CIRP Annals - Manufacturing Technology xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

CIRP Annals - Manufacturing Technology

journal homepage: http://ees.elsevier.com/cirp/default.asp

Manufacturer's strategy in a sharing economy

Nariaki Nishino (2)[a,*], Takeshi Takenaka [b], Hiroki Takahashi [a]

[a] Department of Technology Management for Innovation, School of Engineering, The University of Tokyo, Tokyo, Japan
[b] National Institute of Advanced Industrial Science and Technology (AIST), Tokyo, Japan

ARTICLE INFO

Keywords:
Service
Decision making
Sharing business

ABSTRACT

The rise of the sharing economy is forcing manufacturers to shift their business strategy from pure product sales to a 'product as a service' business. Car sharing businesses, for example, will lead to the reduction of overall production volume of cars. Simultaneously, IoT enables manufacturers to create new production strategies using the usage pattern of products. Our study constructs a durable goods market model with a sharing service where manufacturers and consumers mutually interact. Using multi-agent simulations, we present several cases of abstract situations and compare them with consumer attitudes obtained from questionnaire responses. Then, we discuss the manufacturer's strategy.

1. Introduction

With the progress of the internet of things (IoT), the methods of product utilization have become more diverse [1]. As described in reports of previous studies of Product-Service Systems (PSS), many manufacturers have started use-oriented PSS by which their products are leased or shared rather than simply sold [2]. Moreover, products that are privately owned by users can be shared or rented out via peer-to-peer marketplaces. Such a shareconomy or collaborative consumption is expected to become more common in the near future [3]. Accordingly, manufacturers should alter their strategies of product development or product design against the anticipated decrease of manufacturing volume [4].

Consumers' attitudes about owning and sharing products are apparently changing. For example, people of younger generations are regarded as being less concerned about owning cars and other goods. Moreover, some consumers prefer eco-friendly products. Those differences in consumer lifestyles must also be considered in future product development [5].

Such diversification of usage patterns of products can strongly affect manufacturers' decision-making related to product development strategies. Especially, manufacturers should appropriately estimate the functionality of their products and the durable years of their products considering various usage patterns. An optimistic prediction for the future shareconomy is that manufacturers will have a greater chance at development of their new products with higher functions and high durability through research and development (R&D) because users will require more sophisticated products with increasing opportunities for experiencing products with higher quality through rental or sharing services. Moreover, manufacturers will develop new products with high durability to meet higher frequency of use in such services [6]. In contrast, a negative prediction is that manufacturers will be adversely affected by severe price competition in the market because the total amount of manufactured goods will decrease as sharing services increase. Eventually, it will be more difficult for manufacturers to spend sufficient funds for R&D.

Against that background, the authors examine manufacturers' strategies related to product development considering market prices, R&D investment, and product quality, of which we especially consider the service life of products. So far empirical studies have been conducted using data in actual sharing business (e.g. [7,8]), whereas there are only a few studies about a mathematical model of sharing business [9,10]. Then our study constructs a general model of shareconomy, especially addressing manufacturers' point of view. First, in the next section, we conducted a questionnaire survey of consumer acceptance of sharing services, including car sharing services.

2. Questionnaire survey of consumer acceptance of sharing services

The survey was administered in Japan via the internet in December 2016, with responses received from 1545 respondents who have a driver's license (1030 men, 515 women, sample size was balanced among 20s, 30s, 40s, 50s and 60s and over). The questionnaire was designed to elucidate consumers' daily use and expenses for cars, and attitudes about ownership and sharing of goods. Additionally, we asked about their lifestyles based on the authors' earlier studies [11].

2.1. Analysis of overall consumer acceptance and attitudes about sharing services

As overall tendencies, 76.0% of respondents reported owning a car; 23.2% reported driving a car more than 3 days a week. The averaged estimated purchase amount of cars is approx. 15,300 USD. Fig. 1 shows a frequency distribution of their willing-to-use years of their owned cars in a total period. The averaged willing-to-

* Corresponding author.
E-mail address: nishino@tmi.t.u-tokyo.ac.jp (N. Nishino).

http://dx.doi.org/10.1016/j.cirp.2017.04.004
0007-8506/

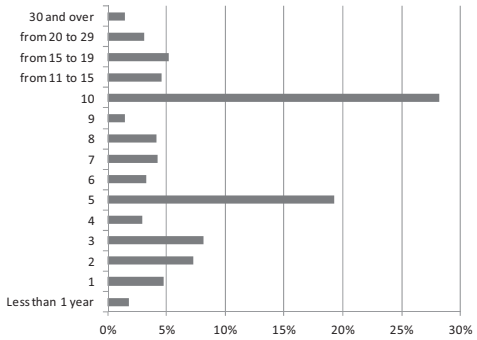

Fig. 1. Willing-to-use years for use of their own cars in a total period.

use years are 7.7, but 42.5% of consumers like to use their own car for more than 10 years.

