The Effect of Firm's Routine on Product Evolution: The Mobile Phone

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Abstract--**This paper aims to identify how products evolve by the interaction between consumers purchase decision-making and firm's routine. This paper applies the Agent-Based Model to a simulation focused on a mobile phone industry with five firms. The attributes of firms' routines are classified as imitation, incremental innovation, radical innovation, and routine. Furthermore, consumers purchase behavior is estimated by adopting a hedonic pricing model that reflects the shadow price of the products. The results show that there is more product diversification when firms have similar entry strategies but different new product development strategies. Market share of a firm tends to increase when it improves existing product characteristics rather than introducing new characteristics. Thus, firms that focus on imitation or incremental innovation dominate the industry.**

I. INTRODUCTION

Product evolution is similar to biological evolution since both select dominant entities that survive market competition and develop variants through mutation and recombination [27]. Product evolution occurs when firms, as the main actors in the market, manufacture products that reflect consumer tastes. Firms develop new products with a combination of their unique attributes and routines, which is reflected in the product. In evolutionary economics, routine is considered a firm's gene and includes strategies for new product development, innovation, business, and human resources [18]. In a competitive market, a firm releases a new product that reflects its unique routine to make profits.

Firms constantly try to make profits, which has a very strong relationship with the firm's survival. Products are evaluated and selected by consumers; hence, to survive, firms must launch new products that satisfy consumer needs. Products that fail to satisfy consumers are not selected and they die out. Firms that dissatisfy consumers and consistently manufacture the same products without any innovation or improvement will be liquidated. In other words, firms produce goods with their routines and their performances are assessed by consumers' evaluation of their products. Consumer evaluation affects a firm's routine and can be crucial to the firm's problem solving processes. During these iterative processes, firms develop products that evolve through interaction with consumers, and determine how the products will evolve and what kinds of products will be launched. Therefore, this study analyzes the effect of the new product development strategies and entry strategies on product evolution, which are based on a firm's routine.

This study uses the Agent-Based Model (ABM) to identify how products evolve among firms with different routines that are influenced by the consumers' selection process. We complement consumers purchase decision-making logic by adopting hedonic price coefficients that measure consumer utility in the mobile phone industry. This study aims to help firms frame new product development strategies, entry strategies, and market policies that are suitable for the market conditions; in addition, it aims to assist the government to frame an appropriate corporate welfare policy.

II. LITERATURE REVIEW

A. Routine

A routine is considered a firm's gene and implies a regulated and predictable pattern of the firm [18]. The concept of a routine defined by [18] includes technical issues necessary for the manufacturing process, employment procedures, prioritization of new inventions, research and development (R&D), and business strategies for product diversification or inward investments of foreign capital. A firm's routine is inheritable as the gene of an organism [18] and is determined by an accumulation of the experiences the firm has gone through [4, 18]. It can also be considered a unique characteristic of the firm that can neither be imitated nor exchanged [6, 7]. Hence, a routine accrues from what the firm has experienced in the market and a firm strategy is developed based on the routine. Thus, it is likely that a variety of routines are not independent but are coevolving through interaction.

Among the various routines, this study focuses on the firms' innovation routines, which affects new product development strategy directly and influences a firm's entry strategy as it also includes the firm's risk acceptance rate [2]. Unlike research that analyzed a firm's routine in terms of growth [8, 18, 20], this study analyzes products that imply the firms' routines, and examines product evolution and firm survival affected by the evolutionary processes.

B. New product development strategy

A new product is determined by a firm's routine and consumer choice [5]. A firm frames the new product development strategies based on its innovation routine. In the new product development, strategies that a firm can choose are innovation, imitation, and routine strategies [2]. Innovation means finding something new [11] and is categorized as new to the market, the world, and the firm [19]. Although innovation can be differently categorized [11], from the firms' perspective, this study classifies the concepts of innovation into radical innovation and incremental innovation according to the impact and performance of the outputs on the market. In the context of product innovation, radical innovation implies that new characteristics are applied and

incremental innovation indicates improvement of the characteristics that have already been adopted [9]. In the context of consumer satisfaction, radical innovation indicates a very new development that gives consumers relatively high satisfaction whereas incremental innovation has a relatively low change in technical level and consumer satisfaction [3]. Likewise, innovation can be defined with respect to the newness of the outputs and the change in consumer satisfaction.

