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# **The roles of internet of things in enabling servitized business model: A systematic literature review**

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## **Abstract**

Internet of things has increasingly gained attention regarding its potential in enabling servitized business model. However, the academic research that explains this concept is still underexplored. Thus, this paper aims to provide a consolidation and comprehensive analysis of the relevant literature, through conducting a systematic review. From analysing 53 articles, four types of IoT-enabled servitized business model: add-on, sharing, usage-based and solution-oriented are identified. The framework was established to present the relationships of the roles of IoT, firm's benefit and inhibiting factors in enabling each type of business model. This framework provides a useful and inclusive overview of the topic.

**Keywords:** internet of things, servitization, literature review,

## Introduction

The term internet of things (IoT) was first coined by Kevin Ashton in 1999 to describe the interconnection of physical objects through adding radio frequency identification and other sensors for various purposes including identification, communication and data collection (Ashton, 2009). It has gradually gained attention from both practitioners and scholars regarding its potentials in enabling firms to offer advanced services integrating with their products or redesign their current business (Rymaszewska et al., 2017). This could be linked to the concept of servitization or product-service system (PSS) which is defined as the innovation of firms' capabilities to transition from selling products to selling integrated product-service offerings (Baines et al., 2009).

In order to initiate servitized offerings, firms need to modify their current business model and its value proposition to align specifically with individual customer interests (Zhang and Banerji, 2017). By adopting IoT, firms can fundamentally transform its business models and enable various types of service-oriented business models, which facilitate the provision of servitized offerings beyond the traditional servitized offerings. In spite of recognising IoT as the key enabler of servitized business model in practice the academic research that explains this emerging concept is still lacking.

Accordingly, the purpose of this paper is to investigate and explain this emerging concept by reviewing the current literature available in this area. The paper aims to identify different types of IoT-enabled servitized business models and report the corresponding roles of IoT used in different types of IoT-enabled servitization and benefits and inhibiting factors that firms might confront when deciding to adopt different types of IoT-enabled servitized business models, through conducting a systematic literature review (SLR).

## Methodology

In order to increase the rigorousness in reviewing literature, the methodology adopted in this paper is a systematic review, basing on an improved five-step approach, proposed by Denyer and Tranfield (2009). These five steps are question formulation, locating studies, study selection and evaluation, analysis and synthesis, and reporting and using the results.

The review question and review sub-questions were formulated from setting the scope of the study, identifying emerging research field and through the discussion with the panel members. The review question is derived as:

- What are the different types of IoT-enabled servitized business models?

This review question suggested three following supplementary questions:

- What are the different types of IoT used and which business models do they support?
- What are the benefits of the different IoT-enabled servitized business models?
- What inhibits firms from adopting IoT-enabled servitized business models?

Two classes of keywords relating to the concept of servitization and internet of things and internet of things were used to were used to construct search strings with Boolean operators as shown in Table 1.

*Table 1 - Specification of search terms used in a systematic review*

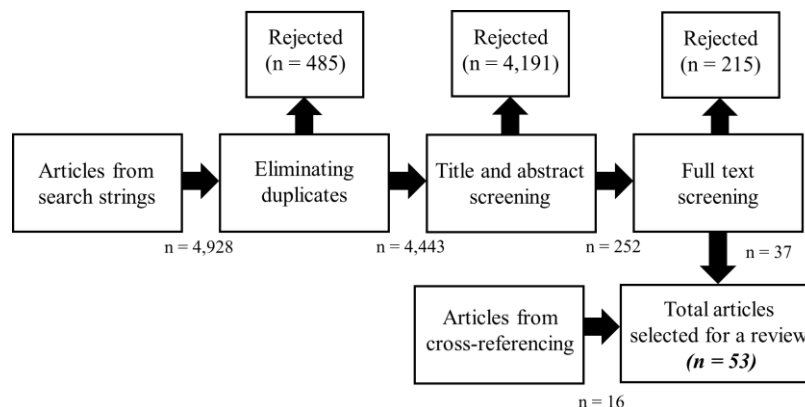
Servitization		Internet of Things
(Serviti* OR Servicis* OR Serviciz* OR "Service-dominant logic" OR "Product-Service System" OR "Product Service System" OR "Product-Service" OR "Integrated solutions" OR Service-orient* OR Service-cent* OR "Service-based business model" OR "Value Co-creation" )	AND	("Internet of Thing*" OR IoT* OR "Cyber-Physical" OR "Connected Device")

