On the Dynamic Model of Service Innovation in Manufacturing Industry

Yongyoon Suh, Chulhyun Kim, and Moon-soo Kim

***Abstract*—**As the trend of manufacturing is being dominated depending on services, products and processes are more and more related with sophisticated services. Thus, this research starts with the discussion about integration of the product, process, and service in the innovation process. In particular, this paper sets out some foundations for a theory of service innovation in the field of manufacturing, and proposes the dynamic model of service innovation related to product and process. Two dynamic models of service innovation are suggested to investigate major tendencies and dynamic variations during the innovation cycle: co-innovation and sequential innovation. To structure dynamic models of product, process, and service innovation, the innovation stages in which two models are mainly achieved are identified. The research would encourage manufacturers to formulate strategy and planning for service development with product and process.

Keywords- dynamic model; service innovation; service innovation models; innovation cycle; manufacturing industry

I. Introduction

As the service sector has dominated global economies and economic growth, the strategic gravity of services is highlighted in almost all industries. Among others, the dominating trend of the manufacturing industry is the movement of corporations towards services [1]. Manufacturers have tended to recognize services as a means of enhancing the value of manufactured goods in the market [2]. However, as service plays a critical role in the global economies, the manufacturers become more active in integrating services into a total offering and services are already being considered in the development phase [1][3]. The services are developed to enhance the product value for customers and provide interesting business models for producers [4]. It is indicated that the service aspect is important during the whole processes from development phase in the manufacturing firms to after-sales phase in the market. The innovative activity and behavior for transition from producing products to delivering services is called as "servitization" [5]. In this respect, a lot of terms have been coined to define combinations of products and services for servitization such as "bundles" [5], "extended product" [6], "integrated product and service offering" [1], and "product-service systems" [7].

A research question is derived from the extension of product and process innovation of manufacturing firms into service innovation. Service innovation is strongly associated with product and process innovation and it becomes difficult to individually consider the innovation. Thus, the service innovation is recognized as one of the recent issues in the manufacturing industry. Previously, the dynamic model of process and product innovation has been well known by [8] and the service innovation which is identified as the reverse product cycle was studied by [9]. Regarding the innovation theory, many studies have focused on the differences between product and service innovations [10]-[14]. However, previous studies have tended to separately concern the product and service innovation as well as manufacturing and service firms. There have been few empirical and quantitative works that suggest major tendencies and dynamic variations of service innovation with product and process innovation. Therefore, we investigate central tendencies and dynamic patterns of three types of innovation together. In addition, to include dynamism, the innovation cycle is considered, and through this cycle, patterns of three types of innovation can be distinguished. The innovation cycle can be defined in terms of the market environment and firms' strategy. The dynamic model of product, process, and service innovation through the innovation cycle is useful for understanding which innovation can be achieved at each innovation stage.

The main purpose of this research is to empirically examine two service innovation models in the manufacturing industry. First, we propose the co-innovation and sequential innovation models, regarding the relationships between products and services. The co-innovation is defined as the integrated development of both product and service from the development phase. On the other hand, the sequential innovation is defined as development of the product-related service after the launch of new products. Furthermore, two models can explain major tendencies and dynamic variations of service innovation compared to product and process innovation. Second, two service innovation models in manufacturing firms are explored in terms of the innovation stages and cycle. To understand dynamic models of service innovation, the innovation stages in which the co-innovation or sequential innovation is mainly achieved are identified. Two service innovation models are empirically examined using the Korean Innovation Survey 2005 (KIS 2005) of the manufacturing industry published by the Science and Technology Policy Institute (STEPI) of Korea. We expect that the integrative approach to product, process, and service innovation would encourage the servitization of

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manufacturing firms to formulate strategy for development of the new product and service as well as integrative product-service concepts.

The remaining part of this research consists of four sections. Following on from a literature review of innovation in the product, process, and service in Section 2, Section 3 describes the research design with the two service innovation models, procedure, and data. Section 4 presents the innovation stages and the service innovation models during the innovation cycle. Finally, the paper ends with conclusions in Section 5.

