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# Commercialization and Other Uses of Patents in Japan and the U.S.: Major findings from the RIETI-Georgia Tech inventor survey

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# Commercialization and other uses of patents in Japan and the US: Major findings from the RIETI-Georgia Tech inventor survey[1]


## Summary

Based on the newly implemented inventor survey in Japan and the US, we have examined the commercialization and other uses of triadic patents. Although the two countries have a similar overall level of commercialization (60% of the triadic patents), the structure is different: in Japan, we see a higher incidence of in-house use relative to the overall level of commercialization, more inventions being licensed and less used for startups. We also see more multiple uses (in-house and license/startup) in Japan. In both countries licensing plays a relatively important role for commercializing the inventions from R&D targeted to new business and to enhancing the technology base. Consistently, licensing becomes more important as a patenting reason as the invention involves more scientific knowledge. The key difference in startups between the two countries is a high incidence of the inventions of university researchers being used for startups in the US (35%). In both countries strategic holding (use of the patents for blocking and the prevention of inventing around) is one of the major reasons of non-commercialized patents. Only 20% of the internally commercialized patents can be used on a stand-alone basis in both countries, and both the incidence of cross-license conditional on license and the incidence of license itself tend to increase with the size of the bundle of the patents to be jointly used with that invention. As appropriation measures, the first mover advantage (FMA) in commercialization and the FMA in R&D are the most important in both countries, while the latter becomes more important as the invention involves more scientific knowledge. The US inventors rank patent enforcement significantly higher than possessing complementary capabilities, while the reverse is the case for Japanese inventors. In addition, enhancing the exclusive exploitation of the invention is a more important patenting reason in the US. The fact that the commercialization rate of patented inventions is quite similar between the two countries despite of the significant difference of the appreciation of exclusivity indicates that exclusivity may promote exploitation in certain areas and retard it in others. Finally, non-conventional patenting reasons are also important in both countries: blocking and pure defense are at least as important as licensing, and corporate reputation is an important reason for patenting by small firms.


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## 1. **Introduction**

Turning inventions into innovations is a key step in generating economic benefits from inventive activity. Since a grant of the patent does not guarantee that the invention is commercialized, it is important to understand how many inventions are actually commercialized through internal use, licensing and startups and to understand the mechanism for and the constraints on commercialization. In addition, it is important to recognize that a patent is also used for other objectives than for protecting the commercialization of the invention, such as blocking others from commercializing inventions or for the prevention of being blocked by others and acquiring reputation. However, the research on the commercialization and other use of inventions has been significantly constrained by the absence of large-scale systematic empirical data on the use of patents. Until recently, to the best of our knowledge, there had been only one large-scale published survey on the utilization of patents, which was done in 1957 with respect to US patents (Rossman and Sanders (1957) and Sanders (1964))[2]. A firm level survey is available in Japan for recent years (See also Nagaoka and Nishimura (2005)). Also, the recently published PatVal-EU survey collected data on the uses of patents in Europe (Giuri, et al., 2007). We report a comparative analysis of the commercialization process in Japan and the US, based on the new large scale survey of inventors. The survey focused on the inventions associated with "triadic" patents, i.e., those for which a patent was granted by the US patent office and applied for at both the Japanese and European Patent offices. The design of our survey questionnaire, while depending on the recently implemented European inventor survey (PatVal survey, see Giuri, et al. (2007)), significantly adds new dimensions, which allows us to analyze the commercialization and use of the patents from new perspectives (see the Appendix 1 for the key aspects of the survey method).

[2] According to the survey, the percentage of use either currently or in the past was over 55% for all patents. The sample covered randomly 2% of the patents issued in three years (1938, 1948 and 1952).

