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A new dimension of potential resources in innovation: A wider scope of patent claims can lead to new functionality development

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Abstract

Notwithstanding a significant expectation to increase the contribution of technology to productivity in megacompetition, the productivity of technology in Japan's high-technology industry has been declining, resulting in a decrease in competitiveness.

The only solution to this twisted trap is to shift the current vicious cycle between R&D, technology stock and production to a virtuous cycle. Given strong constraints in fiscal investment, a practical solution to achieving a virtuous cycle is effective utilization of potential resources in innovation. A wider scope for patent claims can be an ingenious trigger leading to a virtuous cycle involving new functionality development, increased productivity of technology, production increases, greater R&D investment and a sustainable wider scope of patent claims.

Japan's Patent Office introduced the Revised Examination Guideline (June 1993 Examination Guideline), including description requirements for patent applications. This induced leading high-technology firms to broaden their scope relative to claiming patents and succeeded in constructing the foregoing virtuous cycle, thereby demonstrating the significance of a new dimension of potential resources in innovation.

On the basis of an empirical analysis focusing on techno-managerial efforts by Japan's pharmaceutical firms with both indigenous and the US capital, this paper attempts to demonstrate the foregoing hypothetical view.

A noteworthy implication obtained from the research is that while leading pharmaceutical firms with indigenous capital have constructed a virtuous cycle by means of a wider scope of patent claims and have achieved new functionality development as a result, firms with the US capital have demonstrated a higher level of performance.

Keywords: Potential resources in innovation; New functionality development; Patent claims; Pharmaceutical

1. Introduction

Notwithstanding a significant expectation to increase technology contribution to productivity in a megacompetition, productivity of technology in Japan's high-technology industry has been declining resulting in decreasing its competitiveness. This can be attributed to the organizational inertia in an industrial society impeding an elastic shift corresponding to a new paradigm in an information society that emerged in the 1990s (Watanabe and Nagamatsu, 2003).

Among high-technology industry, pharmaceutical industry displays the outpacing R&D intensity urging the industry heavy burden of R&D investment while at the same time gigantic R&D challenge has become indispensable for the firms in the industry to survive (Watanabe, 2003). Consequently, M&A between leading pharmaceutical firms has been increased in Japan aiming at securing the economies of scale, particularly for R&D.

However, given the declining trend in technology productivity, such efforts in securing huge resources for R&D is anticipated to decrease firms operating income (Watanabe et al., 2001).

Only a solution to this twisted trap is shifting a vicious cycle between R&D, technology stock and production to a virtuous cycle, and given the strong constraints in fiscal investment, practical solution toward this virtuous cycle can be expected by the effective utilization of potential resources in innovation Kryazhimskii et al., 2002; Watanabe et al., 2003b). While every efforts for maximum utilization of potential resources in innovation has been endeavored by high-technology firms including efforts for cumulative

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learning and assimilation of spillover technology, effects of these efforts have been stagnating urging pharmaceutical firms to explore new dimension of potential resources in innovation (Takayama et al., 2002).

Patent protection or wider scope of patent claims can be a prospecting soft policy instrument corresponding to such requirement of the new dimension (Arora et al., 2003; Crepon and Duguet, 1997; Jaffe, 1999; Sakakibara and Branstetter, 1988). This can be an ingenious trigger leading to a virtuous cycle of new functionality development, increase in productivity of technology, production increase, higher R&D investment and sustaining wider scope of patent claims.

Induced by an introduction of the Japanese Patent Office's Revised Examination Guideline in June 1993, including description requirements for patent applications, Japan's leading pharmaceutical firms devised to wider scope of patent claims and succeeded to construct the foregoing virtuous cycle demonstrating the prospecting new soft policy instrument corresponding to the requirements of the new dimension of potential resources in innovation.

To date, while not a few works have undertaken for identifying effective policy and firms strategy toward maximum utilization of the potential resources in innovation (Thomas, 2004; Takayama and Watanabe, 2002; Watanabe et al., 2002) and also the significance of the patent strategy for the competitiveness of pharmaceutical industry (Penner--Hahn and Shaver, 2000), none has undertaken the significant role which the wider scope of patent claims might play.

In light of the foregoing state with respect to the low development of the identification of the possible contribution of the new dimensional approach by means of the wider scope of patent claims, this paper attempts to assess the significance of this approach for the shift from current vicious cycle to a virtuous cycle between new functionality development, increase in productivity of technology, production increase, higher R&D investment and sustaining wider scope of patent claims.

On the basis of an empirical analysis focusing on techno-managerial efforts in Japan's leading pharmaceutical firms both with indigenous capital and the US capital, demonstration of the foregoing hypothetical view is attempted.

Section 2 reviews current state of Japan's high-technology industry amidst megacompetition. Section 3 provides analytical framework. Section 4 presents the results of the analysis and their interpretation. Section 5 briefly summarizes new findings and their policy implications.