Imitation means that a firm launches a product similar to a rival's dominant product [9]. Of course, it is important for a firm to innovate for survival in the market, but a firm can succeed by imitation. According to [23], to be a dominant firm, the firm must be a successful imitator consistently. Therefore, if a firm only conducted imitation strategies and constantly succeeded in launching more satisfactory products for its consumers, then the firm would launch a product nearly equal to the rival's dominant product [10].

In the strategy selection process, the difference between innovation and imitation depends on the risk acceptance rate, which is determined by the firm's innovation routine. A firm with a high risk acceptance rate is likely to opt for innovation, while the others are likely to develop imitation or routine strategies [2]. Firms can choose either imitation or routinized strategy, but will select the latter if the firm has a limited capability that does not allow for imitation. In this study, a firm's new product development strategies are classified into the following: focusing on radical innovation, incremental innovation, imitation, or routine.

C. New product development strategy based on entry strategy

A firm's entry strategy can be classified into the first-mover strategy and the latecomer strategy according to its routine. First, a firm that adopts the first-mover strategy has a routine that puts up with uncertain market conditions to enter the initial market. By catching a new opportunity, the first-mover can attain profits as a market leader [14, 15]. It can also have competitive advantages on technological leadership, resources, market dominance, and consumer transaction costs and several empirical studies show that these advantages do exist [1, 13, 22]. To strengthen its advantages, the firm executes strategies that help to build loyalty among initial consumers or releases new products that have high quality through technological innovation and constant R&D [15].

However, the latecomer can achieve dominance over the first-mover by following a free-rider strategy that imitates the first-mover's technologies and market strategies, flexibly changing its products according to consumer needs, and diminishing market uncertainty [21, 24, 26]. To overcome the first-mover advantage, the latecomer must innovate and imitate the technologies of the first-mover, and satisfy the needs of potential consumers [15, 21].

Considering the new product development strategies and entry strategies together, a firm with a high possibility to adopt the imitation strategy is likely to copy the dominant product produced by the first-mover and may even launch products with superior qualities. If a firm performs incremental innovation frequently and copies the characteristics of the dominant product, then it will possibly produce a new product with higher utility than the leading product in the market.

Both imitation and incremental innovation are significant factors for the latecomer's market survival. Especially, since the innovative latecomer probably takes more market share than the non-innovative latecomer or the pioneer [25], the latecomer who establishes an incremental innovation strategy is expected to exceed the market share of the first-mover more easily. Furthermore, the firm focusing on incremental innovation can lead product evolution and has a high likelihood of becoming a dominant firm in the market. Hence, this study verifies that the latecomer who chooses the incremental innovation strategy will likely have the highest market share as it takes the lead in product evolution. By analyzing market structures, this study identifies not only the market conditions that accelerate product evolution but also the relationship between a firm's routine and product evolution.

III. METHODOLOGY

In this study, we adopt ABM to analyze the phenomena that firms and consumers, considered core agents in economics, interact in the market. ABM is a computer based simulation model that is effective for analyzing the decision-making of agents based on the three following elements: agents, their inter-relationships, and the market conditions; in addition, the model can be applied to the changes in the market conditions by considering the competitive or collaborative relationship between agents and their decision-making [16, 17]. By applying evolutionary algorithms to ABM, we develop the algorithm for product evolution, where a firm frames its strategy for new product development and business by considering its routine and consumer choice.

Consumers purchase products that maximize their utilities and the product chosen by most consumers will be regarded as the dominant product. In the simulation, we derive the shadow price of the products by analyzing the relationship between product quality and price. We analyze consumer purchase behavior using the hedonic pricing model to derive consumer utility from product characteristics [12].

A. Product evolution model

The algorithm for the product evolution model adopted in this study is shown in Fig. 1. First, the initial condition is input: duration of the simulation (T), the number of repetitions (REP), the number of product characteristics (n), the number of firms in the market (J), and the number of consumers (C). The initial products are generated randomly and they are expressed as the gene arrangement (e.g., [g1, g2, …, gn]). Consumer utilities for the products are calculated based on the hedonic pricing model, which is assumed to be a linear model in this study, although it can be applied as a linear model, a semi-log model, or a log model.

