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Remaining innovative without sacrificing stability: an analysis of strategies in the Japanese pharmaceutical industry that enable firms to overcome inertia resulting from successful market penetration of new product development

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Abstract

Firms competing in increasingly technologically sophisticated markets have encountered a new set of challenges. Often as a firm becomes successful in technology development, inertia enters into the process. Successful co-evolution of technology often stimulates this inertia as a preference to just refine and market the same product, which ensures stability for the firm. Unfortunately, this tendency stifles innovation. We can observe this phenomenon by analyzing product changes in the pharmaceutical industry, which is a typical high intensive R&D industry. As an inevitable result of too much strengthening of a specific core field, one failure often observed is the inability to quickly move into complementary or different product areas. One survival solution is co-evolution of technology products developed in such a way that external and internal firm circumstances that affect the customer are constantly considered. The question this analysis addresses is, "How do we construct an interface between core and new products in order to simultaneously maximize core competence and yet at the same time remain flexible?" Institutional elasticity is one mechanism for creating such a trade-off between stability and ongoing new product development. Flexibility at the edge of product development could keep a firm from falling into a dangerous equilibrium position, thereby enabling it to remain innovative without sacrificing stability

Keywords: Co-evolution; Trade-off; Flexibility; Institutional elasticity; Innovation; New product development

1. Introduction

Firms competing in increasingly sophisticated technology markets have encountered a new set of challenges. Responding to customer needs is crucial for survival, while for society as a whole, there are requirements for expanding the reach of technological benefits to larger numbers of individuals.

At the firm level, maximizing customer satisfaction by providing an efficient internal manufacturing system and simultaneously securing flexibility corresponding to dynamic and rapid change have become important aspects of any competitive survival strategy. It is well known that incremental product innovation is well managed by cooperation between marketing knowledge and technology knowledge (Allen, 1966; von Hippel, 1979, 1980, 1982, 1988; Clerk and Fujimoto, 1991; Ohno, 1988; Fujimoto, 1993; von Hippel et al., 1999). The innovator has the dilemma of constantly changing and consequently often fails to survive (Bower and Christensen, 1995; Christensen, 1997). Firms very often fail to seize opportunities to master the dynamics of innovation in the face of technological change (Utterback, 1994).

Knowledge creation theorists suggest that organizations that can control the chaos between rapid technology and market change recognized will survive (Nonaka, 1991; Nonaka and Takeuchi, 1995; Nonaka et al., 1997; von Krogh et al., 2000). To maintain a core competence,

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it is important to bring both technical and managerial branches of an organization together to ensure that future changes are appropriately made. Recent study has in particular recognized the importance of the search for management-driven marketing opportunities (Hamel, 2000). The competitive innovator typically succeeds in bringing new technologies to market, but this ultimately leads to failure as firm inertia encourages the innovator to over depend on technology already in place instead of exploring new technology opportunities.

As an inevitable result of too much strengthening of a specific core field, one failure often observed is an inability to quickly move into complementary or different product areas. One survival solution is co-evolution of technology products developed in such a way that external and internal firm circumstances affecting the customer are constantly considered. The question this analysis addresses is, "How do we construct an interface between core and new products in order to simultaneously maximize core competence and yet at the same time remain flexible?" Institutional elasticity is one mechanism for creating such a trade-off between stability and ongoing new product development.

Intriguing in-depth recent case studies on Sears Roebuck, Monsanto, Royal Dutch Shell, the US Army, British Petroleum, Hewlett Packard and Sun Microsystems (Pascale et al., 2000), demonstrate that in business, as in nature, there are no permanent winners. There are just firms that either react to change and evolve, or those that get left behind and become extinct. Equilibrium is a very dangerous position for survival, and innovation usually takes place on the edge of chaos. Self-organization and emergence occur naturally. Organizations are generally more turbulent than directed.

Monsanto has successfully remained on the edge of the new business front managing the trade-offs in technology co-evolution. However, although it has leading core competence for technology in the bio- and life-industry, it could not move beyond its core products and merged with Pharmacia Upjohn in 2000 due to a systemic disconnect between management, technology and market signals. This clearly shows that core competence for technology is not sufficient for successive survival.

At the society level, serving the needs of those in society who do not have full access to the market is an equally important goal. What are the aspects, in the notion of co-evolution of technology, which can affect the lives of those who cannot yet participate in the market? Can co-evolution of technology increase accessibility for the treatment of diseases common to the poor? Can it increase the availability of public goods such as a clean environment or wider public health coverage? Is it possible for this market-based mechanism to provide greater access to the basic amenities of life? This article attempts to address these possibilities, which confront firms and society in the 21st century.

Section 2 outlines the successful co-evolution of technology in a high intensity R&D industry. Section 3 examines the concept of overcoming the inertia of having a successful product in the marketplace and yet remaining flexible. Section 4 evaluates strategic alliance as a key mechanism of technology spillover which continuously stimulates flexible technology development and Section 5 briefly summarizes concluding remarks and implications.