These search strings were applied to search five databases (Emerald, ABI/INFORM Global, ScienceDirect, Scopus, Web of Science) for the title and abstract of English language scholarly articles, conferences paper, a chapter of edited books and report published between 1999 and 2017. 4,928 papers were identified from the initial search. The duplicates were removed and the titles and abstract of remaining papers were then screened against inclusion and exclusion criteria as shown in Table 2.

*Table 2 - Criteria for including and excluding papers*

Criteria	Rationale
<b>Inclusion</b>	
Publications since 1999	The term “Internet of things” was first coined in 1999 by Kevin Ashton
Publications included academic journals, conferences papers, report and chapter of the edited book.	To ensure that all relevant published work were included
Journal quality include peer and non-peer reviewed publications (e.g. conferences proceedings, a chapter of edited books and business reports)	Since the research in this area is considered as infancy, so there is a trade-off between journal quality and the available publications in this research topic
All business contexts (e.g. business-to-business, business-to-consumer, business-to-government)	To make a comparison between roles of IoT in different business contexts
Papers in the field of information systems, engineering, manufacturing technology and marketing	To ensure that all possible fields relating to the research were covered
<b>Exclusion</b>	
Non-English language papers	This is due to limited language capability of author
Papers focus on IoT platform or architecture development	The main objective of this research is to identify and explore IoT-enabled business model rather than developing IoT platform or architecture

The remaining papers were read in full and the quality of each paper was carefully evaluated against the quality assessment criteria. After this final screening, 37 papers were identified as relevant to this research since it focused on IoT in enabling servitized business models. Additional 16 papers from cross-referencing were added because they were revealed as relevant to the research but were not identified from the initial literature search. Accordingly, the total number of 53 papers were selected for further analysis and synthesis. The systematic selection process is illustrated in figure 1.



*Figure 1 - Summary diagram of the systematic selection process*

The content from individual studies was analysed descriptively and thematically. The descriptive analysis focuses on the classification of papers according to a year of publication, type of publication, methodology and industry. On the other hands, the thematic analysis identifies and categorises different types of IoT-enabled servitized business model. Finally, the findings were reported through the established framework.

## Descriptive Findings

The 53 papers selected through a systematic review are descriptively analysed in this section in respect of the year of publication, research methodology, types of publication, journal and field of study, in order to investigate the trends in the emerging concept of IoT and servitized business models.

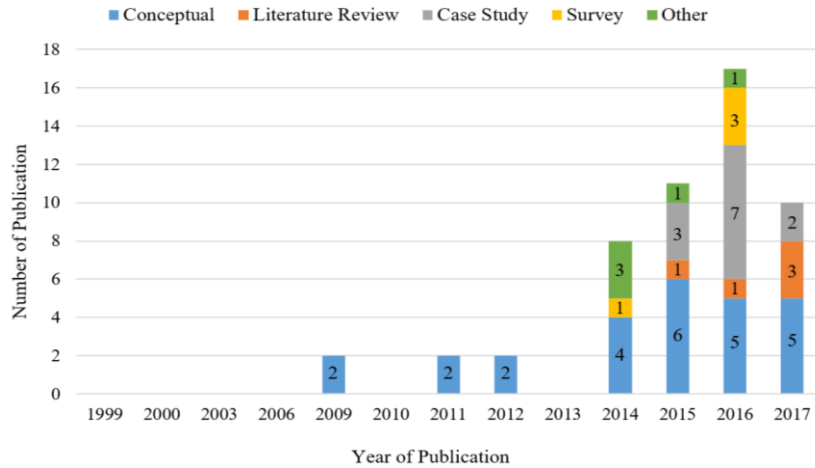


Figure 2 - Analysis of papers according to publications across the year and research methodology

