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Diverse Entry and Catch-up Strategies of Firms under Different Demand Conditions: Evolutionary Economics Simulations

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If an entering firm chooses the path-following strategy, the fluctuation of demand can be a blessing for new entrants whereas incumbent firms may suffer. If an entering firm chooses the stage-skipping or path-creating strategy, they can catch up with incumbents more easily in the long run than with the path-following strategy. However, under expanding demand, catch-up becomes slower because growing demand helps incumbents take a full advantage of scale economy that can serve as an entry barrier. Among the three entry strategies, a path-creating strategy is the best, while the path-following is the worst, because productivity of a path-following firm is an average of productivity of old and new technologies, whereas that of a path-creating firm is based on newest technologies. However, the gap is reduced if the market regime is of fluctuating demand.

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1 Introduction

Asian newly industrialized economies (NIEs) such as Korea and Taiwan have succeeded in rapidly catching up with industrialized nations in a short period of time. Many firms in these countries challenged the leading firms in various industries and even caught up with the incumbent, like the case of Samsung against Sony, which is analyzed in Chang (2008) and Joo and Lee (2010). The rapid economic growth achieved by the NIEs has generated much research on the mechanism behind the economic success, at the national, sectoral, and firm levels. However, it is not easy to sort out main determinants of the performance, as diverse factors tend to be involved, such as technological regimes of sectors, demand/market conditions, polices and strategies of firms and governmental agencies, and surrounding socio-economic institutions. Such recognition of diverse factors is consistent with the concept of the national systems of innovation (Nelson, 1993; Lundvall, 1993) as well as the sectoral systems of innovation (Malerba 2004).

While Malerba (2004) applies the SSI (sectoral systems of innovation) framework to industries in advanced countries, Malerba and Mani (2009) is a collection of paper applying the concept to the case of developing countries. Even before this book, the SSI framework as a whole or its conceptual components has been applied to developing or latecomer economies in the works of Lee and Lim (2001), Mu and Lee (2005), and Lee, Mani and Mu (2011) when they analyze the industry cases from China, Korea, Brazil, and India. While these are qualitative analyses of catching-up case, there have been less attempt at doing theoretical analysis using formal models. One exception is Kim and Lee (2003), which does an evolutionary simulation modeling of the impact of technological regimes on the entry and catching up by the latecomer firms, especially large diversified firms in semi-conductor industry. In their models, the demand is assumed to be fixed as the focus of the paper is on the supply-side or technologies. Also, while two different types of firm organizations, small specialized vs. large diversified, are considered in modeling, no considerations are given to the possibility of firms choosing diverse catching up strategies. This paper will do a similar Nelson and Winter style modeling with focus on the impact of demand/market conditions and their interaction with diverse catch-up strategies of firms.

Lee and Lim (2001) proposed three different patterns of catch-ups: path creating, stage skipping, and path following to explain the evolution of the selected industries in Korea. Path-following catching-up means that latecomer firms follow the same path as that taken by forerunners. The second pattern, stage-skipping catching-up, means that latecomer firms follow the same path but skip some stages, and thus intend to save the time required for catching up. Path-creating catching-up means that latecomer firms explore their own path or technological trajectories by choosing emerging technologies While the advantage of path-creating catch-up is higher potentials from the latest generation of technology, the initial productivity of new technology might be low or unstable and thus there tend to be higher risk during early days. In the worst case, early choice of emerging technologies or standard might be wrong ones ex post sense. In contrast, while the path-following strategy should be safer choice, they might never able to catch up with the forerunners or always stay behind the leading firms. Thus, costs and benefits of different strategies are an important issue to explore. This is even more so when we consider the possibility that their relative advantages are different under different demand

conditions, such as increasing or decreasing demand as well as steady or fluctuating demand conditions.

As a matter fact, various market regimes and demand conditions are important factors that determines firms' performance, in particular the odd of late entry and catch-up possibility. On one hand, market expansion is helpful to incumbents since they can enjoy economy of scale because of increase in demand (Bain, 1956; Mann, 1966; Harris, 1976; Hilke, 1984). This kind of scale economy of incumbents can be an entry barrier for entering firms. However, market expansion can also be favorable to late entrants, since it provides a higher chance for survival to entering firms. Hirschey (1981), Kessides (1990), Yamawaki (1991), and Rosenbaum (1993) found that sales growth is related to more frequent net entry.

We will investigate the effect of three different catch-up strategies under different demand conditions. Specifically, four different market regimes are considered, such as fixed demand condition, fluctuating demand with constant average, expanding demand with constant growth, and fluctuating demand with constant growth rate. It will be shown that various market regimes are an important selection mechanism. For instance, fluctuating demand, especially downturns, weakens the entry barriers of incumbents, since they reduce investment costs, as noted by Mathews (2005). The cost of new facility construction also decreases during a downturn, which provides entry chances to new firms. It can be expected that fluctuation is favorable to entering firms whereas expanding demand is advantageous for incumbent firms. However, too much fluctuating might kill the path-creating strategy firms during their early unstable days, while this strategy might easily beat other strategies under normal (more stable) demand conditions.

We will derive several hypotheses of this sort in section 2, and then build an evolutionary model in section 3 to test them. Section 4 presents the results of various simulations. Section 5 summarizes the findings and concludes with some remarks.

2. THEORETICAL FRAMEWORK AND HYPOTHESES

1) The literature

The distinction between invention, innovation, and imitation is often attributed to Schumpeter (1950). Routine behavior and limited foresight characterize the demand side of the market, and entrepreneurs become drivers of innovation in the sense that they persuade buyers to change their preferences. Thus, the Schumpeterian concept of innovation determines a specific view of the relationship between innovation and demand. Market demand does not automatically bring about innovation in his concept.

The Nelson-Winter model was designed to clarify the confusing Schumpeterian heritage. The major simplification was obtained by modeling the demand side of markets in the simplest possible way. Since the pioneering research of Nelson and Winter, much of the research on technological change has concentrated on supply-side dynamics. This strategy allowed a gradual increase in the sophistication of supply-side aspects of economic evolution, but emphasized only the role of technological regime. They did not make cover market regimes and various demand conditions as a selection mechanism.

Focused on firms' activities and interactions, the literature has largely overlooked the role of demand environment in which these interactions take place. The demand context however, affects both the immediate success of firms' activities and the nature of future activities. The

one-sided focus on supply faces diminishing returns. Therefore, demand-side aspects of economic evolution have become increasingly popular. Recent papers on the demand-side approach argue that emphasis on demand-side factors is crucial to understanding economic evolution. In this regard, Anderson (2003) observes that demand represents the core force of selection that gives direction to the evolutionary process, and that firms' innovative activities relate, directly or indirectly, to the structure of expected and actual demand.

Adner (2001) developed a demand-based view of technology evolution focused on the interaction between technology development and the demand environment in which the technology is ultimately evaluated. He used a simulation model that explicitly considered the influence of heterogeneity in market demand on firms' innovation choices. He assumed that consumers have different needs and requirements in the model. His model is used to examine the dynamics of product and process innovation.

Empirical researchers are interested in the relationship between various market and technological regimes. Using data on 46 Dutch sectors, Kleinknecht and Verspagen (1990) found evidence of a significant relationship between R&D and demand growth; however, this correlation cannot be seen simply as confirmation of the unidirectional demand-pull hypothesis, since their results showed a mutual dependence of demand and innovation. The research of Kydland and Prescott (1982), and Long and Plosser (1983) are based on the belief that stochastic technological shocks are a major source of business fluctuations. However, they studied only the effect of technology shock on the fluctuating demand. They were not interested in the effect of demand conditions on the various catching up processes.

The results of research about the relationship between demand growth and market share of the entrants contradict each other. Shapiro (1983); Highfield and Smiley (1987); Baldwin and Gorecki (1987); Dunne and Roberts (1991); and Chappell, Kimenyi, and Mayer (1992) showed that past sales growth encourages gross entry. In contrast, Morch von der Fehr (1991) and Mata (1993) did not detect such a relationship for entry into Norwegian or Portuguese manufacturing, respectively. Siegfried and Evans (1992) detected no connection between recent sales revenue growth and entry. Harris (1976), and Masson and Shaanan (1982) did not find an association between pre-entry sales growth rates and entrant market shares.

The inconsistent research results can be attributed to the various factors in determining the catch-up results of entering firms. If prospective entrants expect future demand to grow faster than established firms have anticipated, they may enter despite low or even declining profits. Expected demand growth affects expected profits because the higher the growth rate of industry output, the less an entrant's new production will depress industry price, given the established sellers' expected rate of supply expansion. Demand growth may not be sufficient to encourage entry into an industry however, because potential entrants might expect increased aggressive responses from incumbents who have more expected future demand to lose.

