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2nd Theory-Oriented Research Group

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Changing Appropriability Conditions and Technological Opportunities of Innovation in Japan: 1994–2020

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ABSTRACT

It has been thought that the main determinants of innovation are the appropriabilities of profits for the company that carried out the innovation and the acquisition of technological opportunities that link the research and development of the company to the innovation. NISTEP conducted a survey in 1994 to clarify the actual conditions of those factors in the Japanese manufacturing industry. They also conducted a "Survey on Research and Development Activities of Firms in the Private Sector 2020" with questions that are comparable to those in the past survey. In this paper, using the data obtained from these two surveys, we analyzed the changes that occurred in appropriabilities and technological opportunities during the past quarter century and obtained the following results. First, the effectiveness of the various methods for profiting from the innovations implemented by the company has diminished, and the appropriability of profits has declined significantly. Second, the time taken by competitors to introduce a competing alternative (imitation lag) has become considerably longer. Third, while universities and public research institutions have become significantly more important as sources of information to provide technological opportunities, competitors have become less important as sources of information. These findings suggest a decline in competition among companies for innovation and new challenges for science and technology innovation policy.

1. Introduction

Previous research on the determinants of innovation has revealed two key factors.

The first is appropriability, defined as the degree to which the innovating company can appropriate profits from the innovation. When companies invest in R&D for innovation, they need to have a prospect of gaining a return on the investment. High appropriability means that the innovator has a decent prospect of obtaining a high level of profit, which provides a greater incentive to invest in the R&D for that innovation. On the other hand, if the resulting technology is likely to flow out to other companies, appropriability would be low and the company would have less incentive to invest. Innovators can use mechanisms to prevent such technological spillover and ensure that they capture the outcomes of the R&D investment. One such mechanism is patent protection, but a range of other options are also available. For example, innovators could rely on their control over complementary assets, such as production assets and distribution channels, or they could make use of their lead time by bringing the innovation to market as early as possible to capture profits while competitors are still trying to catch up.

The second key factor for innovation success is technological opportunity, which refers to the opportunity for the R&D project to yield innovation. Such opportunity arises within the technical information environment surrounding the innovating company's R&D activities. Suppose an R&D project is closely related to a highly innovative scientific or technological field in which new scientific and technological knowledge is being produced. In such a case, the innovator may obtain such knowledge from various information sources and then incorporate it into the development of new products or production methods, increasing the likelihood of its R&D investment yielding innovation.

While appropriability and technological opportunity were once hard to quantify, in the mid-1980s four economists used a questionnaire survey, rarely used in economics research at the time, to gain quantitative insights into the importance and role of these two factors for innovation (Levin et al., 1987).

Known as the Yale survey, the study extensively shaped the direction of research on innovation and inspired a project led by Wesley Cohen , Akira Goto that involved surveys conducted in 1994 in the USA and Japan on the same two factors (Goto & Nagata, 1997; Cohen et al., 2002). Also, the questionnaire used in the Yale survey was cited when the OECD examined methods for internationally standardizing statistical data related to innovation; the OECD recommended adopting the survey items related to these two factors in its first edition of the Guidelines for Collecting and Interpreting Innovation Data, commonly known as the Oslo Manual (OECD, 1992). Hence, the early stages of the Japanese National Innovation Survey, which followed the first edition of the Oslo Manual, used a questionnaire that allowed comparison with the 1994 survey. However, in subsequent revisions to the Oslo

Manual, items on appropriability were removed from the survey. Consequently, it has become difficult to follow trends over time regarding these key factors for innovation.[1]

To address this problem, we included the survey items related to appropriability and technological opportunity (both of which are instrumental to understanding the innovation process) in the 2020 NISTEP Survey on Research and Development Activities of Firms in the Private Sector and compared these responses with those for the equivalent items in the 1994 survey to examine how the innovation system in Japan has changed between 1994 and 2020.[2]

Japan's economic landscape changed considerably between the 1994 and 2020 surveys. These changes occurred in the context of global economic change, including globalization, digitalization, and the economic advances of South Korea and China. The 1994 survey occurred soon after Japan's asset price bubble burst. Between 1974 and 1990, the Japanese economy was growing by 4.2% a year on average. By contrast, annual growth averaged at just 0.7% between 1991 and 2020, with a 0.5% contraction in 1991 and a growth of just 1.5% in 1994. Similarly, the 2020 survey was conducted during an economic downturn, with the growth rate dropping to negative 4.6% amid the economic effects of COVID-19.

Japan's demographic issues, such as a shrinking total population, a shrinking working-age population, and an aging society, have become serious concerns, whereas they barely garnered any attention when the economy was growing rapidly or steadily. China and South Korea have continued to catch up economically. Another change has been the global digital revolution driven by the rapid growth of US IT enterprises. Meanwhile, Japan has witnessed a slump in its electronics industry, part of the hi-tech sector that once powered Japan's economic growth. In connection with this, Japan's once-leading share of the world semiconductor market has shrunk rapidly. A similarly large decline has occurred in terms of trade: a trade index set at 100 in 2015 has gone from 150 in the mid-1990s to around 100 in the 2000s. Okada (2022) notes that Japan has faced rising competition from emerging Asian economies in general, electronic and transportation machinery and that this may explain why Japan has struggled to pass on the high prices of import-dependent commodities in export prices.

During the same period, R&D expenditure increased. Japan's R&D expenditure totaled 11.8539 trillion JPY in 1994 and 19.4725 trillion JPY in 2019 (based on 2015 OECD purchasing power parity). Japan's total R&D

[1] The survey items on appropriability were retained until the second Japanese National Innovation Survey (NISTEP, 2010), but they appeared in a much simpler format compared with the items in the Yale survey.

[2] We wish to acknowledge the advice and guidance we received from Hiroyuki Tomizawa, Director of Research at NISTEP, in writing this paper.

expenditure ranked third in the world, behind the USA and China. However, while Japan's R&D expenditure increased only 1.6-fold, in the same period, those of the USA, Germany, China, and South Korea increased 2.4-, 2.1-, 30.8-, and 6.5-fold, respectively.

The main institutional changes relevant to innovation are outlined below. In 2001, Japan narrowed the period of request for examination of patent application from seven to three years after the patent examination system became unable to cope with a huge increase in applications. The narrowing of the period was designed to encourage firms to think more carefully before applying and to eliminate the uncertainty caused by long application periods for patents with ambiguous rights. Patent applications peaked at 439,175 in 2001. In 2020, they were down to 288,472.[3]

During the late 1990s, deliberative councils of the Ministry of Economy, Trade and Industry and the Japan Patent Office emphasized the need for a Japanese pro-patent policy along with robust and wide-reaching patent protection. Nevertheless, damages for patent violations remain modest. South Korea and China have introduced punitive damages for patent violations, signaling a tougher approach to violations and a greater willingness to protect the rights of patent holders.[4]

In 1995, member states of the World Trade Organization signed the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) to establish international standards for protecting intellectual property and an internationally harmonized process for dispute resolution. The TRIPS agreement was designed to encourage developing countries to tighten their regulations for protecting holders of substantial intellectual property rights. As such, it dealt an enormous blow to India's pharmaceutical industry and also prompted a revision of Japan's Patent Act.[5]

In 2015, Japan's Unfair Competition Prevention Act was revised, tightening the protection for trade secrets. This legislative revision was directly prompted by a public outcry demanding the protection of technology held by Japanese firms from being stolen by Korean and Chinese companies. The revision raised hopes of an alternative approach, one that would protect technology not through patents but by ensuring its confidentiality as trade secrets or know-how. It may also have encouraged companies to be more cautious about letting their engineers share technical information with engineers in other companies.

[3] One reason for this decrease was that the shortened the period of request for examination had encouraged companies to be more thorough in their review of whether to submit a patent application. However, the other reasons were the slump in the electronics industry, from which many patent applications are submitted, and many companies to submit their applications overseas instead.
[4] See chapter 9 of Suzuki, Yasuda, and Goto (2021).
[5] See Odagiri et al. (2010) for more on how the TRIPS agreement affected innovation and economic development in different countries.

Important changes also took place at universities, another important contributor to innovation. The year 2004 saw the incorporation of Japan's national universities. The idea was to remove the national universities from the state's organizational structure to boost their independence and autonomy and enable a more dynamic approach to university management, as well as increase inter-university competition to encourage the national universities to improve their performance.[6] Universities have always been expected to drive innovation through their education and research programs, but they were now increasingly expected to contribute to the economy by transferring their technology to private companies. The organizational framework for facilitating such a transmission was laid in 1998 with the Act to Facilitate Technology Transfer from Universities to the Private Sector. Kanda and Tomizawa (2015) found that this process of university reform significantly reduced university faculty's time for engaging in research. Aoki and Kimura (2014) suggested that this reduction explains the decline in the share of published research by Japanese researchers.

Research institutes were similarly affected. In 2001, a total of 15 research institutes under the Agency of Industrial Science and Technology were consolidated into the National Institute of Advanced Industrial Science and Technology (AIST). As with the national universities, the expected role of research institutes changed. Whereas research institutes had tended to focus on basic research, the emphasis was now placed on the need for research to be reoriented toward practical use. Public research institutes established by local governments, which had played a major role in modernizing local industries, were also pulled into this wave of reorganization.[7]

Changes also occurred in business administration and industrial structures. During the early 1990s, Odagiri and Goto (1993) analyzed Japan's national innovation system. They found that Japanese corporations could invest in R&D projects for long-term growth because shareholder activism was restricted by Japan's "main bank" system and by cross-shareholdings. They also found that the practice of rotating jobs under a lifetime employment system had helped nurture business leaders who understood both technological seeds and market needs and had fostered close-knit interdepartmental collaboration. About 15 years later, the University of California's Ulrike Schaede analyzed Japanese corporations and changes in the environment in which they operated, noting a number of key changes: the decline of the main bank system, a reduction in cross-shareholding arrangements, a loosening of keiretsu (vertically structured business groups) and subcontracting relations, an increase in mergers and acquisitions, and the decline of lifetime employment (Schaede, 2008). Some of the claimed changes require further verification, but if such changes have indeed occurred in the institutions and practices that have formed the foundation of Japan's private sector and industrial structure, they would also have affected the mechanisms by

[6] Chapters 5 and 6: Suzuki et al. (2021).

[7] Suzuki et al. (2021), Chapter 7.

which companies ensure their appropriability and technological opportunity and produced changes in Japan's innovation system. If this is the case, the country requires a new strategy for promoting science, technology and innovation. By comparing the survey data from 1994 and 2020, the present report examines the changes in the innovation system that occurred between these two points in time.

2. Comparing the Two Survey Samples (1994 and 2020)

2.1 Comparing the Samples

The title of the 1994 survey is the Innovation Survey on Industrial Technology ("Innovation Survey").[8] The sample consisted of companies selected from a company register compiled by the survey division within the Science and Technology Policy Bureau of the Science and Technology Agency, which at the time was responsible for conducting the annual Survey on Research and Development Activities of Firms in the Private Sector ("R&D survey"). The subjects of the R&D survey are private companies that have at least 1 billion yen in capital and are engaged in R&D. Of these, 1,219 manufacturing companies were surveyed in the Innovation Survey. All manufacturing companies with at least 1 billion yen in capital are subjects of the complete enumeration in the Survey of Research and Development conducted by the Statistical Bureau of the Ministry of Internal Affairs and Communications. In the 1994 Survey of Research and Development, 1,722 of the companies surveyed were in the manufacturing sector. Thus, the 1,219 manufacturing companies surveyed by the Innovation Survey (below, the "1994 survey") covered 71% of those included in the Survey on Research on Development. The 1994 survey obtained valid responses from 642 companies (a response rate of 52.7%).

