Winner-Take-All Contention of Innovation under Globalization: A Simulation Analysis and East Asia's Empirics

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Keywords: Concentration and diffusion of innovation; East Asia; Industrialization
JEL classification: F12; L25; O31; O33

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Abstract

This paper sets out to examine how innovation enhances export competitiveness: The proposition that export volume becomes enhanced as more productivity-enhancing innovation is captured by the exporting economy is the focus of this study. From a Schumpeterian perspective, innovation can be characterized by continuous creation and subsequent diffusion of newer technologies on the basis of the exporters' existing capital stock. Then we highlight the theoretical possibility that concentration of innovative activities in a small group of "winner" economies would lead to larger shares of "winner" economies' exports of innovation-active commodities than those commodities for which technology involved is already mature. The world's export data corroborates this theoretical prediction overall, and a focus upon East Asia has revealed the region's increasing resort to technology-intensive commodity sectors, which has presumably been enabled through attracting technology-bearing inward foreign direct investment. Considering the overall gains from innovation, acceleration of full "cycle" of innovation and imitation might be a desirable option.

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1. The Role of Knowledge in Industrialization

The critical role of knowledge in development through industrialization is pronounced in recent years (Nelson and Winter 1982; Dosi et al. 1988; Grossman and Helpman 1991). There may be incidences in which a country benefits from having superior technology, whereas there may also be instances in which multiple competitive advantages stand to gain by increased exports. The underlying concept here is the

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existence of a three-stage sequence of value[1]-creation, starting from (1) knowledge creation, then (2) embodiment of the knowledge in manufactured products, and finally, (3) exports of those products for foreign sale. It is up to the economy which of these three aspects to focus upon. The recent trend in "selection and specialization" industrialization strategy can be regarded as an attempt to reap economic rents a la Schumpeter (1961), depending on the economy's self-perception of where its competitive advantage resides.

With an "evolutionary" view in mind, this paper addresses innovation process with a particular focus on its possibility of concentration among existing innovators. This paper is structured as follows. Section 2 discusses the nature of innovation from a disequilibrium viewpoint. Then Section 3 undertakes a simulation analysis of innovation concentration. Section 4 attempts to empirically substantiate the implication of the previous section, with an emphasis upon East Asia. Section 5 concludes this paper and provides prospects for future research.

2. "Disequilibrium view" of innovation

The previous section has briefly investigated the nature of knowledge creation in the context of export-led economic development. This section reviews the role of technological knowledge in the economic process, and then attempts to associate the argument with international trade. Otani (2003) propounds the concept of "globalization cycle" within the empirical context of economic globalization and also under the theoretical purview of evolutionary theory. According to Otani, the dynamic aspect of

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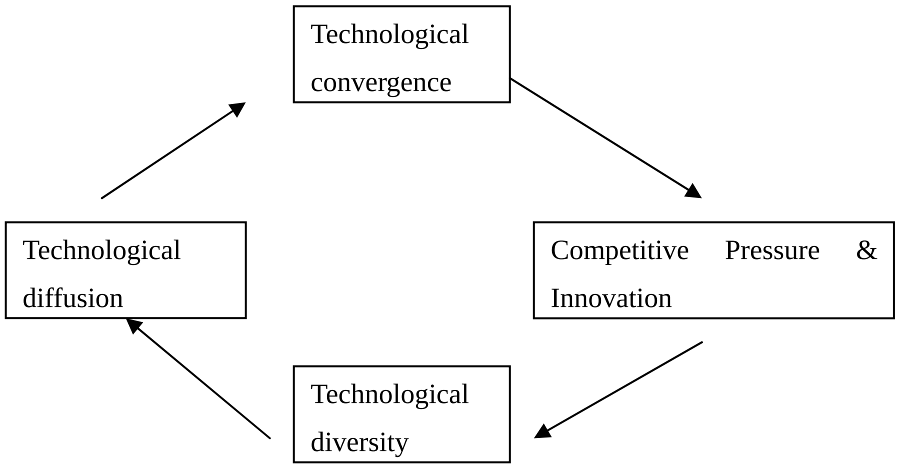
[1] Schumpeter (1961: 66) enumerates the following five cases as "development" alias "innovation": (1)the introduction of a new good—that is one with which consumers are not yet familiar— or of a new quality of a good;
(2) the introduction of a new method of production, that is one not yet tested by experience in the branch of manufacture concerned, which need by no means be founded upon a discovery scientifically new, and can also exist in a new way of handling a commodity commercially;
(3) the opening of a new market, that is a market into which the particular branch of manufacture of the country in question has not previously entered, whether or not this market has existed before;
(4) the conquest of a new source of supply of raw materials or half-manufactured goods, again irrespective of whether this source already exists or whether it has first to be created;
(5) the carrying out of the new organization of any industry, like the creation of a monopoly position or the breaking up of a monopoly position.
In a broad sense, therefore, the value-creation through cheap labor utilization can be seen as "rent-creation", since not only industrial invention but also, such extensive utilization of cheap labor can be seen as innovation.

economic globalization can be schematically presented as in Figure 1:

> "In a dynamic real economy, firms engage in continuous struggle to innovate newer goods and newer technologies to gain pronounced competitive advantages. Through the diffusion of knowledge, these innovations will stimulate other firms to catch up and the competitive advantage of the original innovator will dissipate. […] This dissipation of the older competitive advantages will push firms to further innovations to regain a newer competitive advantage. […] Therefore globalization can be divided up into the process of convergence and that of creative innovations through intensified international competition (Otani, 2003: 126).



Source: Adapted from Otani (2003), Figure 1.