Figure 2 illustrates that the studies on the concept of IoT in the context of servitized business models began and gained attention in academic research in 2009. Only 6 publications were published between 1999 and 2013. From 2014 onwards, the research was gradually increased of which 47 papers were published, which accounts for 90% of the papers in this study. This indicates an increased interest in IoT opportunities, implementing in servitized firms and how it could be leveraged in enabling a successful servitized business model.

Furthermore, almost half of the papers are conceptual (49%), indicating the immature stage of promoting theory development in the literature. Only in recent years that empirical papers have been presented where case study (23% of papers) is the most popular method in this type of paper. Nevertheless, the small number of quantitative studies result in a lack of theoretical development and validation.

The papers selected for a systematic review were mainly published in academic journal (60%) and conference proceedings (25%) whilst the rest are a chapter of edited books (11%) and business report (4%). This shows that the research is currently still at an immature stage as there is not much research on this topic published in the academic journal. Furthermore, the majority of the papers were published in operation management and information management journals in a similar number of papers, indicating that the topic of IoT and servitized business model has currently gained attention in both fields.

Finally, regarding the industry sectors, which contributed to the body of knowledge on IoT-enabled servitized business model, the findings show that the applications of IoT in the concept of servitization are predominantly discussed in the context of manufacturing/machinery (38%) and consumer goods (23%) industry case studies.

## Thematic Findings

Through the analysis of the content of selected articles, four types of IoT-enabled servitized business models including add-on, usage-based, sharing and solution-oriented are classified with supporting evidence as shown in table 3.

*Table 3 – Articles that discuss the four types of IoT-enabled servitized business model*

<b>Business model</b>	<b>References</b>
Add-on	Bohli et al. (2009), Haller et al. (2009), Metjofit (2011), Leminen et al. (2012), Li et al. (2012), Fleisch et al. (2014), Harvard Business Review Analytic Services (2014), Turber and Smiela (2014), Turber et al. (2014), Westerlund et al. (2014), Andersson and Mattsson (2015), Atzori et al. (2015), Dijkman et al. (2015), Keskin and Kennedy (2015); Lee and Lee (2015), Mikusz, (2015), Rong et al. (2015), Wunderlich et al. (2015), Dominici et al. (2016), Gerpott and May (2016), Hagberg et al. (2016), Kralewski (2016), Parry et al. (2016), Sassanelli et al. (2016), Scholze et al. (2016), Shih et al. (2016), Takenaka et al. (2016), Vendrell-Herrero et al. (2016), Wiesner et al. (2016), Zheng et al. (2016), Balaji and Roy (2017), Gierej (2017), Green et al. (2017), Ng and Wakenshaw (2017), Risteska Stojkosk and Trivodaliev (2017), Woodside and Sood (2017)
Sharing	Bucherer and Uckelmann (2011), Leminen et al. (2012), Harvard Business Review Analytic Services (2014), Schenkl et al. (2014), Rong et al. (2015), Carpanen et al. (2016), Ardonilo et al. (2016), Dominici et al. (2016), Gerpott and May (2016)
Usage-based	Bucherer and Uckelmann (2011), Fleisch et al. (2014), Ardonilo et al. (2016), Gerpott and May (2016), Kralewski (2016), Noventum (2016), Zancul et al. (2016), Wiesner et al. (2017)
Solution-oriented	Bucherer and Uckelmann (2011), Fleisch et al. (2014), Lee at al. (2014), Paluch (2014), Herterich et al. (2015a), Herterich et al. (2015b), Mikusz (2015), Porter and Heppelmann (2015), Tuunanen et al. (2015), Ardonilo et al. (2016), Kralewski (2016), Noventum (2016), Zancul et al. (2016), Gierej (2017), Helo et al. (2017), March and Scudder (2017), Rymaszewska et al. (2017), Wiesner et al. (2017), Zheng et al. (2017)