2. Successful technology co-evolution in the high intensity R&D industry

For successful industrial growth, the most crucial issue is the successful development and marketing of innovative products. Successful co-evolution is embodied in continuous product development that moves technology to the marketplace. Fig. 1 shows 18 new products and the number of years from major technology discovery to first market launch in the 20th century. Surprisingly, the period from technology development to market is much shorter after World War II. In the post-war era, all major technologies were launched within 4 years from first discovery. One characteristic of this time period is a high R&D intensity.

Fig. 2 compares R&D intensity among industries in Japan. The R&D intensity of the pharmaceutical industry is outstanding. This is because medical supplies are purely based on R&D (Dimasi et al., 1991; Cockburn and Henderson, 1994; Henderson and Cockburn, 1994). R&D intensity (the ratio between R&D expenditure and sales) in Japan's pharmaceutical industry was 8.1% in 1998, which is the highest across all industries. Even Japan's well-known manufacturing industry's average R&D intensity is only 3.9%. The high R&D intensity of the pharmaceutical industry is universal in all leading countries because new medicines require intensive R&D activities, including huge investments in R&D resources. Therefore, the pharmaceutical industry must be a technology driven industry. Huge amounts of R&D resources are required for generating new products. However, these resources are generally a large burden for smaller pharmaceutical firms as well as larger pharmaceutical firms, compelling them to depend on effective utilization of technologies and research developed by their competitors. How to best utilize these technologies depends on assimilation capacity. Firms with a well-developed assimilation capacity succeed in effectively utilizing technology spillover resulting in a very productive R&D structure.

One myth of technology development in Japan is that it is widely believed that Japanese companies are not good at new product innovation, but rather rely on improving existing products. In fact, Japan's pharmaceutical industry produces globally innovative products.

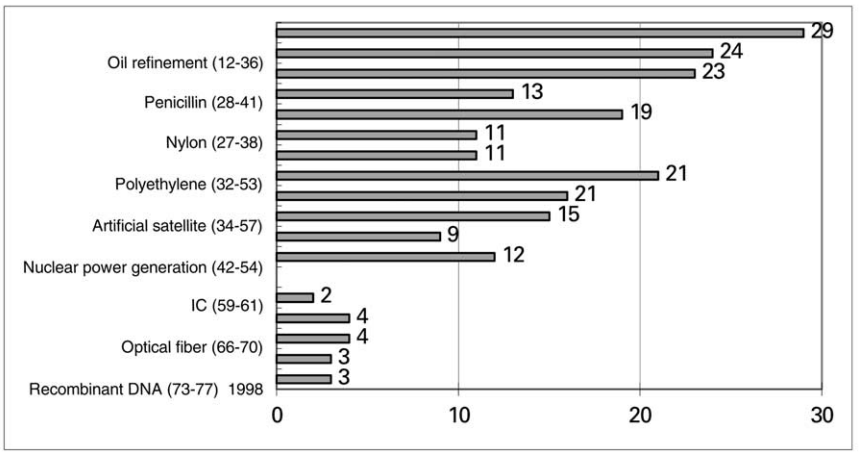

Fig. 1. Years from major technology discovery to first market launch.

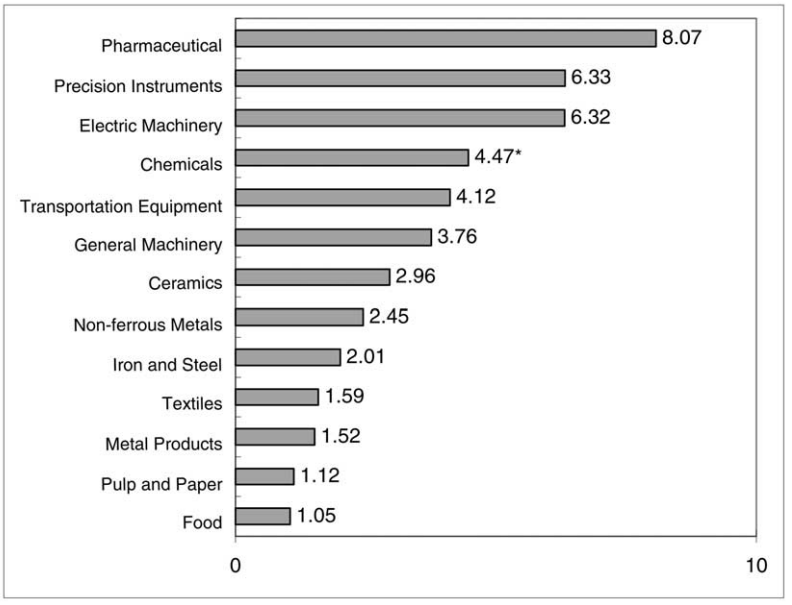

Fig. 2. R&D intensity in Japan's pharmaceutical industry in 1998. R&D expenditure per sales (%); chemicals: do not include pharmaceutical.