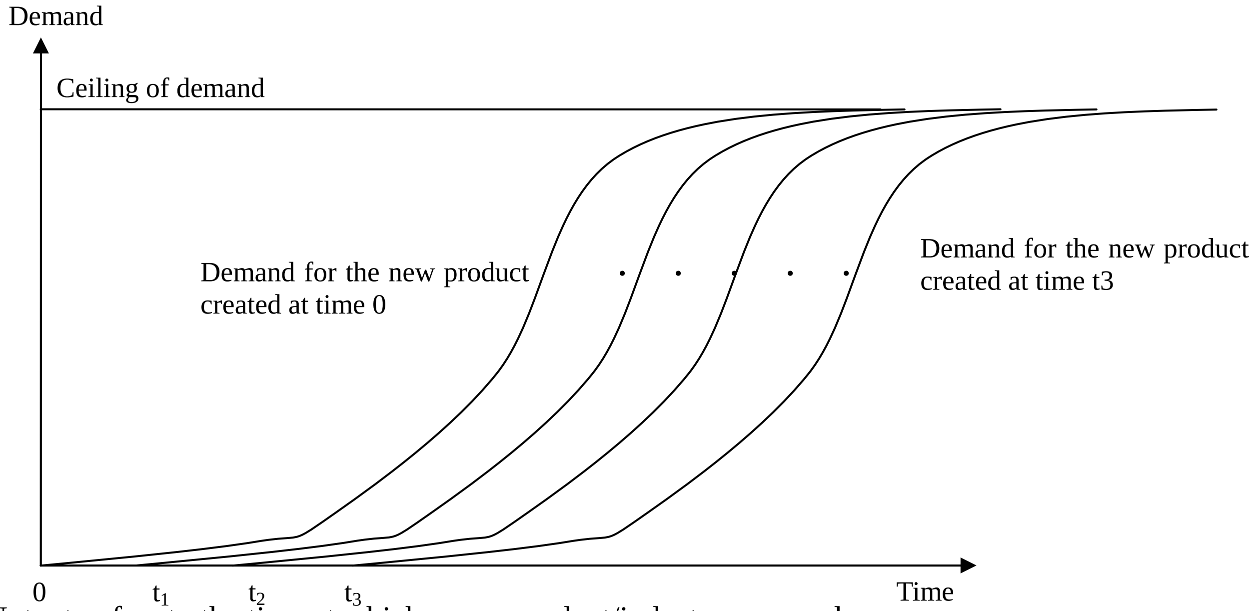
Figure 1. Globalization Cycle

This dynamic or "evolutionary" view of globalization is not only in line with Schumpeterian creative destructions but also Aoki and Yoshikawa's (1999) "growth cum incessant innovation". An empirical illustration of Figure 2 would be: demand for "tele"-communication (to mean communication "from a distance") lead an entrepreneurial firm to create at time t_1 the innovation (or invention) of telegraph; as the demand for telegraph saturates and competitive pressure pushes down the price, the economic rent for manufacturing telegraphs dissipates; then the firm strives for creating a newer product, culminating at time t_2 in the innovation (invention) of radio; then at time t_3, by the same token, the emergence of "tele"-vision follows. The same line of argument can be made for almost all the other industrial products.[2]

While empirical anecdotes abound with respect to innovation, the mainstream branch of economics tends to stay away from this important phenomenon. The next

[2] The births of semiconductors, personal computers, cellular phones and internet services are just a few such examples.

section makes a theoretical investigation into how this sort of technological innovation can be captured from an evolutionary perspective.



Note: t_i refers to the time at which a new product/industry emerged
Source: Adapted from Aoki and Yoshikawa (1999).

Figure 2. Divergence and Convergence of Newer Technologies

3. Theoretical analysis of innovation

3.1 Overall feature of the model for simulation

Our simulation model is heavily dependent on Nelson and Winter (1982, ch. 12). In the present model, we introduce the Schumpeterian competition of innovation. The model does not focus on equilibrium analysis. Firms' profits remain in each firm for tomorrow's R&D expenses and investments, there are winners and losers, and the process of competition is one of continuing disequilibrium. In this section we focus on technological progress: How firms survive competition of innovation, how firms obtain advanced technology through innovation and imitation, what kind of market structure is obtained, etc. As the result, we show how the rank-size relationship is obtained.

Moreover, we test two hypotheses: (1) The more aggressively R&D activities and innovation are done, the steeper the slope of the rank-size linear relationship becomes, (2) Besides aggressive R&D activities and innovation, the less technological diffusion there is (i.e., there exists less technological spillovers or more stringent intellectual property rights (IPRs) protection), the steeper the slope of the rank-size linear relationship becomes. The first hypothesis shows that the virtuous circle of innovation continues for the group of winners along with accumulated capitals as a main source of innovation activities in the present model, whereas the vicious circle of (unsuccessful) innovation continues for the group of losers along with small accumulated capitals. As a result, the slope of the rank-size linear relationship becomes steeper. As for the second hypothesis, we can observe effects of technological diffusion. Success of imitation is dependent on technological spillovers or the degree of intellectual property rights (IPRs) protection. If the firms cannot imitate advanced technology, they cannot catch up with the group of winners and the firms become losers eventually.

3.2 The Model

Firms in a country compete in a single-homogeneous-good exporting market[3]. The good is produced by a single primary input, capital. A production function is,

$$Q_{it} = A_{it} K_{it} \tag{1}$$

where Q_{it} denotes outputs of firm i, A_{it} technology of firm i, K_{it} capital stocks of firm i, respectively. Subscripts t denote time. The firms do not have market power: They are price-takers. Initially, the firms are symmetric but, as we introduce the Schumpeterian R&D competition, the firms become different each other in terms of their technology and capital stocks in the long run.

The Cobb-Douglass utility function is implicitly assumed to formulate a representative household's preference. After solving a normal maximization problem, we obtain a well-known hyperbolic (inverse) demand function;

$$P_t = \mu Y / Q_t \tag{2}$$

where P_t denotes the price of the homogeneous good, μ the share of payments, Y the income of the households, $Q_t (= \sum_{i=1}^{n} Q_{it})$ the total outputs of n firms, respectively.

The profit function for firm i is defined as follows:

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[3] We ignore the domestic market for simplicity. We can also take account of foreign firms into this market competition as long as we concentrate on an analysis of an export market such as the third market. However, in order to keep the discussion consistent with the other sections of this paper, we focus only on the export market competition of domestic firms.

$$\Pi_{it} = P_t Q_{it} - (c + r_{in} + r_{im}) K_{it} \tag{3}$$

where c denotes marginal costs for production, r_{in} marginal innovative R&D costs, r_{im} marginal imitative R&D costs, respectively. For simplicity, we assume that marginal costs, innovative R&D costs and imitative R&D costs are common across all the firms and are not dependent on time. We further assume that the firms expend both innovative and imitative R&D costs in every period[4] and the expenses for the R&D activities are proportional to capital stocks of each firm, i.e., the more capital stocks a firm has, the more amount of the costs it expends. The firms expend the both R&D costs even though they earn negative profits.

Success or failure of innovation and/or imitation follows a random process. Let us define two independent random variables, d_{int}, the probability of success of innovation, and d_{imt}, the probability of success of imitation. The variables have two discrete numbers, one or zero, namely, success in getting an innovation or an imitation draw, or failure. We can rewrite such draws as follows:

$$\Pr(d_{\mathrm{int}} = 1) = a_n r_{in} K_{it} \tag{4}$$

$$\Pr(d_{imt} = 1) = a_m r_{im} K_{it} \tag{5}$$

where a_n and a_m are parameters in order not to encounter the upper-bound probability of one. If a firm gets a draw of success in innovation, it picks up technology from a distribution of technological opportunities, $F(A; t, A_{i0})$, which is dependent on time and the initial value of A_{it}. If a firm gets a draw of success in imitation, it copies the highest (best practice) productivity level.

If a firm picks up both an imitation draw and an innovation draw, the production technology of the following period is

$$A_{i(t+1)} = \max(A_{it}, \tilde{A}_{it}, \hat{A}_t)$$

where $\tilde{A}_{it}$ denotes a random variable that is the result of the innovation draw and $\hat{A}_t$

4 In the simulation analysis of Nelson and Winter (1982, ch. 12, p. 289), it is assumed that the first half of the firms expend both types of R&D costs and the latter half expend only imitative costs. However, in this paper we do not take account of this assumption in order to pay attention to resulting outcomes which are obtained under competition of identical firms at first.

the highest productivity level in the industry in period t. If a firm fails to obtain an innovation draw, $\tilde{A}_{it} = 0$. If it fails to obtain an imitation draw, $\hat{A}_t = 0$. If a firm fails to obtain both an innovation draw and an imitation draw, its productivity level of period $t+1$ remains the same as period t.