Three roles of IoT adopted in enabling servitized business model, including smoothing, adaptation and innovation were identified from the study of Gerpott and May (2016). In smoothing role, IoT is used to help initiate and facilitate the service and transaction but not the main part of product-service offerings. In adaptation role, IoT is used to enable additional functionalities to the standalone product or service, which helps to significantly increase the value of the products, but not the main value driver. In innovation role, IoT is used to enable the functionalities of product or service, which have not been previously offered. It is the main value of product-service offerings. These roles will be discussed in corresponding to each type of business model.

Additionally, the SLR identifies the firm's benefits and the inhibiting factors in adopting each type of IoT-enabled servitized business model. The relationships between four types of IoT-enabled business model and its corresponding IoT roles, benefits and inhibiting factors are ultimately discussed in this section.

#### *Add-on*

It describes the business model that leverage IoT in enabling additional functions or services to the existing product. This corresponds to the product-oriented business model in the traditional PSS model where the provider offers services that are related to the product sold (Tukker, 2004).

Regarding the roles of IoT, it is shown that all three roles of IoT have been applied. For example, Leminen et al. (2012) provided the case of Geis Group who offered an intelligent logistics, where IoT is leveraged to help processing customer's order more efficiently. In other words, IoT is used to smoothing the transaction, referring to smoothing role of IoT. Regarding the adaptation role, Philip Hue, the personal wireless lighting system can be considered as the example in this case. Philip Hue adopts IoT to enable the connection between LED light bulb to personal devices, allowing customers to control light remotely, depending on personal needs (Gerpott and May, 2016). The main value offered is still the function of the lightbulb but the personalised lighting function significantly add value to the existing product (i.e. lightbulb). The case of Nike FuelBand is an example of firms applying innovation role of IoT in offering the service. FuelBand is the wristband that monitors health and fitness activity of the user where this function was previously unavailable before launching this product (Gerpott and May, 2016). Hence, IoT is the main value driver for this offering.

By adopting this business model, firms will mainly benefit from extending their business through creating or adding new value by integrating service to the product (Atzori et al. 2015; Kralewski, 2016). Furthermore, it helps to reduce operating and overall service costs (Leminen et al., 2012; Harvard Business Review Analytic Services, 2014) and improve their current product-service offerings which result in increasing customers' satisfaction (Leminen et al., 2012; Balaji and Roy, 2016).

However, since firms utilise IoT to access to customer's personal information to offer services in this type of business model, the privacy and data security are the main concerns which may inhibit firms from successfully adopting this business model (Wunderlich et al., 2015; Dominici et al., 2016; Takenaka et al., 2016). Furthermore, in order to successfully adopt this business model, it requires firms to develop close relationship and collaboration with all involved stakeholders (Fleisch et al., 2014; Andersson and Mattsson, 2015).

### *Sharing*

This business model adopts IoT to allow customers to pay for getting access to a product or service in a limited time and allow different users to continue using the product or service when it is available while the provider is responsible for ensuring that the product or service is available for other customers to use or access. Thus, this can be considered as corresponding to the use-oriented business model in PSS business model. In the use-oriented business model, customers do not pay for the physical products but instead for using the product where provider assures the availability of the products (Tukker, 2004).

The only role of IoT that has been used in sharing business model is smoothing. This is because this business model can be considered as an improvement of the current traditional product rental business model through the adoption of IoT technology. The example case of sharing business model is Zipcar, who offers car-sharing service (Rong et al., 2015). Zipcar embedded IoT technology to their cars, allowing customers to pick-up and return the car from the convenient locations near customers. IoT helps to reduce service time and decrease the overall transaction cost, hence it can be categorised as smoothing role.