II. Literature Review

Innovation of corporations and industries is the driving force to maintain their competency and to survive in the fiercely competitive market. There is a large body of literature identifying the characteristics and roles of innovation. Among a lot of studies, in this paper, a theory of innovation in the product, process, and service is focused based on [8] and [9]. First, the product and process innovation has been focused on the conventional manufacturing industry. Utterback and Abernathy [8] first suggested the integrative perspective of product and process innovation. They empirically examined that a manufacturing firm tries to achieve the product innovation in order to increase performance and to maximize sales, and then the process innovation is followed to reduce costs. With the innovation stages and cycle, the innovation stage in which product and process innovation is achieved was identified. This study provides managers with significant insights for understanding the innovation cycle. Second, Barras [9] argued that service innovation is achieved with product innovation and called as the reverse product cycle. The basic perspective of the reverse product cycle lies in the customer-supplier relationship between manufacturing and service sectors. If a new product is developed in the manufacturing sector, the service sector can be innovative using that new product. For example, after a personal computer was developed, a service employee could work easy and efficiently using the personal computer. Thus, service innovation is followed by the product innovation to reduce the burden on the labor-intensive work and to increase efficiency. At the final stage of service innovation, a new service can be developed based on a set of new products and infrastructure.

Although the product, process, and service innovation has been studied and its relationships have been also focused, there is still a lack of dynamic model of service innovation in manufacturing firms. As an extension of service innovation in the manufacturing industry, integrative concepts have been suggested as a lot of terms such as the integrated product and service offering or product-service systems, as pointed out before. Conventionally, the innovation studies have been conducted based on the individual industry. If the researchers try to find out the service innovation, the studies tend to be investigated based on the service industry. However, the service innovation is also achieved in manufacturing firms to improve product functions and increase sales of products. Thus, major tendencies and dynamic variations of service innovation in manufacturing firms should be identified to understand characteristics and roles of services.

III. Research Design

A. Service Innovation Models

According to the way of providing services for products, the service is viewed as a tangible product component as well as an intangible system process. First, a firm can simultaneously develop services as components, considering product and process functions from the early phase of development. Second, at the sales and after-sales phase in the market, the service can be provided to reinforce product function as an optional product component or to facilitate uses of products by a streamlined delivery processes. Previously, the prior one can be called as “service products” [12], while the latter one can be referred as to “product-related services” [4]. To sum up, the service innovation is differently achieved based on how to relate with products and processes and when to achieve.

To examine the dynamic model of service innovation in terms of service products and product-related services, two dynamic models of service innovation are proposed as shown in Fig. 1. First, when the service is developed with products together, service innovation is called as the co-innovation (see the Fig. 1(a)). Second, the service innovation is referred as to the sequential innovation (see the Fig. 1(b)) when the service is bundled and delivered after new products have been launched in the market. It especially seems that the sequential innovation has a similar pattern between product and process innovation. It has been known that process innovation is also related with product development and followed by the product innovation. However, the goal of process and service innovation may be different. The purpose of process innovation lies in the cost reduction, while that of service innovation is usually to maximize the sales with complementary or bundled services. Thus, although the product-process and product-service innovation indicates a similar pattern, the motivation and purpose of innovation can be distinguished.

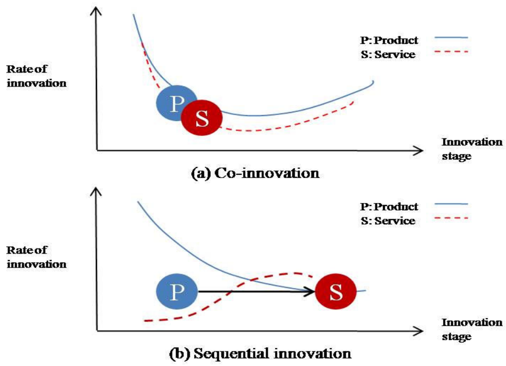

Fig. 1 Service innovation models

Despite these commonalities and differences among product, process, and service innovation, they have been individually considered so far without the integrative framework in the manufacturing industry. Thus, this paper proposes two service innovation models and examines the relationships among the product, process, and service in the manufacturing firms. Also, to consider dynamics of three types of innovations, the innovation stages and cycle are determined. The major tenet of this paper is to identify the dynamic model with innovation stages in which the co-innovation and sequential innovation is mainly achieved. The strength of the service innovation models is derived from the fact that it is an integrative framework encompassing a broad range of relationships among product, process, and service innovation. It is expected that the holistic dynamic model help managers focus on the servitizaiton of manufacturing firms.

B. Research Procedure

The overall process in this study is summarized in Fig. 2. In order to develop the innovation cycle using data of the KIS 2005, the innovation stage should be defined first. Data on the presence and motivation of innovation were collected from the KIS 2005. Specifically, based on the variables of innovation motivation, innovation stages are defined and identified. Then, relevant manufacturing firms were assigned into the innovation stage through the firms' major innovation motivation. The next step is to develop two service innovation models for the product and service as well as process together. The two service innovation models in manufacturing sectors help to understand the overall innovation cycle and pattern of service innovation. Finally, the relationship between innovation types and service innovation models is analyzed to illuminate major tendencies and dynamic variations of product, process, and service innovation.