2. Japan's high-technology industry amidst megacompetition

Fig. 1 compares trends in manufacturing industry's marginal productivity of technology (MPT) between Japan and the US over the period 1976–2000. Looking at the Figure we note that while Japan demonstrated higher MPT than the US up until the end of the 1980s, its MPT dramatically declined in the 1990s corresponding to the emergence of an information society. Contrary to such a decline in Japan, the US manufacturing industry maintained higher MPT over the decade. These trends clearly demonstrate that notwithstanding a significant expectation to increase the contribution of technology to productivity in megacompetition, the productivity of technology in Japan's high-technology industry has been declining, resulting in a decrease in competitiveness.

Fig. 2 compares trends in R&D intensity (ratio of R&D expenditure and sales) in Japan's manufacturing industry over the period 1980–2000. Fig. 2 clearly demonstrates that pharmaceutical industry maintains conspicuously high level of R&D intensity as 9–10%. The Figure also demonstrates that this intensity in pharmaceutical industry has been saturated in recent years suggesting the severe burden of such a huge amount of R&D expenditure as 10% of its sales (Watanabe et al., 2003a).

Table 1 tabulates sales and R&D expenditure in Japan's leading 30 pharmaceutical firms in 2000 which suggests that these 30 firms share 74% of the Japanese pharmaceutical industry's sales and 90% of that of R&D expenditure, respectively. Table 1 also compares these scales with those

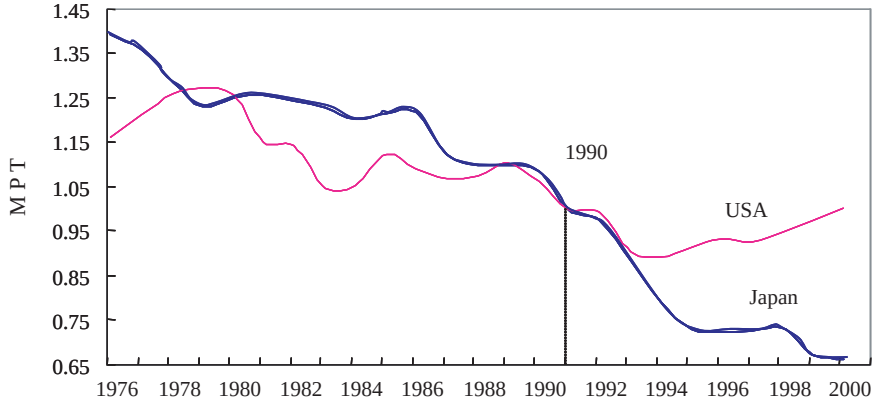


Fig. 1. Trends in Marginal Productivity of Manufacturing Technology (MPT) in Japan and the US (1976–2000)—index: 1990 = 1.
Source: Watanabe (2003) Watanabe and Nagamatsu (2003).

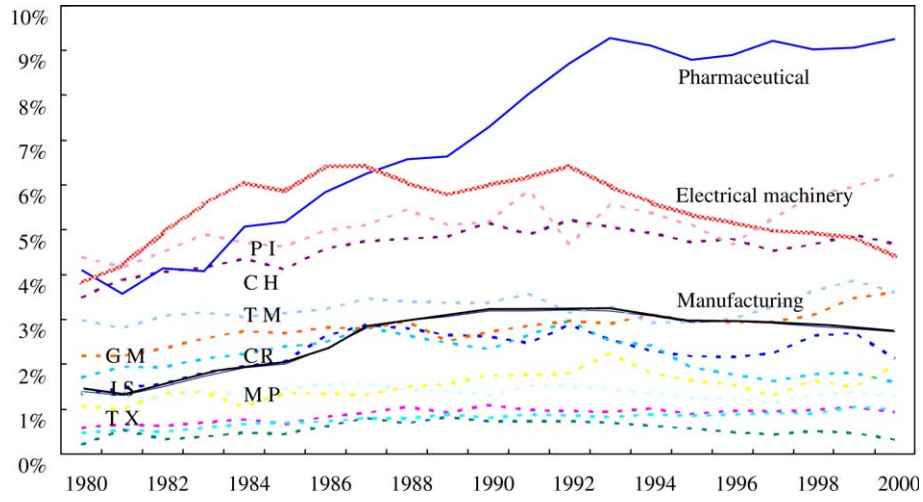


Fig. 2. Trends in R&D Intensity[a] in Japan's Manufacturing Industry[b] (1980–2000): 1990 fixed prices.
[a]Ratio of R&D expenditure and sales by 1990 fixed prices using R&D deflator and WPI (wholesale price index), respectively.
[b]PI, precision instruments; CH, chemicals; TM, transportation machinery; GM, general machinery; CR, ceramics; IS, iron and steel; MP, metal products; and TX, textiles.
Sources: Report on the Survey of Research and Development (1980–2000, Statistics Bureau, Ministry of Internal Affairs and Communication (MIC)), Home Affairs, Posts and Telecommunications (MPHPT)), and Economic Statistics Annual (Bank of Japan, annual issues).

of the US leading pharmaceutical firms Pfizer and Merck which indicates that the volume of R&D expenditure in Pfizer and Merck is 6.7 times and 3.5 times higher than Japans' top firm Takeda Chemical Industries, respectively. All demonstrates megacompetition that pharmaceutical industry has been confronting and significance of the scale of R&D in order to win the race in the competition.