The main benefit for firms in adopting this business model is improve the current product-service offering (i.e. traditional product renting) to customers (Leminen et al., 2012; Rong et al., 2015; Gerpott and May, 2016). Furthermore, firms will benefit from increasing resource utilisation (Schenkl et al., 2016) and reducing operating costs by reducing the resources used in providing service (Bucherer and Uckelmann, 2011).

However, the main factors which inhibit firm in adopting this business model are that it requires firms to find new ways of customer's interaction (Leminen et al., 2012; Carpanen et al., 2016) and collaborate with different stakeholders in order to implement this business model (Bucherer and Uckelmann, 2011).

### *Usage-based*

It describes the business model that uses IoT to measure the amount of product usage and allows customers to pay-per-use or subscribe to the plan based on the actual usage. The provider will be responsible for delivering the results within the time span of subscription or usage. This can be considered as a result-oriented in PSS business model since the service that firms offer to the customer is a certain result or outcome (Tukker, 2004).

The role of IoT adopted in this business models is smoothing and adaptation. The study from Bucherer and Uckelmann (2011) provides the example case of firm adopting smoothing role, which is an information service provider who offers a verification and detection of counterfeits of machinery equipment. The adoption of IoT allows firms to

aggregate information from multiple sources and provide the information required to manufacturing companies. Hence, IoT is adopted to increase the value of the machinery equipment. On the other hands, the example case of firms adopting adaptation role of IoT, provided by Fleisch et al. (2014) is Brothers who offers managed print services where customers can choose to pay per page for their printing regardless of the amount of ink used. IoT is leveraged to monitor the ink level remotely and automatically send the new ink cartridge to the customers. The main value is still the printing service while the adoption of IoT allows firms to increase the significant value of this existing service.

The adoption of this business model mainly benefits firms in extending their business (Bucherer and Uckelmann, 2011; Gerpott and May, 2016). In addition, firms will benefit from generating steady income (Zancul et al., 2016) and reducing operating costs (Fliesch et al., 2014; Harvard Business Review Analytic Services, 2014).

However, as IoT generated a lot of information during product usage, the skilled labours or expertise are required to interpret these data into meaningful information for service provider and make them effectively shared among stakeholders (Bucherer and Uckelmann, 2011; Fliesch et al., 2014). Accordingly, the close relationship between different stakeholders in the service network is required (Bucherer and Uckelmann, 2011).

#### *Solution-oriented*

In this business model, firms leverage IoT to offer advanced services, providing solutions and advice to the customers' core business operations. The solution-oriented business model refers to the business model that utilises IoT in providing specified solutions to customers. With the aid of IoT, firms will be able to offer the specific solutions to the customers, which aligns with customers' needs such as the support of customers' core operations to help in increasing of customer's efficiency and business capabilities (Kralewski, 2016; Noventum, 2016). Hence, this corresponds to the result-oriented in PSS model where firms make an agreement with a customer in order to deliver the specified outcome or results (Tukker, 2004).

The roles of IoT adopted in this business model is adaptation and innovation. The example case study adopts adaptation role of IoT is Agfa Healthcare, the provider of medical imaging technology services to the healthcare customers (Noventum, 2016). By leveraging IoT technology, firm can offer specified uptime guaranteed service and customer pay for the specified performance of the service. The main value provided to the customer is still the imaging technology service but firms significantly increase value to the existing service from the continuous availability of their service. Regarding the innovation role of IoT, the study from Rymaszewska et al. (2017) provides an example case of a provider of sheet metal machinery who leverages IoT to help the customers optimise their production, reduce operating costs and have better fleet management. Hence, the role of IoT in this advanced offering can be categorised as innovation.