On the other hand, market growth raises the scale of the incumbent rapidly. Therefore, scale economies may hinder entry if potential entrants must enter with large output to take advantage of large-scale production cost savings. However, empirical evidence on scale economies as a barrier to net entry is diverse. Orr (1974) found evidence that scale economies are barriers into the Canadian manufacturing industry. Scale economies seem to be stronger barriers into Canadian manufacturing for new specialized entrants. Kessides (1991) concluded that the rate of net entry into U.S. manufacturing industries appears to be slowed by higher

required scales of entry. In contrast to these findings, however, Duetsch (1984), and Rosenbaum (1993) all detected no evidence of scale economies barriers.

Market growth has an effect on the catch-up of entering firms in two ways. The first is the prospective entrants' expectation about demand growth, and the second is the scale economy of incumbents. The effect of the entrant's expectation is proven by many empirical studies. However, the effect of scale economy is ambiguous. Since empirical studies are limited in discerning the complicated factors that decide the catch-up results, this paper analyze its effects using simulation.

Mathews (2005) studied how the business cycle affects catch-up in the LCD industry, and introduced the dynamic strategy of incumbents and challengers. He concluded that incumbent firms do not like cycles and asserted that industry cycles play a vital economic role in that they create opportunities for challengers to stir up and renew the industry.

Within cyclical industries, firm rivalry is framed by the dynamics of upturns and downturns, and particularly by the anticipation of the tipping points that lead from one to the other. As the upswing gathers momentum, production rises, employment rises, and for as long as capacity cannot meet demand, prices rise—up to a point. However, eventually supply starts to exceed demand, and prices start to fall. As soon as the delicate balance is upset, the industry can tip suddenly into a downswing, where everything that was working to increase prosperity, now works in reverse. As prices fall, firms are forced to cut back on production, and then on planned investment, and so orders for equipment are cancelled. Mathews asserts that the competitive interplay between rivals results in cycles and as such, they are beyond the control of any single participant.

In this situation, business downturn can be an opportunity for entrants. In a downturn, the scale economy of an incumbent turns sour. The cost of investment goes down because the price of facilities likewise falls during a downturn.

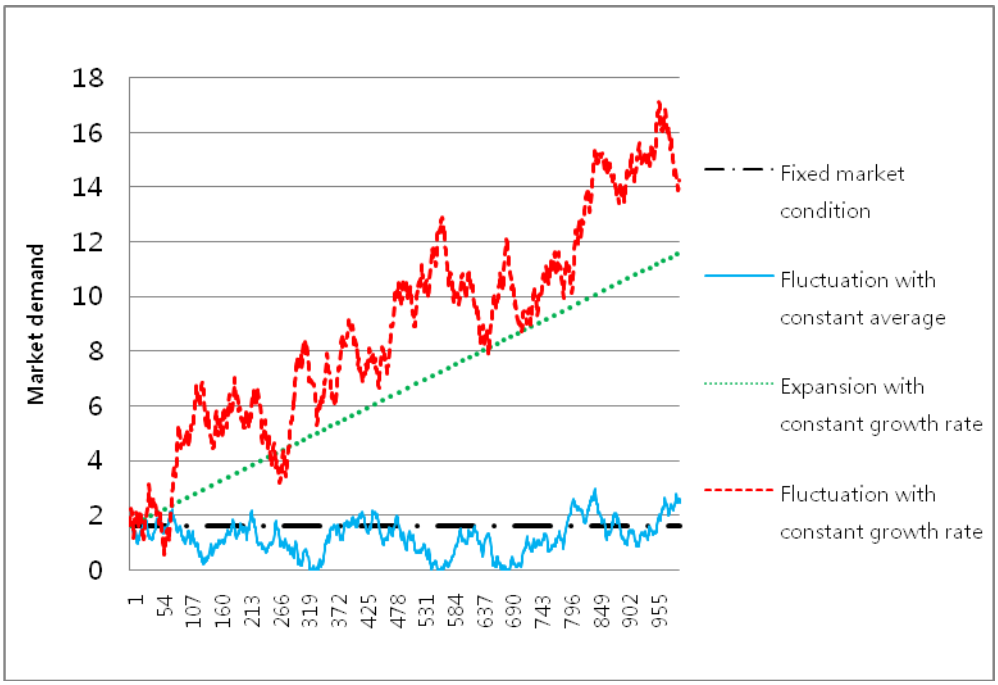
The first aim of this paper is to show how various market regimes affect the catch-up of newcomers. The demand conditions are separated into four cases. The first is the fixed demand condition, and the second is fluctuating demand with constant average. The third case is expanding demand with constant growth. The fourth case is fluctuating demand with constant growth rate.

TABLE 1 FOUR KINDS OF MARKET REGIMES

Fixed demand condition
Fluctuation of the demand with constant average
Expansion of the demand with constant growth
Fluctuation of the demand with constant growth rate

Chart 1 shows an example of various market regimes.

CHART 1 EXAMPLE OF VARIOUS MARKET DEMAND CONDITIONS



2) Different Entry and Catch-up Strategies Under Different Market Regimes

Most technology-oriented views have focused on explaining how developing countries have tried to catch up with advanced countries by assimilating and adapting the obsolete technology of advanced countries, which is consistent with the so-called product life cycle theory (L. Kim, 1980; Utterback and Abernathy, 1975). In this view, catching up is considered as a question of relative speed in a race along a fixed track, and technology is understood as a cumulative unidirectional process. However, it has been also observed that in the catching-up process, latecomers do not simply follow the path of technological development of advanced countries. They sometimes skip stages or even create their own path, which is different from the forerunners. This observation is consistent with the emerging literature on leapfrogging (Perez, 1988) and three catch-up patterns observed in Lee and Lim (2001): path creating, stage skipping, and path following (table 1).

TABLE 2 THREE PATTERNS OF TECHNOLOGICAL CATCH-UP

Path of the Forerunner	• stage A → stage B → stage C → stage D
Path Following Catch-up	• stage A → stage B → stage C → stage D
Stage-skipping Catch-up	• stage A ----------→ stage C → stage D
Path-creating Catch-up	• stage A → stage B → stage C″ → stage D″

Source: Lee and Lim (2001)

The path-creating strategy provides the advantage of the latest technology for entering firms. However, it is more difficult for entering firms to achieve path-creation compared with other strategies. Moreover, it is riskier than the other strategies at the entry since new technology is uncertain. In spite of these weaknesses of path-creating firms, the advantages of the strategy should be considered and weighed. Moreover, there are frequent occasions that a firm with a path-creating strategy is supported by the government, since path creation is often a product of industrial policy. For example, the development of the code division multiple access (CDMA) cellular phone system and the initiation of services in Korea is one of the most successful cases of a path-creating catch-up or leapfrogging, led by a private-public collaboration (Lee and Lim 2001).

Therefore, it is not easy to determine the advantages and disadvantages of diverse strategies. In this case, the simulation method is useful because the exact effect of the strategy can be observed. This paper will also look into the relationship of market regimes and each catching-up strategy with the following hypothesis.

Hypothesis 1

The market share of firms using the path-creating catching-up strategy is higher than other firms' market share. The market share of the path-following catch-up strategy firms is lower than that of the others.

The path-creating strategy has more potential than the other strategies, since it uses up-to-date technology. However, path-creating technology must initially undergo trial and error. Therefore, the initial productivity of entering firms with the path-creating strategy can be relatively low. In this case, how do expansion and fluctuation of market demand affect firms with each catching-up strategy?

Hypothesis 2

The market fluctuation of demand is most unfavorable to path-creating firms and most favorable to path-following firms.

To analyze the relation between technological strategy and catch-up, this paper introduces the vintage capital model. Gilchrist and Williams (2000), and Benhabib and Hobijn (2001) showed that vintage capital models are better able to reproduce important dynamic relationships in the economy compared with the standard real business cycle model. Benhabib and Rustichini (1991) built a vintage capital model and investigated the effect of such features on the dynamics of investment and growth. They concluded that persistent oscillations in investment that are robust can occur with non-linear utility functions when they allow for some "learning by doing."

Silverberg (1985) and Silverberg-Verspagen (1995) introduced vintage capital into their models. Each firm has a variable number of different types of capital goods utilized in production. Profit is the only source of capital accumulation. An innovation rate depends on R&D funds that consist of firm-specific portions of profit and sales. Profits gained from different vintages of capital may be redistributed in such a way that more profitable types of capital accumulate even faster and less profitable even slower, than the norm.