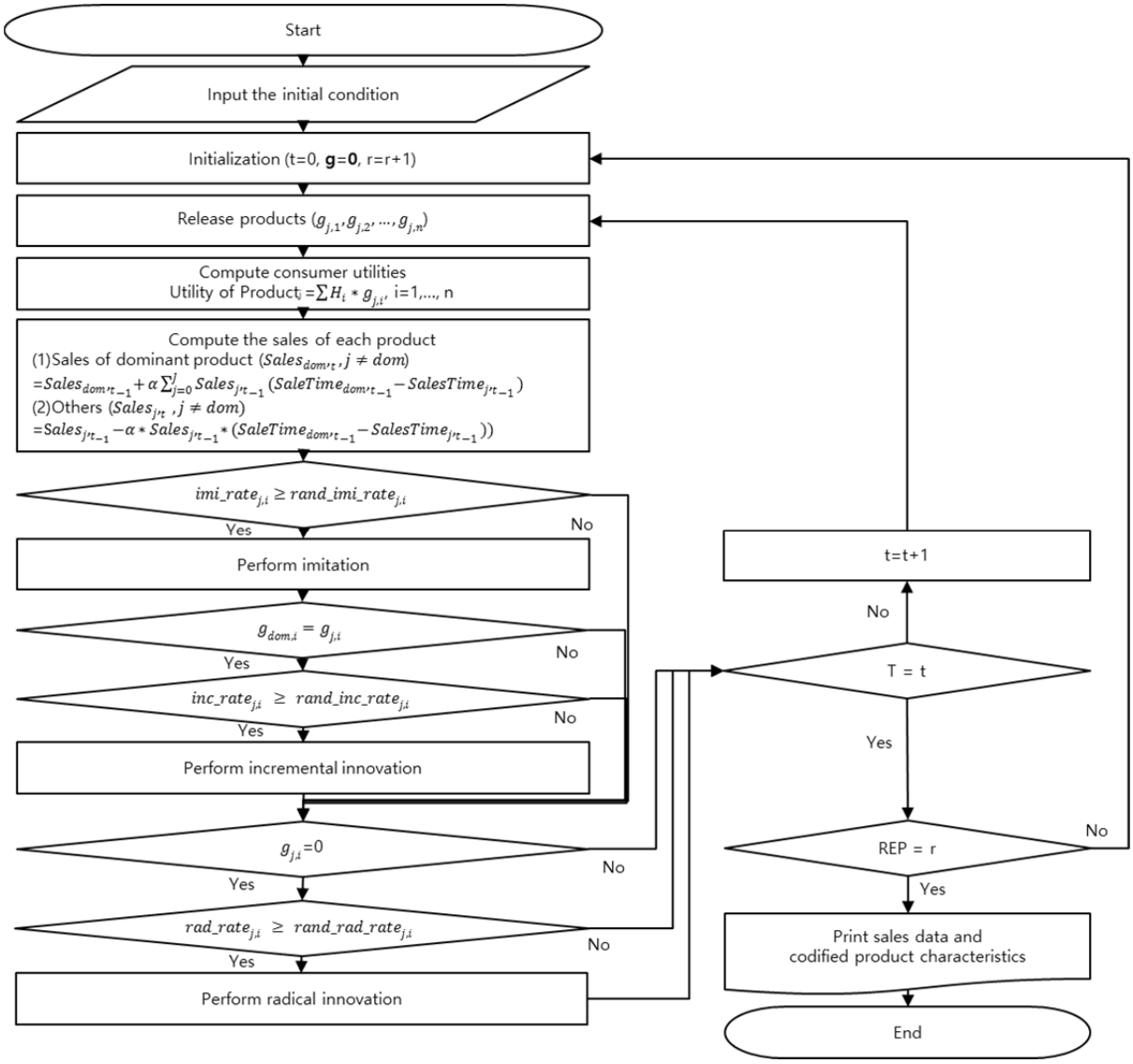

Figure 1. Flow chart of product evolutionary model

B. Simulation circumstances

Based on the rules for evolution, the assumptions for the simulation are framed and the simulation condition for the product evolution model is constructed. In addition, the constraints that affect the logic for product evolution such as the number of consumers in the market and the consumers' purchase behavior and decision-making are defined as some of the assumptions.