Confronting megacompetition in a globalizing economy while productivity of technology has been declining and the burden of R&D expenditure has also become critical, reorganization of pharmaceutical industry including M&A aiming at increasing economies of scale, particularly for R&D, has been dramatically increasing as demonstrated in Fig. 3.

This demonstrates how critical for pharmaceutical industry firms to secure R&D resources for their survival in a megacompetition.

It has been generally demonstrated that the R&D in pharmaceutical industry incorporates a conspicuously high-level of risks and uncertainty (Mensch, 1975; Watanabe et al., 2004). Table 2 demonstrates that the ratio of the number of the drugs approved for commercialization and chemicals indigenously synthesized or extracted is 1/11,000.

In light of such a conspicuously high-level of risks and uncertainty, in order to protect the property right of the invention succeeded in synthesizing or extracting for commercialization by patents, it is indispensable to apply a certain scope of patent claims wider than the scope of the potential property right of the invention at the stage of patents filing with the following reasons:

(i) At the patents filing stage, it is generally difficult to predict which inventions can gain the final approval for the commercialization,
(ii) There exists strong expectation of the similar functionality in certain invention of the chemicals with the close chemical structure of the chemicals identified as effective function, and
(iii) It is relatively easy to find the effective chemical inventions by means of the similarity of the chemical structure.

However, the Patent Law enumerates the following requirements to satisfy in patenting a certain scope of claims:

(i) It is indispensable to incorporate novelty and inventiveness in the inventions to which patents are claimed (Section 29 of the Law),
(ii) Patent filing documents should satisfy the description requirements (Section 36 of the Law), and
(iii) Senior patents filing than the other same inventions could be accepted (Section 39 and Section 29^{bis} of the Law).

In case when the patent applications are refused for patents grant, reasons for refusal are notified in the process of the examination of the applied patents. Table 3 compares reasons for refusal of the patent applications between drugs and furniture which demonstrates that the refusal due to insufficient description requirements (Section 36 of the Law) is conspicuous in patent applications on drugs.

The reason why the refusal due to insufficient description requirements is conspicuously high in drugs patent applications can be attributed to the strict necessity of the descriptions requirements as an examination guideline. Based on this examination guideline, when the applied patent is identified that its patent claims are too wider than

Table 1
State of sales and R&D expenditure in Japan's leading 30 pharmaceutical firms (2000): Yen bils. at 1990 fixed prices

		Sales	(Share, %)	R&D expenditure[a]	(Share, %)
1	Takeda Chemical Industries, Ltd.	793.8	12.24	72.1	11.75
2	Sankyo Co., Ltd.	446.6	6.89	55.9	9.11
3	Yamanouchi Pharmaceutical Co., Ltd.	311.0	4.80	43.8	7.14
4	Taisho Pharmaceutical Co., Ltd	283.0	4.36	19.8	3.23
5	Daiichi Pharmaceutical Co., Ltd.	270.5	4.17	33.3	5.43
6	Eisai Co., Ltd.	263.9	4.07	41.9	6.82
7	Shionogi & Co., Ltd.	227.7	3.51	25.9	4.23
8	Fujisawa Pharmaceutical Co., Ltd.	216.5	3.34	33.3	5.43
9	Tanabe Seiyaku Co., Ltd.	191.7	2.96	20.1	3.27
10	Chugai Pharmaceutical Co., Ltd.	188.8	2.91	36.9	6.02
11	Banyu Pharmaceutical Co., Ltd.	176.1	2.72	15.7	2.55
12	Dainippon Pharmaceutical Co., Ltd.	152.1	2.35	12.4	2.02
13	Terumo co., Ltd.	149.6	2.31	7.1	1.16
14	Yoshitomi Pharmaceutical Industries, Ltd.	140.8	2.17	14.8	2.41
15	Ono Pharmaceutical Co., Ltd.	134.8	2.08	17.2	2.80
16	Santen Pharmaceutical Co., Ltd.	87.2	1.34	7.9	1.28
17	Tsumura & Co.	75.8	1.17	6.4	1.04
18	Kaken Pharmaceutical Co., Ltd.	71.9	1.11	5.2	0.85
19	SSP. Co., Ltd.	68.1	1.05	3.5	0.57
20	Mochida Pharmaceutical Co., Ltd.	66.7	1.03	8.7	1.41
21	Hisamitsu Pharmaceutical Co., Ltd.	63.4	0.98	19.8	3.23
22	Nikken Chemicals Co., Ltd.	60.4	0.93	3.2	0.52
23	Kissei Pharmaceutical Co., Ltd.	57.3	0.88	9.0	1.46
24	Nippon Shinyaku Co., Ltd.	52.8	0.81	7.2	1.17
25	Fuso Pharmaceutical Co., Ltd.	47.1	0.73	1.8	0.29
26	Torii Pharmaceutical Ind., Ltd.	43.0	0.66	3.8	0.62
27	Toyama Chemical Co., Ltd.	39.5	0.61	6.5	1.06
28	Teikoku Hormone Mfg. Co., Ltd.	23.8	0.37	4.2	0.68
29	Fujirebio Inc.	22.2	0.34	3.4	0.55
30	Hokuriku Seiyaku Co., Ltd.	21.3	0.33	3.4	0.55
	Total 30 firms	4783.7	73.76	550.6	89.74
	Total pharmaceutical industry	6485.2		613.5	