They supposed that a new type of vintage capital is created each time an innovation occurs. Because of fixed labor productivity and the increase in real wages over time, at some stage of development, every technology generates negative profits. It is assumed that these losses are financed by an equivalent decrease in the capital stock. This means that losses imply capital scrapping to cover losses. They supposed that the entry of a new firm occurs by compelling another firm to exit. Therefore, the total number of firms is constant. There are also no differences in entering firms' strategies, and there is no decision-making procedure in investment.

In this vintage capital model, productivity is divided into the basic productivity of each vintage and process productivity is increased by learning by doing. The newer vintage has the higher basic productivity. This paper's model assumes that the basic productivity of each vintage is increased constantly as time passes, and that newer vintage appears periodically. Therefore, the basic productivity of each facility is regarded as an exogenous function in this model.

Each firm has its own accumulated experiences on each vintage facility. The process productivity using the specific vintage facility is gradually increased by accumulated experiences. The improving speed of process productivity is slow when a firm starts a product with a new vintage facility. However, with time, if a firm is gradually becomes accustomed to the new vintage facility, the speed of process productivity accelerates; but the improvement of process productivity has a certain limit. The improving speed slows down when process productivity approaches the limit of the productivity. Therefore, this model assumes that the productivity improving patterns follow the logistic function.

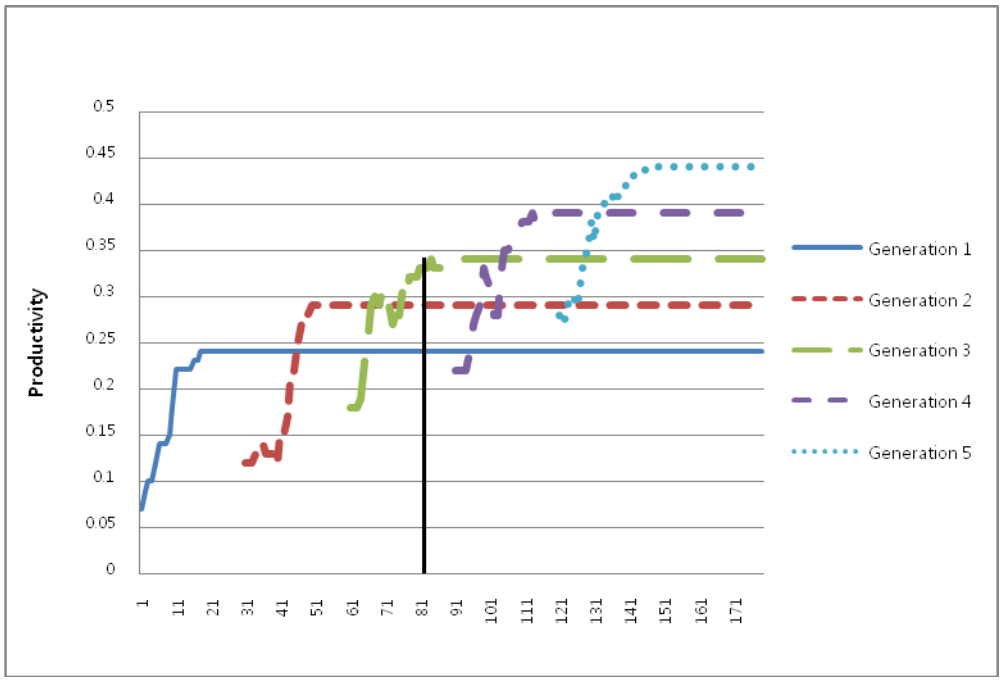
Whenever facilities providers innovate, the basic productivity of the new generation's facilities is increased. If a firm accumulates experiences on specific generation facilities, the productivity is increased through a logistic function. Therefore, a firm's productivity for each generation is overlapped by other generations.

We assume that productivity is divided into basic productivity of the generation and process productivity. The basic productivity goes higher whenever the facility provider succeeds in innovating; innovation of the facility provider occurs periodically in this model. Process productivity increases according to the logistic curve as the experience of the firm accumulates.

Chart 2 shows an example of a firm's productivity in each generation in a 180-period simulation results[1].

[1] The chart is drawn using the formula of the following section.

CHART 2 EXAMPLE OF DYNAMICS OF FIRM A'S PRODUCTIVITY



At the time 101, if incumbent firm A decides to invest, then it chooses the facility of Generation 3 not Generation 4. Generation 4 is the latest generation, but the productivity of Generation 4 facilities is lower than Generation 3's because its experience is not enough. There are many cases that although facility providers develop the new facility, the incumbent firms take the previous facility in this model.

However, entering firms' generation choice is different from the incumbents. First, firms with a path-following strategy choose an incumbent firm randomly and imitate its experience in the oldest generation facility, which the imitating object firm has. In the case of the aforementioned charts, if a path-following firm decides to enter the market at time 101 and selects firm A of the charts as an imitating object, then it chooses the Generation 1 facility and imitates part of the experience of the Generation 1 facility.

The firm with stage-skipping catching-up strategy also selects an imitating firm randomly. It chooses the best productive generation of the selected firms and imitates the experiences of the facility. It can imitate part of the experiences of the selected firm. As in the case of the previous charts, a stage-skipping entering firm at time 101 selects Generation 3, which is currently operated by firm A.

Upon entry, the productivity of entering firms with the stage-skipping strategy is not always higher than that of the path-following strategy. Since the stage-skipping strategy imitates the best productive generation of selected firms, the best productive generation of an incumbent is usually newly installed. Therefore, the accumulated experiences are relatively lower than that of the oldest generation. In this case, if a firm can imitate only part of the experiences, there are cases in which a firm with a path-following strategy has higher productivity from the mature oldest generation than from the immature best generation of selected firms.

The firms with path-creating catching-up always choose the latest generation. However, it cannot imitate the experiences of incumbents. Therefore, in the previous charts, at time 101, an entering firm with a stage-skipping strategy selects Generation 4 technology upon entry.

Kim and Lee (2003), Siverberg and Verspagen (1995), and Dosi et al. (1993) supposed that investment is reversible. Therefore, a firm can increase and reduce investment instantly. However, in the real economy, most facility investment is irreversible, and a firm cannot decrease its investment without any cost in this model. Thus, we also assume that all investment in this model is irreversible, and that a firm needs a certain time to construct a new facility[2].

3. METHODOLOGY AND MODEL

1) Simulation Approach

Evolutionary economics emphasizes the continuously growing variety of the economic structure, continuously creating new technologies, organizations, and firms. Economic phenomena that emerged differed because of the interactions that occur between individual members and the subtle differences that exist within the heterogeneous population. Heterogeneity and emergent property must be considered to study the diversity of catch-up processes. Catch-up results have no optimal solution because they generally follow the adaptive process. However, neoclassical economics is not suitable to study the adaptive process as they tend to suppose that representative firms or consumers sought optimized solutions. Therefore, to study emergent property and adaptive process of the economic phenomena with heterogeneous agents, the researcher uses an evolutionary simulation model.

To analyze this kind of complex economic phenomena numerically, the neo-Schumpeterian economists often used simulation methods, dating back to Nelson and Winter (1982). Their seminal work pioneered the formalization of the Schumpeterian vision of innovation-driven evolution, and it subsequently became a *de facto* standard for neo-Schumpeterian simulation models. The firm is the basic unit of selection in the Nelson-Winter model. Heterogeneity in a population of firms is due to the differential productivity of the production techniques used to produce a homogeneous good.

2) The Model

Production

There is only one kind of product in the industry. A firm that wants to assemble or create products has to construct facilities. Every facility has its own generation and is manufactured by facility providers outside of the industry. Facility providers innovate regularly. When innovation occurs, the basic productivity of facilities is increased. N_{igt} denotes the number of generation g facilities of firm i, at time t.

[2] Kydland and Prescott (1982) also supposed that at least one period is required for the construction of new productive capital.