The simulation is performed focusing on the mobile phone industry and identifies the evolutionary logic of mobile phones. In the simulation, there are 5,000 homogeneous consumers and 5 firms. Each firm produces just one product and the product has 10 characteristics – Size of Display (SoD), Built-in Memory (BM), Messenger, Quality of Telephone Calls (QTC), Camera, MP3, DMB, GPS/Navigation, Operating System (OS), and Application Processor (AP) chipset. In this study, we assume that the simulation will be run for 40 times and each time indicates a financial quarter. In other words, the duration of the simulation is set up as 10 years for 40 quarters. The simulation is repeated for 1000 iterations.

First, to examine the factors that affect the evolution, we develop conditions that are different from the base by assuming that the innovation routine or entry strategy of each firm is different as can be seen in Table 1.

TABLE 1. CONDITIONS OF FOUR MODELS

Model	Innovation routines	Entry strategy
1	Same	Simultaneous entry
2	Different	Simultaneous entry
3	Same	Existence of the first-mover
4	Different	Existence of the first-mover

In case firms have different innovation routines, Firm 1 and Firm 5 are control groups whereas Firm 2 is outstanding in imitation, Firm 3 has high capabilities in radical innovation, and Firm 4 is good at incremental innovation (Table 2). Next, time to market of each firm is varied. In general, there are few firms in the initial market but over time the number of firms in the market increases. Thus, we assume that only Firm 1 is in the initial market and is followed by the entry of four firms.

To estimate consumers' utilities, we adopt coefficients for each feature as seen in Table 3. Hedonic coefficients are separated into the periods of introduction of featured phones and smartphones. Hedonic coefficients ahead of the introduction of smartphones are adopted based on the '2004 Mobile Census Survey' data of Metrix Corporation and hedonic coefficients after the introduction of smartphones are based on the '2011 Survey on the Wireless Internet Usage' from Korea Communications Commission (KCC) and Korea Internet Security Agency (KISA).

IV. RESULTS

A. Evolution of product characteristics

Fig. 2 indicates the evolutionary patterns of product characteristics attained by comparing four models. First, in case that the firms' new product development strategies are similar, the values of product characteristics are converged and the differences in property values between firms are not significant. The difference between Model 1 and Model 3, depending on the firm's entry strategy, shows the evolutionary patterns of values of characteristics. In case the first-mover exists, the initial product characteristics are mainly developed by the first-mover but over time, the pattern shows that the values of characteristics are converged gradually. In particular, if the product characteristics are easy to mimic, then the time to convergence will be found to be shorter. However, innovation and imitation on the product characteristics that are difficult to copy will tend to occur slowly; hence, the characteristics are difficult to converge.

All firms tend to maximize product characteristics that are similar to the rivals', but none of the latecomers launch more dominant products than the first-mover's product. Thus, if all firms have the same new product development strategies, the latecomers will not be able to overtake the position of the first-mover. In particular, regarding product characteristics that the first-mover is good at producing, the first-mover is likely to dominate the evolution of the industry because it is difficult for latecomers to differentiate products with the other features. In other words, it implies that there is a low

TABLE 2. FIRM'S INNOVATION AND IMITATION ROUTINES

Feature number			1	2	3	4	5	6	7	8	9	10
Imitation rate (%)	Same routines		30	20	15	40	20	40	40	30	5	15
	Different routines	Firm 1	30	20	15	40	20	40	40	30	5	15
		Firm 2	60	40	30	80	40	80	80	60	10	30
		Firm 3	30	20	15	40	20	40	40	30	5	15
		Firm 4	30	20	15	40	20	40	40	30	5	15
		Firm 5	30	20	15	40	20	40	40	30	5	15
Radical innovation rate (%)	Same routines		0	0	0	0	10	15	15	10	8	15
	Different routines	Firm 1	0	0	0	0	10	15	15	10	8	15
		Firm 2	0	0	0	0	10	15	15	10	8	15
		Firm 3	0	0	0	0	20	30	30	20	16	30
		Firm 4	0	0	0	0	10	15	15	10	8	15
		Firm 5	0	0	0	0	15	22.5	22.5	15	12	22.5
Incremental innovation rate (%)	Same routines		20	30	10	5	30	0	0	0	20	25
	Different routines	Firm 1	20	30	10	5	30	0	0	0	20	25
		Firm 2	20	30	10	5	30	0	0	0	20	25
		Firm 3	20	30	10	5	30	0	0	0	20	25
		Firm 4	40	60	20	10	60	0	0	0	40	50
		Firm 5	30	45	15	7.5	45	0	0	0	30	37.5