2.2. Categorization of consumer attitude types and analysis of willing-to-use years of their cars

For the analysis of latent attitudes about ownership and sharing of goods or cars, the authors newly designed 14 questionnaire items based on results of earlier studies [11]. By conducting factor analysis, we extracted four factors using Maximum-likelihood method, Promax rotation, with Kaiser normalization. The factor score (Bartlett score) of each factor for each participant was normalized to 1, 2, 3, 4, or 5 (top 20% highest factor consumers are rated as 5, average 3). Table 1 presents characteristics of four attitude factors, the number of consumers who are categorized as '5' of each factor, averaged willing-to-use years of owned car and the estimated car purchase price. This method highlights the characteristics of each factor, but it is noteworthy that the same consumer could be included in multiple factor groups with this method.

Table 1
Attitude factors about ownership and sharing of goods.

Attitude factor	Characteristics of attitudes about ownership and sharing of goods	No. of consumers	Willing-to-use years of owned car	Purchase price of owned car (USD)
A (Love of Cars)	Love of driving a car, prefer owning cars or houses	292	7.60	18,176
B (Active share)	Willingness to use a rental car, sharing their cars with others	220	7.20	15,409
C (Eco-friendly, simple life)	Prefer simple life, eco-friendly car, living with few possessions	233	7.42	14,003
D (Collector tendency)	Love to collect and own goods, keep unnecessary goods	245	5.31	24,325

In light of those results, consumers' willing-to-use years of their own cars and prices for purchasing cars vary according to those attitude factors. The averaged purchased price of a car is highest for group D consumers who like to collect goods. However, their willing-to-use years of their own cars are lowest among all factor groups. By contrast, group C consumers who prefer a simple life and eco-friendly cars do not want to pay much money for purchasing cars. Moreover, their willing-to-use years of owned cars are second highest among the groups. The highest willingness-to-use years are 7.60 years of Group A consumers, who love cars.

Although analyses described for this study are limited, we confirmed that consumers' willingness-to-pay prices or willing-to-use years for their own car might vary according to the customer type. Recently, IoT data play an important role in ascertaining consumers' actual use of cars. Therefore, the analysis of human behavior based on the data is expected to be more important for a manufacturer to consider consumer needs in a market.

3. General durable goods market model with sharing service

With an abstract model of durable goods markets with sharing services, we elucidate a theoretical mechanism about manufacturer's strategies to conform to sharing business. We consider an n-period model with m manufacturers respectively producing their own products of one kind and l consumers making purchase decisions. We assume that consumers can use a sharing service instead of purchasing a product.

3.1. Product durability

In the model, products have durability, which is expressed as d. As one period passes, d decreases by one. For $d = 0$, it represents the end of the product life. A consumer can continue to use the product over periods as long as $d > 0$ if the consumer wants. Thereby, depending on durability d, the magnitude of consumer's utility varies (see Section 3.4).

3.2. Product sharing

It is assumed in the model that a sharing service is available. Accordingly, consumers who own their products can provide them for a sharing service. Consumers who do not own products might choose to use a sharing service without purchasing products.

Then, the model includes the assumption that a product provided by a consumer can be shared k times at most during one period. For simplicity, we additionally assume that the fee for sharing use is a constant, p_s, and that sharing service provider operations are not considered here. Therefore, consumers who provide their products can obtain the revenue directly via the sharing service.

3.3. Manufacturers

Manufacturer j produces products of one kind at some production cost $c_{j,t}$ during period t. Additionally, they make a decision about the level of R&D for product durability, which can change the magnitude of the production cost. Under these circumstances, each manufacturer makes decisions related to the R&D level and price at every period to maximize total profit through all periods. The manufacturer's profit at period t is

$$\pi^M_{j,t} = p_{j,t}Q_{j,t} - c_{j,t},$$

where $p_{j,t}$ and $Q_{j,t}$ respectively signify the product price and quantity consumers purchased at period t. Production cost $c_{j,t}$ is defined as presented below.

$$c_{j,t} = \begin{cases} c_{\text{low}} & (\text{if low R\&D level}) \\ c_{\text{mid}} & (\text{if middle R\&D level}) \\ c_{\text{high}} & (\text{if high R\&D level}) \end{cases}$$

Herein, we assume three R&D levels: low, middle, and high. They must satisfy the condition of $c_{\text{low}} < c_{\text{mid}} < c_{\text{high}}$. Moreover, we assume that the decision related to R&D levels can make the magnitude of durability the following.

$$d_{j,t+1} = \begin{cases} d_{j,t} - \tilde{d} & (\text{if low R\&D level}) \\ d_{j,t} & (\text{if middle R\&D level}) \\ d_{j,t} + \tilde{d} & (\text{if high R\&D level}) \end{cases}$$

In that equation, $d_{j,t}$ stands for the durability set by manufacturer j at period t. Also, $\tilde{d}$ represents the unit of durability variation. The equation above means that R&D costs are required to some extent to maintain the durability. If one shortens the durability, then the R&D cost becomes low. If the durability is increased, then the cost becomes high.

Moreover, some competitive manufacturers produce homogeneous products, so that all manufacturers must confront price competition.

3.4. Consumers

Each consumer chooses an action from four options: purchase a new product, continue to use an owned product, use a sharing service, or provide an owned product for sharing.

Please cite this article in press as: Nishino N, et al. Manufacturer's strategy in a sharing economy. CIRP Annals - Manufacturing Technology (2017), http://dx.doi.org/10.1016/j.cirp.2017.04.004