By adopting this business model, firms mainly benefit from extending their business (Herterich et al., 2015; Helo et al., 2017; Rymaszewska et al., 2017) and gaining a competitive advantage as the service offered is difficult to imitate (Bucherer and Uckelmann, 2011; Porter and Heppelmann, 2015; Rymaszewska et al., 2017). Furthermore, firms will benefit from reducing their operating costs (Noventum, 2016).

However, to adopt this business model, firms need to be capable of offering the solutions that align with customers' needs (Wünderlich et al., 2015; Zancul et al., 2016; Rymaszewska et al., 2017). Firms also need to work closely with all involved stakeholders in order to offer advanced services (Noventum, 2016; Helo et al., 2017; March and Scudder, 2017).



Basing on the thematic analysis, the framework is established to demonstrate the relationships of the findings as shown in figure 3. It shows that the role of IoT that has been adopted by all types of IoT-enabled servitized business model is adaptation. Commonly, the IoT-enabled servitized business model helps firms to reduce operating costs. Additionally, the common inhibiting factors that firms need to consider prior to adopting all types of business models is to develop a close relationship and collaboration between all stakeholders involved in a particular service network.

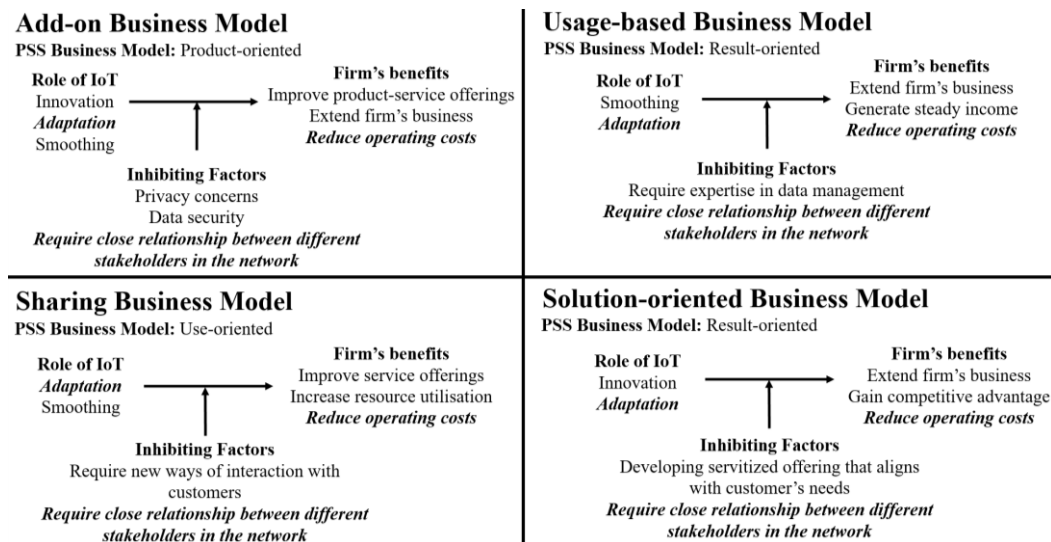


Figure 3 – Relationships between four types of IoT-enabled business model and its corresponding roles of IoT, inhibiting factors and firm's benefit

## Conclusion

This paper investigates the previously unexplored different types of servitized business models enabled by IoT and the roles of IoT adoption, firm's benefits and inhibiting factors, corresponding to each type of IoT-enabled servitized business model, from conducting an SLR. From the analysis of 53 papers, four types of IoT-enabled servitized business model are classified: add-on, sharing, usage-based and solution-oriented. The main outcome of this study is the establishment of the framework, demonstrating the correlation between four types of IoT-enabled servitized business model, and the specific roles of IoT, inhibiting factors and firm's benefits in order to understand the influence of the adoption of IoT on the firm's business. Future research should use this framework as a foundation to develop hypotheses for further empirical work.

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