TABLE 3. HEDONIC COEFFICIENTS AND INITIAL VALUES OF FEATURES

Product Characteristics		Initial values	Coefficients (featured phone)	Coefficients (smartphone)
Feature 1	**SoD**	**1**	**4.40**	**15.40**
Feature 2	**BM**	**1**	**2.51**	**6.48**
Feature 3	**Messenger**	**1**	**7.90**	**3.88**
Feature 4	**QTC**	**1**	**2.78**	**7.20**
Feature 5	**Camera**	**0**	**58.40**	**28.69**
Feature 6	**MP3**	**0**	**17.50**	**8.60**
Feature 7	**DMB**	**0**	**2.51**	**6.48**
Feature 8	**GPS/Navigation**	**0**	**4.00**	**1.97**
Feature 9	**OS**	**0**	**-**	**11.00**
Feature 10	**AP chipset**	**0**	**-**	**10.30**

probability that the first-mover is culled, but the latecomers are quite likely to be culled in the market.

In the case of Model 2 and Model 4 where all firms' new product development strategies are different, the evolution of the product characteristics are mainly caused by the firms focused on imitation or incremental innovation. In Model 2, Firm 3 focuses on radical innovation and causes the evolution of product characteristics. Product characteristics are progressively improved by Firm 2 that focuses on the imitation strategy and by Firm 4 that concentrates on incremental innovation for new product development. After the introduction of the smartphone, the OS and AP chipset was introduced as the result of radical innovation by Firm 3. However, Firm 3 hardly apply incremental innovation and imitation strategies; thus, over time Firm 2, Firm 4, and Firm 5 take leading positions in turn.

Considering the pace of product evolution, the speed of evolution in Model 2 and Model 4 were very fast but different from each other. Largely, the product evolution in Model 2 was the fastest as can be seen in Table 4. Among the four models, without considering DMB, MP3, GPS/Navigation, and QTC, the fastest evolving characteristics in Model 2 were SoD, BM, and OS and those in Model 4 were Camera and AP chipset. Even though the evolutionary speed of AP Chipset and Camera were the fastest in Model 4, there was a very little gap between the evolutionary speed in Model 2 and Model 4. Thus, we conclude that the evolutionary speed of product characteristics was the fastest in Model 2, which indicates that product evolution is most rapid when firms are in competition and have different innovation routines.

A comparison of four models shows that in Model 2 and Model 4 the product characteristics were evolving rapidly and these results are a consequence of intense competition and imitation. Competition among products or firms is intense when consumers can consider all products before making a purchase and all companies launch products simultaneously. Furthermore, technological innovation seems to have been promoted with interaction among firms that have different innovation routines.