Since 2008, the R&D surveys have been conducted by NISTEP. The sample in NISTEP-administered R&D survey consists of companies that have at least 100 million yen in capital and engage in R&D. Such companies were extracted from the survey register of the Statistics Bureau. The 2020 R&D survey (below, the "2020 survey") sampled 3,797 companies (once postal addresses were amended), 1,996 of which responded (a response rate of 52.6%). To compare the 2020 survey with the 1994 survey data, we extracted data pertaining to 800 manufacturing companies that have a capital of at least 1 billion yen.

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[8] See Goto and Nagata (1997) for more details about the survey and its results. Readers should note that the data we have aggregated from the 1994 survey in this paper differ from that in Goto and Nagata (1997) for the following reason: to enable comparison with the US survey, Goto and Nagata (1997) analyzed 593 of the 642 surveyed companies that gave valid responses and used a weighted average to remove US–Japan differences in sample distributions by industry.

Table１． Comparison of Sample Size by Industry					
		1994 survey (Size of capital: 100 million yen or more)		2020 survey (Size of capital: 100 million yen or more)	
No.	Industry	N	%	N	%
4	Food	43	6.7	71	8.9
5	Textile mill products	20	3.1	19	2.4
6	Pulp, paper and paper products	17	2.6	17	2.1
7	Printing and allied indstries	6	0.9	5	0.6
8	Medicines	34	5.3	32	4.0
9	Industral chemicals	57	8.9	67	8.4
10	Oil and fat products amd paints	7	1.1	8	1.0
11	Other chemical products than 9-10	24	3.7	32	4.0
12	Petroleum and coal products	14	2.2	5	0.6
13	Plastic products	18	2.8	33	4.1
14	Rubber products	10	1.6	9	1.1
15	Ceramic, stone and clay products	31	4.8	38	4.8
16	Iron and steel	26	4.0	29	3.6
17	Non-ferrous metals and products	29	4.5	26	3.3
18	Fabricated metal products	25	3.9	35	4.4
19	General-purpose machinery	36	5.6	38	4.8
20	Production machinery	31	4.8	65	8.1
21	Business oriented machinery	14	2.2	29	3.6
22	Electronic parts, devices and electronic circuits	27	4.2	43	5.4
23	Electrical equipment and electric measuring instruments	12	1.9	14	1.8
24	Other electrical machinery equipment and supplies than 23	44	6.9	51	6.4
25	Information and commuincation electronics equioment	26	4.0	25	3.1
26	Motor vehicles, parts and accessories	52	8.1	63	7.9
27	Other transportation quipment than 26	17	2.6	21	2.6
28	Other manufacturng than 4-27	22	3.4	25	3.1
	Total	642	100.0	800	100.0

The sample distribution of each survey by industrial category is presented in Table 1. Japan Standard Industrial Classification (JSIC) underwent three revisions between the two surveys (the 11th, 12th, and 13th editions were released in 2002, 2007, and 2013, respectively). To enable comparison, we changed the 4-digit industrial codes used in the 1994 survey to those in the latest edition of the industrial classification standard to align the industrial categories with those in the 2020 survey. Although the share of the sample represented in the "production machinery" category seems to have undergone a conspicuous increase (relative to other categories) between the two surveys (from 4.8% to 8.1%, an increase of 3.3 points), generally no structural changes are apparent as a result of the adjustment. As such, we used unweighted averages when comparing the two sets of survey data.

2.2 Questionnaire Forms

In both the 1994 and 2020 surveys, the statistical units were individual companies. In questions on R&D and innovation, such as new product or process, both surveys asked the company to answer in relation to their main business unit (the product line that represents the largest share of sales).

The 1994 survey featured a wide range of questions, some of which are also included in the 2020 survey. This includes questions pertaining to the effectiveness of an appropriability mechanism, imitation lag (the time it takes for competitors to introduce a competing alternative product or process), and the sources of technological opportunity (the information sources that suggest new projects or contribute to the completion of existing projects). In the present report, we compared imitation lag between cases in which an innovation was or was not patented and used this difference as a measure of the effect of patent protection on appropriability.

Both surveys generally used the same question wording and response options. However, while the 1994 survey used the word *inobēshon* (a transcribed loanword of "innovation") and also defined the term, the 2020 survey never used the word *inobēshon* directly. While the 1994 survey used the terms *seihin inobēshon* (product innovation) and *kōtei inobēshon* (process innovation), the 2020 survey used *shin seihin dōnyū* (new product introduction) and *shin kōtei dōnyū* (new process introduction) in place of these terms.[9]

Despite the differences in wording, innovation, as defined in the 1994 survey, resembles the concepts of "new product introduction" and "new process introduction" used in the 2020 survey, as illustrated below.

First, the 1994 survey defined *inobēshon* (innovation) as something that is "created as a result of design, R&D, market research, or other such actions as are required in the development of an innovative product or manufacturing process." It defined *seihin inobēshon* (product innovation) as the "bringing to market of a new or improved product." *Kōtei inobēshon* (process innovation) was defined as the "introduction of a new or improved process." "Product innovation" was further described as including "the introduction of a new product featuring substantially changed function, performance, design, materials, or components, or the technological upgrading of an existing product." "Process innovation" was further explained as being "for the purpose of manufacturing a new product or improving the efficiency of the manufacturing process of an existing product."

The 2020 survey defined *shin seihin dōnyū* (new product introduction) as " the introduction of a new or significantly improved product or service" and "the introduction of a product or service that is neither new nor a significantly improved version of a previous product or service but is a modest improvement of a previous product or service." The former was expanded as follows: "a product or service that is new, or a significantly improved

[9] Both questionnaires are included in the Appendix.

version of a previous product or service, in terms of its functionality, performance, technical specifications, usability, raw materials, composition, internal software or subsystems, or delivery method (in the case of a service)." The same survey defined *shin seihin dōnyū* ("new process introduction") as the "introduction of a new method or a significantly improved version of a previous method for producing or supplying a product (R&D, design, production, delivery, distribution, or logistics, etc.)" and the "introduction of a method that is neither new nor a significantly improved version of a previous method but is a modest improvement of a previous method."

Thus, although the 2020 survey differs from the 1994 survey in that it mentioned services along with products (whereas the 1994 survey referred only to products), the two definitions are largely identical; both included cases in which a previous product or process is improved (as opposed to restricting the definition to the creation of an entirely new product) and both described specific effects of the innovation. In any case, the discrepancy between the two surveys in terms of whether "new products" include new services is of no concern to the present report since we are interested only in the data in the 2020 survey pertaining to manufacturing companies. In subsequent chapters, the term "product innovation" will be used to correspond to the 1994 survey's definition of "product innovation" and the 2020 survey's definition of "new product introduction." Similarly, the term "process innovation" will be used to correspond to the 1994 survey's definition of "process innovation" and the 2020 survey's definition of "new process introduction."

The fact that there are similarities between the 1994 survey's usage of "innovation" and the 2020 survey's usage of "new product introduction" and "new process introduction" is unsurprising. The 1994 survey's definition of "innovation" conforms with the first edition of the Oslo Manual. In the 2020 survey, the word "innovation" was avoided to help clarify that the purpose of the survey differed from that of the Oslo Manual-compliant Japanese National Innovation Survey, but the survey defined the outcomes of R&D, which are "new product introductions" and "new process introductions," in accordance with the definition of "innovation" provided in the latest edition of the Oslo Manual. While the wording differ as a result of successive revisions to the manual, there is no substantial semantic difference that would prevent a comparison between the two points in time.

That said, we acknowledge the possibility that the use of the loanword for "innovation" (*inobēshon*) may have produced slight differences in the respondents' understanding of the term. It is unclear how this factor may have affected the results.[10]

[10] According to Yonetani (2012), in comparison to Germany and the US, people in Japan tend to describe an innovation as such (*inobēshon*) only when the innovation in question has a high degree of novelty. Thus, the results of the 2020 survey could have been affected by the use of native Japanese terms *shin seihin dōnyū* (new product introduction) and *shin kōtei dōnyū* (new process introduction) in place of *inobēshon* (innovation) and by Japan's increasing familiarity with the word *inobēshon*.

3. Survey Results and Interpretation

3.1 General Comparison

3.1.1 Effectiveness of Appropriability Mechanisms

Figures 1 and 2 show the percentage of projects, respectively, in which a given appropriability mechanism was considered effective for appropriating profit from the product or process innovation in past three years.[11] For both product and process innovations, the 2020 survey finds that appropriability mechanisms are generally less effective than the 1994 survey.

Being first to market was considered the most effective product innovation mechanism in the 1994 survey, having secured profits for 40.3% of products. In the 2020 survey, however, it ranked third at 26.8%. In the 1994 survey, patent protection was the second-most effective mechanism. In the 2020 survey, it ranked first, but its percentage was lower than that in 1994, at 27.9% compared with 38.3%. Coming third in the 1994 survey were complementary manufacturing facilities and know-how. In the 2020 survey, these had moved up to second place, with a modest decline in percentage from the 1994 level. For process innovation, the top four mechanisms (in descending order) remained unchanged between the surveys: complementary manufacturing facilities and know-how, secrecy, being first to market, and patent protection.

Notably, each mechanism declined markedly in its perceived effectiveness. This observation may imply that companies are struggling to appropriate profit from innovations. Furthermore, it may also suggest that innovations offer less potential profit in the first place.

Another notable observation is that complementary manufacturing facilities and know-how increased in rank as a mechanism for product innovation. This shows that complementary assets, that is, the fixed assets and know-how needed to create innovations, are relatively important for appropriating profit from innovation. Thus, acquiring such assets and managing them well is an effective way to appropriate profit from innovation. This may also reflect the revision of the Unfair Competition Prevention Act following a slew of cases involving the outflow of technology to foreign companies, which set out clear criteria for technology to be classified as trade secrets and led to a crackdown on unauthorized access to such trade secrets.

[11] In the aggregated results, the following median values were used for each of the response categories shown below: less than 10%: 5%; 10–40%: 25%; 41–60%: 50%; 61–90%: 75%; 91% and above: 95%.

Fig.1. Effectiveness of Appropriability Mechanisms for Product Innovations (Mean % of Product Innovations for which Mechanism Concidered Effective.)