[a] R&D expenditure is represented by 1999. Sales and R&D are deflated by corporate goods price index (CGPI) and R&D deflator, respectively.
*Sales and R&D expenditure in the US firms Pfizer and Merck can be compared as follows (yen bils. at current prices. 1$ = 108.35 yen):

	Sales	R&D expenditure
Pfizer	3204.3	480.5
Merck	4373.3	254.0

Sources: Quarterly Japan Company Handbook (Toyo Keizai Inc., Tokyo, quarterly issues), Toyo Keizai Monthly Statistics (Toyo Keizai Inc., Tokyo, monthly issues), and Pharmaceutical Industry Handbook (Jihou, Tokyo, annual issues).

the disclosure with the working examples, the patent application would be refused.

It was in June 1993 when Japan's Patent Office changed its guiding principle by introducing the Revised Examination Guideline. Contrary to the preceding principle that strictly required the correspondence between the scope of the patent claims and the working examples, the Revised Examination Guideline depends on the following principle:

"In the case of inventions in technical fields where it is generally difficult to infer how to make and use a product on the basis of its structure (e.g. chemical substances), normally one or more representative embodiments or working examples are necessary which enable a person skilled in the art to carry out the invention."

The decision of Japan's Patent Office was as a consequence of the efforts to secure the conformity with the standard in the US and European countries.

Fig. 4 compares the scope of patent claims to be granted between the preceding Guideline and the Revised Examination Guideline.

As illustrated in the Figure the Revised Examination Guideline enabled the Japanese pharmaceutical firms to file patents with a wider scope of patent claims similar to the scope of other competitors in the US and Europe.

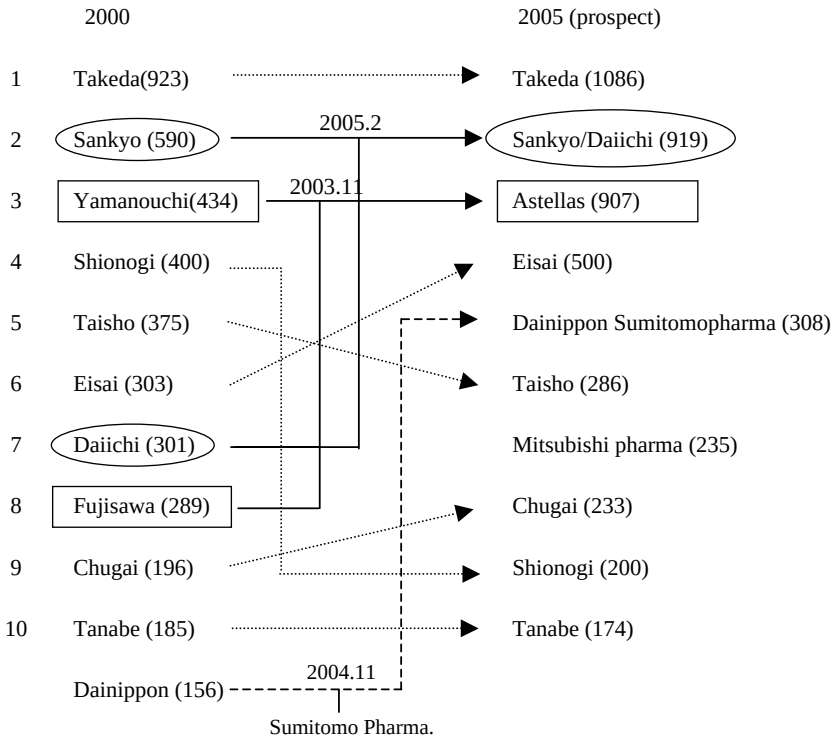


Fig. 3. Reorganization of Japan's Pharmaceutical Industry amidst Megacompetition (2005).
[a]Figures in parentheses indicate sales at consolidated base (billions yen).

3. Analytical framework

3.1. Measurement of the new possibility in wider scope of patent claims

In order to measure the potential benefits of the introduction of the Revised Examination Guideline by means of a new possibility in wider scope of patent claims, extent of the multiformity is measured.