We assumes that if a firm decides to invest, it constructs one facility at a time in this model. A facility cannot be easily divided. A firm usually decides to construct a facility as a unit since its scale is huge. The output of facilities of each generation is depicted as follows.

$$Q_{igt} = h_{igt} N_{igt}$$

Q_{igt} is the total output of all generation g facilities of firm i, at time t. h_{igt} denotes the productivity of generation g facilities of firm i, at time t. Q_{it} is the total output of all generation g facilities of firm i, at time t. Q_{it} is indicated as follows.

$$Q_{it} = \sum_{g} h_{igt} N_{igt}$$

Q_t is the total product of the whole industry at time t

$$Q_t = \sum_{i} Q_{it} = \sum_{i} \sum_{g} h_{igt} N_{igt}$$

Demand and Price

The market regimes are divided into four types. In the first type, market demand is fixed. Total market demand at time t is designated as R_t, and R^0 is a constant. In this case, R_t of the first type is depicted as follows.

$$R_t = R^0$$

The second type is fluctuating demand with a constant average. Then, R_t of the second type is depicted as follows. e_{it} is the uniform distribution from -0.5 to 0.5, and ψ is a constant with the value between 0 and 1.

$$R_t = R^0 + \psi e_{it-1} + (1-\psi) e_{it}$$

The third type of market regime is the expansion of market demand with constant growth. r is a constant that means increments in one period. R_t of the third type is depicted as follows.

$$R_t = R_{t-1} + r$$

The fourth demand condition is the fluctuating market demand with constant growth. R_t of the fourth type is depicted as follows

$$R_t = R_{t-1} + \psi e_{it-1} + (1-\psi) e_{it} + r$$

The market price at time t is determined as follows.

$$P_t = \frac{R_t}{Q_t}$$

Productivity

The productivity h_{igt} depends on the basic productivity of each generation g and the firm's process productivity of generation g. The process productivity relies on the firms' experience on each generation's g facilities. The experience of each firm is different; therefore, each firm has different productivity according to its own cumulative experience on each generation g facilities. Productivity is improved by cumulative experience according to the logistic curve. The h_{igt} of this model is depicted as follows.

$$h_{igt} = T_g + \frac{\eta_2}{1 + Exp(\eta_1 - E_{igt})}$$

$$T_{g+1} = T_g + \theta$$

T_g is the basic productivity of generation g. T_g is increased through the innovation of external facility producers, and innovation occurs every certain period. θ is the amount of one-time increment of basic productivity when innovation occurs. E_{igt} is the cumulative experience using the generation g facilities of each firm i at time t.

$$E_{igt+1} = E_{igt} + k_{igt}$$

$$k_{igt} = \gamma(1 + N_{igt})^{\delta} + \varepsilon_{igt} \qquad \varepsilon_{igt} \sim N(0, \sigma_n)$$

k_{igt} is newly acquired experience at time t. If a firm has more facilities of generation g, the cumulative speed of experience is accelerated. If a firm does not have a generation g facility, the cumulative speed is as low as the minimum level. Therefore, the amount of experiences on the specific generation g depends on the firms' facility number of generation g. Each firm has different k_{igt} because each firm has different path of developing process technology. Therefore, ε_{igt} is a random variable determined by normal distribution, and γ is a constant.

Cost Structure and Profit

Firms are divided into large diversified (LD) firms and small specialized (SS) firms, following Kim and Lee (2003). LD firms tend to carry higher overhead costs per unit of facility or output than SS firms do. This means that unless the output reaches a substantial amount, they cannot expect any cost advantage over SS firms. However, LD firms have lower variable costs with respect to facilities (VCN) than SS firms, which imply that LD firms are able to get cheaper loans from banks and hire more efficient labor relative to SS firms.

In this case, LD firms' advantage might have to do with the economy of scale or scope. In comparison, the relative advantage of SS firms is associated with its more flexible production and overall management system, which implies smaller fixed costs, as well as smaller adjustment costs owing to more flexibility .

Therefore, LD firms' variable costs are smaller than that of SS firms and LD firms' fixed cost is larger than that of SS firms as follows.

$$VCN_L < VCN_S$$

$$FC_L > FC_S$$

Average cost per facility can now be written as:

$$ACN_{it} = VCN_{it} + FC_{it} / N_{it}$$

The profit of firm i at time t is depicted as follows.

$$\pi_{it} = P_t \sum_g Q_{igt} - ACN_{it} \sum_g N_{igt}$$

Investment Decision

Each firm decides whether to invest or not at every period. Each firm can choose facilities among the generations that facility providers have already developed. Every firm invests on the generation with the best productivity. Each firm has diverse productivities of even same generation because of each firm's different experience and different entry times.

When firms try to decide on an investment, they calculate profit using the facilities of the highest productivity generation that they currently have; the generation of the highest productivity is denoted as ĝ.

$$h_{i\hat{g}t} = \max_g h_{igt}$$

π_{it}^N is the expected profit (per unit of capital) when a firm constructs a new facility of generation ĝ.

$$\pi_{it}^{N} = P_t h_{i\hat{g}t} - ACN_{it}$$

Only if the gap of the total expected profit (per unit of facility) during the whole life span of the facility and the facility's price is large enough, a firm would decide to construct a facility of the generation ĝ. In this model, s is the expected life span of the new facility. ρ is time discount. P_t^N is the price of facilities at time t. RA_{it} is the firm i's degree of risk aversion to decide to invest at time t. In this case, the investment condition of firm i is depicted as follows.

$$\sum_{t}^{t+s} \frac{\pi_{it}^{N}}{(1+\rho)^{t}} - P_t^N > RA_{it}$$

Miller and Bromiley (1990), and Wiseman and Bromiley (1996) showed that a firm becomes more risk averse when performance decreases. They suggested that lower performance caused firms to take fewer risks. Therefore, if the profit of a firm deceases, it tends to decrease its investment. RA_{it} is inversely proportional to a firm's own profit for a previous time in this model. α_i is the risk coefficient. Gr is the industry policy that lowers opportunity cost by reducing interest rate, ω is a constant, and RA_{it} is determined as follows.

$$RA_{it} = \frac{\alpha_i - G_r}{\pi_{it-1} + \omega}$$

X_{it} is retained earnings of firm i at time t. Every period, a firm adds the present time's profits to X_{it}. If a firm decides to invest, then a firm subtracts facility investment cost from X_{it}. Therefore, the X_{it+1} is determined as follows.

$$X_{it+1} = X_{it} + \pi_{it} - P_t^N N_{i\hat{g}t}$$

F_{it} is the financial constraint of firm i at time t. G_f is government or public funding. In this case, the financial constraint of SS firms is defined as follows.

$$F_{it} = X_{it} + G_f$$

LD firms may have better borrowing ability due to their size. Thus, if LD firm's borrowing ability premium is denoted as F_L, financial constraint of the LD firms is depicted as follows.

$$F_{it} = X_{it} + F_L + G_f$$

If a firm's financial constraint F_{it} is larger than the facility prices P_t^N, then a firm decides to construct one facility at a period. However, the construction of facilities needs specific time n. N_{igt+n} is determined as follows.

$$N_{igt+n} = N_{igt} + 1$$

δ_t is a constant, and N_t^d is the total facility demand of market at time t. Facility prices are determined by a linear function as follows.

$$P_{t+1}^N = \delta_t N_t^d$$

Exit and Entry

A firm has facilities of diverse generations in this model, with different generation facility for each firm. In this situation, if the profit of the specific generation facilities goes below a certain level, a firm closes one facility of the generation at a time. Y_{igt} is the performance indicator of the generation g facilities. It is the weighted average of the profits of generation g until the present period. Therefore, the exit condition of the facility is depicted as follows[3].

$$Y_{igt} = \beta_g Y_{igt-1} + (1-\beta_g)\pi_{igt}$$

$$If\ Y_{igt} < Y^0 \quad then \quad N_{igt+1} = N_{igt} - 1$$

A firm is forced to exit from the industry when its performance indicators go below a certain minimum level. Y_{it} is the weighted average of the profits. The exit condition of a firm i is depicted as follows.

$$Y_{it} = \beta\, Y_{it-1} + (1-\beta\ )\pi_{it}$$

$$If\ Y_{it} < Y^0 - G_e \quad then \quad N_{it} = 0$$

A firm that tries to enter the market has three strategies in this model. The first strategy is path-following catching-up, the second strategy is stage-skipping catching-up, and the third strategy is path-creating catching-up.

In the incumbent firms' situation, there are many cases that the previous generation facilities' productivity is superior to the latest one, because incumbent firms have cumulative

[3] Y^0 is a constant.

experience on previous generation facilities. Therefore, incumbent firms often do not choose the latest generation even if facility providers introduce a new generation facility.

However, entering firms have a different situation from the incumbents. Entering firms that use the path-creating catching-up strategy always choose the latest generation. Therefore, they have no cumulative experiences. For these firms, the latest technology always has the best productivity among all generations. Therefore, the expected productivities of entering firms are determined as follows.

$$h_{igt}^{N} = \underset{g}{Max}[T_{gt}]$$

Entering firms that use the path-following catching-up and stage-skipping catching-up strategies try to imitate incumbent firms' experience. In this model, path-following or stage-skipping firms choose an incumbent firm randomly and imitate its experience. It is assumed that path-following catching-up strategy firms choose the oldest generation of the selected imitating firm. On the contrary, the stage-skipping catching-up strategy firms can choose the best productive generation of the selected firms and imitate the experiences. However, they cannot imitate the whole experiences of the selected firm.