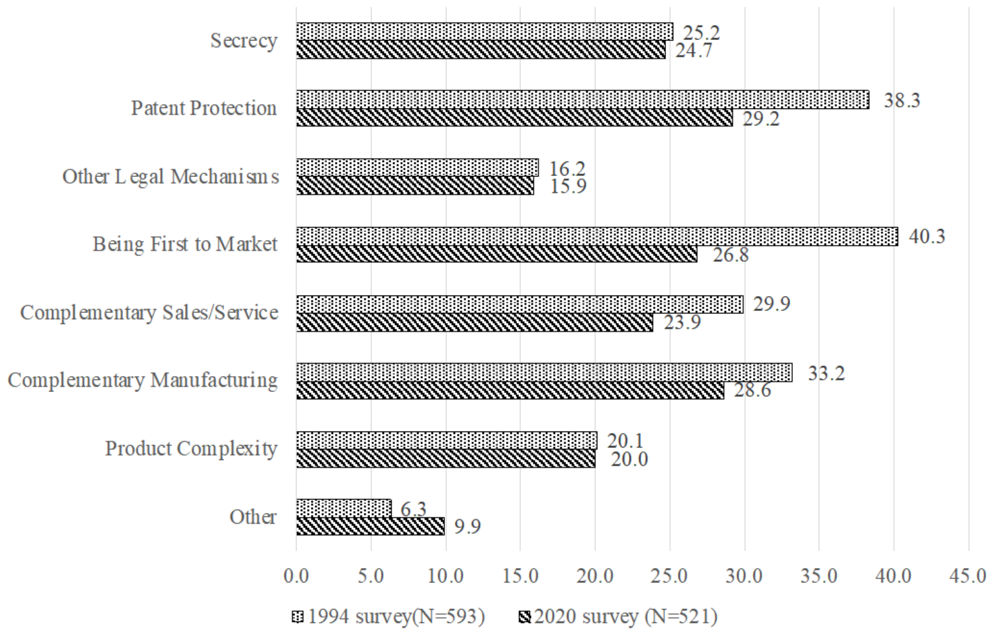
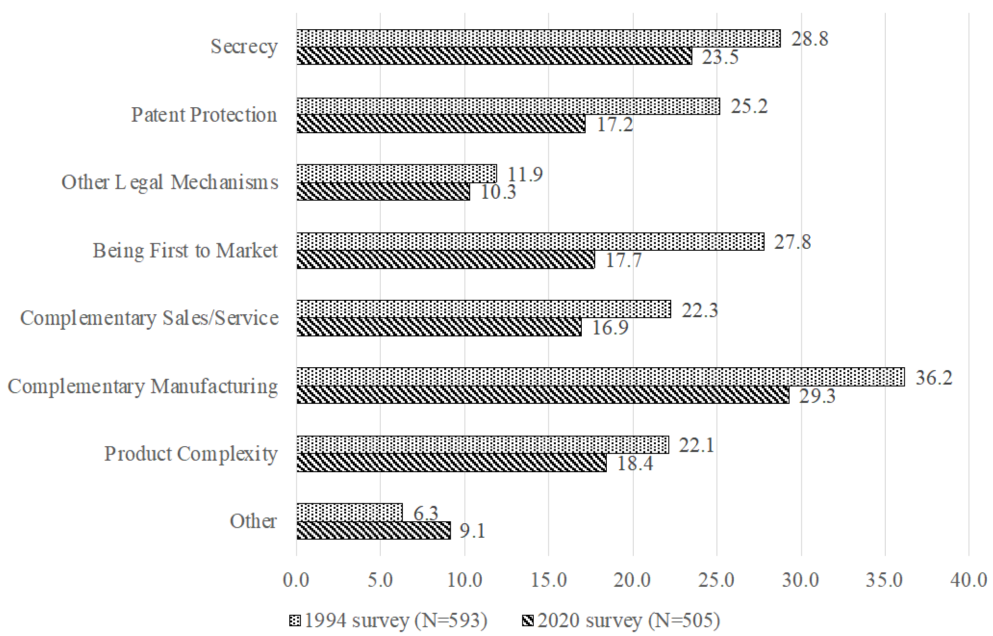
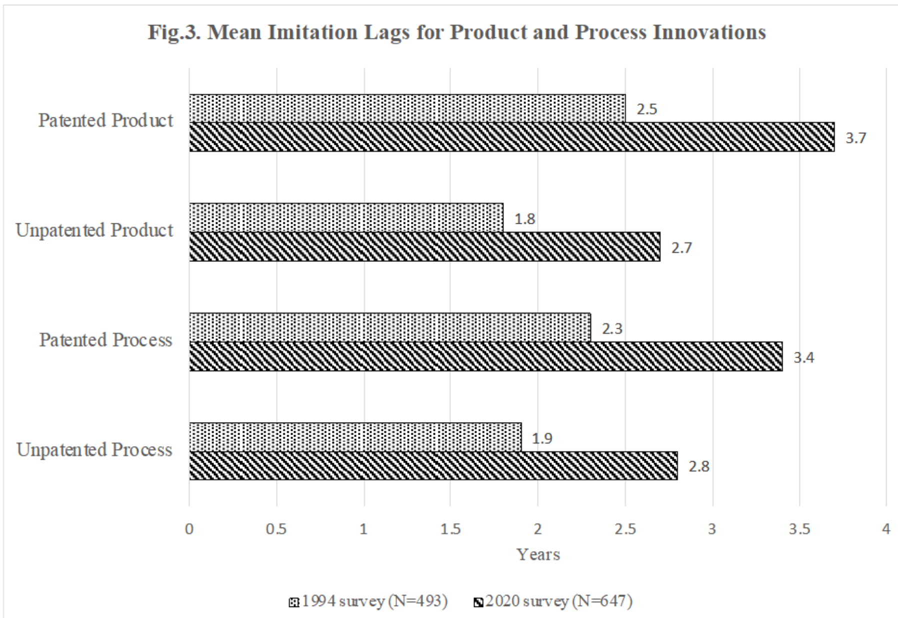


Fig.2. Effectiveness of Appropriability Mechanisms for Process Innovations (Mean % of Process Innovations for which Mechanism Concidered Effective.)



3.1.2 Imitation Lags

The results for imitation lags, denoting the duration of time between the innovating company's implementation of the product or process innovation and a competitor's introduction of a comparable technology, are presented in Figure 3.[12]



Generally, lag times have increased markedly. For patented product innovations, mean lags increased from 2.5 to 3.7 years, an increase of 48% or 14 months. For patented process innovations, they increased from 2.3 to 3.4 years, an increase of 48% or 13 months. Patent protection increased lags to a greater extent in the 2020 survey than in the 1994 survey: in the 1994 survey, patent protection added 0.7 years to the mean lag for product innovations, whereas it added as much as 1 year in the 2020 survey. Similarly, patent protection added 0.4 years to the mean lag for process innovations in the 1994 survey, whereas it added 0.6 years in the 2020 survey. This suggests that patent protection is now affording innovators more time to monopolize a market before an imitator catches up. Longer lags may be an incentive for higher R&D investment as innovators are more likely to appropriate profit from the

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[12] In the aggregated results, the following median values were used for each of the response categories shown below: less than 6 months: 0.5 years; 6 months to 1.5 years: 1 year; 1.5 years to 3 years: 2 years; 3–5 years: 4 years; 6 years or longer: 8 years.

innovation, but they could potentially be impediments to innovation if they are a result of a slump in innovation competition. If competitors are taking longer to catch up and produce a similar product, it could suggest a decline in innovation competition. In other words, it may suggest that companies are monitoring each other's innovations less and that when a company does innovate, others feel less inclined to catch up with the innovator. It is also possible that the innovations in question may be worth less, such that competitors have less profit to gain from catching up with the innovator. Either way, it is a cause for concern if innovation competition is indeed declining.

Further, given the marked difference in lags between patented and unpatented innovations, patent protection seems to have a greater lag-lengthening effect than it did in 1994.

3.1.3 Technological Opportunity (Information Sources)

The results for information sources are illustrated in Figures 4 and 5. For each information source, Figure 4 presents the percentage of respondents who reported that the information source suggested new projects, while Figure 5 shows the percentage who reported that it contributed to the completion of existing projects.

Customers were the most frequently cited information source both for suggesting new projects and for contributing to project completion. Although customers topped both surveys, the percentage was lower in the 2020 survey, both for suggesting new projects and for contributing to completion: In the 1994 survey, 76.4% of respondents said that this information source suggested new projects, and 77.7% said that it contributed to project completion; in the 2020 survey, these percentages were down to 65.6% and 71.6%, respectively.

A sizeable decline between the surveys also occurred in the following three information sources: the firm's manufacturing operations, other R&D units of the firms, and competitors. The decline in the percentage of companies that derived new projects from competitor information is particularly notable; the percentage was just 18.7% in 2020, compared with 45.7 in 1994. Thus, in the 2020 survey, more than 80% of the manufacturing companies gave a negative response when asked whether competitor information suggested new projects. The decline in the other two responses was also notable; in the 2020 survey, more than 70% gave a negative response when asked whether new projects were inspired by their other R&D units and when asked whether new projects were inspired by their manufacturing operations.

However, some information sources were considered more important in the 2020 survey than in the 1994 survey. One such source were universities. In the 2020 survey, 59.1% of respondents indicated that the source inspired new projects, compared with just 39.4% in the 1994 survey, and 60.0% stated that it contributed to project completion, compared with just 39.5% in 1994. Consequently, universities rose from seventh place in 1994 to second place in 2020 in the rankings of information sources for suggesting new projects and of information sources for contributing to project completion.

Another information source that grew in importance were government research institutes, which rose from ninth to fourth and eighth to fifth as a source for suggesting new projects and for project completion, respectively. Similarly, technical societies/associations rose from fifth to third place in both rankings. These results contrast with those of the firm's manufacturing operations and other R&D units: the firm's manufacturing operations declined from second to eighth and second to fourth place as a source for new projects and project completion, respectively; other R&D units declined from third to seventh place in both rankings.

Fig.4. Information Sources Suggeting New Projects

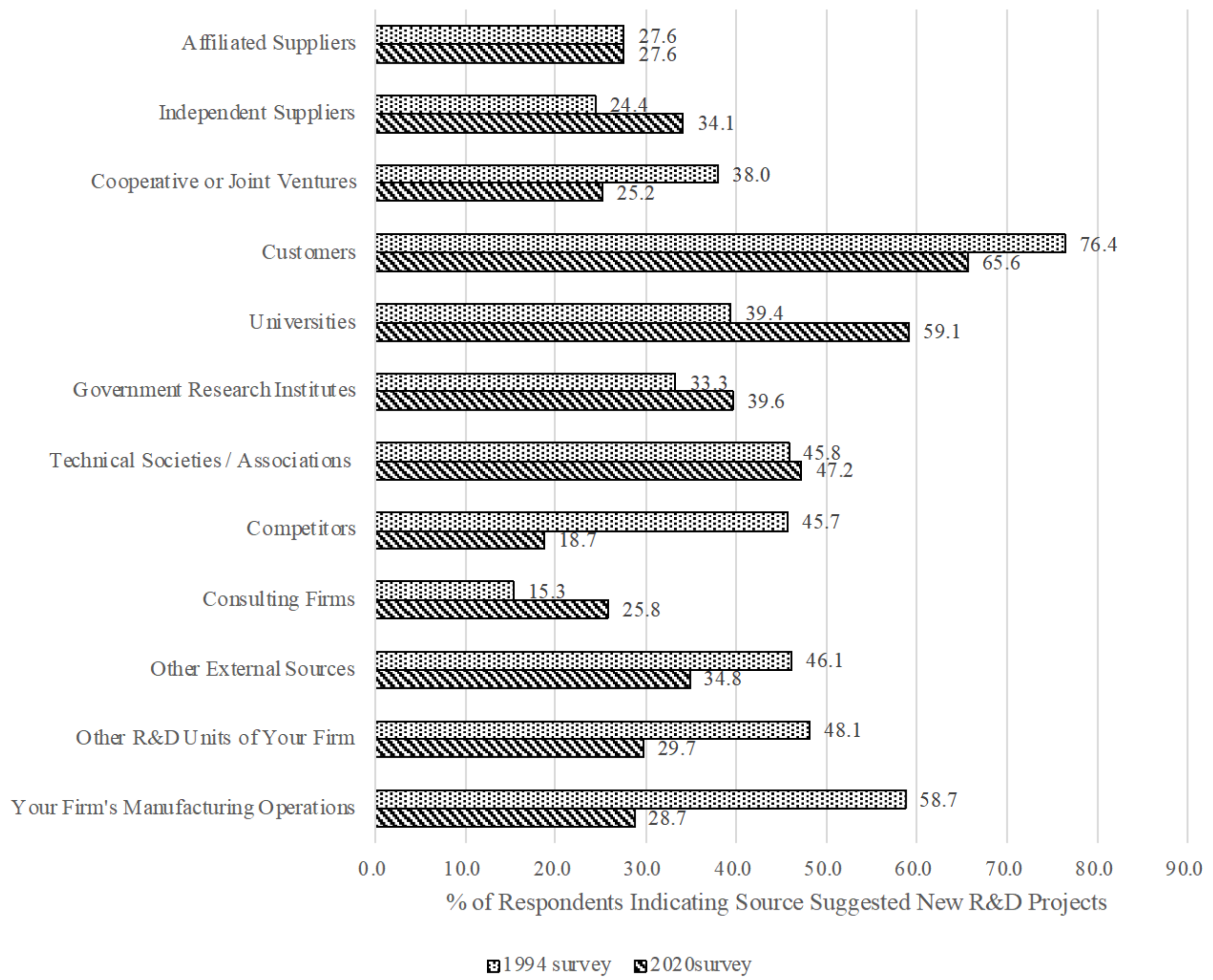
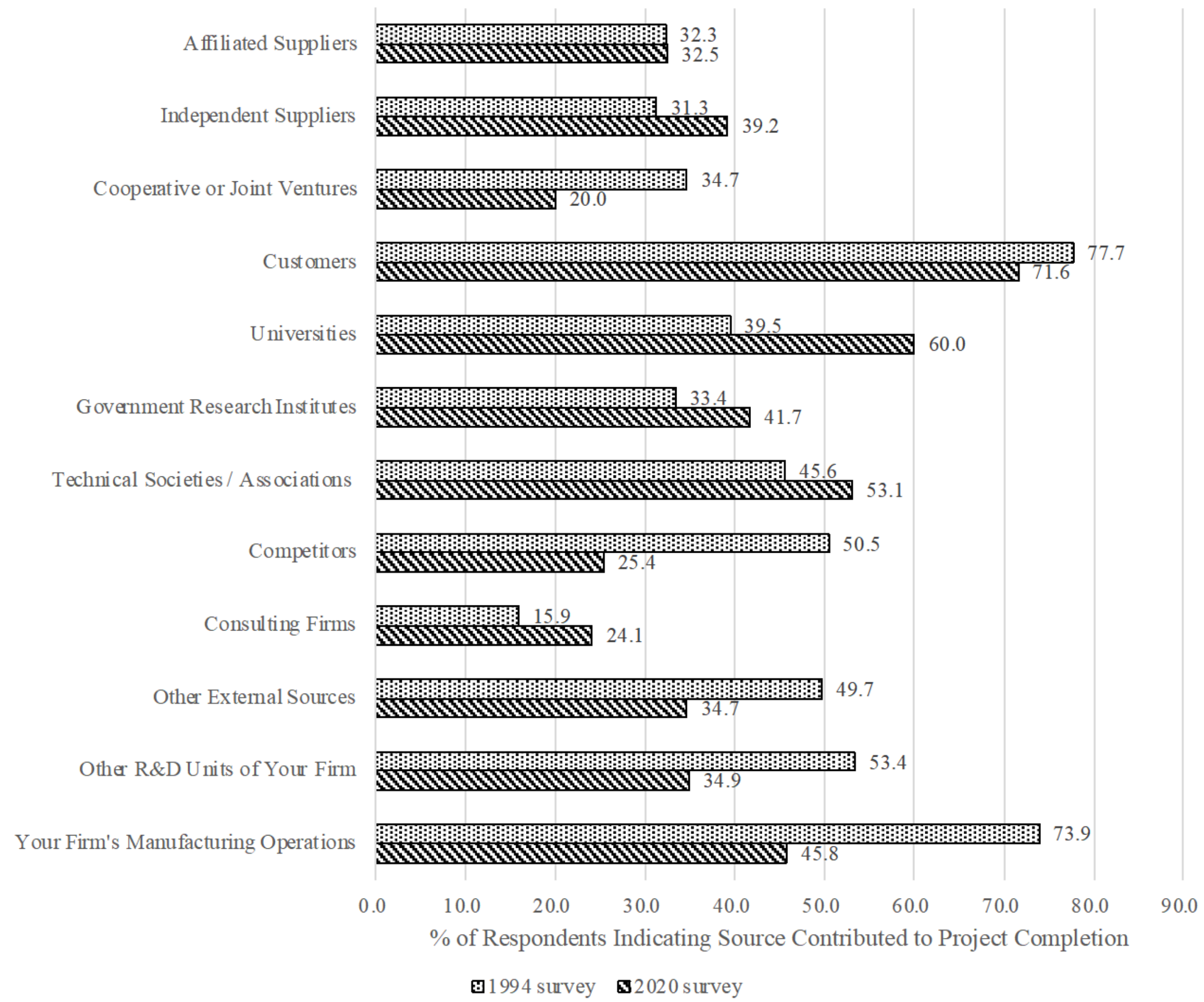