Fig. 5 illustrates a typical example of the chemical structure of the patent claim unit.

The unit in the Figure consists of the five substituents with number of combinations as tabled in Table 4:

Measuring the multiformity by computing combinations of all alternatives defined as substituents, the multiformity

Table 2
Approval ratios of new chemicals for new drug by development stages[a]

	Years	Stage	The number of compounds	Accumulated success rate
15～17 years	2–3 years	The number of compounds synthesized (extracted)	422,647	
	3–5 years	The number starting preclinical test	224	1: 1887
	3–7 years	The number starting clinical test	163	1: 2593
	1–2 years	Application for approval	81	1: 5218
		Approved	39	1: 10,837

[a] Cumulative number of 5 years over the period 1998–2002 in leading 18 Japanese pharmaceutical firms.
Source: Japan Drug Industry Association (2004).

Table 3
Comparison of the reasons for refusal of the patent applications between drugs and furniture[a] (2002–2004)

	Drugs[b]	Furniture[c]
Based on Section 29 of the Patent Law	26 (40)	35 (63)
Based on Section 36 of the Patent Law	25 (38)	6 (11)
Other basis	5 (8)	0 (0)
No first actions	9 (14)	15 (27)
Total	65 (100%)	56 (100%)

[a] One hundred Patents registered from October 2002 to October 2004 were chosen by the Patent Gazette searching in Intellectual Property Digital Library (IPDL) of National Center for Industrial Property Information and Training. Fifty patents are in the two technical fields of A61K and C07D, and 50 patents are in the technical fields of A47 by the International Patent Classification (IPC). The two technical fields correspond to heterocyclic compounds useful as pharmaceuticals and furniture, household articles or equipments, respectively.
[b] IPC A61K and C07D.
[c] IPC A47.

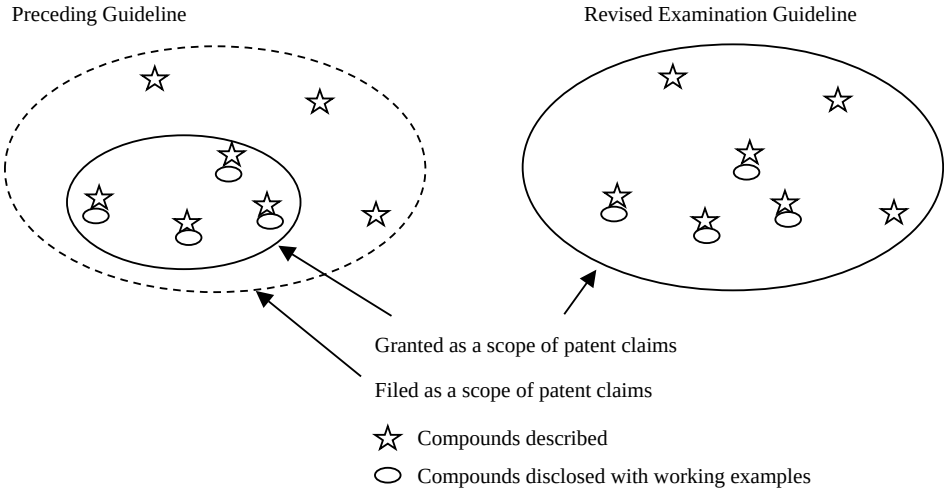


Fig. 4. Scheme of the new possibility in wider scope of patent claims.

of chemicals applicable under a wider scope of patent claims can be identified.

By means of the number of combination in each respective substituent, combinations of all alternatives of substituents can be computed as follows leading to the measurement of the multiformity:

R_1		R_2		R_3		R_4		X		Multiformity
9	×	12	×	2	×	2	×	12	=	864

Based on this approach, an empirical analysis of the measurement of the multiformity of chemicals incorporated in patent application before and after the introduction of the Revised Examination Guideline in 1993 was undertaken taking Japan's pharmaceutical firms with both indigenous and the US capital in the following three clusters:

(i) Large firms with indigenous capital (Takeda, Sankyo and Yamanouchi);
(ii) Medium firms with indigenous capital (Dainippon, Toyama and Kissei); and
(iii) Firms with the US capital (Pfizer and Merck).

3.2. Correlation between multiformity and functionality development

In order to identify the correlation between multiformity and new functionality development essential for the increase in productivity, the following numerical analysis is attempted taking a production function of the pharmaceutical firms:

Sales of the pharmaceutical firm can be depicted by the following production function:

$$S = F(X, T)$$

where S, sales; X, labor (L) and capital (K) and T, technology stock.