The first new dimension of our survey is that we have characterized the inventions in more detail by collecting detailed information on the underlying R&D project such as the objective and its scope. We analyze the commercialization process in light of these characteristics of the inventions. Second, we have asked the inventors to identify the reason(s) for non-commercialization. This allows us to assess how often the patents are used for strategic reasons (i.e., used only for blocking or for the prevention of inventing-around). Third, we have also asked the inventors to identify how many domestically granted patents are used together with the patent in question, in terms of the minimum scope of the product and process for using the patented invention. Whether an invention can be used on a stand-alone basis or not has important implications for the licensing of the patent. Fourthly, we also cover the appropriation strategy and patenting reasons at each patent level. Although there are a number of firm-level surveys on this issue since the Yale survey (Levin, Klevorick, Nelson and Winter (1987)), a systematic survey at the patent level is absent, to the best of our knowledge. The patent or project level survey allows us to investigate how the structural characteristics of R&D are related to the importance of alternative appropriation measures or to the patenting reasons. Finally, a US-Japan comparison helps us identify important similarities as well as key differences across the two distinct national innovation systems, which might in turn help us understand the influence of institutions on the commercialization process.

Before describing the results we would like to provide basic information on the business objectives of the research yielding the surveyed patents. We have asked inventors to identify the business objectives of the R&D projects, from which the patent (or patent application) is generated, which is a novel aspect in our inventor survey. The objectives include: *enhancement of existing business line, creating a new business line, the enhancement of the technology base of the firm or the long-term cultivation of technology seeds, not associated with* *current business* ("*enhancement of the technology base*" for brevity hereafter) and *other,* which is a very small part. Enhancement of the existing business line of a firm accounts for the largest share of R&D projects in both countries (roughly 60% in Japan and 50% in the USA). In both countries R&D for creating a new business line accounts for roughly 20% of R&D projects. A significant difference exists for the share of the R&D projects for enhancing the technology base (or for cultivating seeds), which is much more common in the US (24% in the US vs. 8% in Japan). Nagaoka and Walsh (2008) provide more detailed information and discussions.

The paper is organized as follow. Section 2 analyzes the commercialization channels and rates. Section 3 discusses the reasons for non-commercialization. Section 4 analyzes the bundle of patents necessary for commercialization. Sections 5 and 6 cover the analysis of appropriation strategies and patenting reasons. Discussions of US-Japan differences and similarities are included in each section. Section 7 concludes.

## 2. Commercialization channels and the rates of commercialization

We asked about three channels for commercializing the inventions: internal use by the applicant either for its products or for its processes (*in-house use*), licensing, and use for a startups by the inventor(s)[3]. They are not mutually exclusive, not only because the invention can be used both for internal use and for a license, due to non-rivalry in the use of knowledge, but also because the applicant firm itself may be a startup firm or the invention is licensed to the startup firm of the inventor (a spinoff case). Figure 1 provides the aggregate picture of the commercialization of the inventions in Japan and the US[4]. The two countries have broadly similar patterns of use. In particular, around 60% of the triadic patent inventions are used in both countries by the

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3 Note that the applicant firm itself may be a startup firm, in which case the commercialization by the applicant and the startup use of the invention overlap each other.

4 The national means for cross-country comparisons in this figure and in other figures for overall comparison adjust for the technology composition difference between the US and Japan, based on a set of common technology class weights (see Appendix 1).

applicant(s) either for its products or processes, for a license or for a startup (*any commercialization* in Figure 1)[5]. The in-house use by the applicant is the most important channel for both countries, the level of which is slightly higher in Japan (54% in Japan and 50% in US), but mainly due to the older priority years of the Japanese sample[6].. This level is very close to that of the EPO patents reported by the PatVal_EU survey (55%)[7]. Pure in-house use (the use of the patent only internally by the applicant) is more limited: 35% in Japan and 40% in the US, implying that 65% of the inventions used in-house are used only internally in Japan, but the corresponding share is 80% in the US. Thus, an invention seems to be is used more often used exclusively in the US.

(Figure 1)

The licensing rate is much higher in Japan (21% in Japan vs. 14% in US) [8]. The large difference between the US and Japan could be partly due to the fact that the Japanese survey does not rule out licensing to a related party, given that both the R&D and patenting decision of a firm are largely managed on an individual firm basis rather than on a consolidated group basis in Japan. However, as will be shortly discussed, the licensing rate is significantly higher in Japan than in the US even among small firms, for which the licensing to a related party would be rare. This suggests that licensing is more common in Japan. Note, in addition, that the survey focused on the licensing of a domestic patent, so that it does not cover the licensing of the foreign patent on the invention to the overseas subsidiaries of the applicant. The licensing rate

[5] Assuming the binomial distribution, the standard deviation of its mean is less than 0.8% in Japan (*p=0.6* and *n=3550*) and 1.1% in the US (*p=0.6* and *n=1850*), using the formula s.e.= $\sqrt{p(1-p)/n}$ .