Fig.5. Information Sources Contributing to Project Completiton



The increasing importance of universities and the declining importance of internal units as information sources is revealed all the more starkly in Figures 6 and 7, which show the percentage of respondents who indicated that the information source in question was the most important source for suggesting new projects (Figure 6) or for contributing to project completion (Figure 7). While both surveys reveal customers as the most important source for new projects and project completion. Regarding new projects, customers accounted for 47.9% in the 1994 survey, far exceeding other sources of information. All other sources accounted for less than 10% of respondents. However, in the 2020 survey, while customers decreased to 37.8%, universities increased from 4.0% to 15.6%, making them the second most prominent presence. In the 1994 survey, after customers (cited by 36.3% of respondents), the firm's manufacturing operations and other R&D units were cited relatively frequently for project completion, at 17.3% and 9.5%, respectively. However, in the 2020 survey, both internal sources decreased to less than 5%, while customers increased to 44.8%. By contrast, universities increased from 4.2% in 1994 to 13.9% in 2020, indicating that universities have replaced internal sources as a runner-up to customers.

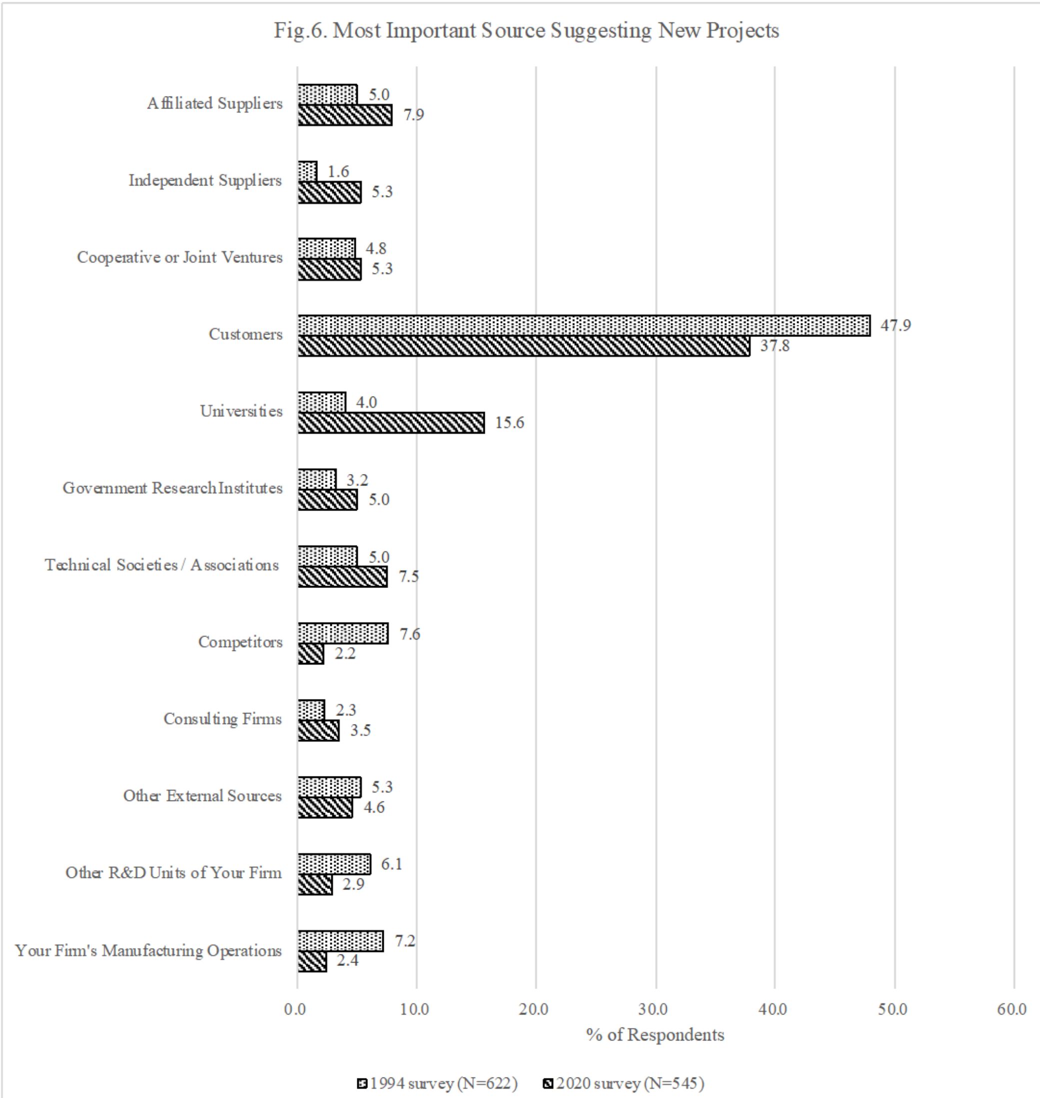
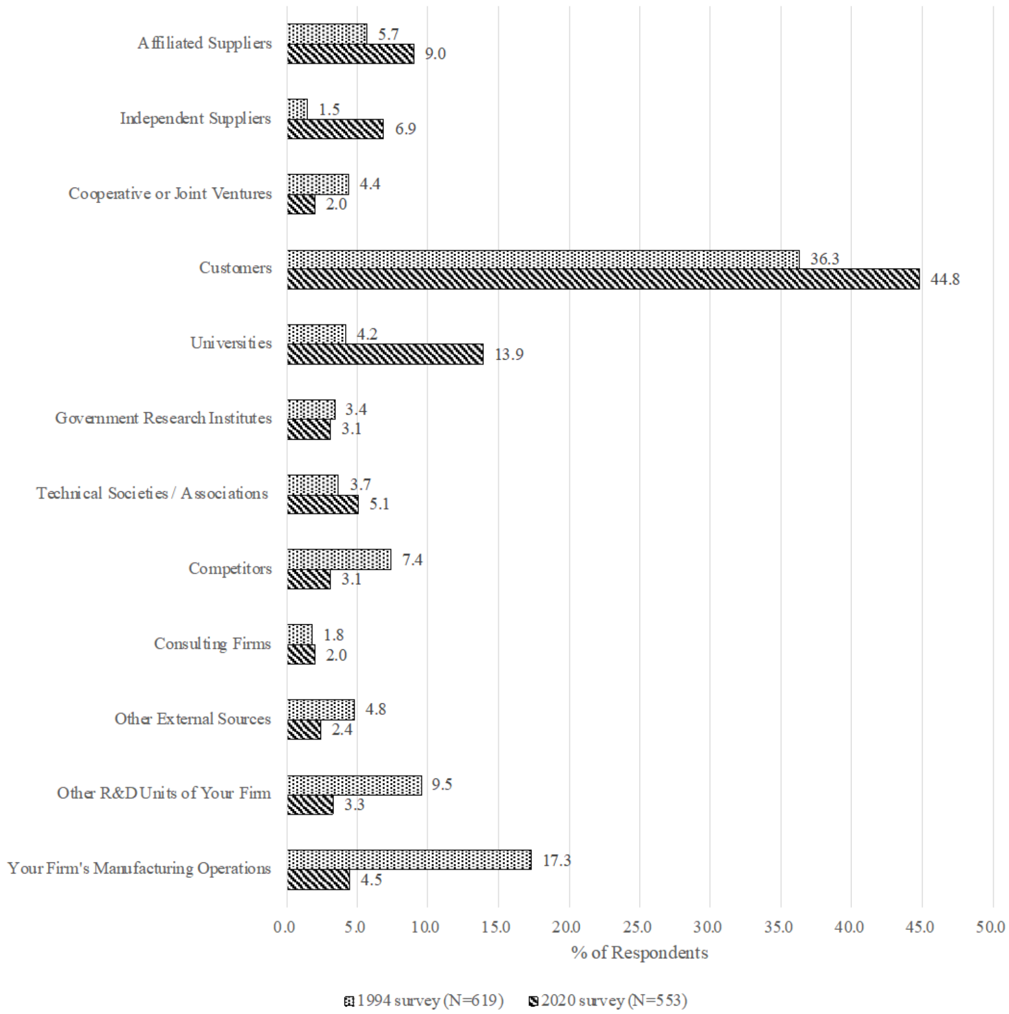


Fig.7. Most Important Information Source Contributing to Project Completion



Universities have increased in importance as an information source because of an interplay of factors. One factor are government policies for supporting industry–academia collaboration. Another is the fact that financial circumstances have compelled both companies and universities to rely on external sources. Additionally, with technology growing more sophisticated and complex, internal technological assets alone are less likely to yield new products or new processes. If companies are placing less importance on feedback from competitors or from internal sources, it may suggest a significant departure from the traditional R&D approach in Japan's corporate and industrial sectors. Under the traditional approach, companies would closely monitor R&D trends among competitors, such as through patent application information, and would immediately gear up their R&D

operations to catch up with the competition. However, the above observations suggest that this practice may be less common today. If so, it is vital to determine how this trend is affecting innovation in Japanese companies.