A growth rate of the sales can be developed as follows:

$$\frac{\Delta S}{S} = \sum_{X=L,K} \left(\frac{\partial S}{\partial X} \cdot \frac{X}{S}\right) \frac{\Delta X}{X} + \left(\frac{\partial S}{\partial T} \cdot \frac{T}{S}\right) \frac{\Delta T}{T}$$

$$\approx \sum_{X=L,K} \left(\frac{\partial S}{\partial X} \cdot \frac{X}{S}\right) \frac{\Delta X}{X} + \frac{\partial S}{\partial T} \cdot \frac{R}{S}$$

where $\Delta S = \frac{dS}{dt}$; and R ($\approx \Delta T$): R&D expenditure.

A growth rate of total factor productivity (TFP) which represents technological advancement can be depicted as follows:

$$\frac{\Delta TFP}{TFP} = \left(\frac{\partial S}{\partial T} \cdot \frac{T}{S}\right) \frac{\Delta T}{T} \approx \frac{\partial S}{\partial T} \cdot \frac{R}{S}$$

Firms' competitiveness depends on TFP growth rate as contribution of labor and capital is limited under the aging trend in labor as well as capital vintage.

In corresponding to mature economy in the 1990s, firms' growth trajectory should switch from 'growth oriented development trajectory' (which achieves firms' growth leveraged by sales growth) to 'new functionality development initiated trajectory' (which maintains sustainable growth based on development of new functionality) as illustrated in Fig. 6.

Since firms' MPT and consequent TFP increase are governed by their new functionality development (FD) in

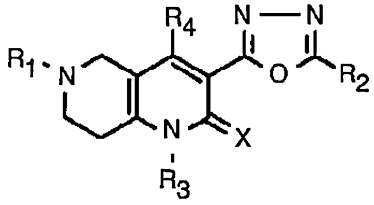
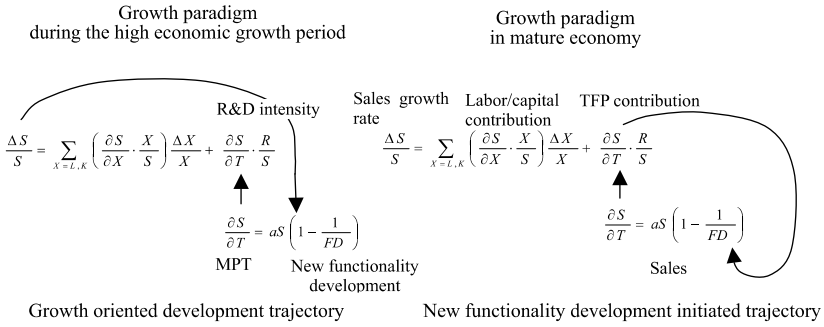


Fig. 5. A typical example of the chemical structure of the patent claim unit. *Source*: Japan Patent No. 2673654.

Table 4
Number of combinations in the substituents

Substituent	Definition	Number of combination
R_1	H, acyl, lower alkyl, lower cycloalkyl-CH–, lower alkenyl-CH_2–, lower alkynyl-CH_2–, benzyl-CH_2–, aryl-CH_2– or heteroaryl-CH_2–	9
R_2	Lower alkyl, lower cycloalkyl, lower alkenyl, lower alkynyl, aryl, heteroaryl halogeno-lower alkyl, lower alkoxy-lower alkyl, lower alkoxy, lower alkenyloxy, phenoxy or lower alkylthio	12
R_3	H or lower alkyl	2
R_4	H or lower alkyl	2
X	Oxygen or sulfur atom	2



S: Sales, *X*: labor, capital; *T*: technology stock; *R*: R&D investment; *MPT*: marginal productivity of technology; *FD*: new functionality development; *a*: coefficient of technology diffusion.

Fig. 6. Growth trajectory options corresponding to mature economy.

mature economy, and given that FD is induced by their wider scope of patent claims (WSPC), a mechanism of WSPC's contribution to virtuous cycle between WSPC, FD, MPT increase, sales increase and increase in R&D can be interpreted as illustrated in Fig. 7.

4. Analysis

First, in order to examine the effects of the introduction of the Revised Examination Guideline in 1993, taking the whole patents applications in six firms with Japanese capital (Takeda, Sankyo, Yamanouchi, Daiichi, Toyama and Kissei), multiformity levels are compared between the average in 1985–1988 (before the Revised Examination Guideline) and 1999–2001 (after the Revised Examination Guideline).

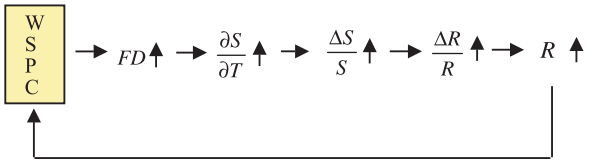


Fig. 7. Scheme of the assessment of a virtuous cycle between wider scope of patent claims (WSPC), new functionality development, marginal productivity increase, sales increase and increase in R&D.
[a]Given the increase rate of R&D expenditure ($\Delta R/R$) is stable, R&D expenditure at time t can be depicted as follows: $R_t = R_0(1 + (\Delta R/R))^t$.

Fig. 8 demonstrates the result of the comparative analysis.