If firm $\tilde{i}$ is the randomly selected firm by entering firm with the stage-skipping and path-following strategy firm, and $\hat{g}$ is the selected firm's best productive generation that currently operates facilities at the, the initial experience of the path- skipping catching-up strategy firm is determined as follows.

$$E_{igt}^{N} = \lambda \cdot E_{\tilde{i}\hat{g}t}$$

The $\bar{g}$ is the selected firm's oldest generation that currently operates facilities, in this case, initial experiences of the path-following strategy is depicted as follows.

$$E_{igt}^{N} = \lambda \cdot E_{\tilde{i}\bar{g}t}$$

λ is the coefficient that represents the degree of imitating the incumbent firm's experiences. The entering firm cannot imitate 100% of the incumbent's experience. Therefore, the value of λ is larger than 0 and smaller than 1. In this model, I set λ as 0.7.

The productivity of the stage-skipping and path-following strategy firms is determined as follows.

$$h_{igt}^{N} = T_{\hat{g}} + \frac{\eta_2}{1 + Exp(\eta_1 - E_{igt}^{N})}$$

A firm decides to enter the market when the expected profit is larger than the degree of risk aversion of newcomers[4].

$$P_t h_{igt}^N - ACN > RA^e$$

4. SIMULATION RESULTS

1) Initial Settings

There are three types of catching-up strategies in this model: path following, stage skipping, and path creating. If a firm can randomly select its own catching-up strategy, what is the difference of each strategy?

In this model, entering firms with the path-following strategy are assumed to randomly select an incumbent firm, and that entering firms imitate experiences of the selected incumbent firm. This paper also assumes that the path-following firms adopt oldest generation technology of the selected firms. However, they cannot imitate the whole experiences of incumbents because of the knowledge gap. In this model, the researcher assumed that path-following firms can imitate only 70% of experiences of the oldest generation facility.

The entering firms with stage-skipping strategy randomly select a firm like the path-following strategy firms. However, they adopt best productive generation technology of the selected incumbent firm; they can also imitate 70% of experiences of the selected generation technology.

In this case, the basic generation productivity of stage-skipping firms is usually higher than that of path-following firms. However, there are many cases in which the selected incumbent firm's cumulative experiences of the best productive generation are less than those of the oldest generation. In this case, although path-following and stage-skipping firms can imitate the same portion of the incumbent's experiences, the imitating experiences of path-following firms is often more than that of stage-skipping firms. Therefore, if entering firms with a path-following strategy try to imitate the incumbents with the same effort as the stage-skipping firms, they easily absorb the process technology of the selected generation compared with the stage-skipping firms. As such, there are cases in which the path-following firms' process productivity is higher than that of stage-skipping firms.

Entering firms with path-creating strategy do not imitate incumbents; they adopt the latest (emerging) generation facilities, newly developed by the facility providers. The latest generation facility has the highest basic productivity and has more potential than the other strategies. There is a strong possibility that entering firms with a path-creating strategy may have higher productivity than the other strategies in the future. However, there are no cumulative experiences to imitate; therefore, they have a disadvantage in process productivity during entry time compared with stage-skipping strategy firms. In the initial stage, the

[4] RA_0 is the coefficient representing the degree of risk aversion when a new firm enters the market.

productivity of firms with path-creating strategy may be lower compared with stage-skipping strategy firms. That means that the risk of the entering firm is higher than that of the stage-skipping or the path-following firms.

In this section, the results of the path-following, stage-skipping, and path-creating catching-up strategies are compared. In the first part (experiment), all entering firms in the market are assumed to choose one catching-up strategy. In the second experiment, entering firms are assumed to randomly choose their own catching-up strategy between the path-following strategy and the stage-skipping strategy with a probability 0.5 upon entry. Entering firms that choose their own strategy between stage skipping and the path creating are also analyzed with a probability of 0.5. In the third part or experiment, firms randomly choose their own catching-up strategy among the path-following, stage-skipping, and path-creating strategy with a probability of 1/3. The market share of the entering firms and the incumbent firms for the last period of the simulation are then analyzed.

The initial values of the parameter and coefficients used in the simulations are as follows.

First, there are five firms in the initial state, and all firms start with three facilities.

Second, the basic productivity of the facility is set up as 0.05 at the initial stage. Then the basic productivity, θ, is increased by 0.06 whenever facility providers succeed in innovation. The innovation of the facility providers occurs every 30 periods in this model.

Third, a firm that tries to enter the market appears every period and the success probability of entry of each time is 0.05.

Fifth, the one period means one month, and 500 periods corresponding to about 40 years in the real economy was used in this simulation.

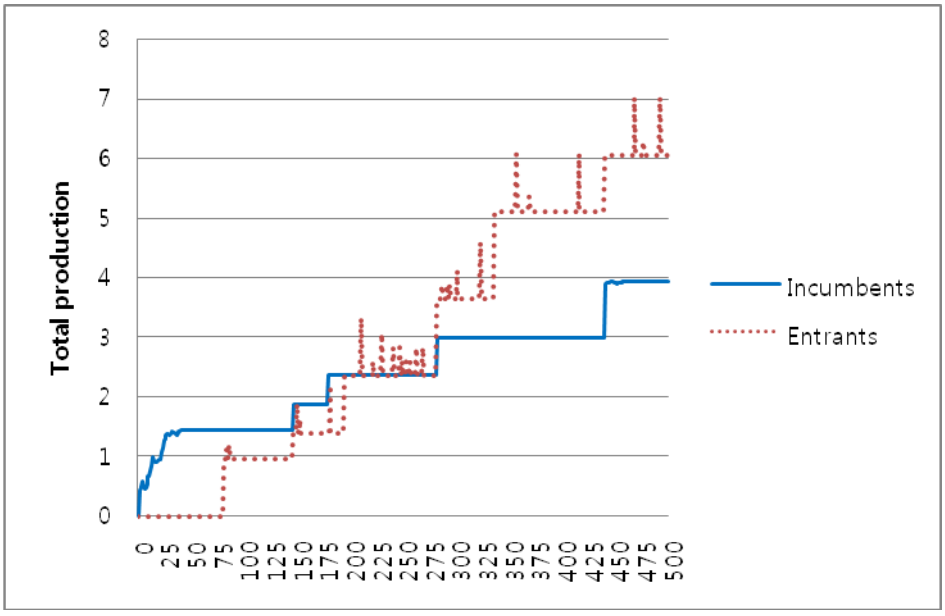
It is assumed that there are initially five LD (large diversified) firms, and all entering firms are also LD firms.

2) **When the Entering firms choose one of the three Entering Strategies**.

Fixed Market Demand

In this case, if initial market demand is fixed as 1.6, a simulation example of total production of the incumbents and entrants until the 500th period is depicted as follows.

CHART 3 EXAMPLE OF TOTAL PRODUCTION UNDER FIXED DEMAND (PATH FOLLOWING STRATEGY, INITIAL MARKET DEMAND = 1.6)



The total production of entrants is relatively smaller than that of incumbents until approximately the 200th period. However, as time passes, the total product of entrants exceeds gradually that of the incumbents.

Under the fixed demand condition, the entering firms' average market share of the results of 400 simulations at the 500th period is depicted as table 3. Each case shows the final market shares of the entering firms when they choose one of the three strategies. The market share above 0.5 does not mean that each entering firm beats the incumbent individually, because of the discrepancy of the firms' number between incumbents and entrants. The incumbent firms' number at the initial state is fixed at five, but the entering firms' number is variable because it is determined by probability. In this model, the number of the entering firms exceeds five in many cases.