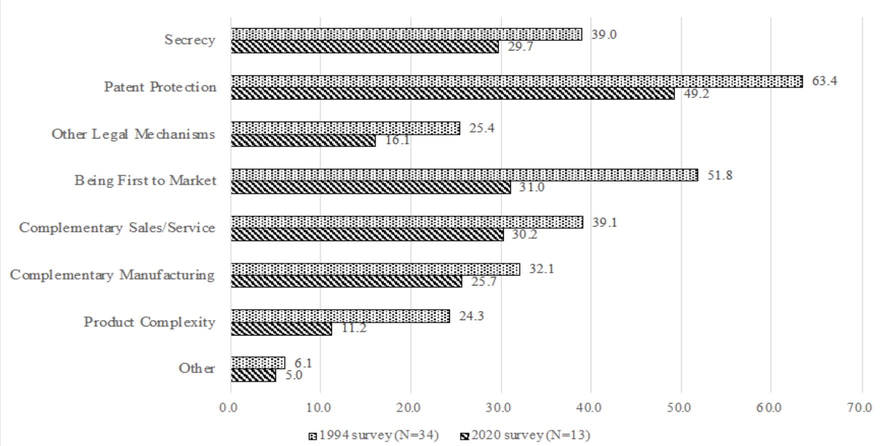
3.2 Results by industry

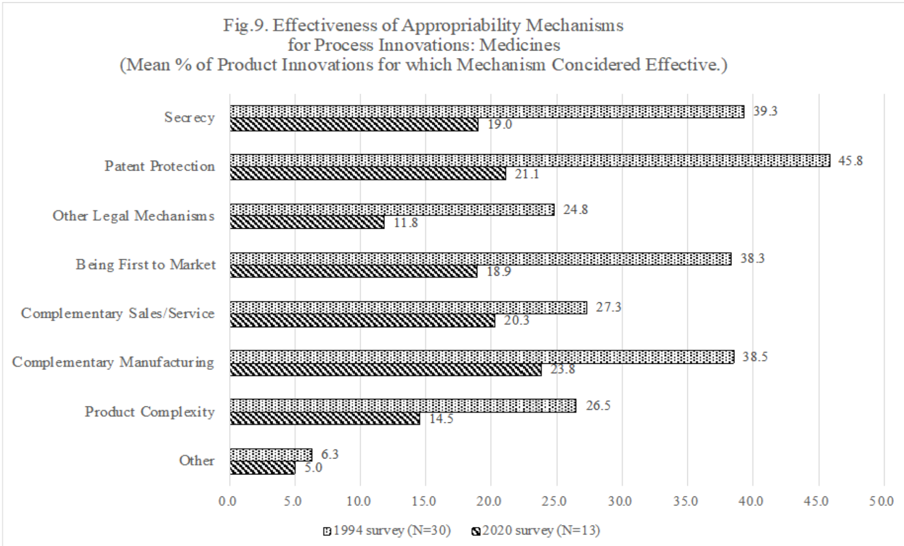
The conditions surrounding the appropriability and technological opportunity of innovations vary by industry. The results for three industrial categories associated with notable innovation processes are outlined below. The first is “pharmaceuticals” (industrial classification code No. 8 “medicines”). The second is “electronics”, which consist of “electronic parts, devices, and electronic circuits” (No. 22) and “electrical equipment and electric measuring instruments” (No. 23). The third is “motor vehicles” (No. 26 “motor vehicles, parts and accessories”).

3.2.1 Pharmaceuticals

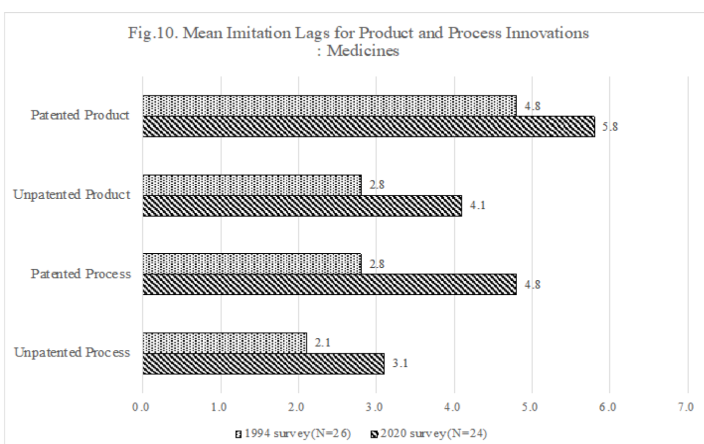
In the pharmaceuticals industry, many of the appropriability mechanisms exceeded the manufacturing-industry mean in the percentage of innovations for which the mechanism was considered effective, particularly in the case of patent protection. However, as observed in the data for the manufacturing industry as a whole, the perceived effectiveness of the mechanisms declined between the two surveys (see Figures 8 and 9). For product innovation, patent protection was considered effective by 49.2% of innovation in 2020, compared with 63.4% in 1994. For process innovation, effectiveness declined significantly from 45.8% to 21.1%. Patent protection retained the top spot as a mechanism for product innovation; however, in the rankings for process innovation, it slipped to second place, with complementary manufacturing facilities and know-how taking the top spot at 23.8%. A sizeable decline also occurred in being first to market.

Fig.8. Effectiveness of Appropriability Mechanisms for Product Innovations: Medicines (Mean % of Product Innovations for which Mechanism Concidered Effective.)



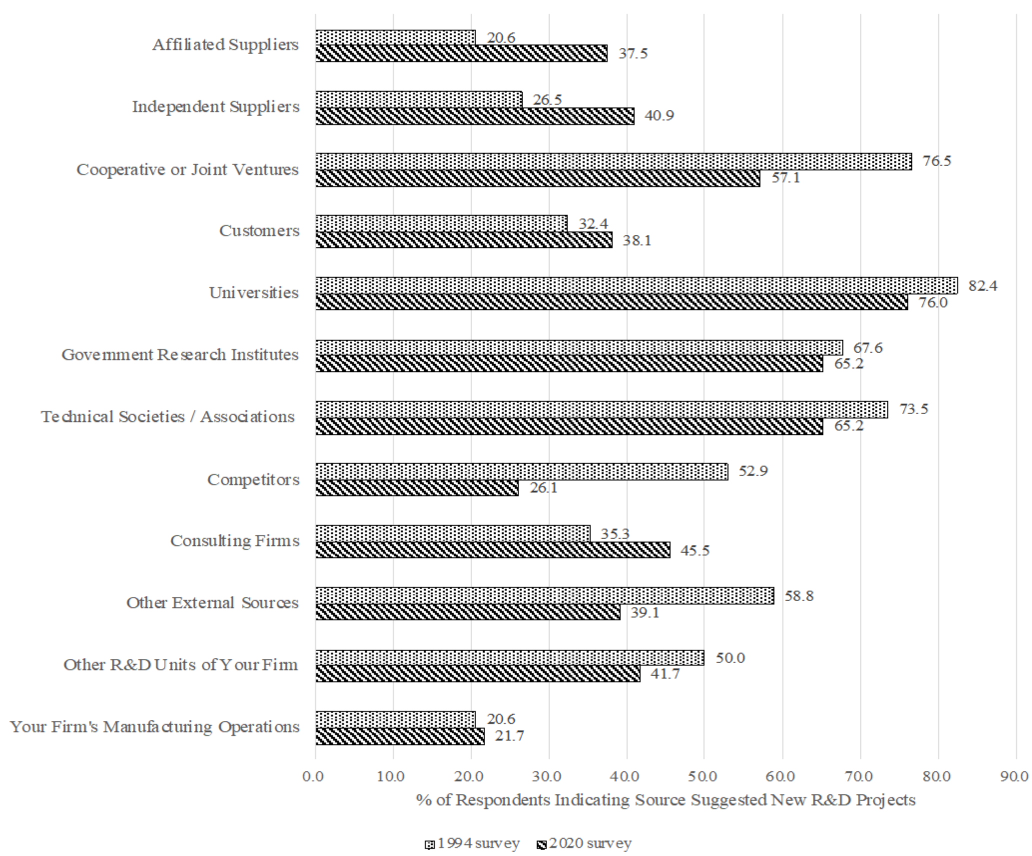


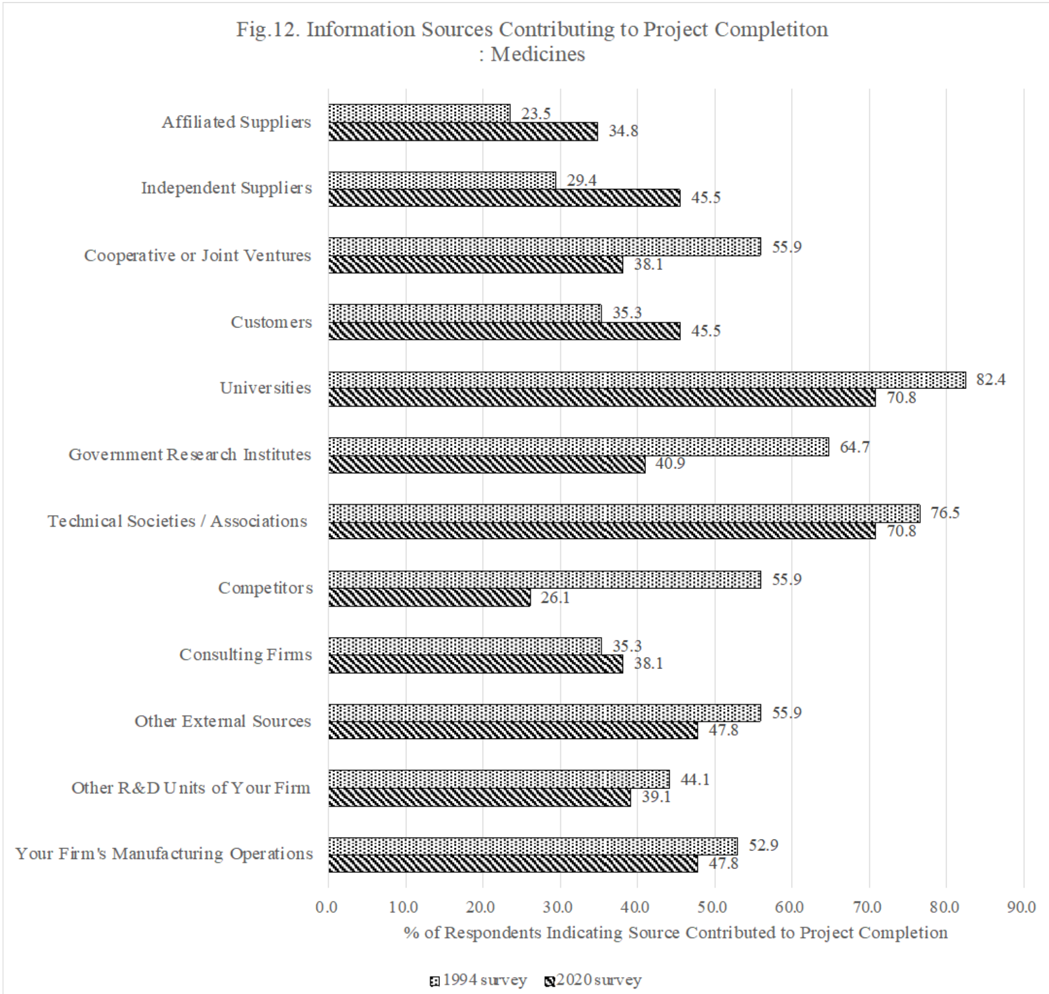
Reflecting on the perceived importance of patent protection among manufacturers of pharmaceuticals, imitation lags vary markedly between cases in which the innovation is patented and those in which it is not. The effect of patent protection in lengthening the imitation lag was more prominent in product innovation with patented product innovations, where they held a mean imitation lag of 4.8 years, two years more than unpatented product innovations (2.8 years) in the 1994 survey. In the 2020 survey, imitation lags lengthened in both cases, with patented innovations holding a mean lag of 5.8 years, 1.7 years (20 months) more than unpatented innovations (4.1 years). Thus, the extent to which patent protection delays imitation diminished by four months between the two surveys. This implies that, although patent protection is still lengthening imitation lags in general, its lengthening effect is relatively lower than before. This is consistent with the results concerning the effectiveness of appropriability mechanism (Figure 10).