Fig. 3 demonstrates the strength of Japan's pharmaceutical industry. The revenue by export exceeded the payment of imports in 1996. This indicates that Japan's new product development (NPD) in the pharmaceutical industry is accepted as globally competitive.

One critical issue confronting all advanced countries is how to construct a highly productive R&D structure. Pharmaceutical firms with their highly productive R&D structure based on well-developed assimilation capacities provide us with a constructive model for addressing this issue at the national level. An empirical analysis of R&D activities was undertaken focusing on inter-firm technology spillover in Japan's 30 leading R&D intensive pharmaceutical firms (Watanabe et al., 2001). Further work covered the last two decades elucidating the sources of success in constructing a highly productive R&D structure and proved the existence of original core field of each firm as a base of core competency (Takayama et al., 2001).

The market leader is generally in the best position to collect technology seeds and market needs through a network of customers. In the pharmaceutical industry, due to strong contact with professionals (often doctors) as customers, market leaders can often utilize their superior position to collect leading information on market and technology. The professional serves as the change agent (Rogers, 1995) for the market leader. This strong relationship with professionals contributes towards keeping a good position for incorporating the market needs and technology seeds into their market knowledge and technology knowledge, and hence enforces the core competence for continuous technology co-evolution. As

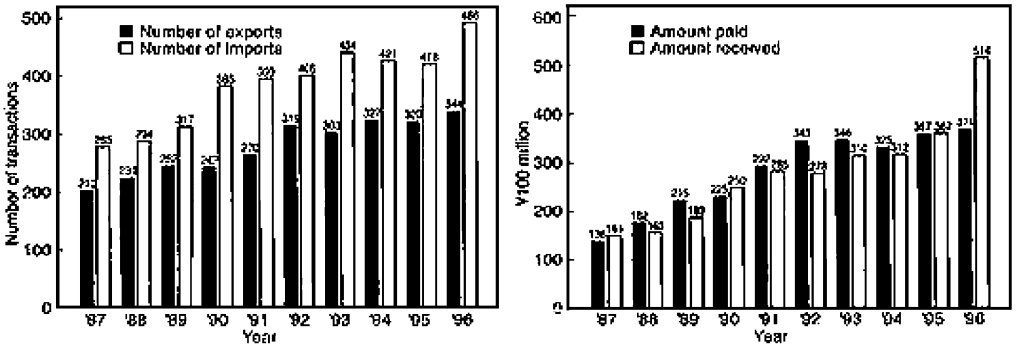

Fig. 3. Export/import ratio of Japan's pharmaceutical industry. Source: JPMA, 2001.

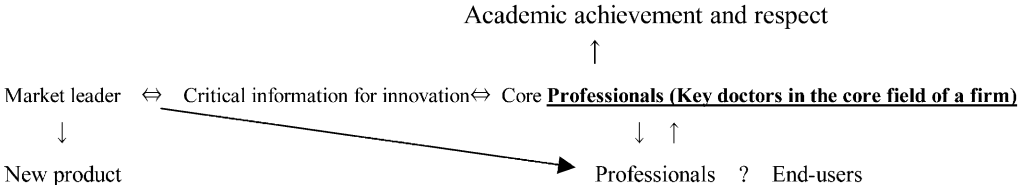

Fig. 4. Co-evolution between (core) professional and market leader.

summarized in Fig. 4, co-evolution between the (core) professionals and market leaders is based on a give-and-take relationship between the core leaders and core professionals. To identify the next research target for the next new product, the market leader has the best position to collect sufficient information on the next product.

For the existing firms, responding to customer needs is crucial for survival. In addition to the high R&D intensity of the pharmaceutical industry, the average development cost is 300–1000 million dollars for one product and is increasing rapidly as shown in Table 1. Table 2 summarizes that the success ratio of NPD was approximately 1/6000 between 1992 and 1996. Notwithstanding the high risk of investment, the time of exclusivity of a product is extremely short and recently dropped to less than one year very recently. The survival strategy of pharmaceutical R&D is represented by a robust co-evolution structure of successful technology and marketing competence through a leading customers network.

In addition, the exclusive period of an innovative product became shorter. The innovator can enjoy exclusive profit until a similar product is launched in the market, but this time frame is decreasing. Fig. 5 compares the exclusive period from the launch of an innovative product to the introduction of a competing product in the pharmaceutical industry. In the 1960s this period was 10 years. In 1998, it was less than five months. This fact clearly means that development of the same type of product by different firms is usually initiated almost simultaneously. In fact, market leaders all know possible R&D targets for an innovative product through professional networks. The most critical issue to a pharmaceutical firm is the selection of the next target for competitive survival. The character of the competition has greatly intensified among the pharmaceutical industry's players (Grabowski and Vernon 1990, 1994).

