internet, products are better considered to be services. Thus, the organisations and designers trying to create value with their own connected product should gradually transform the way of designing and business tactics from a goods-dominant logic to service-dominant logic.

Over decades of a goods-dominant logic, designers have become skilled at mediating value (Speed & Maxwell, 2015). By this, they have frequently played a significant role in providing ways to further understand the customer's needs and solve problems from a user-centred perspective. However, through the traditional NPD processes, more often than not, designers were excluded from the majority of discussions around the creation of a product's core value, and instead, were hired to add value through the use of type, colour and form at an elementary level. Moreover, developing innovative products in the past, challenged designers as they were only able to access to limited information on existing needs in a reactive manner at a single point beyond its selling point (Speed & Maxwell, 2015). After launching a product, designers played a significant role in adding value to a product through marketing campaigns, making sure that a product's 'worth' was commensurate with its perceived value but not exceeding the costs of production. There was a peak moment of value which is the point of sale (see Figure 2A. below) when consumers perceived value for a product or service was 'worth' the offer made by the company. The limitation of the designers' contribution to the object of design (a thing) and marketing campaign is illustrated with the yellow area on Figure 2A.

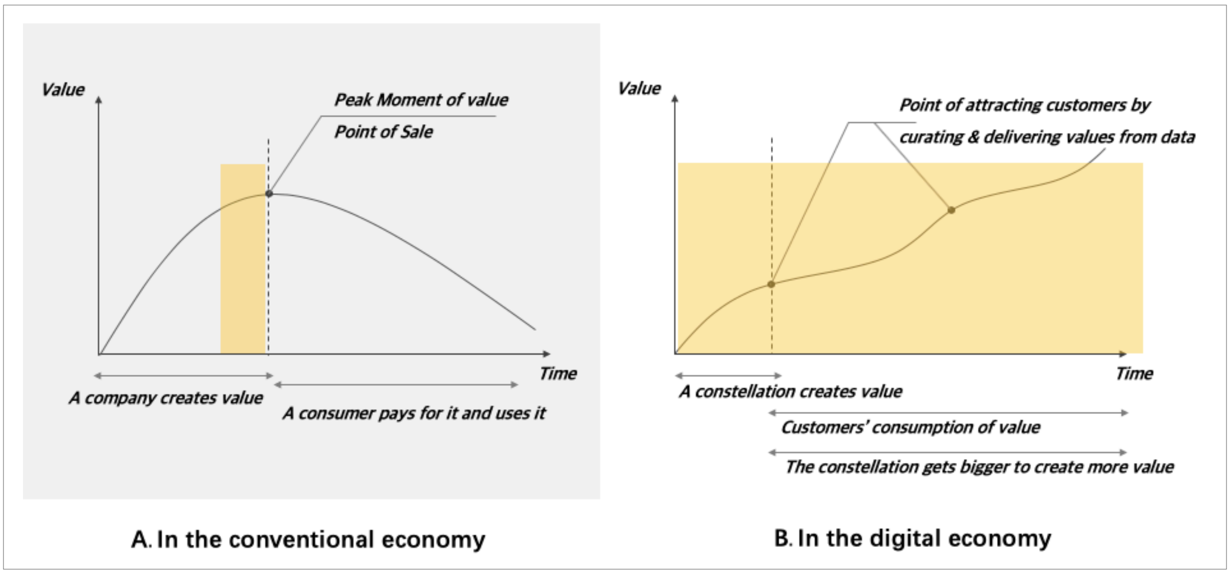

Figure 2: The emergence of Value in the Time Frame.

However, in the context of IoT, there is no critical peak moment of adding value due to the underlying connection to the internet. The value of connected objects, therefore, does not decrease while being used, instead it increases depending on what value is provided through the networked objects. Moreover, the emergence of value has a rising curve as new services are added (Figure 2B. above) based on a growing constellation of internet products. This is due to real-time data frequently being analysed to construct personal value propositions. Through the analysis of large, linked data sets, organisations are thus able to keep creating and refining value propositions across a broad spectrum of stakeholders. Real-time data which is not a natural medium for designers to work with challenges designers, however, it enables more effective and faster feedback about the assumptions of where value lies, whilst further analytics are able to track the production of unforeseen value.

The acceleration of these cycles ultimately leads to the co-production of value through the push and pull between producers and consumers. This is one of the reasons why design is now at the core of many successful products and services in the digital economy. As such, designers should get involved in value creation more actively over IoT NPD processes which is illustrated with the yellow area in Figure 2B. Certainly, an important way to begin to create value with an IoT business model is to start with identifying latent human needs that are concealed beneath huge amounts of customer-generated data.

Conclusions

The authors examined established literatures and a featured a case study to provides attention to the core research questions at large: 1) How are the conventional NPD processes and value creation different to its counterpart in IoT context? 2a) How are IoT products and services actually being developed and 2b) what are the risks inherent over the duration of the NPD process? 3) How should design be reframed as a critical enabler to mediate value over IoT NPD process? Although this study has explored issues and value creation related to design and development processes for IoT, there are a number of limitations. As a single case study is only explored within this study, risks and activities of each stage are not profoundly uncovered and limited in findings and generalizing. Notwithstanding these limitations, however, the authors argue that the research study also has some important contributions for wider adoption. For practitioners, this research will enable industry practitioners to understand how design contributes to value creation through a defined NPD process. For academics, this research project contributes to augmenting the body of literature regarding emergent innovation processes for IoT and serves a starting point of future in-depth research on IoT NPD processes.

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