Fig. 8 clearly demonstrates the notable increase in multiformity induced by the introduction of the Revised Examination Guideline as 7 times higher than before the introduction of the Revised Guideline. This analysis demonstrates the significance of the introduction of the Revised Examination Guideline in inducing the multiformity of chemicals incorporates in patents applications.

Second, in order to identify the firms performance in utilizing the potential benefits derived from the introduction of the Revised Examination Guideline by firms clusters: large and medium firms with indigenous capital as well as firms with the US capital, *t*-test with respect to

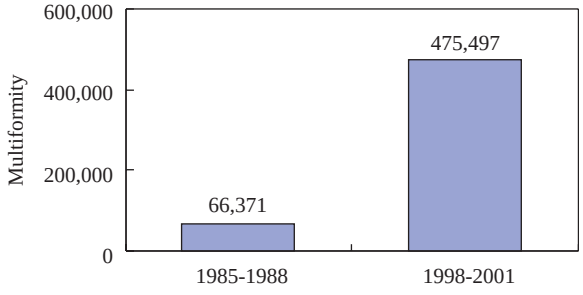


Fig. 8. Trend in the multiformity of chemicals incorporated in patent application in six6 firms with Japanese capital.

Table 5
Number of the patent samples examined

		1985–1988	1998–2001
Firms with indigenous capital	Large 3 firms	10	10
	Medium 3 firms	8	8
Two firms with the US capital		10	10

the significance of the structural change in multiformity before and after the introduction of the Revised Examination Guideline is conducted.

Table 5 tablets the number of the patent samples examined for this analysis.

Table 6 summarizes the result of the *t*-test. Looking at the Table we note that the multiformity change in large firms with indigenous capital demonstrates statistically most significant followed by those in medium firms. This suggests that large firms with indigenous capital made extensive efforts for maximum utilization of the possible benefits provided by a wider scope of patent claims enabled by the introduction of the Revised Examination Guideline.

In comparison to those statistical significances in firms with indigenous capital, *t*-value in firms with the US capital is not so significant. However, the absolute value of those firms with the US capital demonstrates extremely higher than the levels in firms with indigenous capital even before the introduction of the Revised Examination Guideline. While such a high level of multiformity since before the introduction of the Revised Guideline led to the low level of *t*-value with respect to the structural differences of the multiformity level between before and after the introduction of the Revised Examination Guideline, we note that careful strategic action was taken in firms with the US capital for maximizing the possible benefits of patent applications by fully realizing the significance of the scope of the patent claims even before the introduction of the Japan's Patent Office's Revised Examination Guideline in 1993.

Third, in order to demonstrate the significance of the wider scope of patent claims (WSPC) in constructing a virtuous cycle between new functionality development, marginal productivity of technology increase, sales increase and increase in R&D as illustrated in Fig. 7, by utilizing the result of the computation of multiformity in large and medium firms with indigenous capital before and after the introduction of the Revised Examination Guideline, correlation between multiformity of chemicals in patent application and R&D expenditure is analyzed.

Fig. 9 illustrates the result of this analysis which demonstrates statistically significant except multiformity of medium firms before the introduction of the New Examination Guideline in 1993.

Elasticities of multiformity to R&D expenditure is compared in Table 7.

Fig. 9 and Table 7 demonstrate that multiformity plays a significant role in increasing R&D expenditure in Japan's pharmaceutical firms with indigenous capital after the introduction of the Revised Examination Guideline while it reacted negative in large firms before the introduction.

Since positive correlation between new functionality development (FD), marginal productivity of technology (MPT) increase, sales increase and increase in R&D in Japan's high-technology industry firms including pharmaceutical firms have been demonstrated (Watanabe et al., 2005), the above analysis demonstrates the virtuous cycle between the wider scope of patent claims (WSPC), FD, MPT increase, sales increase and increase in R&D as postulated in Fig. 7, thereby demonstrating the significance of WSPC in inducing firms R&D for enhancing competitiveness while facing crucial constraints in fiscal investment.

5. Conclusion

In light of the significance of the effective utilization of potential resources in innovation in overcoming the current crucial problem of the decline in productivity of technology in Japan's high-technology industry amidst a megacompetition, this paper examined the effectiveness of new dimension of potential resources in innovation by means of the wider scope of patent claims which incorporates a similar effects of new functionality development.