This phenomena in the pharmaceutical industry indicates that one key for successful co-evolution in a high intensity R&D industry is core competence for competing in increasingly technologically sophisticated mar-

Table 1
R&D expenditure/product (unit: M$)

	1991	1994	2000[a]
USA[a]	M$230	M$400	M$1000
Europe[b]	150	300	700
Japan[c]: large-size firms	128	300	600
Japan[c]: middle-size firms	80	160	300

[a] Source: USA: estimated by Purdue University.
[b] Source: Europe: survey of Inter Pharma Consulting.
[c] Source: Japan: estimated by Japanese Licensing Association.

Table 2
Success ratio of new pharmaceutical product (calculated from data for 17 member companies of JPMA for the 5 year period of 1992–1996)

Stage	Number of compound	Ratio to become the next stage	Accumulated success ratio
Synthesized compounds in discovery research stage	32,0832		
Pre-clinical study	280	1:1146	1:1146
Clinical studies	167	1:1.68	1:1,921
Submission for new drug approval (NDA)	106	1:1.158	1:3027
NDA approval	(88)	(1:1.120)	(1:3646)
Self-made compounds from discovery research phase	53		1:6053
Under license compounds	(35)		

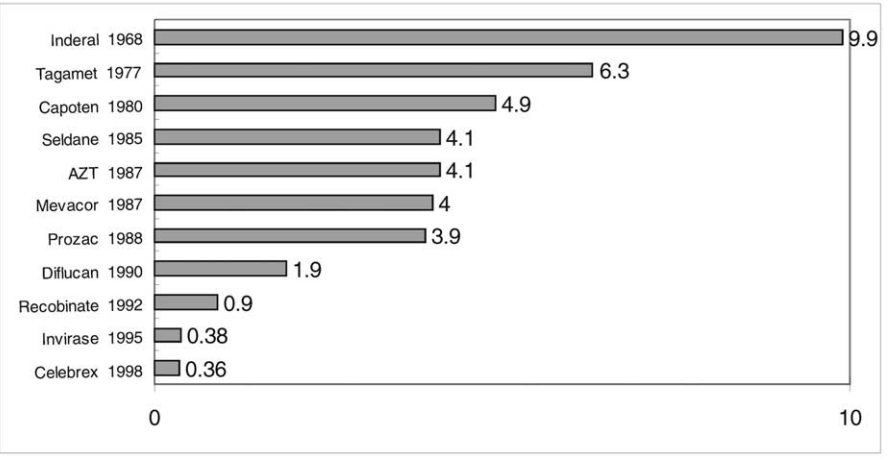

Fig. 5. Exclusive period of innovative products (in years). Source: Survey by Pricewaterhouse Coopers, November 2000.

kets. Maximizing customer satisfaction with dynamic, rapid change is more and more important for survival. Therefore, technological competence should be harmonized and synergized with marketing for successful NPD.

It should be noted that the key to successful co-evolution in high intensity R&D industries differs between industry types. As explained in Table 3, the essential core competencies for creative R&D are integrity in the assembly/manufacturing industry and originality in the material industry sector. The importance of isolated creative activity has been universally discussed and described for product innovation in the material industry, which includes the pharmaceutical subsector (Galbraith, 1976). If so, can isolation from operations actually result in best performance for successful co-evolution?

3. Remaining flexible while maintaining stability

It is generally believed that strong players who understand markets and technology take the lead in terms of product innovation. For this reason, a market leader has a stronger position in making an innovative product successful using its marketing and technological competence to connect with market needs and nurture appropriate technology seeds (Freeman, 1982; Dosi, 1982, 1984; Dosi et al., 1988).

Table 3
Key factors for successful co-evolution in high intensity R&D industry

	Crucial factor of core competence for successive NPD	Essential competence for creativity
Assembly industry	Integration of parts	Integrity
Material industry	Spot searches	Originality

If knowing marketing needs and technology seeds are enough to develop new products, market leaders with research capability hold the best position to become successful in a field (Hammer and Champy, 1993; Pfeffer and Sutton, 2000). However, in actual business practice, reality is quite different. It is well known that a successful leader is often displaced (Porter, 1998; Porter and Takeuchi, 2000).

When a novel technology emerged, technology serves as a major driving factor to introduce another relevant new product into a market. It is also well recognized that market knowledge can stimulate successful NPD. It seems to be obvious that market knowledge assists successful co-evolution by accumulating technology knowledge. Apparently, both technology knowledge and market knowledge are able to serve as key factors that enhance successful NPD. If so, the market leader can keep its leading position in the market for the next generation of new products and hence the market leader cannot be easily taken over by a new comer even if a new product creates a new market.

In pharmaceutical products, we have selected the anti-hypertensive product to focus on the mature stage of market needs and technology 'seeds' for product innovation. In this mature stage, all the companies recognize the research target for the existing innovative product since market needs and technology seeds are commonly shared among all firms (Takayama and Watanabe, 2001).