[6] We would expect Japanese inventions to be commercialized more than the US inventions, given that the former have priority years from 1995 to 2001 and the latter have the priority years from 2000 to 2003. If we limit our comparisons to the 2000-2001 (priority years) cohorts in each country, we find that any commercialization is 60% in Japan and 63% in the US, and internal use is 54% in Japan and 52% in the US.

[7] See Giuri, et al. ( 2007). It is the sum of internal use (50.5%) and licensing use (4%).

[8] Note that the licensing rate seems to be significantly more influenced by the quality of the inventions than the rate of internal use. According to the Japanese survey, the licensing rate for non-triadic patents is 14%, while the rate of their internal use is 41%.

in the US is comparable to that of the PatVal_EU survey (13.4%). Finally, the use of inventions for startups accounts for only a small share of the inventions in both countries but it is more common for the US than in Japan (7% in US vs. 4% in Japan). This is comparable to that of the European survey (5.1 %).

The business objective of the underlying R&D projects significantly affects the pattern of commercialization, as shown in Figures 2A and 2B. R&D projects directly related to the existing business of a firm would have an advantage in that their results can be more easily used by a firm, since a firm is more likely to have the assets complementary to the invention, such as manufacturing and sales capabilities. Thus, even the research results that are relatively minor technological improvements could more easily find profitable applications. In contrast, licensing rates should be lower for inventions related to existing businesses, since anther firm is less likely to have these same complementary assets. Indeed, in Japan, the share of internal use of the inventions by the applicants is the highest for the inventions from R&D for enhancing the existing business (61%), while it is significantly lower for the inventions from R&D for creating a new business line (52%) and very low for the inventions from the R&D for enhancing the technology base (28%) in Japan. In the US, the pattern is similar, although the differences by project types are not so great. In particular, the rate of internal use of the inventions from R&D projects focusing on developing the technology base of the firm is relatively higher (43%), nearly as high as the rate for new business projects.

The licensing rate, on the other hand, does not vary so much in Japan: it varies from 24% for existing business related inventions, to 21% for new business related inventions to 17% for technology base related inventions. Thus, in Japan, licensing plays the important role (that is, the ratio between the licensing rate over the internal use rate is larger) for commercialization of inventions from R&D oriented to the technology base. In the US, R&D targeted to new business is most likely to be licensed (19%), followed by new technology base projects (13%) and existing business least likely (8%), again suggesting that US firms tend to emphasize exclusive use for innovations related to their existing businesses. The incidence of the startup use of the invention is uniformly low across the business objectives (although slightly higher for the inventions from the projects targeted to new business) in Japan, while, in the US, it is again most significant for the inventions from projects targeted to new businesses.

The comparison between the level of any commercialization and the rate of in-house use suggests that Japanese inventions related to new businesses are relatively more likely to be commercialized in house on the average than the US inventions (See Figure 1). Such tendency is especially the case for the inventions from R&D oriented to the new business (it also holds for the inventions to the existing business, but not for the inventions to the technology base). Since the US and Japan do not differ in the level of any commercialization, these differences suggest that markets for technology through licensing and startups, especially related to new businesses, are more developed in the US, in the sense that they maker more net contribution to the overall commercialization of the inventions. That is, in the US, we have a system where inventions related to new businesses are likely to be licensed out and/or used for startups and simultaneously, the inventions related to existing businesses are likely to be developed exclusively, while in Japan, we have a system where the inventions for existing business are no less likely to be used through licensing nor through startups than the inventions for new businesses.

(Figures 2A, 2B)

In both the US and Japan, the rate of in-house commercialization by the applicant is higher for smaller firms (the border lines between large, medium, small and very small firms are

500, 250 and 100),[9] as shown in Figure 3. It is 50% for a large firm and 60% for a very small firm in the US and the corresponding rates are 55% and 70% in Japan. In addition, the ratio between the inventions the commercialization of which are under investigation and the commercialized inventions is smaller for smaller firms. This indicates that larger firms have relatively more inventions which are difficult to commercialize internally.