As for investments, they are determined by the following investment function:

$$I_{it} \equiv \iota\left(\overbrace{\frac{P_t A_t}{c}}^{(+)}, \overbrace{\frac{Q_{it}}{Q_t}}^{(-)}, \overbrace{\Pi_{it}}^{(+)}, \overbrace{\delta}^{(+)}\right) K_{it} \tag{6}$$

where $P_t A_t / c$ denotes the percentage margin over cost, Q_{it} / Q_t the market share, Π_{it} the profits, δ the depreciation rate, respectively. Positive and negative signs denote the signs of partial derivatives of I_{it} with respect to each argument. Following the mechanism (6), I_{it} (resulting amount of investments) is added to K_{it} and $K_{i(t+1)}$ is obtained.

3.3 The Specification of the model for simulations

Following the model in the preceding section, we specify the exogenous variables and the formulae of the model. The specifications of the exogenous variables are as follows: $\mu Y = 67$, $c = 0.16$, $\delta = 0.03$, $A_{t0} = 0.16$. n (the number of the firms) can be determined arbitrarily. $K_0 = -11.1901 + 242.783 * n^{-2/3}$ where $K_0 = \sum_{i=1}^{n} K_{i0}$, $a_n = 0.125$, $a_m = 1.25$, $nr_{in} K_0 = 8$, $nr_{im} K_0 = 0.4$. $\tilde{A}_{it}$ has the log-normal distribution $N(\lambda(t), \sigma^2)$ where $\sigma = 0.05 * \alpha$ and $\lambda(t) = 0.16 + 0.01 * \beta * t$. ($\alpha$ and β are shift parameters for numerical simulations.) All the random variables are generated by *Mathematica*.

Taking account of the above, the specifications of the formulae are as follows:

(The demand function)

$$P_t = \frac{67}{Q_t}.$$

(The profit function)

$$\Pi_{it} = P_t Q_{it} - (0.16 + r_{in} + r_{im}) K_{it} .$$

In our analysis, we use the following definition to keep simulations consistent with Nelson and Winter (1982, ch. 12):

$$\tilde{\Pi}_{it} = \Pi_{it} / K_{it} . \quad \text{(profits per unit of capital)}$$

(The probability in getting an innovation draw)

$$f(d_{\text{int}}) = \frac{\eta^{d_{\text{int}}}}{d_{\text{int}}!} \exp(-\eta), \quad \text{(the Poisson distribution)}$$

where $\eta = a_n r_{in} K_{it}$ (the variance and the mean of the above distribution).

(The probability in getting an imitation draw)

$$g(d_{imt}) = \frac{(\gamma\xi)^{d_{imt}}}{d_{imt}!} \exp(-(\gamma\xi)), \qquad \text{(the Poisson distribution)}$$

where $\xi = a_m r_{im} K_{it}$ (the variance and the mean of the above distribution). γ is a shift parameter for numerical simulations. We assume that γ shows the degree of technological spillovers or the stringency of IPRs protection. The change of γ directly affects the variance and the mean of the Poisson distribution function of imitation. The larger γ, the easier to imitate.

(The distribution of technological opportunities)

$$N(\tilde{A}_{it}) = \frac{1}{\sqrt{2\pi}\sigma\tilde{A}_{it}} \exp\left(-\frac{(\log \tilde{A}_{it} - \lambda(t))^2}{2\sigma^2} \right), \text{ (the log-normal distribution)} \quad (7)$$

where $\sigma = 0.05 * \alpha$ (the standard deviation) and $\lambda(t) = 0.16 + 0.01 * \beta * t$ (the mean), as we have mentioned above. In our model (7) is a main source of innovation, as innovation occurs randomly after the firms get an innovation draw. In numerical simulations we vary α and β from 0.5 to 1.5 in order to observe effects of changes of the range of technology choices (σ) and the accumulations of knowledge over time (λ) on technological innovation.

(The investment function)

$$I_{it} = \max\left[0, \min(k(s_{it}, \rho_{it}), h(\tilde{\Pi}_{it}))\right] K_{it} \geq 0,$$

where $s_{it} = Q_{it} / Q_t$, $\rho_{it} = P_t A_{it} / 0.16$, $k(s_{it}, \rho_{it}) \equiv 1.03 - (2 - s_{it})/(\rho_{it}(2 - 2s_{it}))$, and

$$\begin{aligned} h(\tilde{\Pi}_{it}) &= 0.03 + \tilde{\Pi}_{it} \quad (\tilde{\Pi}_{it} \leq 0), \\ &= 0.03 + \beta\tilde{\Pi}_{it} \quad (\tilde{\Pi}_{it} > 0), \end{aligned}$$

where $\beta > 1$, an exogenous variable, denotes availability of bank credits. In our simulations we define $\beta = 2$, following the original setting. The firms can get bank credits even though their profits are negative, which can often be seen in reality. We assume that the firms with positive profits can get more bank credits than those with negative profits.

$k(s_{it}, \rho_{it})$ has the following property: $\partial k(s_{it}, \rho_{it}) / \partial s_{it} < 0$ and $\lim_{s_{it} \to 1} I_{it} = 0$. In Nelson and Winter (1982, ch. 12) it is assumed that the firms become reluctant to invest as their market shares get larger, based on the idea that the firms enjoying large market shares do not have to make the competition fiercer. However, in reality, firms may continue to invest almost eternally otherwise the time to exit from the market may come even towards current winners. Therefore, we introduce another type of the investment function:

$$J_{it} = \max\left[0, h(\tilde{\Pi}_{it})\right] K_{it} \geq 0 .$$

$h(\tilde{\Pi}_{it})$ has the following property: $\partial h(\tilde{\Pi}_{it}) / \partial \tilde{\Pi}_{it} > 0$ and $\lim_{\tilde{\Pi}_{it} \to \infty} J_{it} = \infty$. In this case the firms continue to invest even though they are the current winners. In numerical simulations we use only J_{it} to formulate the investment function.

3.4 Numerical Simulations

We conduct numerical simulations for 20 firms ($n = 20$) and 160 periods. Containing random variables in our simulations, we took 100 samples per firm and computed the mean of the accumulated capitals in the final period, applying a method *a la* Monte Carlo. Among many variables, we focus on accumulations of capital stocks as it is a key variable and a main source of both the R&D expenses and investments. To see the rank-size relationship, we show a sample plot in Figure 3.