Two categories of products such as the Ca antagonist (Ca) and the ACE inhibitor (ACE) were prevailing pharmaceutical products in the anti-hypertensive market as seen in Table 4. In the Japanese anti-hypertensive medication market, Ca had the biggest share. Most Japanese firms perceive that Ca is most effective for treating patients with hypertension.

The merit of Ca is that it works quickly to reduce blood pressure. The demerit of Ca is that it cannot be used to treat patients with a risk of organ malfunction such as diabetic and hyper-lipidemia. ACE is recognized as the second choice product due to its mild efficacy, although ACE can be used with patients that have a risk of organ malfunction (JPMA, 1999; Pharma Projects, 2001).

Very recently, another category of anti-hypertensive product, ATII antagonist has been marketed in the USA, Europe and Japan (Scrips Magazine, 2000). It is a new technology-push product discovered by finding the involvement of ATII to elevate blood pressure. The ATII antagonist (ATII) does not only have no cough side effect but also can be used with patients at risk of organ malfunction. Due to the organ protection function, ATII can treat diabetic patients, kidney malfunction patients, heart disease patients, etc. but the efficacy is between ACE and Ca. ATII is superior to ACE and yet differentiated. Table 5 summarizes the position of ATII in the market and in the R&D of NPD.

Compared to Japan, American and European consumers are concerned about the risk of organ damage due to the difference in life style. Disease trends are changing in Japan because of the increase of 'life-style disease'. However, the organ protection function of ATII will become more important also in Japan in the near future similar to the USA and Europe. ACE has no warning label for diabetes patients due to the mild efficacy but does produce some side effects such as a cough.

The top Japanese pharmaceutical company (Takeda) made the first ATII product in the world and its potency is the strongest. Nevertheless, even though it was originally discovered by a Japanese firm, it took a long time in Japan to convince firms that ATII would expand in the anti-hypertensive market and would replace some old products including Ca (Monthly Mix, September 1999). that the market, however, moved quickly and ATII became the top drug in the anti-hypertensive medication market obtaining 67.5% of the prescription rate for new patients (Monthly Mix, September 1999). The original hesitation of Japanese firms to introduce the product into the market effectively 'killed' the opportunity for the product to get the leading position in newly emerging markets. American and European companies took the prevailing position in Japan as evidenced in Table 6. Although seven products are marketed or are in development in 2001, all of the other products (more than 20) were developed by Japanese firms and discontinued due to the delay in the start of development.

The behavior of major players of ACE and Ca in Japan are summarized in Tables 7 and 8. ACE players could catch up with the development of ATII since ATII is a superior product to ACE.

This finding is also applicable to American and Euro-

Table 4
Anti-hypertensive market in Japan, USA and Europe (source: IMS World Review, 1999)

	Japan (%)	USA (%)	Europe (%)
Ca blockers	51.1	37.4	28.3
ACE inhibitors	25.0	36.4	43.1
Beta blockers	13.8	11.6	13.2
Alpha blockers	5.6	9.6	6.8
Diuretics	4.4	5.0	8.6

Table 5
Competition of ATII to the existing products

	ACE inhibitor	Ca blocker
Competitive advantages in the market	Superior	Differentiated
Style of market penetration	Replaced	Produce new market
Influence to new product development	Enhancing	Inhibitory

Table 6
Final stage of competition of ATII in the Japanese market (source: authors' interview to firms and physicians based on Asuno Shin-yaku, February 2001)

Product	Firm (Licensee)	Order of launch	Year of launch
Losartan	Merck (Banyu)	1st	1998
Candesratn	Takeda	2nd	1999
Valsartan	Novartis	3rd	2000
Telmisartan	Boehringer Ingelheim	4th	2002
Irbesartan	BMS (Shionogi)	5th	2002
CS-866	Sankyo	6th	2003
KD-671	Kotobuki (Daiichi)	7th	2004

Table 7
Japanese leading top 10 firms of Ca antagonist in 2000 and the development of ATII (source: IMS Health data base, February 2001)

Leading firms	Market share (%)	Development status of ATII in Japan
Pfizer (US)	27.2	No
Bayer (Germany)	14.8	No
Sumitomo	13.6	No
Kyowa Hakko Kogyo	11.0	No
Yamanouchi	7.1	No
Tanabe	7.0	No
Fujisawa	5.6	No
Takeda	5.0	2nd
Welfide	1.9	No
Mochida	1.2	No

Table 8
Japanese leading top 10 firms of ACE in 2000 and the development of ATII (source: IMS Health data base, February 2001)

Leading firms	Market share (%)	Development status of ATII in Japan
Banyu	28.4	1st
Tanabe	15.8	No (Ca)
Sankyo	15.4	6th
Shionogi	7.7	4th
Daiichi	5.7	9th
Dainippon	4.5	No
Eisai	4.5	No
Welfide	3.4	No
Novartis (Switzerland)	3.3	3rd
Zeneca (UK)	2.7	No

pean firms. In the top 10 firms in the global Ca market given in Tables 9 and 10, none of the firms have internally developed ATII. The behavior of ACE leaders is different and the positive behavior of leading companies for developing ATII and ACE/NEP is definitely a contrast to the Japanese firms. As shown in Table 10, seven of the top eight leading companies that have no Ca are developing their own products and one company is developing a licensed product.