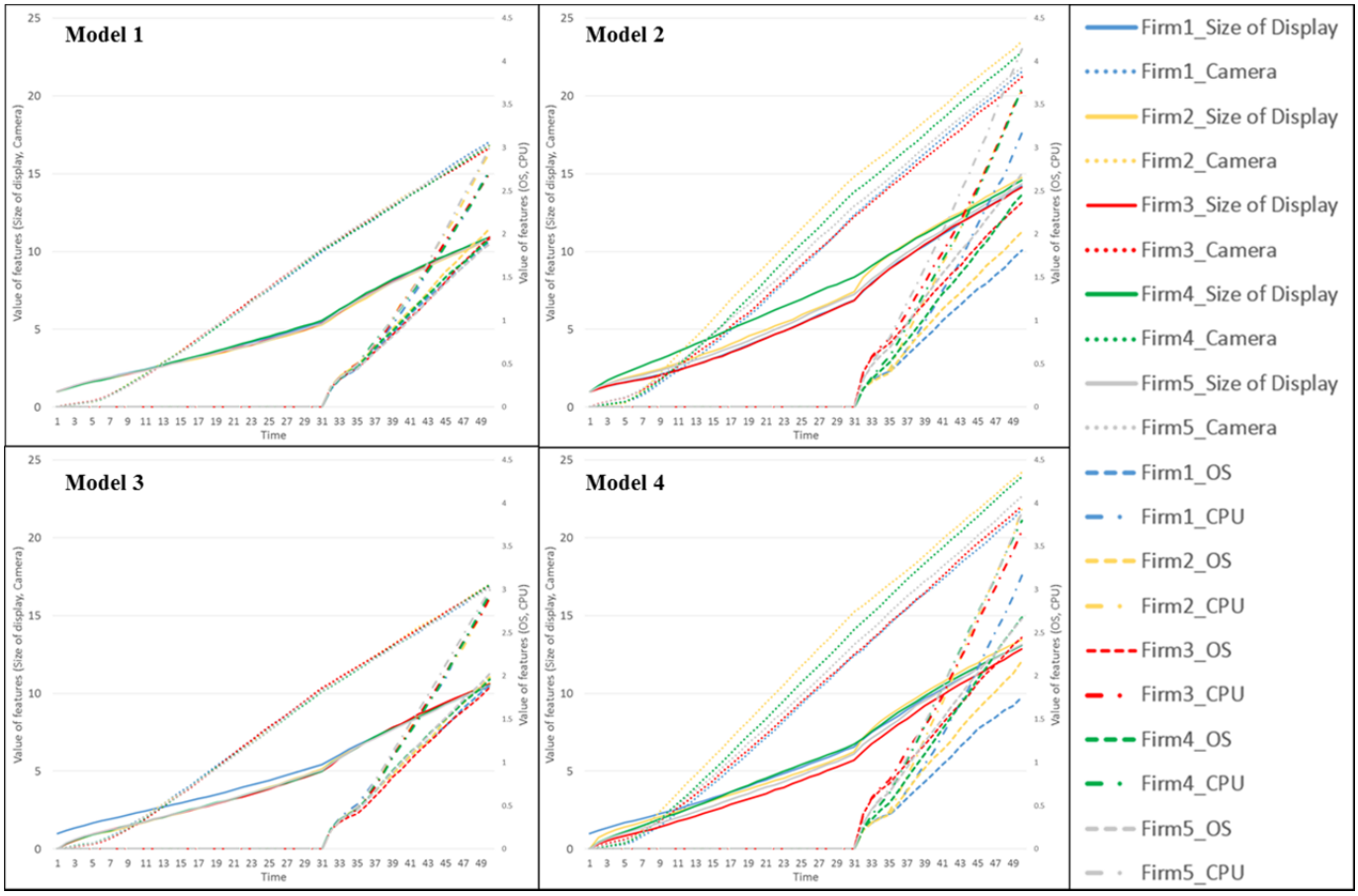

Figure 2. Comparison of the evolution of product characteristics in the models

TABLE 4. COMPARISON OF THE EVOLUTIONARY SPEED OF EACH MODEL

	SoD	Camera	Messenger	BM	OS	AP chipset
Model 1	10.84	16.86	4.89	12.28	1.96	2.83
Model 2	**14.39**	**22.18**	6.56	**18.20**	2.27	3.67
Model 3	10.54	16.92	4.53	11.82	1.95	2.94
Model 4	**13.12**	**22.93**	5.22	14.85	2.34	3.70

B. Firms' innovation routines and sales

Comparing Model 1 and Model 2 with Model 3 and Model 4, we find the effect of imitation and innovation of a firm on product sales (Fig. 3). If the innovativeness of each firm were similar, the changes of sales volume would occur relatively slowly. On the other hand, if there are differences in the innovativeness of the firms, the market will change dynamically. The gap between the sales volumes of the products was seen to differ dramatically by comparing Model 1 with Model 2. This gap is a result of competition through the release of a variety of products. In Model 2 there were more products than in Model 1, as Firm 2 copied the product of the dominant firm and Firm 4 consistently released innovative products, which widened the gap.