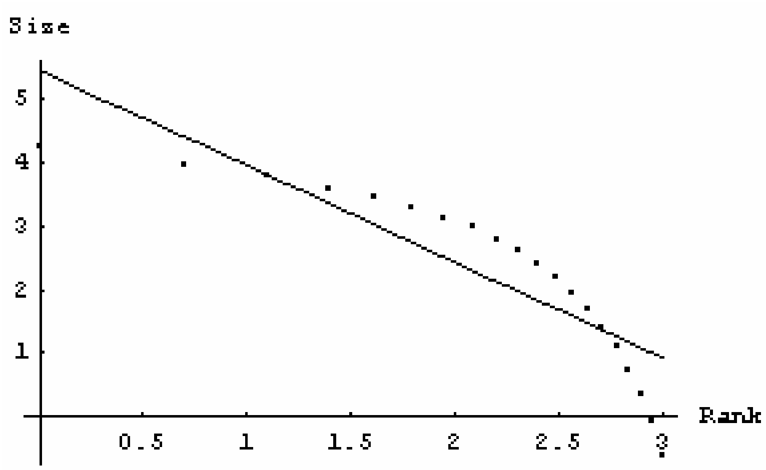

Figure 3: A Sample Plot ($\alpha = \beta = 0.5$)

The dots are the simulation results (a mean of 100 samples of accumulated capitals in the final period), the horizontal line shows the rank (the log of the ranking), the vertical line shows the size (the log of the size) and the solid line shows a regression line (by ordinary least squares). In the first hypothesis, the slope of the regression line becomes steeper as R&D activities and innovation are done more aggressively. In order to observe if this occurs, we vary the range of technology choices (σ) and the accumulations of knowledge over time (λ) by changing both α and β from 0.5 to 1.5.

The results (the slopes of the regression lines) are shown in Table 1. As we can see, the slope becomes (negatively) greater as α and β becomes greater. Intuitively, large σ represents broad technology choices, namely, the technology of this industry is not mature yet, such as information and communication technology (ICT) industry. On the contrary, small σ represents an industry which has mature technology such as agriculture or textile. As for the accumulations of knowledge over time (λ), it obviously contributes to make the slope steeper.

For the second hypothesis, we vary α and γ as well[5]. The results are shown in Table 2. It shows that the slope becomes steeper as γ gets smaller and α gets larger. The change of α brings the same effect as in the first hypothesis. The

[5] We omit β because effects of the change of β on the results seems predictable.

change of γ shows the effect of technological diffusion. If technological spillovers are large enough or the stringency of IPRs protection is weak enough, it becomes easier for the firms to imitate advanced technology and the slope becomes flatter. If technological spillovers are small enough or the stringency of IPRs protection is strong enough, the opposite occurs and the slope becomes steeper, as the winners keep on winning with advanced technology whereas the losers hardly catch up.

Table 1. The Slopes of the Rank-Size Relationship with Varied α and β

		β										
		0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5
α	0.5	-1.48574	-1.66593	-1.81785	-1.96375	-2.05122	-2.12187	-2.17544	-2.19030	-2.26762	-2.29312	-2.32353
	0.6	-1.54408	-1.76756	-1.87983	-1.98018	-2.06585	-2.14203	-2.18139	-2.24014	-2.27605	-2.30815	-2.34288
	0.7	-1.62629	-1.78409	-1.91269	-2.02396	-2.10916	-2.15862	-2.22674	-2.25602	-2.29522	-2.31926	-2.35211
	0.8	-1.75929	-1.82989	-1.98914	-2.02994	-2.11306	-2.19054	-2.24867	-2.26646	-2.30955	-2.32939	-2.36114
	0.9	-1.76866	-1.90979	-2.01307	-2.08844	-2.15764	-2.23154	-2.27798	-2.30024	-2.32090	-2.34747	-2.36379
	1.0	-1.81826	-1.92547	-2.07665	-2.12866	-2.19864	-2.24561	-2.28414	-2.31878	-2.34136	-2.35554	-2.37478
	1.1	-1.87948	-2.02620	-2.08558	-2.17771	-2.22540	-2.25980	-2.30538	-2.34010	-2.36473	-2.37927	-2.38356
	1.2	-1.97965	-2.03995	-2.12848	-2.20918	-2.22410	-2.29786	-2.32354	-2.36152	-2.37513	-2.38086	-2.38740
	1.3	-2.00714	-2.09263	-2.16905	-2.21793	-2.26945	-2.30674	-2.32620	-2.36662	-2.38431	-2.38635	-2.39337
	1.4	-2.09027	-2.16488	-2.21028	-2.23663	-2.30896	-2.33495	-2.37129	-2.37986	-2.39453	-2.41107	-2.42910
	1.5	-2.11299	-2.22733	-2.25020	-2.30168	-2.32109	-2.34706	-2.37123	-2.40052	-2.42008	-2.42080	-2.44258

Table 2. The Slopes of the Rank-Size Relationship with Varied α and γ

		γ										
		0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5
α	0.5	-2.25873	-2.24497	-2.20190	-2.16763	-2.13507	-2.12284	-2.09894	-2.03958	-2.02922	-1.97413	-1.95269
	0.6	-2.26607	-2.25952	-2.22333	-2.17795	-2.16274	-2.13954	-2.11515	-2.07544	-2.05291	-2.03238	-2.01116
	0.7	-2.27759	-2.26675	-2.24389	-2.22292	-2.19356	-2.15212	-2.12841	-2.09134	-2.06356	-2.06299	-2.04788
	0.8	-2.30184	-2.29550	-2.24869	-2.24067	-2.23626	-2.19836	-2.17058	-2.12846	-2.11352	-2.08902	-2.05816
	0.9	-2.33585	-2.31145	-2.28349	-2.26117	-2.24010	-2.22083	-2.19409	-2.16111	-2.14512	-2.11017	-2.09894
	1.0	-2.35809	-2.31421	-2.28624	-2.27777	-2.25487	-2.24767	-2.20623	-2.19335	-2.18600	-2.13579	-2.12201
	1.1	-2.36474	-2.32083	-2.30162	-2.29555	-2.27579	-2.26197	-2.23973	-2.21609	-2.20834	-2.17758	-2.15897
	1.2	-2.37871	-2.32937	-2.31382	-2.30546	-2.29727	-2.29154	-2.25846	-2.25604	-2.22046	-2.20735	-2.19126
	1.3	-2.39735	-2.35904	-2.34563	-2.34158	-2.34139	-2.32375	-2.30271	-2.28034	-2.26823	-2.25175	-2.19452
	1.4	-2.41633	-2.38324	-2.38168	-2.35943	-2.35077	-2.33568	-2.31331	-2.30110	-2.28907	-2.26105	-2.24967
	1.5	-2.44028	-2.41188	-2.40616	-2.37820	-2.36031	-2.34569	-2.34149	-2.32767	-2.31314	-2.28091	-2.27497

4. Some empirical evidence

4.1 World's cross-sectional results and East Asia

Following the argument so far, this sub-section makes an empirical analysis of export performance. The theory in the previous section leads to the hypothesis that in a particular industrial sector in which winners keep on innovating advanced technology with a disproportionately high frequency, the "rank-size" curve becomes steeper than otherwise.