Table 9
World leading top 10 firms of Ca antagonist in 1998 and the development of ATII (source: IMS World Review, 1999 (The Pharmaceutical Market))

Leading firms	Market share (%)	Development status of ATII in USA and/or Europe
Pfizer	33.9	No
Bayer	12.8	No
Hoechst	9.0	3rd (license-in from SmithKline Beecham)
Astra	3.7	5th (license-in from Takeda)
Basf	2.7	No
Monsanto (Searle)	2.4	No
Kyowa Hakko Kogyo	2.2	No
Yamanouchi	2.0	No
Takeda	2.0	9th license-out to Recordati
Novartis	2.0	Originally No (2nd)

Table 10
World's leading top 10 firms of ACE inhibitor in 1998 and the development of ATII (source: IMS World Review, 1999 (The Pharmaceutical Market))

Leading firms	Market share (%)	Development status of ATII in USA and/or Europe
Merck Co.	31.0	1st
Zeneca	13.4	5th (license-in from Takeda)
Bristol-Meyers Squibb	10.7	4th and 1st of ACE/NEP inhibitor
Warner-Lambert	6.4	No
Novartis	5.3	2nd
Hoechst	3.8	3rd
Servier	3.7	2nd of ACE/NEP inhibitor
Tanabe Seiyaku	1.9	No
Banyu Seiyaku	1.8	1st (Merck's Japanese affiliate)
Sankyo	1.7	8th (license-out to an European company)

By analyzing the characteristics of the behavior of the pharmaceutical companies for the product change in an anti-hypertensive market, it is demonstrated how strongly an existing product inhibits the product change when new products are differentiated creating a new market as described in Table 5. The company acts to increase the strength of its own product as a market winner in Ca based on the strength of its own product (Monthly Mix, April 1999). This reduces the market value of a new product and inhibits creation of a new market.

In conclusion, product innovation to create a new market by means of differentiation is inhibited by the marketing of a firm's successful existing products and the market knowledge that is acquired to gain or accumulate expertise through marketing of such products. Thus, inertia in the marketplace is created.

4. The strategic alliance as a technology spillover mechanism in technology development

We have already demonstrated the role of a core field for a firm as a base of core competence for high intensity R&D industries (Takayama et al., 2001). To focus on a core field for each firm, a licensed alliance product can be utilized as a tool for maintaining or injecting originality. This finding was demonstrated by a comparative study of the core fields of each firm in Japan's pharmaceutical industry.

The significance of enforcing core competence for creativity in new product development, while hedging risks against dynamic changes in customer preference, has emerged as a key strategic consideration (Hamel and Prahalad, 1994a,b; Hamel, 2000). In order to reduce risk, a strategic alliance is recognized as an effective tool. By utilizing a loose and flexible strategic alliance as insurance, it is possible to balance the trade-off between maximizing a firm's core competence and securing flexibility.

To clarify the role of assimilation capacity through technology spillover for successive NPD involving strategic alliances in the pharmaceutical industry, we selected 11 firms from among 30 leading Japanese pharmaceutical companies. Surprisingly, alliance products are utilized as a tool for maintaining a core field, and they are very often pulled from the major product pipeline once a firm has developed its own original product. This

finding is proven by the fact that peak sales are smaller for licensed products than in-house products. Moreover, product lifetimes are shorter for licensed products than in-house products as summarized in Table 11.

We then undertook to develop an alliance index to survey the utility of an alliance product. The alliance index is defined as the ratio of peak sales of an alliance product versus the peak sales of an in-house product. Comparing all alliance indices, the alliance indices of Ono and Yoshitomi are the highest at 1.94 and 1.57. Also, peak sales of the alliance product is much higher than peak sales of the in-house product. Fig. 6 analyzes the utility of alliance products. In Yoshitomi's case, it did not launch a major in-house product within 6 years after the launch of an alliance product in its core field. It needed products to keep contact with professionals in the market. Therefore, the lifetime of the alliance product extended over a very long period of time.

In contrast, the indices of Sankyo and Daiichi are the lowest at 0.118 and 0.154. Fig. 7 shows an example of new market creation by using an alliance product as a tool for technology spillover by creating greater assimilation capability. The lower index is due to the creation of a new core field by catching up with the in-house product. Special cases of sales trends for those alliance products are shown in bold line in Fig. 7. Once a firm creates a new core field by its own in-house product, the alliance products are pulled of the market.

Our findings are summarized below:

1. *Alliance utility index <0.16.* The alliance product is used as leverage for creating a new core field through in-house product development.
2. *Alliance utility index >1.5.* To complement a firm's product pipeline in its original core field, the alliance product is strategically used as a tool for linkage, in case the period between in-house products is over eight years.