Finally, the latecomer effect can be explained by comparing Model 1 and Model 2 with Model 3 and Model 4. Firm 1 was the first to enter the market and with this advantage it maintained its position until middle stage of the simulation. However, the duration of these advantages depend on consumer choice and the differences in firm characteristics. In Model 4, Firm 4 was a latecomer but had superior incremental innovation ability, while Firm 2 was also a latecomer but had superior imitation ability, and together they rapidly eroded the market share of Firm 1. Thus, we draw that if first-mover try to maintain their advantages, then they should frame sustainable innovation or imitation strategies.

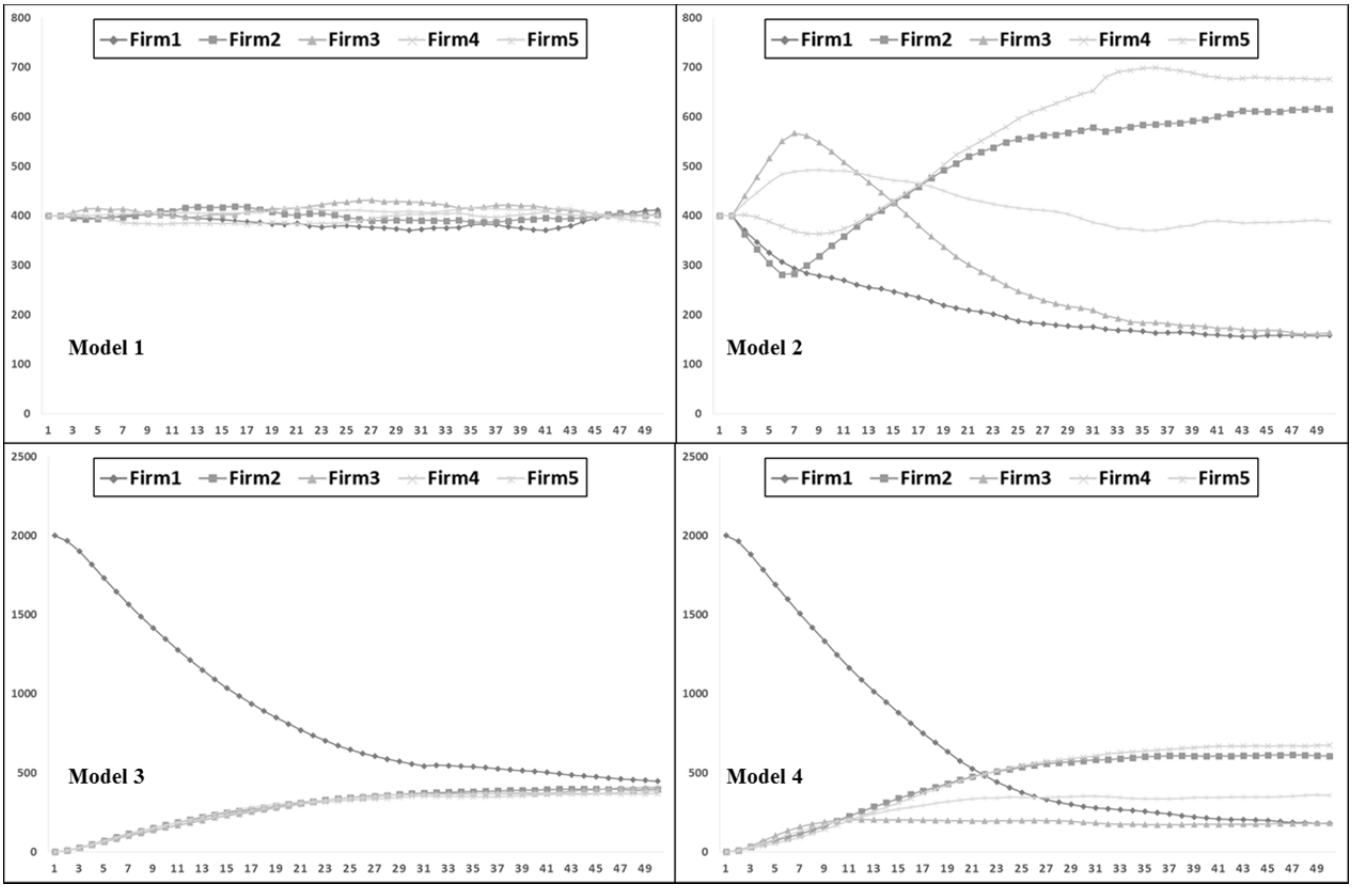

Figure 3. Comparison of sales volumes of firms in the models

C. Comparison between simulation results and real world

We confirm the competition between firms by analyzing real mobile phone industry with actual market share data. Firm 1 entered as a first-mover but has weak innovation and imitation routines. Consequently, Firm 1 lost the lead, so it can be represented by Motorola. Firm 2 is likely to be LG Electronics since it is good at imitation, and Firm 3 is similar to Apple which has a strong point in radical innovation. Samsung is considered as Firm 4 because it performs incremental innovation quite well. Finally, Firm 5 is seen as Nokia that performs innovation better than the average. Let Fig. 4 illustrate the mobile industry far after the early stage. The failure of Motorola, the success of Samsung, and the decrease of market share of Nokia after its short success have similar aspects to the simulation results. However, Apple and LG Electronics show different development; Apple's radical innovation has the large impact on its sales and LG Electronics imitates traditional featured phones rather than the new smartphones. Thus, to gain more accurate simulation results, the real impact of radical innovation and the time that takes to recognize the results of radical innovation must be included in the simulation.

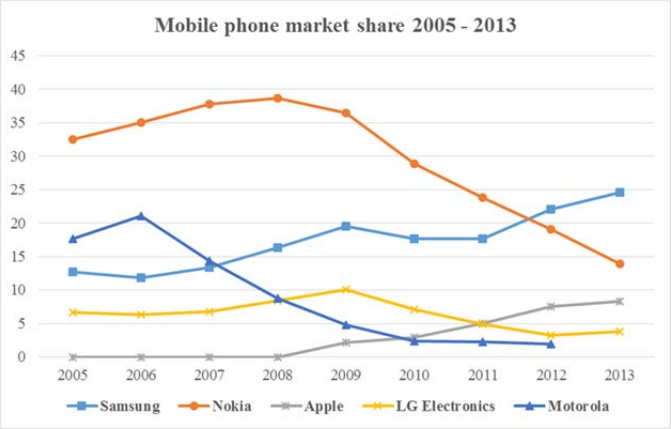

Figure 4. Mobile phone market share from 2005 to 2013

V. CONCLUSIONS

This study uses ABM to examine the evolution of mobile phones by analyzing a firm's strategies for new product development and market entry that reflect the firm's routine. Furthermore, by differentiating a firm's innovation routine and entry strategies, we examine the effect of the interaction between the firm's decision-making and consumers' purchase behavior on product evolution.