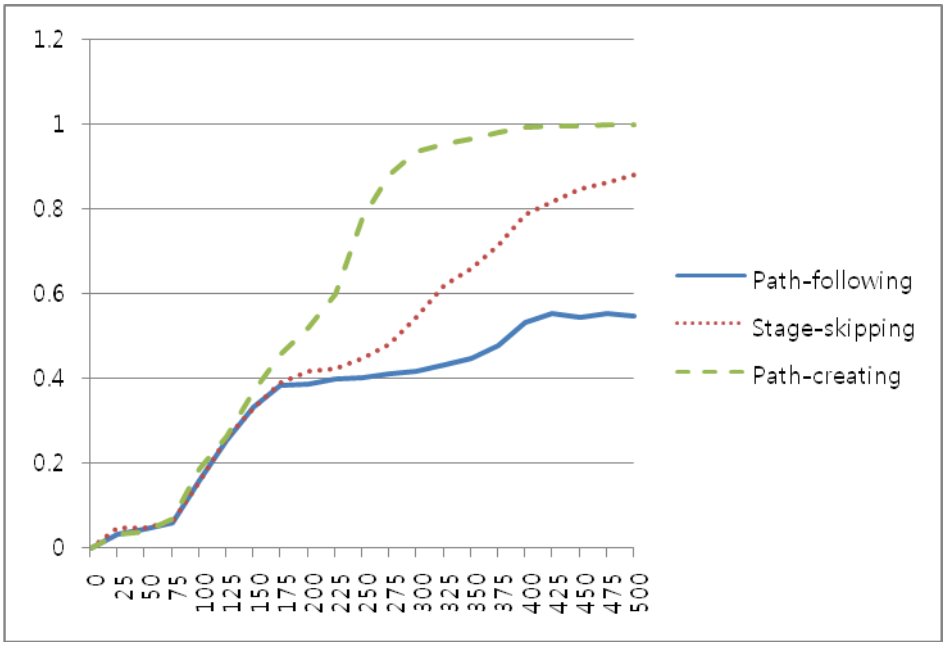
TABLE 3 ENTERING FIRMS' MARKET SHARE UNDER FIXED DEMAND CONDITION

Initial demand	1.6	3.2	6.4
Path-following	0.547823	0.908817	0.810584
Stage-skipping	0.889671	0.93518	0.83017
Path-creating	0.998779	0.999861	0.991086

The results show that the path-creating strategy is superior to the other strategies, and the path-following strategy is inferior to the other strategies in the fixed demand condition. The market share of the path-creating strategy is greater than that of other strategies. A path-creating firm can choose the latest generation in the market, although it cannot imitate the incumbents' experience.

Chart 4 depicted the catch-up dynamics of each strategy. All entering firms choose the same strategy in one market. Every 25 periods, the researcher calculated the average market share of entering firms with each strategy across 400 simulations with a fixed market demand value of 1.6.

CHART 4 MARKET SHARES OF THE ENTERING FIRMS UNDER FIXED DEMAND (1.6)



The market share of entering firms increases as time passes. The gap of market share among the three kinds of strategies is small until the 175th period. After this time, the market share gap gradually increases and the market share of entering firms with a path-creating strategy increases more rapidly.

Fluctuation with a constant average

When fluctuation is introduced to the model, the results change a little. A simulation of the total production of entering firms and incumbents under the fluctuating demand with constant average show that total production of entrants exceeds that of incumbents at approximately 225 periods, and the gap of total production between entrants and incumbents increases as time passes. Table 4 depicts the market share of entrants at 500 periods under fluctuating demand with constant average.

TABLE 4 FIRMS' MARKET SHARE UNDER FLUCTUATING DEMAND WITH CONSTANT AVERAGE

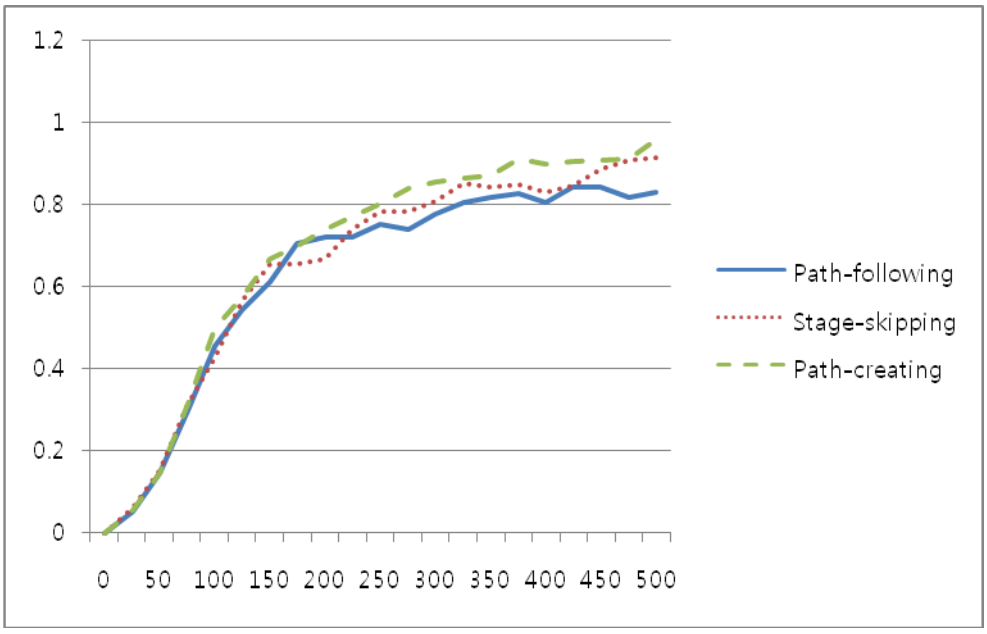
Initial demand	1.6	3.2	6.4
Path-following	0.822549	0.92897	0.902813
Stage-skipping	0.903155	0.9346	0.906564
Path-creating	0.912815	0.98117	0.973707

The fluctuation allows entering firms with the path-following and the stage-skipping strategies to catch up. When market demand fluctuates, the market share of entering firms with path-following and stage-skipping strategies is bigger than under the fixed market demand. Market demand fluctuates as shown in upturns and downturns. In a downturn, the scale economy effect of incumbents is decreased, and the price of facilities decreases. Therefore, the downturn of market demand can be an opportunity for entrants.

On the other hand, the market share of entering firms with a path-creating strategy under fluctuation with constant average is lower than that under fixed market demand. The results can be attributed to the different entry risks of each strategy. Path-creating strategy firms are exposed to higher risks than that of the path-following strategy or stage-skipping strategy firms at the entry time, because they start with low process productivity without imitating experiences. Therefore, many cases in which the productivity of path-creating strategy is lower than that of the other strategies during entry exist. The downturn of entry time makes it difficult for entrants with a path-creating strategy. On the contrary, the path-following strategy firms are exposed to lower risks upon entry, because they can imitate mature experiences from a randomly selected incumbent firm.

Chart 6 depicts the dynamics of catch-up with each strategy under fluctuation with constant average.

CHART 5 MARKET SHARES UNDER FLUCTUATION WITH CONSTANT AVERAGE = 1.6

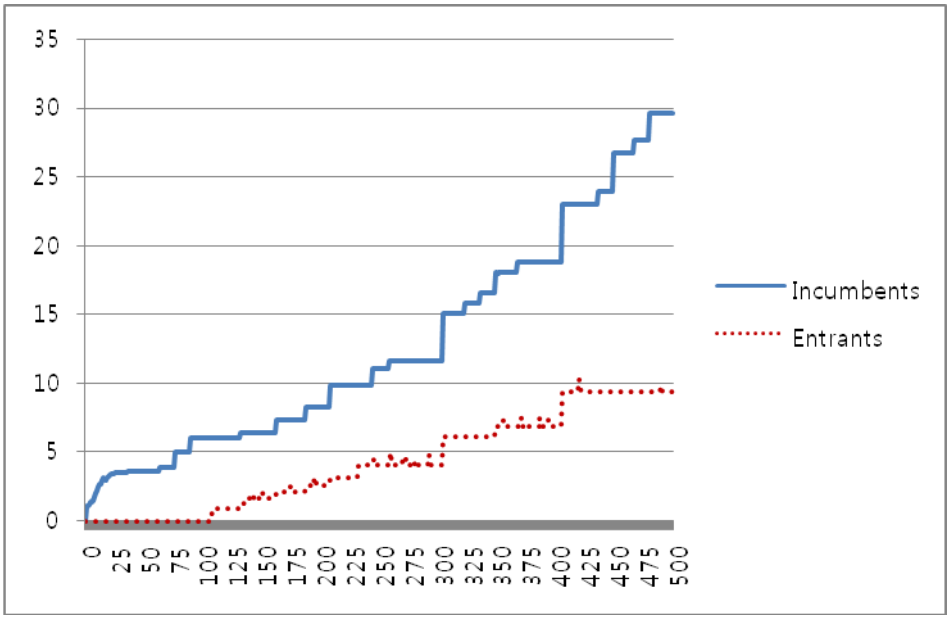


The market share of entering firms increases as time passes. The gap of market share among three kinds of strategies is small compared with fixed market demand, which means that fluctuation allows path-following and stage-skipping firms to enter the market successfully.

Expanding Demand with a constant growth rate

Chart 6 shows total production of incumbents and entrants when the demand expands with constant growth rate.