Empirical calculation has therefore been made in order to observe the validity of this hypothesis. We have used fob-based export data contained in the United Nations' online database UNCOMTRADE and conducted the linear regression of the rank (horizontal axis)-size (vertical axis) distribution (both axes in logarithm) for each commodity sector across all the countries listed in the database. The sector classification we have drawn on is provided in the Appendix. For normalization purpose, rank 1 economy's export volume (size) is set equal to 100 and all the other economies' export volumes are indexed on this basis.

Table 3 shows the results of our linear regression. As shown, the slope is steeper for apparently more technology-intensive commodity sectors including "Electrical", "Machinery" and "Transportation", and the slope is less steep for less technology-intensive commodities, i.e., "Agriculture", "Food" and "Textiles". This result seems to be in line with the theory-driven hypothesis above.

Separate calculation has also revealed that the East Asia as a whole has been climbing up the ladder of world ranking in the two most technology-intensive sectors, i.e., "Electrical" and "Machinery" over the past two decades, as shown in Table 4. In a nutshell, it is said that East Asia on the whole has successfully been capturing technological innovation. The next sub-section touches upon East Asia's recent performance in terms of the creation and utilization of industrial knowledge.

Table 3. Linear-regression results of rank-size distribution for the world's exports (across all countries) by commodity, 1976, 1985, 1995 and 2003

Commodity sector	Item	1976	1985	1995	2003	Simple average of slope
Electrical	Slope	-4.3 (-17.29)	-3.56 (-16.63)	-3.81 (-24.05)	-3.83 (-20.77)	-3.88
	Intercept	3.44 (11.40)	4.34 (13.12)	5.04 (18.45)	5.31 (16.61)	
	Adj R squared	0.90	0.77	0.82	0.77	
	No. of obs.	35	82	126	129	
Machinery	Slope	-4.28 (-15.27)	-3.54 (-1854)	-3.68 (-25.95)	-3.65 (-24.47)	-3.79
	Intercept	3.63 (10.69)	4.45 (15.00)	4.87 (19.90)	5.07 (19.56)	
	Adj R squared	0.87	0.81	0.84	0.82	
	No. of obs.	36	83	126	129	
Transportation	Slope	-4.23 (-15.08)	-3.54 (-19.69)	-3.67 (-23.96)	-3.61 (-23.30)	-3.76
	Intercept	3.28 (9.56)	4.24 (15.25)	4.83 (18.27)	4.86 (18.12)	
	Adj R squared	0.86	0.83	0.82	0.81	
	No. of obs.	37	82	127	128	
Pottery	Slope	-4.07 (-11.76)	-3.64 (-12.98)	-3.65 (-18.31)	-3.36 (-16.28)	-3.68
	Intercept	4.01 (9.39)	4.87 (11.14)	5.17 (14.97)	4.98 (13.90)	
	Adj R squared	0.79	0.67	0.73	0.67	
	No. of obs.	38	84	127	129	
Metal	Slope	-4.44 (-11.02)	-3.14 (-13.53)	-3.52 (-17.77)	-3.30 (-17.00)	-3.60
	Intercept	3.91 (7.92)	4.35 (12.11)	5.13 (14.93)	4.97 (14.72)	
	Adj R squared	0.77	0.69	0.71	0.69	
	No. of obs.	37	82	128	130	
Chemical	Slope	-4.11 (-11.68)	-3.03 (-14.95)	n.a.	-3.57 (-16.82)	-3.57
	Intercept	3.86 (8.97)	4.16 (13.13)		5.18 (13.99)	
	Adj R squared	0.79	0.73		0.68	
	No. of obs.	37	85		131	
Wood and Paper	Slope	-4.14 (-12.80)	-3.10 (-15.99)	-3.44 (-1925)	-3.33 (-16.42)	-3.50
	Intercept	3.89 (9.67)	4.07 (13.47)	4.85 (15.72)	4.91 (13.95)	
	Adj R squared	0.81	0.75	0.75	0.68	
	No. of obs.	39	85	126	129	
Others	Slope	-3.96 (-13.99)	-3.16 (-15.81)	-3.10 (-20.30)	-3.14 (-18.59)	-3.34
	Intercept	3.71 (10.71)	4.38 (14.00)	4.45 (16.86)	4.65 (15.85)	
	Adj R squared	0.84	0.75	0.76	0.73	
	No. of obs.	37	85	128	130	
Mining	Slope	-4.05 (-8.61)	-2.96 (-10.36)	-3.15 (-15.10)	-3.09 (-14.31)	-3.31
	Intercept	3.41 (5.83)	4.38 (9.84)	4.78 (13.20)	4.78 (12.75)	
	Adj R squared	0.66	0.56	0.64	0.61	
	No. of obs.	39	84	128	129	
Light	Slope	-3.44 (-12.83)	-3.07 (-13.87)	-3.22 (-19.56)	-3.10 (-18.54)	-3.21
	Intercept	3.88 (11.53)	4.13 (11.96)	4.63 (16.25)	4.50 (15.55)	
	Adj R squared	0.81	0.69	0.75	0.73	
	No. of obs.	40	85	128	128	
Food	Slope	-3.39 (-7.95)	-2.51 (-12.92)	-2.80 (-16.86)	-2.61 (-14.46)	-2.83
	Intercept	4.06 (7.72)	3.73 (12.23)	4.25 (14.78)	4.10 (13.07)	
	Adj R squared	0.63	0.66	0.69	0.62	
	No. of obs.	38	86	128	130	
Textiles	Slope	-3.30 (-10.95)	-2.51 (-9.57)	-2.35 (-13.32)	-2.37 (-11.72)	-2.63
	Intercept	3.55 (9.56)	4.24 (10.34)	4.30 (14.05)	4.40 (12.50)	
	Adj R squared	0.76	0.52	0.58	0.51	
	No. of obs.	38	85	128	130	
Agriculture	Slope	-2.28 (-10.62)	-2.21 (-13.55)	-2.29 (-21.76)	-2.39 (-16.05)	-2.29
	Intercept	3.11 (11.57)	3.45 (13.38)	3.70 (20.23)	3.91 (15.11)	
	Adj R squared	0.51	0.67	0.79	0.66	
	No. of obs.	40	89	130	131	

Notes: Commodity sectors in the rows are listed in the descending order (in magnitude) of the simple average.
The numbers in parentheses are t-statistics.
Source: Authors' calculation on the basis of the United Nations' trade statistics, UNCOMTRADE.