Considering the simulation results, product evolution occurs more actively when all the firms' routines are different. In particular, when firms have similar entry strategies there is more competition and product evolution occurs more actively, which leads to more frequent innovation and imitation.

Focusing on entry strategy, even though a firm has initial success in the market, it cannot enjoy the first-mover advantages unless it is willing to innovate and imitate for new product development. The latecomers pursue the first-mover by establishing an imitation strategy and overtake the first-mover by choosing an innovation strategy.

These results highlight the capability requirements and market strategies for both new entrants and incumbents. According to the comparison between simulation results and case study, to survive in the market new entrants have to set strong imitation and incremental innovation routines while incumbents need to reinforce their routines against new entrants. These suggest that government policies for enhancing product competitiveness in a certain industry must support firms that perform product innovation based on imitation or incremental innovation. To support firm's imitation strategies, organization supported by government may be considered to set up a knowledge pool to support the domestic firms.

The limitations of this study are the lack of accuracy of hedonic coefficients and that it ignores the actual factors that consumers evaluate when they choose a product. In the real market environment, if consumers are uncomfortable with improved product performance, then consumer utility of product decreases. However, this logic was absent in the simulation. In addition, cash flow and firm capability were not reflected in the simulation; thus, it is difficult to identify the changing aspects of product evolution as firm capability is varied.

Therefore, future studies must derive the consumer's utility function to enhance the accuracy of the data and obtain the actual utilities derived by the hedonic price function. In addition, the model should include a comparison of the actual environment and account for the firm's internal environments by considering its internal capabilities. Furthermore, as a forecasting tool that complements expert intuition, the real simulation model must be supplemented with additional case studies and simulation results.

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