The above findings demonstrate not only the nature of the alliance product but also the assimilation capacity of a firm based on NPD from the alliance product. Furthermore, the knowledge spillover, including technology spillovers and marketing knowledge spillovers, are successfully managed in the well-known territory of the original core field for each firm before the firm shifts core fields. Based on this transition between an alliance product and the firm's own product, assimilation capacity is maintained in the original core field for each firm. Thus, to compete in rapidly changing pharmaceutical markets, both efficiency and creativity is maintained in NPD by using the alliance product strategy. In conclusion, the key for co-evolution of creativity and efficiency is the constant injection of original products. Originality is nourished in the core field for each firm through this process, which enables the firm to achieve

Table 11
Peak sales of major products in the core field of major Japanese pharmaceutical firms

Firm	Origin of product	Average peak sales (10 billion yen)	Alliance index ratio of peak sales (Alliance/In-house)
Takeda	Alliance	8.2	0.607
	In-house	13.5	
Sankyo	Alliance	12.9	*0.118*
	In-house	109.2	
Yamanouchi	Alliance	10.1	0.467
	In-house	21.6	
Daiichi	Alliance	7.0	*0.154*
	In-house	49.9	
Fujisawa	Alliance	7.3	0.238
	In-house	30.7	
Tanabe	Alliance	6.9	0.361
	In-house	19.1	
Ono	Alliance	17.3	*1.94*
	In-house	8.9	
Yoshitomi	Alliance	8.5	*1.57*
	In-house	5.4	
Santen	Alliance	9.5	0.703
	In-house	13.5	
Total	Alliance	9.2	0.430
	In-house	21.4	

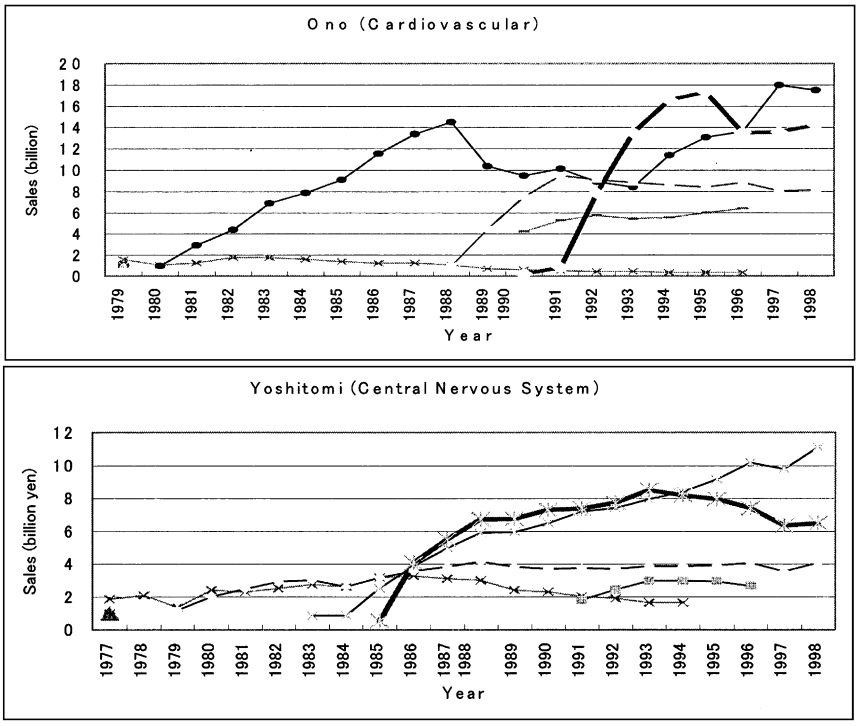

Fig. 6. Highly utilized case of alliance product. The bold line represents the alliance (license-in) product.