Table 4. East Asian economies' average ranking in the world in terms of trade volume (measured in US dollars), 1985, 1995 and 2003

(ranking)

Commodity sector	Year	Indonesia	Malaysia	Philippines	Singapore	Thailand	China	Hong Kong, China	Japan	Korea	Simple average
Electrical	1985	38	15	31	9	28	33	8	1	10	19.2
	1995	28	7	25	4	16	12	7	1	5	11.7
	2003	28	11	15	7	16	4	5	2	6	10.4
Machinery	1985	39	29	49	14	31	37	12	2	22	26.1
	1995	30	17	38	6	19	14	10	1	13	16.4
	2003	32	16	24	10	20	4	8	3	11	14.2
Transportation	1985	65	27	43	22	44	29	23	1	8	29.1
	1995	37	23	44	20	28	15	22	1	10	22.2
	2003	43	42	36	30	21	12	32	2	9	25.2
Pottery	1985	39	35	42	30	19	28	14	5	16	25.3
	1995	35	26	46	23	15	10	12	7	24	22.0
	2003	26	29	47	32	15	8	12	10	25	22.7
Metal	1985	31	25	39	26	36	41	22	2	12	26.0
	1995	33	29	48	22	36	9	13	2	11	22.6
	2003	36	29	53	30	33	4	17	2	11	23.9
Chemical	1985	25	20	44	13	30	26	21	6	19	22.7
	1995	25	22	53	16	19	13	11	4	12	19.4
	2003	25	22	57	15	18	11	17	6	14	20.6
Wood and Paper	1985	12	7	25	20	35	33	24	14	27	21.9
	1995	7	12	43	29	32	19	15	1	27	20.6
	2003	10	18	51	39	28	11	21	20	25	24.8
Others	1985	43	31	29	18	25	28	6	3	12	21.7
	1995	24	23	30	17	15	4	2	8	10	14.8
	2003	29	24	36	14	20	2	3	8	13	16.6
Mining	1985	6	16	51	14	56	12	47	33	31	29.6
	1995	9	18	55	15	51	16	28	23	26	26.8
	2003	12	19	60	17	42	16	57	34	24	31.2

Table 4. East Asian economies' average ranking in the world in terms of trade volume (measured in US dollars), 1985, 1995 and 2003 (Continued)

(ranking)

Commodity sector	Year	Indonesia	Malaysia	Philippines	Singapore	Thailand	China	Hong Kong, China	Japan	Korea	Simple average
Light	1985	41	44	35	24	30	23	9	15	5	25.1
	1995	13	24	36	34	9	3	2	25	8	17.1
	2003	17	25	37	41	19	1	3	30	23	21.8
Food	1985	38	41	22	29	15	27	12	18	21	24.8
	1995	41	30	49	14	15	12	10	20	26	24.1
	2003	37	28	44	18	17	13	20	26	23	25.1
Textiles	1985	29	33	38	17	16	1	44	11	55	27.1
	1995	68	21	19	2	6	38	34	11	26	25.0
	2003	75	3	55	7	53	27	56	18	28	35.8
Agriculture	1985	21	17	30	22	15	13	31	26	28	22.6
	1995	21	16	32	27	14	9	26	41	28	23.8
	2003	20	16	35	40	14	7	36	42	38	27.6

Notes: Commodity sectors in the rows are listed in the same order as in Table 3.

Comparable ranking for 1976 is not available due to a much small number of countries listed in the trade database than for the other years.

Source: As for Table 3.

4.2 Creation and utilization of industrial knowledge: a focus on East Asia

Within the whole spectrum of export commodities, what could be called "knowledge-intensive products" have been increasing rapidly in East Asian economies (Table 5). That the "knowledge" component of those knowledge-intensive products comprises the major source of economic rents is a well-known proposition (Schumpeter, 1961). It is then imperative for a developing economy to capture ever-progressing industrial technology through streamlining its domestic productive capacity. Since, as is often the case, developing economies lack the very capacity to do so, they oftentimes rely on attracting foreign direct investment (FDI) from developed economies including the EU, the US and Japan. As long as those developing economies can *effectively* capture knowledge, they acquire economic rents. FDI here can be viewed as a transfer of money *and* the channel of acquiring knowledge.

As Table 5 suggests, both European and East Asian economies have increasingly been dependent on inward FDI as the source of capital stock formation. It is generally observed that smaller economies in terms of GDP, most notably Hong Kong and Singapore in Asia, and Ireland, the Netherlands and Sweden in Europe, record a larger ratio of FDI to capital stock. A major difference between East Asia and Europe may lie in the casual observation that whereas European economies have been serving as donors and recipients of FDI simultaneously, most developing East Asian economies have simply been hosting, as genuine recipients, those FDI projects undertaken by the region's developed economies (viz., Japan and Korea) serving as donors. Put differently, the increasingly higher share of knowledge-intensive products (as shown in Table 5) reflects this concentration of FDI in those East Asian economies (as shown in Table 6). In sum, with respect to the "midstream" part of the entire economic value-creating process of goods production, East Asia has been dependent on foreign manufacturing capacity.

Table 5. Trade matrix of knowledge-intensive goods

(US$ million)

From \ To	ASEAN Five[b]	China	Hong Kong	Korea	Japan	USA	EU12[c]	World Total[a]
ASEAN Five[b]								
1990	4,946[d]	317	1,505	851	2,107	11,373	5,276	32,598
1995	21,965	1,247	7,442	2,631	10,975	29,784	14,197	109,297
2000	35,023	4,554	10,417	5,655	16,502	40,252	27,220	161,500
China								
1990	77	—	1,094	3	55	101	152	1,734
1995	1,216	—	4,362	373	2,346	3,075	2,125	16,431
2000	3,478	—	9,251	1,520	5,294	11,529	8,610	45,370
Hong Kong								
1990	186	889	—	43	66	533	495	2,581
1995	1,066	2,036	—	112	335	1,179	604	6,200
2000	775	1,789	—	68	205	982	1,818	5,436
Korea								
1990	1,430	n.a.	892	—	2,011	5,210	2,245	15,357
1995	5,771	1,608	2,797	—	4,287	11,202	4,024	36,908
2000	7,986	3,633	3,766	—	5,591	15,268	7,966	54,513
Japan								
1990	7,589	1,563	4,047	4,283	—	25,064	15,862	74,415
1995	22,280	4,307	8,868	8,709	—	38,355	18,981	122,602
2000	22,819	7,532	10,044	9,992	—	44,485	26,992	122,566
USA								
1990	8,605	1,457	2,046	3,704	11,787	—	25,886	104,797
1995	17,451	3,268	4,722	8,083	16,324	—	29,126	151,334
2000	24,195	5,758	5,173	12,504	20,821	—	62,469	199,983
EU12[c]								
1990	2,927	254	203	1,314	3,021	10,994	n.a.	n.a.
1995	9,266	4,028	3,570	2,489	5,479	18,321	n.a.	n.a.
2000	11,782	5,402	4,532	4,315	8,188	49,853	221,631	439,972
World Total[a]								
1990	30,583	2,513	4,251	12,477	23,472	86,321	n.a.	n.a.
1995	95,682	32,468	42,744	26,752	52,240	168,171	n.a.	n.a.
2000	120,721	55,046	56,100	38,244	61,805	238,778	n.a.	1,218,827

Notes: See Annex IV-A (pp.87-88) of OECD (Organisation for Economic Co-operation and Development) [1994] "The Measurement of Scientific and Technological Activities using Patent Data as Science and Technology Indicators, Patent Manual 1994", Paris: OECD (http://www.oecd.org/dataoecd/33/62/2095942.pdf, accessed on 28 September 2005) for the trade classification codes of "knowledge-intensive products".