(Figure 3)

We asked our respondents if they had licensed the focal invention, and included as possible answers, “yes”, “no” and “no but willing to license” (also “don’t know”). This allows us to distinguish the potential market for technology to the actual market. We find a large gap between the willingness to license and actual licenses in both countries (40% vs. 21% in Japan, and 30% vs. 14% in the US). This suggests that a significant efficiency gain might exist for both enhancing R&D incentives and for enhancing the use of technology in both countries if the market for technology was more developed. Although the licensing rate becomes larger as firm size declines in both the US and Japan, the willingness to license (the sum of the actually licensed patents and those which the inventors are willing to license) is roughly constant across firm size, except for the very small firms with less than 100 employees, which are especially willing to license in each country (see Figure 4). This suggests that the licensing propensity of a large firm is lower not because it is less willing to license but it has inventions that are harder to license. The inventions by university researchers are far more often licensed in the US than in Japan (53% vs. 35%). This may not be too surprising since in Japan many of the inventions by university researchers were transferred to the firm sponsoring the research. In Japan, only 18% of the inventions by university researchers were assigned to the university, while in the US,

[9] More specifically, very small firm: employment with 100 or less (less than 100 in the US), small firm: employment with 101-250 (100-250 in the US), medium firm: employment with 251-500 (250-500 in the US), and a large firm: employment with 500 or more (with 501 or more in the US).

64% were. Recent changes in employee invention rules for national universities in Japan, which are supposed to give the university ownership of professors' patents (and the establishment of university licensing offices) would affect this difference. In addition, conditioning on the licensing of the patent, the incidence of a single licensee is high in both countries. In the US, 65% of the licenses involve only one licensee, while the corresponding share is 70% in Japan, with large firms in both countries showing a similar pattern (see Figure A-2 in the Appendix). On the other hand, for university researcher inventions, almost 90% of the US inventions are exclusively licensed, while in Japan, significantly fewer (74%) are licensed to a single firm. Small firms have a similar pattern.

(Figure 4)

The use of the inventions for startups is 4% in Japan and 7% in the US. As shown in Figure A-1A and A-1B, in each country, close to 90% of the inventions used through a new firm are internally used, implying that the startups are the applicants themselves or the subsidiaries of the applicants (in the latter case, licensing would be involved) in most cases.[10] The use of inventions for startups is equally rare in both countries for the inventions from medium to large scale firms:[11] only 3% of the inventions from the large firms in both US and Japan, and 2.9% in the US and 5% in Japan for the medium sized firms, as shown in Figure 5. However, almost 30% of the inventions from the very small firms are used by startups in the US, compared to 10% in Japan. Note, however, that a substantial proportion of these firms in the US are likely to

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[10] There are several possibilities for this overlap. The applicants themselves could be the startups, the invention is used both for the internal use of the applicant and for the startup, or the new firm could be a subsidiary of the applicant (Note that there are some difference of the shares between Figure 1 and Figure A-1, because the latter Figure uses only the inventions with no missing values for the three commercialization measures).

[11] Note the organizational affiliation of an inventor is identified by the time of conducting the underlying research of the invention, not at the time of patent application or the survey, in both countries.

be the startups themselves (that is the inventions by the inventors affiliated with startup firms). A key difference exists for the inventions by university researchers: 36% of them used for startups in the US versus only 7% in Japan. On the other hand, since most inventions are from the inventors affiliated with large firms, these firms still account for a relatively large share of the inventions used through the startups. If we exclude the inventions from the very small firms which are likely to be the inventions by startup themselves, 71% of the inventions used by startups are from the large firms in Japan and 61% in the US. The university sector accounts for 4% in Japan but 21% in the US. In the US, startups are most common (more than twice the average rate) in biotech and medical instruments.  In Japan, startups are found at more than twice the average rate in gas, nuclear and x-ray, material processing equipment, agriculture/food and apparel/textiles. Thus, use of patents for startups in the US is most likely for high-tech sectors, while in Japan, the most startup intensive areas are much less R&D intensive technology classes.