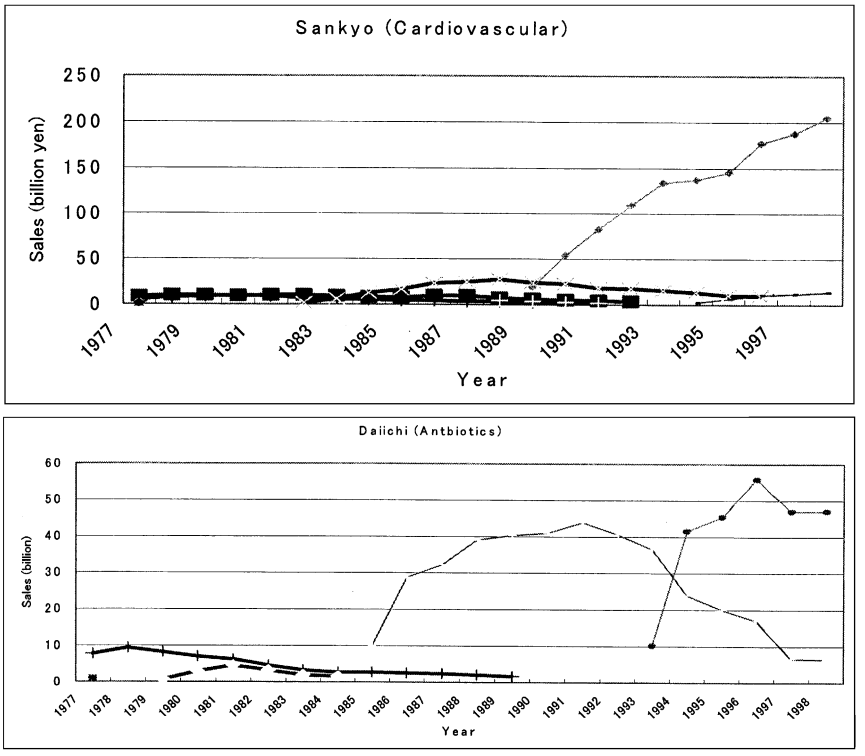

Fig. 7. Creation of new core fields through utilization of alliance products. Bold lines represent alliance (licensed) products.

cumulative development along with unique product development along a new core competence path. The role of the alliance strategy is to work as a linkage for continuous NPD, and to function as a tool for stimulating creativity while maintaining efficiency.

The pharmaceutical industry differs from assembly-type industries because R&D begins with spot searches. This kind of R&D has been very much influenced by technology change and customer preference. On the edge of technology and product change, the pharmaceutical industry has a mechanism to address the need for technology co-evolution by licensing alliance products. Notwithstanding the high risk and low success ratio structure, alliance products can be easily pulled through in-house product development. Therefore, firms cannot avoid the structural problem of giving attention to in-house R&D and in-house product development. Typically, this is a dilemma for high intensity R&D industries.

5. Concluding remarks and implications

As shown by the above analysis of the behavior of pharmaceutical firms, even if new product development can be carried out in a technology-push manner, new products are often not successfully developed. A lack of appropriate marketing knowledge is sometimes a failure factor for successful NPD even if a new product creates a new market. This contributes to the focus of management in terms of R&D capability, which must maintain momentum in the marketplace while developing new products.

This investigation shows that in Japan's pharmaceutical industry, alliance products are not only fully utilized for maintaining and nourishing core fields. Rather, these products are abandoned within a short time frame. Looking at the ambiguity and uncertainty of change in customer preferences, it could be thought that alliance products would be used effectively. However, because of extremely tough competition and the high risk of R&D investment, alliance products are used only as a linkage between in-house products.

In the pharmaceutical industry, enormously high R&D investment requires a rigid structure in which technological competence must be harmonized and synergized with marketing competence for successful technology co-evolution to take place. Although there is a rigid structure in which marketing core competence is tied to technological core competence, this system works as a strong support for enforcing the original core field of individual firms. Therefore, it potentially creates inertia which keeps a firm from moving beyond its past. This rigid structure also accelerates the early abandonment of alliance products and tends to ensure over-investment in a core field of each firm.

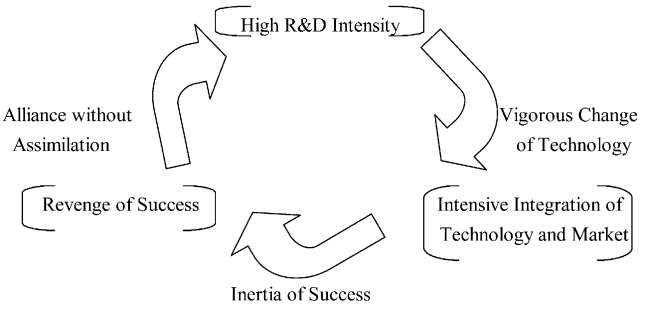

Fig. 8. Inertia cycle of high R&D intensity.

In addition, because of hyper-competition resulting in extremely high R&D intensity, the environment surrounding the pharmaceutical industry is such that the firm that remains competitive must be in a highly 'qualified' position. To maintain a qualified position in the market, technological core competence and marketing core competence have been rigidly united for NPD. This structure tends to cause an excess of R&D investment and is a structural cause of inertia in R&D as illustrated in Fig. 8. In this cycle, a new opportunity has stolen the position of a market winner because of rapid product change brought about because of rapid technological innovation.

The condition that produces the ability to overcome this cycle is the case in which a new product creates a new market by differentiating itself from an existing product. When a new product emerges from the interface between market and technology, a different R&D structure should be undertaken. For managing this interface between market and technology, a loosely unified assessment system is essential, and it must not be isolated such as in the case of an incubator system. However, the assessment system for differentiated products should be somewhat separate from the ongoing primary product structure in order to simultaneously maximize core competence but enable flexibility.

In summary, institutional elasticity addresses the need to balance trade-offs in the co-evolution of technology. Instead of firms getting stuck at equilibrium and ultimately losing their position, they can use strategic alliances to avoid inertia and continue to create completely new innovations yet at the same time maintain a competitive market position.

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