The 1994 survey revealed three prominent information sources that companies in the pharmaceutical industry rely on to suggest new projects and contribute to project completion: universities, government research institutes, and technical societies/associations. However, by the 2020 survey, these sources were being accessed less often for information on technological opportunities, a reversal of the trend seen in the manufacturing-industry mean scores. Despite this decline, these three information sources remained relatively important. A notable change occurred in suppliers: Information from suppliers, whether affiliated or independent, was cited by a much higher share of respondents in the 2020 survey. Similarly, a higher rate of new projects suggestions from firms' manufacturing operations was seen in the 2020 survey, albeit to a modest degree, whereas this indicator decreased among the manufacturing industry as a whole. Although the rate of firms' manufacturing operations for contribute to project completion has declined, the extent of the decline has been small compared to other information sources (Figures 11 and 12).

Fig.11. Information Sources Suggeting New Projects
: Medicines





3.2.2 Electronics

In the electronics industry, being the first to market and patent protection declined in their effectiveness as appropriability mechanisms for product innovations, which is consistent with the trend across the manufacturing industry as a whole. However, bucking the industry-wide trend, the perceived effectiveness with respect to product innovations increased in secrecy, other legal mechanisms, complementary sales/services, complementary manufacturing facilities and know-how, and product complexity (Figure 13). For process innovations, many of the mechanisms declined in perceived importance, with being the first to market declining by 10% points, as it did among the whole manufacturing sample (Figure 14).

Fig.13. Effectiveness of Appropriability Mechanisms
for Product Innovations: Electronics
(Mean % of Product Innovations for which Mechanism Concidered Effective.)

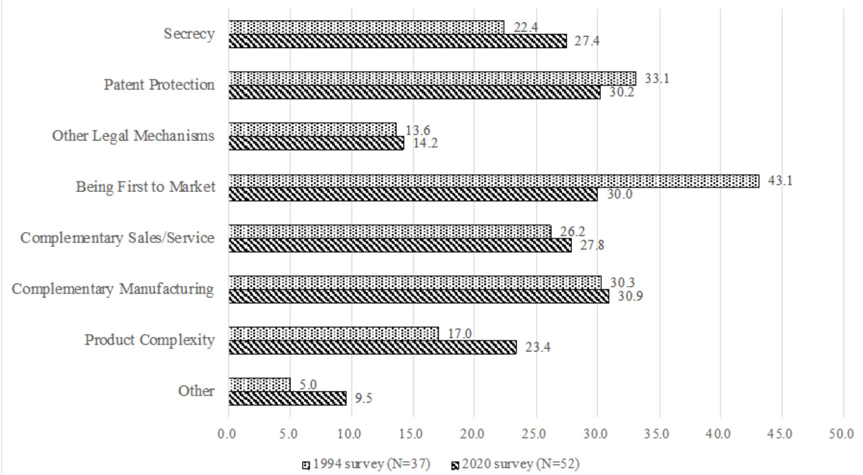
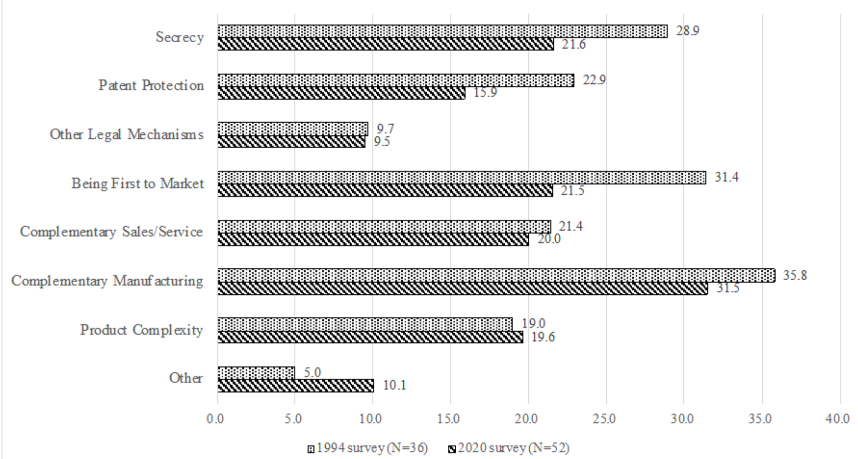
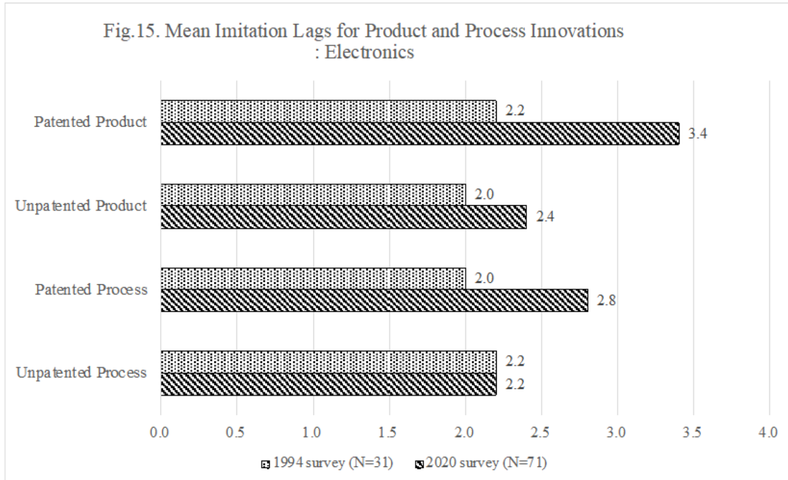


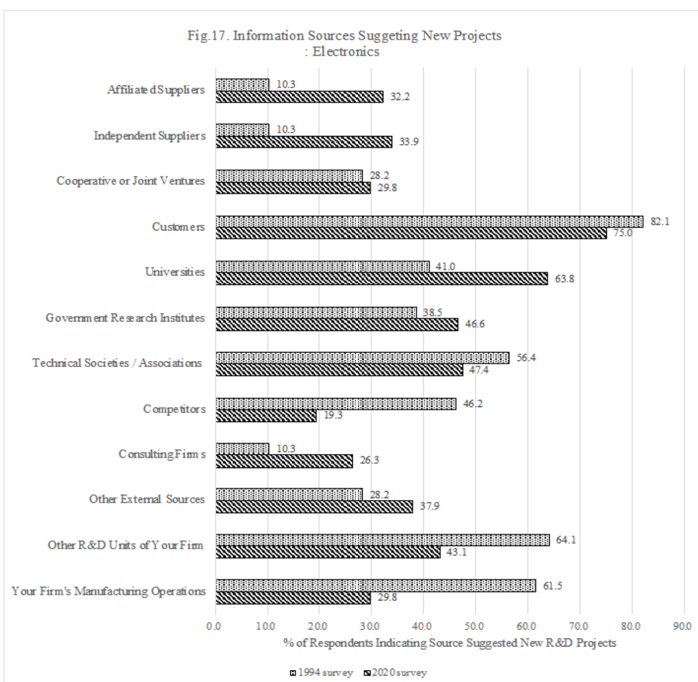
Fig.14. Effectiveness of Appropriability Mechanisms
for Process Innovations: Electronics
(Mean % of Product Innovations for which Mechanism Concidered Effective.)

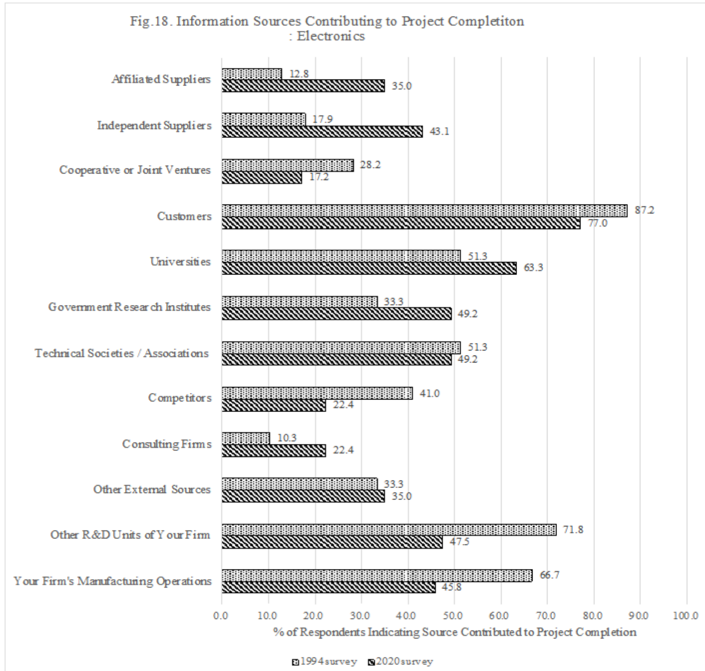


In the 1994 survey, patent protection added just two months to imitation lag in product innovation, and such protections conversely shortened the lag by two months for process innovations. By contrast, in the 2020 survey, lags were longer than in the 1994 survey, except in the case of unpatented process innovations. For product innovations, patent protection lengthened the lag by one year, and it held a lengthening effect on imitation lag for process innovations, unlike in 1994 (Figure 15). This is consistent with the aforementioned decline tendency for the spillover of technologies within an industry through patents.



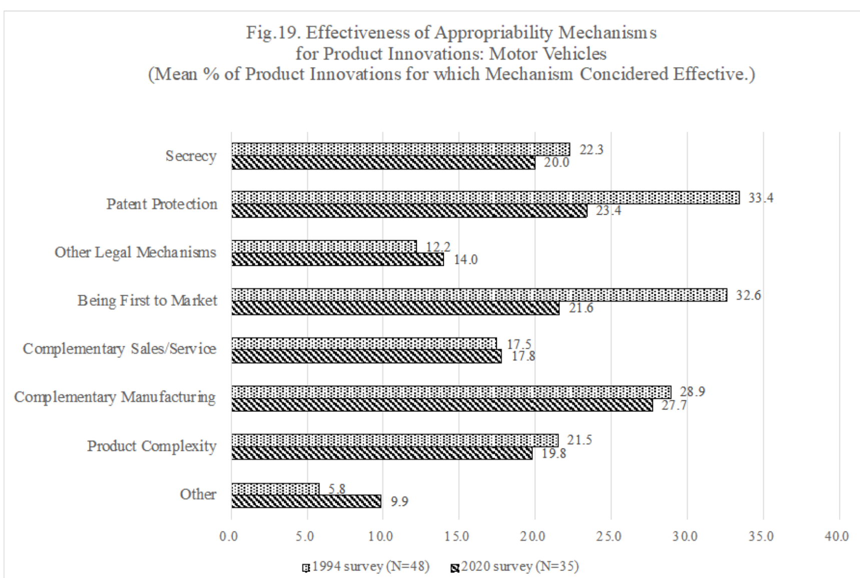
In the 1994 survey, customers, other internal R&D units, and internal manufacturing operations were prominently cited as information sources both for suggesting new projects and for project completion. Of these, the two internal sources were cited much less frequently in the 2020 survey (Figures 16 and 17). In these respects, electronics is consistent with the manufacturing industry as a whole. However, the notable increases in the prominence of universities and government research institutes in electronics. A notable increase can also be observed in suppliers: in the 2020 survey, suppliers, both affiliated and independent, were considered even more important than they were among the respondents in the pharmaceuticals industry.