CHART 6 TOTAL PRODUCTION UNDER EXPANDING DEMAND WITH CONSTANT GROWTH RATE (PATH-FOLLOWING STRATEGY, GROWTH RATE = 0.08)



The product of entrants is increased more rapidly than that of the entrants. Therefore, the amount of products of entrants cannot exceed that of the incumbents in this case.

The results in Table 11 are the average market share of entrant firms at 500 periods as the results of 400 simulations under market expansion with constant growth rate.

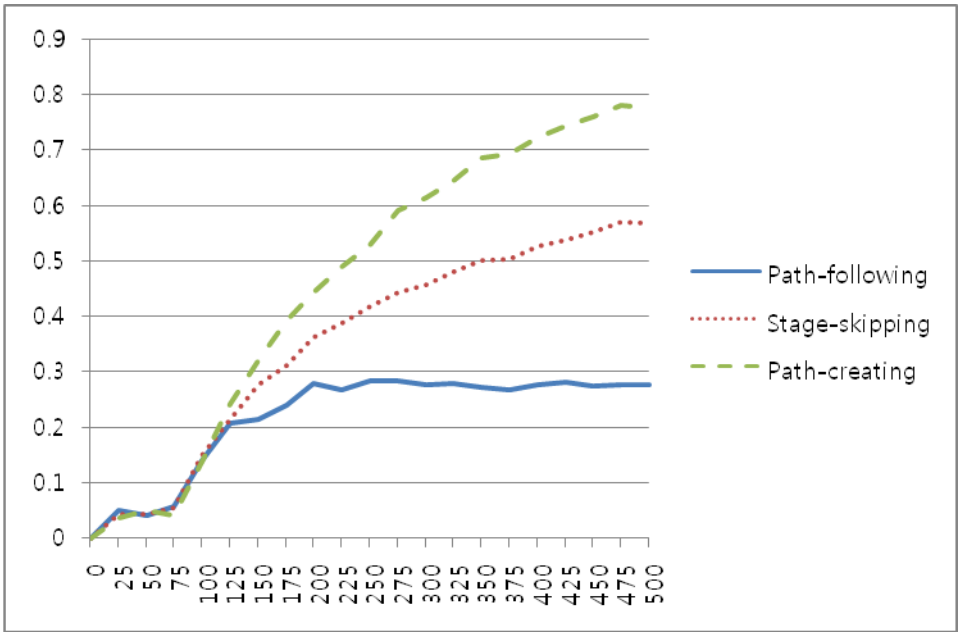
TABLE 5 MARKET SHARE UNDER EXPANDING DEMAND WITH CONSTANT GROWTH RATE

Value of r	0.004	0.008	0.012
Path-following	0.361908	0.264423	0.255616
Stage-skipping	0.718268	0.568473	0.469947
Path-creating	0.957467	0.790079	0.601332

If the market expands with constant growth rate, incumbents grow faster than fixed market demand. In this case, incumbents enjoy sufficient scale economy to prevent newcomers from entering with the help of demand growth. Therefore, under market expansion, new firms that want to enter the market must have more investment than that under the fixed demand condition. However, in this model, the initial capital of entering firms is fixed. Therefore, under market expansion, it is more difficult to enter the market for entering firms than under the fixed market demand. If the expansion speed of market demand increases, the entering firms' market share becomes smaller.

Chart 7 depicts the dynamics of catch-up with each strategy. Every 25 periods, the researcher calculates the average market share of entering firms with each strategy resulting from 400 simulations.

CHART 7 MARKET SHARES UNDER EXPANDING DEMAND WITH CONSTANT GROWTH

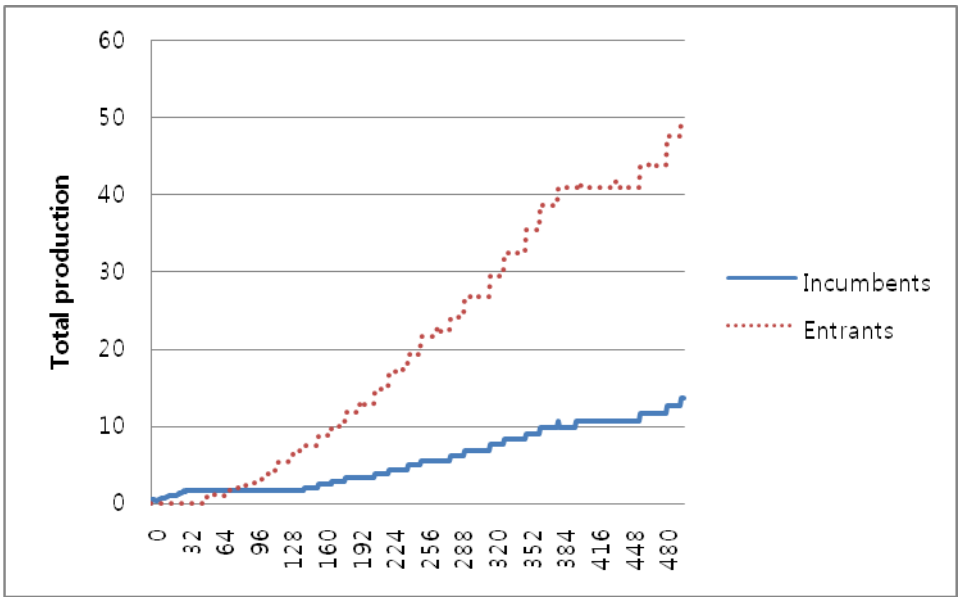


The market share of entering firms increases as time passes. Until the 125th period, the gap of market share among the three kinds of strategies is small. However, after this time, the gap of market shares between firms with three strategies gradually increases. The growth of entering firms' market share also gradually slows down, which means that the chance of entering firm's success diminishes as time passes. The market share of entering firms with a path-following strategy goes steadies after 200 periods.

Fluctuating demand with a constant growth rates

In contrast with expansion with constant growth rate, the fluctuation of market demand with constant growth rate provides opportunities to entering firms. Chart 8 shows an example of total production under expanding demand with constant growth rate.

CHART 8 TOTAL PRODUCTION UNDER FLUCUATING DEMAND WITH CONSTANT GROWTH (PATH-FOLLOWING STRATEGY, DEMAND GROWTH RATE = 0.008)



The product of entrants exceeds that of incumbents easily. This result is different with the case of expansion of demand with constant average.

Average market shares of the entering firms as a result of 400 simulations under the fluctuation of demand with constant growth rate are depicted as table 17.

TABLE 6 MARKET SHARE UNDER FLUCTUATING DEMAND WITH CONSTANT GROWTH RATE

demand growth rates (r)	0.004	0.008	0.012
Path-following	0.793664	0.825606	0.73645
Stage-skipping	0.887736	0.845513	0.846352
Path-creating	0.910353	0.898597	0.878115

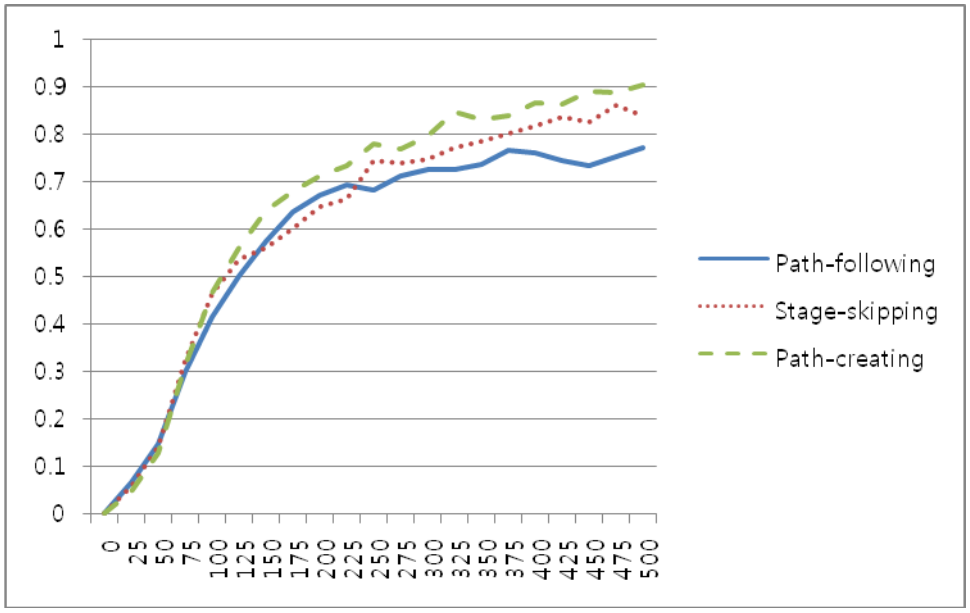
Under fluctuating demand with constant growth rate, there are upturns and downturns of market demand. While upturns create opportunities to harvest profits and production expansion, downturns force weaker players into bankruptcy and release resources to be picked up by stronger incumbents or by challenger firms looking to enter the industry[5].