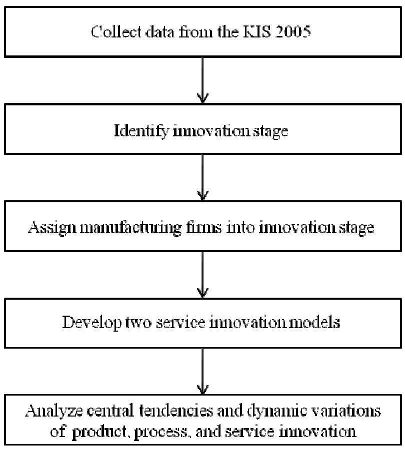

Fig. 2 Overall process

C. Data Collection

In this paper, the KIS 2005 for the manufacturing sector provided by STEPI of Korea was used to collect data and variables. The dataset was designed to provide information on various innovative activities at the firm level. The KIS 2005 was conducted in accordance with the guidelines of the Oslo Manual, OECD. Its main purpose was to gather information about the levels and characteristics of technologically and non-technologically innovative activities of Korean manufacturing firms between 2002 and 2004. The survey includes information on the product, process, and service as well as the innovative activities and environmental factors influencing firm's innovation behaviour. For instance, the survey contains detailed internal information of firms, such as motivations, methods, and performances during innovation processes. With regard to these advantages, the KIS data has been widely used for innovation studies of Korea [15]-[17]. Among data of KIS 2005, due to the inaccurate information and missing responses of specific questions, 279 manufacturing firms which experienced one among product, process, and service innovations were used across a range of industries: food and kindred products, textile products, chemicals and allied products, non-metallic mineral products, primary metal products, general machinery and equipment, electronic and other electric equipments, and transportation equipments.

As pointed out before, the goal of this paper is to figure out the innovation stage of services in manufacturing firms. To this end, the data of 279 manufacturing firms were used for two objectives. First, we identified whether or not the firms do innovative activities based on three types of innovation: product, process, and service innovation. Second, the variables of innovation motivation were used to identify innovation stages and to assign manufacturing firms into the respective innovation stage. The 22 variables were used and measured by 5 Likert scale for recognizing the degree of strategic focus of firms on the innovation activities. For example, the motivation of innovation could be the primary initiating factor for the innovation such as "improvement of product quality" or "substitution of existing products". To implement a classification methodology, the motivation or stimulus to which a majority of a firm's innovations responded seemed the most reasonable way to classify firms into innovation stages [8]. Thus, the data of KIS 2005 satisfying the two objectives support a quantitative test for relevance to the service innovation models.

IV. Test for Service Innovation Models

A. Development of Innovation Stages and Cycle

The factor analysis was conducted with 22 variables related with innovation motivations to explore the latent variables. As a result, three latent variables for motivation were extracted. Each latent variable (or called as factor) can be characterized by a set of motivations, and the factor 1, factor 2, and factor 3 can be matched with "market-oriented motivation", "process-oriented motivation", and "organization-oriented motivation", respectively. Of three factors, only two factors of the market-oriented motivation and process-oriented motivation are used for identification of innovation stages because the organization-oriented motivation is less related with product and service innovation. The manufacturing firms were assigned into respective innovation stage based on the factor loadings of two latent variables.

The innovation cycle can be described as shown in Table I. According to the growth cycle identified by Schumpeter with conditions at each innovation stage [9], manufacturing firms are classified into the recovery, prosperity, recession, and depression stage based on the market-oriented motivation and process-oriented motivation. This classification is a similar approach to a study of product and process innovation by [8] based on the degree of market maturity except the Stage 4. As the qualitative study of product and service innovation, Barras [9] argued that the product and service innovation was reversely achieved by innovation stages of the growth cycle, since there is the customer-supplier relationship between manufacturing and service sectors. However, it is difficult to consider product and service innovation as the

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customer-supplier relationship recently since manufacturing firms have also concentrated themselves on the service offering with products. Thus, structuring the dynamic model of product, process, and service innovation is important for understanding the pattern of service innovation in the perspective of servitization. With such innovation stages of the growth cycle, the stage in which service innovation is mostly achieved can be identified and the relationship between product, process, and service innovations can be analyzed in terms of co-innovation and sequential innovation.