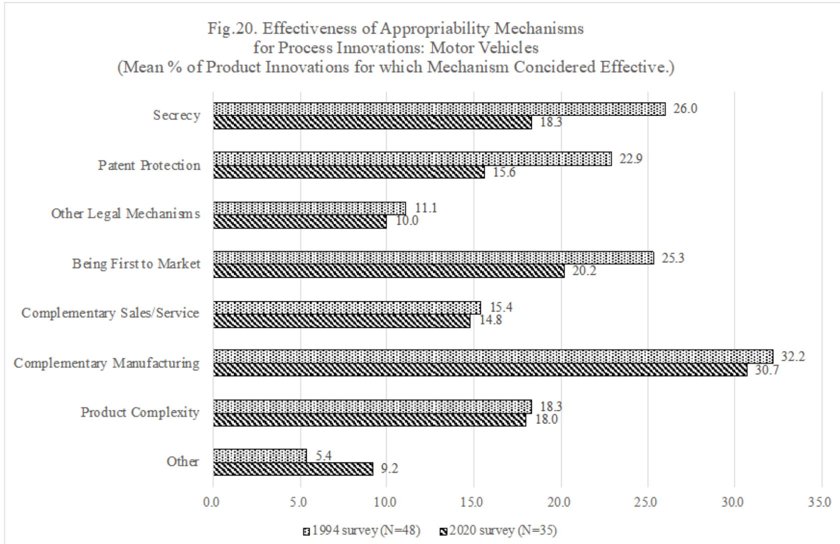




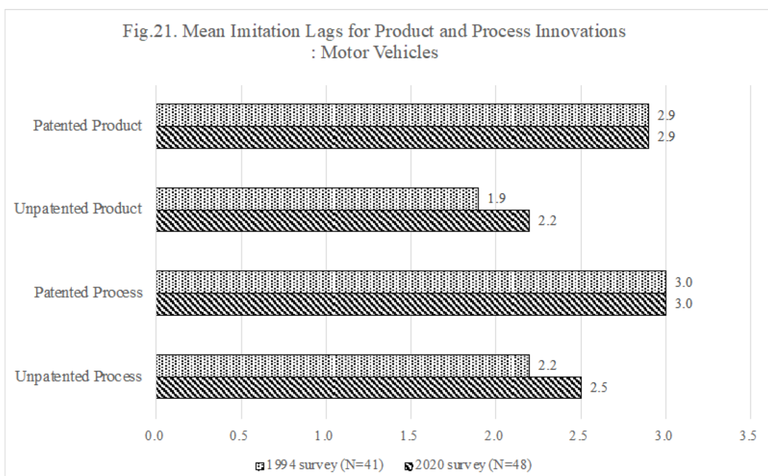
3.2.3 Motor Vehicles, Parts, and Accessories

As with the manufacturing industry in general, a large decline occurred between the two surveys in terms of the perceived effectiveness of being the first to market and patent protection in the motor vehicle industry. In contrast, the decline in the effectiveness of complementary manufacturing and know-how was small, such that this mechanism's relative effectiveness became more prominent in 2020 (Figures 19 and 20).

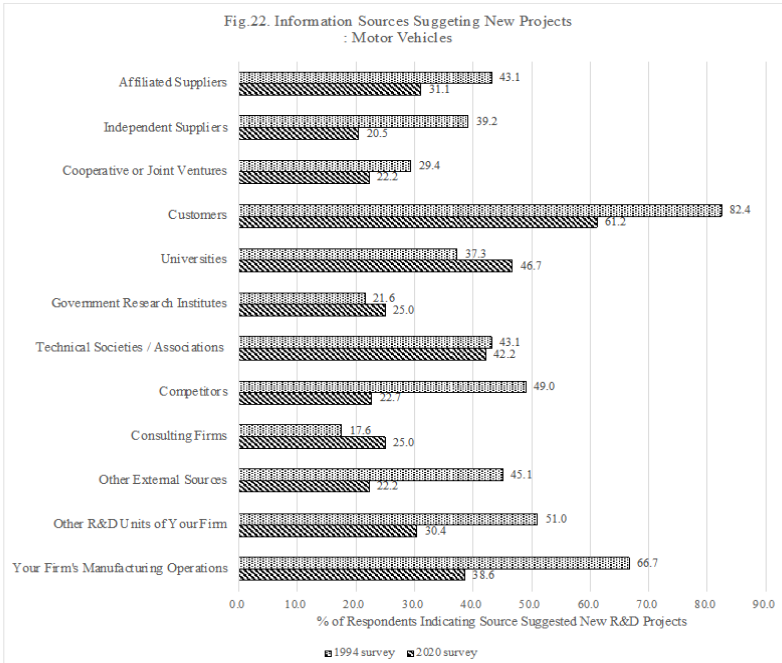


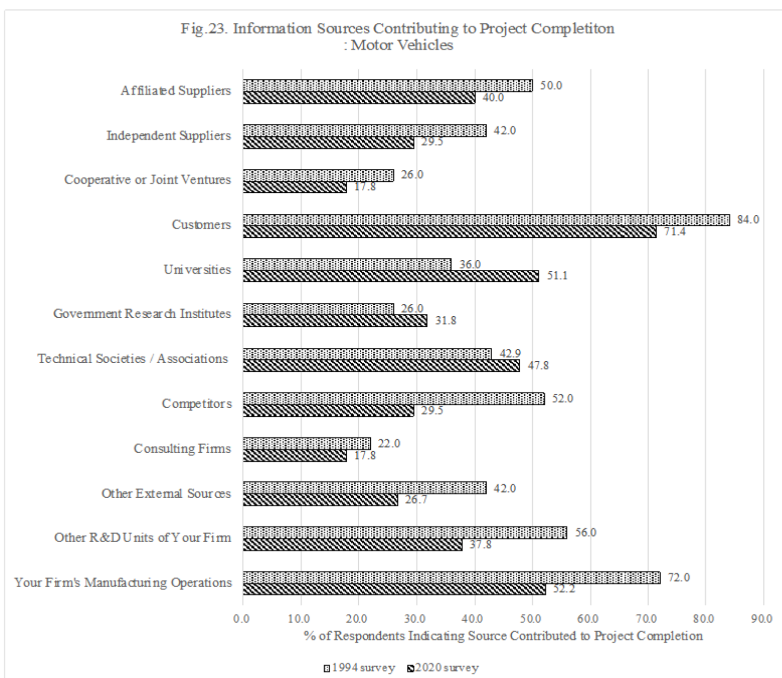


In the motor vehicle industry, the extent to which patent protection lengthened imitation lag was constant for both product and process innovations, and that the lag-lengthening effect is unaffected by the type of innovation (product or process). The imitation lag for unpatented innovations increased between the surveys, resulting in a relatively smaller imitation delaying effect of patent protection (Figure 21).



In the motor vehicles industry, customers and internal manufacturing operations were key information sources for both new projects and project completion. However, while their relative importance remained unchanged, these sources markedly declined in absolute importance between the surveys. Suppliers, affiliated or independent, were considered relatively important information sources; however, unlike in pharmaceuticals and electronics, a decline occurred in the percentage of respondents stating that they obtained useful information from suppliers. The decline in the number of responses citing competitors as an information source is particularly conspicuous. On the other hand, universities and government research institutes increased in importance, as they did among electronics respondents (Figures 22 and 23).





4. Discussion

By comparing the results of the 1994 and 2020 surveys in this report, we identified several changes that have occurred in the innovation process of Japanese companies during the quarter-century interval between the surveys.

First, effectiveness has declined for almost all the mechanisms by which companies appropriate profit from an innovation, with a particularly sizeable decline in the effects of being early to market.

Second, imitation lag (the time it takes competitors to introduce a competing alternative) has lengthened considerably. Across the manufacturing industry as a whole, the lag has lengthened more for patented innovations than for non-patented innovations.

Third, universities and government research institutes have become increasingly important as information sources: that is, as sources of technological opportunity. Conversely, internal sources and competitors have become less important in this respect.

While an analysis from a more diverse set of viewpoints is necessary to clarify how these trends have reshaped Japan's innovation system, the above findings raise two important questions.

(1) Has innovation become less profitable, and has innovation competition waned?

Our survey results present an apparent contradiction: While they reveal that imitation lags have lengthened such that innovators can now enjoy a longer monopoly, they also indicate that innovators expect less return than they once did from being the first to market. To reconcile this apparent contradiction, we suggest the following interpretation: with innovations offering less potential profit than they once did, potential imitators now have less incentive to invest in imitation. Less imitation has naturally resulted in longer imitation lags, but this means that innovators have less to gain from rushing the innovation to market.

If this interpretation is accurate, it would further imply that less profit can be obtained from innovation and that innovation competition has waned. However, the results indicate that competition has increased: the datasets for both surveys included categorical data for a number of competitors in the Japanese market. When such data are summarized, respondents reported having 14.5 competitors in the 1994 survey and an average of 19.0 competitors in the 2020 survey.[13] Thus, if innovation competition has waned, it has done so despite an increase in

[13] The response categories differed between the two surveys. Response categories from the 1994 survey were converted into numerical values as follows: "0" as 0, "1–2" as 2, "3–5" as 4, "6–10" as 8, "11–20" as 16, and "21 or more" as 32. Response categories from the 2020 survey were converted into numerical values as follows: "0" as 0, "1–4" as 3, "5–9" as 7, "10–19" as 15, "20–39" as 30, and "40 or more" as 60.

the number of competitors. This trend may, therefore, imply that a large number of companies in the same industry are now pursuing less profitable innovation options separately.

Has it become harder to obtain profit from innovation, and has innovation competition really waned? If innovation has indeed become less profitable, what are the institutional and organizational causes? These are important research questions that will guide innovation policymaking in the years ahead.

(2) Is there now less of a shared knowledge base among competing companies?

The fact that competitors have become less important as an information source for obtaining technological opportunities supports our suggestion that companies are pursuing innovation options in a more disparate manner. We can also find a separate line of corroborating evidence in the 1994 survey.

The 1994 survey included data about the competitive interactions. Respondents reported the point at which their firm learned of a competitor's innovation project, the percentage of their firm's R&D projects that had the same objective as that of a competitor, and the percentage of projects that their firm had launched to compete with a competitor's projects. Results for the first item varied widely between Japan and the USA: In the Japan survey, 43.9% of respondents reported that their firm learned of a competitor's project by the research stage, compared with just 15.6% of US firms. However, Japan and the USA differed little in terms of the other items. Among Japanese and US respondents, respectively, 52.1% and 53.7% of projects had the same purpose as a competitor and 23.3% and 27.7% of projects were launched in response to a competitor's project.[14] Thus, in the 1994 survey, Japan had a similar level of innovation competition to that of the USA. Given that the competition in Japan created technological spillover at an early stage in the innovation process, it likely resulted in a homogenous pattern of competition in which firms competed with each other upon a shared base of common technology and know-how within the industry.[15] Early technological spillover is also consistent with the survey finding that imitation lag was shorter in Japan than it was in the USA.

[14] Goto and Nagata (1997), pp. 56–57.