[a] Total of exports by economies listed in PC-TAS.

[b] ASEAN Five refers to Indonesia, Malaysia, the Philippines, Singapore and Thailand.

[c] EU12 refers to Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain and the United Kingdom.

[d] The Philippines' data is not included.

Source: Author's calculation on the basis of United Nations Trade Database PC-TAS.

Table 6. Inward FDI stock as a percentage of gross domestic product, by region and economy, 1980-2003

(Percent)

Economy	1980	1985	1990	1995	2003
Japan	0.3	0.3	0.3	0.6	2.1
Asia (excl. Japan)	17.9	20.9	17.9	19.1	30.3
Indonesia	13.2	28.2	34.0	25.0	27.5
Malaysia	20.7	23.3	23.4	32.3	57.2
Philippines	3.9	8.5	7.4	8.2	14.5
Singapore	52.9	73.6	83.1	78.7	161.3
Thailand	3.0	5.1	9.6	10.4	25.8
Cambodia	2.4	2.0	3.4	12.1	46.4
Laos	0.3	-	1.5	11.6	30.1
Myanmar	..	..	..	6.1	..
Vietnam	0.2	1.1	4.0	28.5	50.6
China	3.1	3.4	7.0	19.6	35.6
Hong Kong	623.8	525.5	269.6	163.4	236.5
Taiwan	5.8	4.7	6.1	5.9	11.9
Korea	2.1	2.3	2.1	1.9	7.8
India	0.6	0.5	0.5	1.6	5.4
Bangladesh	0.4	0.5	0.5	0.5	5.0
Sri Lanka	5.7	8.6	8.5	10.0	15.6
Pakistan	2.9	3.5	4.8	9.1	10.7
Nepal	0.1	0.1	0.3	0.9	2.5
Western Europe	6.2	9.3	11.0	13.3	33.0
Austria	4.0	5.6	6.1	7.4	23.7
Belgium and Luxembourg	5.8	21.2	27.8	38.3	-
Denmark	6.1	6.0	6.9	13.2	36.1
Finland	1.0	2.5	3.8	6.5	28.6
France	3.8	6.9	7.1	12.3	24.7
Germany	3.9	5.1	7.1	7.8	22.6
Greece	9.3	20.2	6.7	9.3	9.8
Ireland	149.9	157.7	71.5	60.2	129.7
Italy	2.0	4.5	5.3	5.8	11.8
Netherlands	10.8	18.8	23.3	28.0	65.6
Portugal	12.3	18.7	14.8	17.1	36.3
Spain	2.3	5.2	12.8	18.7	27.4
Sweden	2.2	4.2	5.3	12.5	47.5
United Kingdom	11.8	14.1	20.6	17.6	37.4
Central and Eastern Europe	-	0.2	1.3	5.4	23.7
West Asia	..	0.2	1.3	5.3	9.2
Pacific	22.5	24.8	29.2	27.1	40.6
Africa	8.2	9.9	10.8	15.6	25.3
Latin America, Caribbean	6.5	11.0	10.4	11.8	36.8
North America	4.5	5.5	8.0	8.3	15.4
USA	3.0	4.4	6.9	7.3	14.1
World total	6.7	8.4	9.3	10.3	22.9

Notes: .. Negligible - Not available.
Source: UNCTAD, *World Investment Report*, various years.

There is yet another nexus to knowledge-intensive international trade in the further "upstream" part of the whole economic process: knowledge creation itself. One aspect of this knowledge creation is reflected in intellectual property right figures, e.g., patent counts and royalty receipts and payments. In terms of patent counts shown in Table 7, most Asian economies listed (with the exception of Japan, and Korea to some extent) have smaller numbers of patent counts as knowledge creation than European economies, and those small numbers of patent counts are dominated by non-residents.

A close look at the Table might reveal ambivalent observations. On the positive side, as shown in the Table, most East Asian economies are increasing their number of local patent applications. Indeed, the numbers of patents filed by ASEAN economies in recent years exceed that for Korea in 1980. Yet on the negative side, again, their local patent markets remain both small relative to the U.S. as well as European economies, and dominated by foreign applications. Overall, it seems East Asian economies' knowledge creation has been disproportionately low vis-à-vis its midstream (production) and downstream (export) sizes.

Reflecting the small size of the patent application but disproportionately large demand for production technology, royalty receipts and payments, as in Table 8, register deficit (excess payments) for all the East Asian economies listed (including Japan). A more detailed observation, though, reveals that Korea has been an active "imitator", with as four times more payment counts than China, in 2002. The US, France and the United Kingdom, in contrast, serve as net donors of the knowledge, as the sheer volume of the royalty receipts in these economies suggests.

Table 7. Patent filed by East Asian and other economies, 1980-2001

(number)

Economy	1980	1985	1990	1995	1999	2001
East Asian economy						
Indonesia	-	-	-	-	42,503 (0)	77,407 (0)
Malaysia	282	1,080	-	4,052 (141)	6,451 (179)	- (-)
Philippines	904	1,551	1,256	97	3,361 (144)	13,598 (0)
Singapore	-	1,257	880	11,881 (10)	51,495 (374)	79,026 (0)
Thailand	-	-	-	-	5,071 (477)	5,665 (1,117)
Vietnam	-	9	29	16,982 (23)	42,212 (37)	76,542 (0)
Korea	4,041	5,339	20,595	96,557 (59,249)	133,127 (56,214)	190,022 (74,001)
China	-	417	28,176	41,773 (10,066)	52,348 (146)	149,294 (30,324)
Hong Kong	713	958	1,093	1,961 (23)	6,040 (42)	8,914 (74)
Taiwan	-	-	-	-	31,115	-
Japan	408,101	501,819	303,960	388,957 (335,061)	442,245 (361,094)	496,621 (388,390)
Other economies						
India	1,020	1,962	2,129	6,566 (1,545)	38,362 (14)	78,522 (234)
USA	62,280	72,238	91,245	235,440 (127,476)	294,706 (138313)	375,657 (190,907)
United Kingdom	-	-	12,699	115,754 (25,355)	192,875 (31,326)	264,706 (34,500)
Germany	59,179	67,666	69,943	136,615 (51,948)	220,761 (74,232)	292,398 (80,222)
France	30,349	18,554	15,430	89,766 (16,140)	138,455 (20,998)	175,122 (21,790)
Italy	7,953	47,793	14,824	64,955 (1,625)	128,260 (9,613)	156,858 (3,819)

Note: Figures in parentheses for 1995, 1999 and 2000 denote the number of patent applications filed by residents.
- not available.

Sources: The European Patent Office database (http://ep.espacenet.com/) for 1990; World Bank (2002) for 1995 and 1999; World Bank (2004) for 2001.