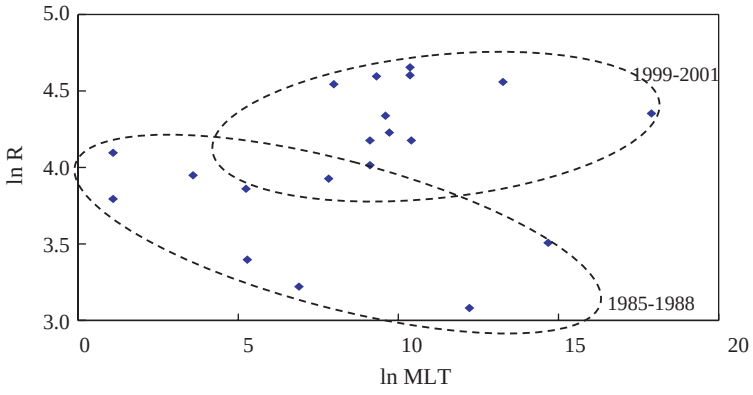
Prompted by the Japanese Office's Revised Examination Guideline in 1993, including description requirements for

Table 6
Comparison of multiformity of chemicals incorporated in patent application before and after the introduction of the revised examination guideline in 1993

		Number of the sample	Before		After		*t*-value (*p*-value)
			Multiformity	SD[a]	Multiformity	SD	
Firms with indigenous capital	Large firms[b]	30	3.29	3.28	6.14	4.02	3.05 (0.00)
	Medium firms[c]	24	3.84	2.08	5.95	2.91	2.82 (0.01)
Firms with the US capital[d]		20	9.63	10.10	14.15	13.37	1.21 (0.24)

[a] Standard deviation.
[b] Represented by Takeda, Sankyo and Yamanouchi.
[c] Represented by Dainippon, Kissei and Toyama.
[d] Represented by Merck and Pfizer.

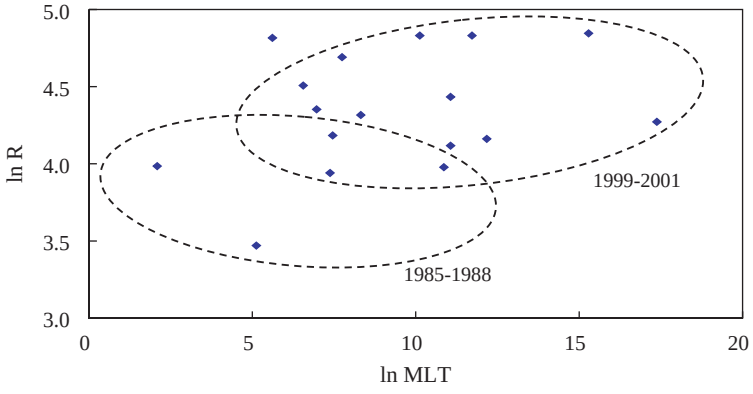
Large firms



$$\ln R = \underset{(40.71)}{5.97} - \underset{(-2.47)}{0.05}\, D \ln MLT + \underset{(2.42)}{0.04}\,(1-D)\ln MLT \qquad adj.\ R^2\ 0.656$$

where R: R&D expenditure; MLT: multiformity; and D: dummy variable (1985-1988 = 1, others = 0)

Medium firms



$$\ln R = \underset{(27.65)}{4.24} - \underset{(-0.63)}{0.01} D \ln MLT + \underset{(2.81)}{0.04}(1-D)\ln MLT - \underset{(-4.99)}{0.64} D \qquad adj.\ R^2\ 0.707$$

D:1985-1988 = 1, others= 0

Fig. 9. Correlation between multiformity of chemicals in patents applications and R&D expenditure in Japan's leading six pharmaceutical firms with indigenous capital (1985–2002).

patent applications which enables firms the wider scope of patent claims, an empirical analysis was attempted taking Japan's leading pharmaceutical firms which depend on extremely high level of R&D intensity, and demonstrated the foregoing hypothetical view.

New findings obtained include:

(i) IPR (intellectual property right) Department of the leading pharmaceutical firms examined have fully realized significant implications of the above new guiding principle on their R&D strategy.
(ii) These firms have succeeded in constructing a virtuous cycle between new functionality development, increase in productivity of technology, production increase, higher R&D investment and a wider scope of patent claims.
(iii) Firms with the US capital performed better than those with indigenous capital in constructing the foregoing virtuous cycle.
(iv) These firms with the US capital have been given more intensive learning exercise in the treatment of IPR for their R&D strategy than firms with indigenous capital.

Table 7
Comparison of elasticities of multiformity to R&D expenditure in firms with indigenous capital

		1985–1988	1999–2001
Firms with indigenous capital	Large 3 firms	−0.05	0.04
	Medium 3 firm	*	0.04

*Statistically non-significant.

These findings lead to the following noteworthy policy implication:

(i) Patent Office's Revised Examination Guideline functioned well in inducing firm's new functionality development leading to constructing a virtuous cycle thereby played a significant role for firms effective utilization of potential resources in innovation.
(ii) Therefore, both the government and industry should consider the significance of such a soft policy instrument in order for the effective utilization of potential resources in innovation thereby constructing a virtuous cycle between innovation and sustainable growth.
(iii) Inspired by the better performance demonstrated by the firms with the US capital, further close collaboration between IPR Department and R&D department in high-technology firms should be developed.

Further studies should focus on the analysis of the similarity and dissimilarity of firms counteractions to the Revised Examination Guideline depending on their business models and also the similar analysis taking another high R&D intensive industry as electric machinery industry.

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