[15] The literature suggests that such homogenous competition was occurring in a number of industries in Japan at the time. Yoneyama and Nonaka (1995) noted the homogenous set of technological options pursued by Japanese firms that were developing dynamic random-access memory (DRAM) with greater capacity (from 4 kilobytes to 256 megabytes) and argued that this homogeneity was a result of a shared set of technology and know-how across the industry. Shimizu (2016) documented a similar trend in the development of semiconductor laser diodes; engineers from rival firms engaged in unofficial cross-company communications regarding the R&D challenges associated with such innovations. Similarly, Onishi (2007) noted cases of unofficial exchanges between engineers from rival firms in connection with the process of developing liquid crystal displays.

These items on competitive interactions were absent from the 2020 survey, so we are unable to compare the two time points using the same set of variables. We can, however, glean insights here from the previously discussed survey results, which indicated that imitation lags have lengthened and that competitors have declined in importance as information sources. This implies that, whereas Japanese companies once held much technology and know-how in common as a result of early spillover and competed over the same types of innovations in an effort to be the first to bring them to market, they now pursue innovation in a more disparate manner. This trend may be creating a vicious circle by reducing the shared knowledge base in each industry, leading, in turn, to ever less innovation competition and an ever slower innovation pace.

Is it true that these shared information bases are being depleted? If so, is this depletion the cause of waning innovation competition? These too are questions that must be examined in identifying new challenges to address in innovation policymaking.

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Appendix
Questionnaires

This appendix presents a part of questionnaire used for the 1994 survey (Innovation Survey on Industrial Technology) and the 2020 survey (Survey on Research and Development Activities of Firms in the Private Sector). The definitions of terms used in the survey are also provided.

The full text of the 1994 survey is included in Goto and Nagata (1997). The full text of the 2020 survey is included in NISTEP (2021).

Excerpt from the 1994 Survey Questionnaire (Innovation Survey on Industrial Technology)

○Definitions of terms

Innovation (*inobēshon*)

Innovation is the result of design, R&D, market research, or other such actions as required in the development of an innovative product or manufacturing process. There are two types of innovation:

Product Innovation (*seihin inobēshon*)

This term refers to the bringing to market of a new or improved product. It is the introduction of a new product featuring substantially changed function, performance, design, materials, or components or the technological upgrading of an existing product. This definition excludes cases in which a product was differentiated by adding decorative or cosmetic changes without changing its technical functionality or capacity.

Process Innovation (*kōtei inobēshon*)

This term refers to the introduction of a new or improved process. Process innovation are introduced to produce new products or to improve the efficiency of processes that produce existing products.

Ⅲ. Sources of Information

13. During the last three years, has your R&D unit obtained information from any of the following sources which either suggested new projects or contributed to the completion of existing projects ?

	Suggested New Projects		Contributed to Completion	
	Yes	No	Yes	No
a. Affiliated suppliers (supplier linked to your unit through ownership)	1.	2.	1.	2.
b. Independent suppliers (not linked through ownership)	1.	2.	1.	2.
c. Cooperative or joint ventures	1.	2.	1.	2.
d. Customers	1.	2.	1.	2.
e. Universities	1.	2.	1.	2.
f. Government research institutes	1.	2.	1.	2.
g. Technical societies / associations	1.	2.	1.	2.
h. Competitors	1.	2.	1.	2.
i. Consulting or contract R&D firms	1.	2.	1.	2.
j. Other external sources	1.	2.	1.	2.
k. Other R&D units of your firms	1.	2.	1.	2.

l. Your firm's manufacturing operations	1.	2.	1.	2.

14. Which one of these sources was the most important for suggesting new projects ?

Enter letter corresponding to source

15. Which one of these sources made the most important contributions to the completion of existing projects ?

Enter letter corresponding to source

VI. Protecting the Returns to Innovation

38. During the last three years, for what percent of your product innovations were each of the following effective in protecting your firm's competitive advantage from those innovations ?

	Below 10%	10 - 40%	41 - 60%	61 - 90%	Over 91%
a. Secrecy	1.	2.	3.	4.	5.
b. Patent protection	1.	2.	3.	4.	5.
c. Other legal mechanisms (such as design registration or copyright)	1.	2.	3.	4.	5.
d. Being first to market	1.	2.	3.	4.	5.
e. Complementary sales / service	1.	2.	3.	4.	5.
f. Complementary manufacturing facilities and know-how	1.	2.	3.	4.	5.
g. Product complexity	1.	2.	3.	4.	5.
h. Other	1.	2.	3.	4.	5.

39. During the last three years, for what percent of your process innovations were each of the following effective in protecting your firm's competitive advantage from those innovations ?

	Below 10%	10 - 40%	41 - 60%	61 - 90%	Over 91%
a. Secrecy	1.	2.	3.	4.	5.
b. Patent protection	1.	2.	3.	4.	5.
c. Other legal mechanisms (such as design registration or copyright)	1.	2.	3.	4.	5.
d. Being first to market	1.	2.	3.	4.	5.

e. Complementary sales / service	1.	2.	3.	4.	5.
f. Complementary manufacturing facilities and know-how	1.	2.	3.	4.	5.
g. Product complexity	1.	2.	3.	4.	5.
h. Other	1.	2.	3.	4.	5.

46. For your most significant product and process innovations introduced <u>over the last ten years</u> which you <u>did patent</u>, approximately how long was it until another firm introduced a competing alternative ?

	< 6 Months	6 Months - 1.5 Years	1.5 - 3 Years	3 - 5 Years	> 5 Years
a. Most significant product innovation	1.	2.	3.	4.	5.
b. Most significant process innovation	1.	2.	3.	4.	5.

47. For your most significant product and process innovations introduced <u>over the last ten years</u> which you <u>did not patent</u>, approximately how long was it until another firm introduced a competing alternative ?

	< 6 Months	6 Months - 1.5 Years	1.5 - 3 Years	3 - 5 Years	> 5 Years
a. Most significant product innovation	1.	2.	3.	4.	5.
b. Most significant process innovation	1.	2.	3.	4.	5.

Excerpt from the 2020 Survey Questionnaire

(Survey on Research and Development Activities of Firms in the Private Sector)

Question 3.6. During the last three years, how effective was each of the following mechanisms for appropriating profit from new product introductions (*shin seihin dōnyū*) [Note 1] and new process introductions (*shin kōtei dōnyū*) [Note 2] in your main business unit? For each of the eight mechanisms listed below, please check the box that matches the percentage of all of your firm's R&D projects for which the mechanism proved effective [*].

[*] For example, if secrecy enabled your firm to obtain profit from certain new products, calculate the number of R&D projects that your firm conducted that were related to those products (V) as a share of the total R&D projects your firm conducted (R) (V/R) and then check the box that corresponds to this percentage.

Note 1: "New product introduction" combines "new product introduction 1" and "new product introduction 2" as defined in Question 3.5. Specifically, it refers to "introduction of a new or significantly improved product or service" and to "introduction of a product or service that is neither new nor a significantly improved version of a previous product or service but is a modest improvement of a previous product or service."

Note 2: "New process introduction" combines "new process introduction 1" and "new process introduction 2" as defined in Question 3.5. Specifically, it refers to the "introduction of a new method or a significantly improved version of a previous method for producing or supplying a product (R&D or design; production; delivery, distribution, or logistics)" and to the "introduction of a method that is neither new nor a significantly improved version of a previous method but is a modest improvement of a previous method (R&D or design; production; delivery, distribution, or logistics)."

(1) New product introduction

Mechanism for appropriating profit		Percentage of your R&D projects for which the mechanism proved effective				
		Below 10%	10–40%	41–60%	61–90%	91% or more
1.	Secrecy	☐	☐	☐	☐	☐
2.	Patent protection	☐	☐	☐	☐	☐
3.	Other legal mechanisms (such as design registration or copyright)	☐	☐	☐	☐	☐
4.	Being the first to market	☐	☐	☐	☐	☐
5.	Complementary sales / service	☐	☐	☐	☐	☐
6.	Complementary manufacturing facilities and know-how	☐	☐	☐	☐	☐
7.	Product complexity	☐	☐	☐	☐	☐
8.	Other	☐	☐	☐	☐	☐

(2) New process introduction

Mechanism for appropriating profit		Percentage of your R&D projects for which the mechanism proved effective				
		Below 10%	10–40%	41–60%	61–90%	91% or more
1.	Secrecy	☐	☐	☐	☐	☐
2.	Patent protection	☐	☐	☐	☐	☐
3.	Other legal mechanisms (such as design registration or copyright)	☐	☐	☐	☐	☐
4.	Being the first to market	☐	☐	☐	☐	☐

5.	Complementary sales/service	☐	☐	☐	☐	☐
6.	Complementary manufacturing facilities and know-how	☐	☐	☐	☐	☐
7.	Product complexity	☐	☐	☐	☐	☐
8.	Other	☐	☐	☐	☐	☐

Question 3.7: For the most significant new product introductions and new process introductions over the last ten years in which you developed new technology in your primary industry, how long was it until another firm introduced a competing alternative? Please check the best fit answer, both for cases in which you did patent the technology and those for which you did not.

Note: "new product introduction" and "new process introduction" are as defined in Question 3.6.

(1) Cases for which you did patent the new technology

	Time until another firm introduced a competing alternative				
	1. < 6 months	2. 6 months to 1.5 years	3. 1.5 years to 3 years	4. 3–5 years	5. > 5 years
a. Most significant new product introductions	☐	☐	☐	☐	☐
b. Most significant new process introductions	☐	☐	☐	☐	☐

(2) Cases for which you did not patent the new technology

	Time until another firm introduced a competing alternative				
	1. < 6 months	2. 6 months to 1.5 years	3. 1.5 years to 3 years	4. 3–5 years	5. > 5 years
a. Most significant new product introductions	☐	☐	☐	☐	☐
b. Most significant new process introductions	☐	☐	☐	☐	☐

○ Definitions of new product introduction and new process introduction

New product introduction 1: Introduction of a new or significantly improved product or service

New product introduction 2: Introduction of a product or service that is neither new nor a significantly improved version of a previous product or service but is a modest improvement of a previous product or service

New process introduction 1: Introduction of a new method or a significantly improved version of a previous method for producing or supplying a product (R&D or design; production; delivery, distribution, or logistics, etc.)

New process introduction 2: Introduction of a method that is neither new nor a significantly improved version of a previous method but is a modest improvement of a previous method (R&D or design; production; delivery, distribution, logistics, etc.)

Note 1: In this context, "new" describes what your firm would regard as newness. As such, it can include products that are already on the market.

Note 2: A "new or significantly improved product or service" includes cases in which a new functionality, capacity, specifications, usability, raw materials, composition, internal software or subsystems, or delivery method (in the case of a service) was introduced to a product or service or cases in which one of these items was significantly improved.

Question 5.5: In your main business unit R&D during the last three years, did you obtain from any of the sources listed in 1 to 12 below information that suggested new projects or that contributed to the completion of existing projects? For each of the 12 items, check 1 or 2 to answer yes or no. If you answer yes to any of the 12 sources, please indicate in the field below the source that proved most effective.

		Did you obtain information from this source that suggested new projects?		Did you obtain information from this source that contributed to the completion of existing projects?	
		1. Yes	2. No	1. Yes	2. No
1.	Affiliated suppliers (suppliers linked to your firm through ownership)	☐	☐	☐	☐
2.	Independent suppliers (not linked through ownership)	☐	☐	☐	☐
3.	Cooperative or joint ventures	☐	☐	☐	☐
4.	Customers	☐	☐	☐	☐
5.	Universities	☐	☐	☐	☐
6.	Government research institutes	☐	☐	☐	☐
7.	Technical societies/associations	☐	☐	☐	☐
8.	Competitors	☐	☐	☐	☐

9.	Consulting or contract R&D firms	☐	☐	☐	☐
10.	Other external sources	☐	☐	☐	☐
11.	Other R&D units of your firms	☐	☐	☐	☐
12.	Your firm's manufacturing operations	☐	☐	☐	☐
	If you answered yes to any of the 12 sources, please indicate in the field below <u>the source that proved most effective</u>.	Number (1 to 12) of one of the sources for which you answered yes: ______		Number (1 to 12) of one of the sources for which you answered yes: ______	

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