Table 8. Royalty receipts and payments for selected economies [a]

(US$ million)

Economy	1980	1985	1990	1995	2000	2002
Korea	23	3	37	299	688	826
	122	323	1,364	2,384	3,221	2,979
China	n.a.	n.a.	n.a.	n.a.	80.4	196
	n.a.	n.a.	n.a.	n.a.	1,281	491
Taiwan	n.a.	2	121	241	371	n.a.
	n.a.	150	582	937	1,834	n.a.
Malaysia	n.a.	n.a.	n.a.	n.a.	18	12
	37	n.a.	n.a.	n.a.	546	628
Philippines	n.a.	n.a.	1	2	7	1
	19	17	38	99	197	230
Thailand	n.a.	0.04	n.a.	0.6	8.7	7
	30	46	170	630	710	1,104
Japan	350	n.a.	n.a.	6,005	10,227	10,422
	1,330	n.a.	n.a.	9,417	11,007	11,021
US	7,080	6,680	16,640	30,290	38,030	44,142
	730	1,170	3,140	6,930	16,100	19,258
United Kingdom	1,135	1,162	3,055	6,080	7,538	7,701
	925	807	3,575	5,198	6,503	5,993
France	496	522	1,295	1,850	2,310	3,241
	1,028	982	1,629	2,320	2,051	1,956
Germany	608	617	1,987	3,134	2,821	3,765
	1,449	1,216	3,797	5,917	5,454	5,064
Italy	96	64	1,040	462	563	539
	450	332	1,959	1,166	1,198	1,273

Note: [a]Upper figures denote receipts, and lower figures, payments.
Source: International Trade and Investment Center (Japan) (2002); World Bank (2004).

Considering that even economically advanced Japan and Germany still remain net importers of knowledge in terms of the balance of royalty receipts and payments (as shown in Table 8), however, royalty payment is not a "bad option" for the country's economic development. After all, economical or efficient capturing of industrial knowledge pays off, be the knowledge generated inside or outside of the region. All told, most East Asian countries have not been creators of but recipients of "knowledge". Those East Asian economies' strategy was one of "catching up", i.e., they have been preoccupied largely with transforming themselves away from less lucrative commodity sectors including textiles and agricultural products towards more profitable, or rent-capturing sectors, represented most notably by the electrical/electronics and machinery sectors.[6]

[6] Malaysia's almost exclusive dependence on FDI in the electrical/electronics sector is a typical case in point (see, e.g., Hobday, 1999; Brooks and Hill, 2004).

5. Conclusions and prospects for future research

The knowledge-creation aspect of economic activity can be viewed as "dynamic" as opposed to "static" within the standard framework of trade analysis. While the importance of the former has long been recognized, however, theoretical sophistication has tended to focus on the latter. This paper has studied technological innovation with an emphasis on its "dynamic" evolutionary property: technological breakthrough takes place discontinuously yet on the basis of existing industrial operation. The important feature of this modeling is that once innovation has been made, it becomes more probable for the innovative producer to make further innovation. From this view, "innovating by doing" might be an appropriate characterization.

Theoretical part of this study has argued that those industrial fields with either rapid rate of innovation or difficult technological absorption exhibit the "winner-take-all" property, i.e., a large-scale exporter with state-of-the-art capital stock would build further upon its existing productive facility and facilitate the next round of innovative industrial operation, resulting in a larger export share than in the case of mature or standardized industrial sectors with little scope for further technological upgrading. With this in mind, the theoretical part of this paper has demonstrated conceptualization of knowledge-creation, or innovation, in conjunction with an evolutionary model of export-competition.

Empirical part of this study has first identified the stronger "winner-take-all" property for apparently more technology-intensive export commodities, exemplified most by the electronics and machinery products. The paper has next made an overview of East Asia's performance in terms of knowledge-utilization (rather than internal knowledge creation) and discussed that the region has basically been capturing the fruit of innovation from outside the region, through the conduct of attracting foreign direct investment undertaken by multinational firms. In spite of the region's status as a net importer of technology in the "upstream" part of the economic process, its export performance as the most "downstream" part of the economic process in general has been illuminating, especially in the said technology-intensive sectors.

As argued above, East Asia's economic dynamism is brought about by capturing innovation through direct royalty payment and foreign direct investment as indirect technology transfer: In essence, the region's economies have largely been "borrowing" from winners rather than "stealing" from them. East Asia has made an increasing resort to technology-intensive commodity sectors, the process of which has presumably been enabled through purchasing licensing and attracting technology-bearing inward foreign direct investment. What could be the welfare implication of the cycle of innovation and imitation?

Existing literature studying the impact of IPRs protection on the rate of technological development[7] points out that a large demand difference between developed "North" and developing "South" could serve as deterrent against potential IPR infringement, since such conducts in the developing South would discourage innovators in the North from incurring R&D costs for fear of potential free-riding by the South. In other words, a high level of IPR protection and observance in the South would encourage innovation in the North. On the other hand, an enhanced level of IPR protection is said to suppress economic growth in the South due to expensive imitation costs (Grossman and Helpman, 1991).

Under the circumstance of what could be termed "non-strategic" R&D investment, i.e., the investment being made anyway *irrespective of* the rival's behavior (the innovator's behavior for the imitator and vice versa), an increased pace of innovation and imitation between North and South (as a result of East Asian economic integration involving both developed and developing economies, for example) could accelerate the pace of "globalization cycle" (which is discussed in the former part of this paper). Considering the overall gains from innovation, therefore, acceleration of the full cycle of innovation and imitation might be a desirable option.

Prospects for future study would be as follows: Regarding innovation in its generic form, the importance of "heterogeneity" should be emphasized more in the theoretical formulation of innovation[8]: given the neoclassical treatment of "representative" (hence identical) firms, there seems to be little scope for depicting really "endogenous" innovation process except for an ad-hoc assignment of increased values to "total factor productivity". The model used in the present study is not free from this criticism. As for prospects for future research, therefore, dynamic gains from interaction among heterogeneous agents would seem to shed more light on the contentious arguments of whether or not "winner-take-all" innovation process is welfare-enhancing for the global society as a "monolith" or a coherent economic entity. In essence, non-strategic or "single-minded" engineering effort in pursuit of further innovation would in principle be desirable for the whole society.

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[7] See, for instance, Diwan and Rodrik (1991).

[8] Aoki (1996, 2001) constructs models of innovation and imitation among heterogeneous agents. This approach could be introduced in the theoretical formulation of international trade and investment with innovation arising from heterogeneity..

Appendix: Definition of commodity sectors in terms of Standard International Trade Classification Revision 3 (SITC-R3)

Commodity sector	2 digit code of SITC-R3
Agricultural products	00-05, 07, 08, 22, 29, 41-43
Food and beverages	06, 09, 11, 12
Mining products	27, 28, 32-35
Chemicals	23, 51-59, 62
Light industry products	21, 61, 81-83, 85
Wood and paper	24, 25, 63, 64
Textiles	26, 65, 84
Pottery products	66
Basic metals	67-69
General and precision machinery	72-75, 87, 88
Electrical machinery	71, 76, 77
Transportation machinery	78, 79
Others	89, 96, 97

Source: Fukao, Ishido and Ito (2003).

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