TABLE I
INNOVATION CYCLE AND STAGE

Innovation Stage	Growth cycle	Market-oriented	Process-oriented
1	Recovery	Strong	Weak
2	Prosperity	Strong	Strong
3	Recession	Weak	Strong
4	Depression	Weak	Weak

B. Empirical Test of Service Innovation Models

Through the analysis of the service innovation models, the dynamic model of service innovation in manufacturing firms can be developed. The main purpose of this analysis is to find out the dynamic model with innovation stages in which service innovation is mostly tried and achieved. Particularly, it aims at the identification of the innovation stage for co-innovation and sequential innovation. A breakdown of frequencies of product, process, and service innovations with firms classified into Stage 1-4 is shown in Table II. To be specific, the value in Table I is the number of firms which achieve each innovation type. Counting the number of firms is based on the most focusing innovation type. For example, if a firm achieves more product innovation than other innovations in Stage 1, the firm puts into the type of product innovation of Stage 1. The results arguably support the differences across innovation types during the innovation cycle with less than significant value of 0.001.

TABLE II
INNOVATION TYPES AND STAGES

	Stage 1	Stage 2	Stage 3	Stage 4	Sum
Product	39↑ (25.6)	35↓ (44.2)	16↓ (24.3)	31↑ (26.9)	121
Process	12↓ (23.9)	49↑ (41.3)	35↑ (22.7)	17↓ (25.1)	113
Service	8↓ (9.5)	18↑ (16.5)	5↓ (9.0)	14↑ (10.0)	45
Sum	59	102	56	62	279

χ^2=32.8660, $p < 0.001$

* Note: value in parentheses is the expected frequency; an arrow means the comparison between frequency and expected frequency.

The differences of frequencies indicate that the pattern of innovation differs from each type as exhibited in Fig. 3. The result in relationships between product and process innovation is similar to previous research in [8]. First, it is found that product innovation is reduced during the period from Stage 1 (recovery phase) to Stage 3 (recession phase), but in Stage 4 (depression phase) product innovation is renewed. Second, process innovation increases between Stage 1 and Stage 2 (prosperity phase), and reduces in Stage 3 and 4. However, service innovation has a distinctive pattern compared to product and process innovation. The frequency of the service innovation fluctuated during the growth cycle. From Stage 1 to Stage 2, firms try to increase service innovation, while in the next Stage 3 the number of firms is decreased. In the final Stage 4, service innovation is facilitated again. Furthermore, we can see that service innovation is followed by co-innovation in the period between Stage 3 and Stage 4 and sequential innovation in the period between Stage 1 and Stage 2. The different pattern of service innovation should be described with the innovation motivation and the pattern of other innovation.

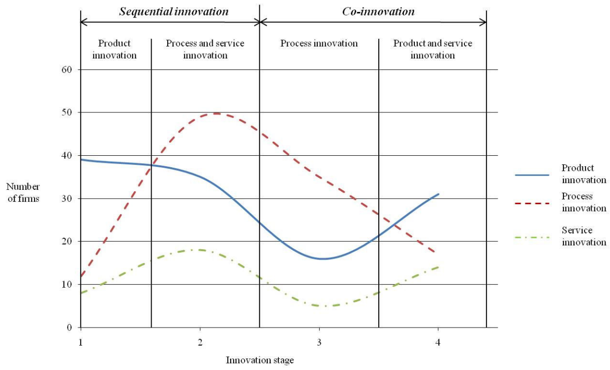

Fig. 3 Dynamic model with two service innovation models

V. CONCLUSION

The development of services is becoming a key strategy for manufacturing firms. However, product, process, and service innovation is less considered simultaneously. Based on the theoretical arguments in the proposed two service innovation models, this paper provides the innovation cycle with an integrative approach to the dynamic model of product, process, and service innovation. It aims to examine differences of innovation patterns and purposes during the innovation cycle. Relationships among three types of innovation are identified to suggest major tendencies and variations of innovations during the innovation cycle.

Through the development of the innovation cycle for product, process, and service innovation, this study proposes an integrative theory of product, process, and service innovation. For this, service innovation models, which are co-innovation and sequential innovation, are developed and examined with application to the KIS 2005 data for the Korean manufacturing industry. From the analysis of service innovation models, we first develop the innovation stages and cycle, and major tendencies and dynamic variations are identified. Identifying a dynamic model of service innovation is expected to help managers understand the integrative theory and practice in terms of the product, process, and service innovation simultaneously.

Despite its significant contribution, this study has some limitations as fruitful future research. First, the level of innovation stage and growth cycle is different. Actually, the growth cycle is traditionally based on the economic cycle at the industry level, but the innovation stage in this paper is determined at the firm level. Thus, it can be irrelevant to match the innovation stage with the growth cycle. To overcome this problem, the financial data can be used for classifying corporations into innovation stages with the economic cycle. Second, at the industry level, the patterns of service innovation can differ from each industry. The service innovations in the electronic industry and the chemistry industry can be differentiated. If the distinct characteristic of service innovation of each industry can be found, it is more helpful for mangers and policy makers.

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