In the downturn, the entry barrier of scale economy of incumbents is weakened as well. Under expanding demand with constant growth rate, incumbents usually keep up stable growth. However, under fluctuating demand with constant growth rate, entering firms easily challenge the incumbents' position. If market demand fluctuates, the opportunity of entering firms increases.

Chart 9 depicts the dynamics of catch-up with each strategy under fluctuating demand with constant growth rate.

[5] Mathews (2005)

CHART 9 MARKET SHARES: FLUCUATION OF DEMAND WITH CONSTANT GROWTH RATE = 0.008



Under fluctuating demand with constant average, market shares of entering firms grow faster than that under expanding demand with constant average. The gap of market shares between different strategies is smaller than that under expanding demand with constant average, and the market shares of entering firms increased within 500 periods. This means that the fluctuation provides opportunities to entering firms, in contrast with the case of expansion with constant growth rate.

3) Comparison of the Two strategies chosen in the same market

When path-creating and stage-skipping strategies compete with each other in the same market, what happens to the catching-up process and consequence? It is now assumed that new entering firms choose the path-creating strategy or the stage-skipping strategy with a probability 0.5. The "PC/SS ratio" is introduced, in which the market share of the path-creating firms is divided by that of the stage-skipping firms. Tables 6 and 7 show the average of the PC/SS ratio of 400 simulations at 500 periods.

TABLE 6. PC/SS RATIO UNDER NON-GROWING DEMAND CONDITION

Initial market demand	1.6	3.2	6.4
Fixed demand condition	2.588551	2.07383	2.777784
Fluctuation with constant growth	1.250946	1.536375	1.952025

TABLE 7. PC/SS RATIO UNDER GROWING DEMAND CONDITION

Value of r	0.004	0.008	0.012
Expansion with constant growth rate	1.968001	1.621246	1.319586
Fluctuation with constant growth rate	1.276815	1.314282	1.239184

If the value of PC/SS ratio is over 1, then the path-creating firms' market share is larger than that of the stage-skipping firms. Therefore, the simulation results show that if the path-creating and stage-skipping strategies compete in the same industry, the path-creating strategy firms are more competitive than the stage-skipping strategy firms. Therefore, the market share of the former is higher than latter.

The results also show that fluctuation is unfavorable to path-creating firms. These firms are exposed to higher risks upon entry, because they have no experiences to imitate, unlike firms with stage-skipping or path-following strategies. However, they have a great potential, because they choose the latest generation facilities. Therefore, if they could survive the initial stage, they can accumulate enough experiences to defeat the incumbent.

Next is the case in which firms with path-following and stage-skipping strategies compete in the same market. The SS/PF ratio is calculated as the market share of the stage-skipping firms divided by the path-following firms. Tables 8 and 9 show the average of SS/PF ratio resulting from 400 simulations.

TABLE 8. SS/PF RATIO UNDER NON-GROWING DEMAND CONDITION

Initial Market Demand	1.6	3.2	6.4
Fixed demand condition	2.600223	1.531038	1.05111
Fluctuation with constant growth	1.405826	1.39112	1.282615

TABLE 9. SS/PF RATIO UNDER GROWING DEMAND CONDITION

Value of r	0.004	0.008	0.012
Expansion with constant growth rate	2.222783	2.145609	2.096892
Fluctuation with constant growth	1.072486	1.38412	1.239184

Stage-skipping firms are more competitive than path-following firms and adopt the randomly selected incumbent's latest generation facility. Path-following firms adopt the incumbent's oldest generation facility. The latest facility has higher basic productivity than that of the oldest facility. However, the selected incumbents' accumulated experience of the latest generation facility is lower that of the oldest generation. Therefore, there are cases in which the productivity of stage-skipping firms is lower than path-following firms upon entering the market. However, with time, if stage-skipping firms accumulate their own experiences, then their productivity grows faster than that of the path-following firms. Therefore, fluctuating market demand is unfavorable to stage-skipping firms. There exist upturns and downturns in fluctuating demand, and demand downturn is more unfavorable to the stage-skipping firms than the path-following firms upon entry.

4) Comparison of the three Strategies in the same market

If the three strategies compete in the same market, how will the results turn out? Tables 10 and 11 show the average market share of firms with three strategies of 400 simulations at 500 periods, with non-growth demand.

TABLE 10 MARKET SHARES UNDER FIXED MARKET

Strategies	1.6	3.2	6.4
Incumbents	0.041921	0.015383	0.075377
Path-creating	0.586198	0.550054	0.565667
Stage-skipping	0.216744	0.254482	0.197344
Path-following	0.155136	0.180081	0.161612

TABLE 11. MARKET SHARES UNDER FLUCTUATION WITH CONSTANT AVERAGE

Strategies	1.6	3.2	6.4
Incumbents	0.084947	0.0364	0.048448
Path-creating	0.374272	0.427979	0.499165
Stage-skipping	0.31719	0.295799	0.243923
Path-following	0.223591	0.239822	0.208465

The market share of firms with a path-creating strategy is larger than the other strategies. However, if the market fluctuates, their market share decreases, and the market share of stage-skipping and path-following firms increases. Therefore, the gap of market share between three strategies decreases. These results are similar with the cases previously introduced in this chapter.

Tables 12 and 13 show the average market share of firms with three strategies of 400 simulations at 500 periods, when demand expand with or without fluctuations.

TABLE 12 MARKET SHARES UNDER EXPANSION WITH CONSTANT GROWTH

Strategies	0.004	0.008	0.012
Incumbents	0.223243	0.419361	0.536913
Path-creating	0.4048	0.283463	0.212931
Stage-skipping	0.232271	0.193716	0.163847
Path-following	0.139686	0.10346	0.086309

TABLE 13 MARKET SHARES UNDER FLUCTUATION WITH CONSTANT GROWTH

Strategies	0.004	0.008	0.012
Incumbents	0.128195	0.130638	0.182157
Path-creating	0.39078	0.37099	0.371665
Stage-skipping	0.268591	0.299975	0.263932
Path-following	0.212435	0.198396	0.182246

The market share of incumbents increases under the expansion of the market demand with constant growth. If the growth rate increases further, the market share of incumbents likewise increases. In this case, market share of entering firms decreases regardless of their strategies. However, in the case of fluctuation with constant growth, the market share of incumbents decreases, which is an opportunity for entering firms to increase their market share.

5. SUMMARY AND CONCLUSIONS

Dynamic simulations have been conducted to examine performance dynamics of entry firms taking three different entry strategies (path-following, stage-skipping, and path-creating) under four different market regimes (fixed demand condition, fluctuating demand with constant average, expanding demand with constant growth, and fluctuating demand with constant growth rate). It is shown that various market regimes are an important selection mechanism. The catch-up dynamics of entering firms change as each market regime is different and organizational selection is affected by market regimes. The effect of each catch-up strategy and various market regimes interact with each other.

If an entering firm chooses the path-following strategy, the fluctuation of demand can be a blessing for new entrants whereas incumbent firms may suffer from fluctuating demand. If an entering firm chooses the stage-skipping or path-creating strategy, they can catch up with incumbents more easily in the long run than with the path-following strategy. However, in market situations with expanding demand, catch-up becomes slower than that under other demand conditions. This is because growing demand helps incumbents take a full advantage of scale economy that can serve as an entry barrier. Thus, it can be concluded that market expansion is favorable to incumbent firms, and market fluctuation is favorable to entering firms.

Among the three entry strategies, a path-creating strategy is usually best, while the path-following strategy is worst. This is because that while productivity of a path-following firm is an average of productivities associated with old and new technologies, whereas that of a path-creating firm is based on newest technologies only. However, the gap in catch-up performance is reduced if the market regime is of fluctuating demand with constant growth. In contrast, under expanding demand with constant growth rate, the gap between each strategy increases.

In this research, the catching-up mechanism is replicated using a simulation method. This research focuses on distinguishing the factors that make such differences. The results of this simulation model suggest that market regimes must be considered in research on the effectiveness of the strategy of firms, whereas the literature tends to overlook the fact that the effectiveness of a firm's strategy is related to market regimes.

While the modeling in this paper assumes that different or new technologies arrives and become available to late-comers, in reality this is not the usual case and the late-comer often cannot get access to technologies. Given that technology transfer and the role of intellectual property rights is very critical, this idea can be incorporated into analysis in the future.

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