(Figure 5)

### 3. The profile of non-commercialized inventions

Even though these are triadic patents, a substantial proportion of the patented inventions are not commercialized either through the commercialization by the applicants, licensing or startups (around 40% in both countries as shown in Figure 1). The non-commercialization rate is the highest for those inventions from R&D for enhancing the technology base of the firm, and the lowest for those inventions enhancing the existing business (see Figure 2). This gap between inventions from these two types of R&D projects is much larger in Japan than in the US (where even inventions focusing on enhancing the technology base have relatively high commercialization rates). Understanding the causes of non-commercialization of patents would be important in shedding light on the extent of the strategic use of patents, such as for blocking purposes, as well as on the sources of risk for R&D projects. Therefore, we asked the inventor to identify the reasons in the case where his invention is not commercialized, including the use of the patent for blocking or for the prevention of inventing-around.[12] Blocking is to prevent others from commercializing similar inventions (as in the PatVal survey), while the prevention of inventing around is to prevent others from inventing around applicant's existing patents by an alternative (dissimilar) technology. Thus, a patenting for the purpose of the prevention of inventing around can imply the patenting of a technology that is quite different from the invention in use by the firm. It is important to note that an invention may be used for blocking or for the prevention of the inventing-around only because a firm does not currently have the internal assets to commercialize it or it cannot find a licensee. Thus, we can distinguish two types of these patents, those for which a firm is willing to commercialize once such opportunities arise ("currently" blocking but which a firm is willing to commercialize) and those which a firm is not ("pure" blocking). An important reason for such pure blocking might be to protect the market exclusivity of another technology that is being commercialized.

According to Figure 6, the incidence of an invention used for blocking or for the prevention of inventing-around is highest when the patent is from an R&D project for enhancing the technology base. In Japan, 21% of the inventions from R&D for enhancing the technology base are used for these strategic objectives, significantly higher than the share of inventions licensed (16%). Similarly, in the US, 19% of inventions focusing on enhancing the technology base were used strategically, versus 10% of these patents being licensed. Furthermore, the differences in strategic non-use by project goal are much greater in Japan (21% for technology base v. 13% for existing business) than in the US (19% v. 16%). However, a firm is either investigating the possibility of internal use or it is willing to provide a license for

[12] This question was not asked in the European survey, although Giuri, et al. (2007) provide estimates of the shares of blocking and sleeping patents, based on the motivations to apply for patents.

about half of these inventions. For an example, in Japan, 10% of the inventions from the R&D enhancing the technology base are being currently used strategically (only for blocking or for the prevention of the inventing around), but the firm is willing to commercialize, so that the share of the patents for purely strategic holding is 11% of triadic patented inventions. The corresponding pure strategic share is 7% for the inventions from R&D enhancing the existing business line and 6% for the inventions from R&D for creating new business. We find similarly high shares of strategic holding in the US, although the rate for new business is relatively lower, with only 3% of patents associated with new business projects being designated as purely for strategic non-use. These findings suggest that a firm often chooses to strategically hold their patents, even though it has no immediate business lines to be protected.

(Figures 6A and 6B)

In addition to strategic holding (blocking and the prevention of inventing-around reasons), we identify two more groups of reasons for non-commercialization: technology reasons specific to the invention (the technology level of the invention, availability of complementary technology) and general market or business reasons (such as the downsizing of the relevant business line of a firm). In Japan, the incidence of market or business constraints is 46%, that of strategic holding is 40% and that of technology-specific constraints is 37%, including the cases where the other constraints are also binding, as shown in Figure 7A. Market and business constraints are the only reason for 27% of the non-commercialized cases, strategic holding reasons for 19% of the cases and specific technology constraints for 18% of cases. This implies that, in Japan, 62% of the triadic patents are commercialized, 14% (7%) remain non-commercialized but used for strategic holding (non-commercialized and used only for strategic holding) and 24% (31%) remain non-commercialized purely for non-strategic reasons (non-commercialized partially for non-strategic reasons). In the US, market or business constraints explain 41% of the non-used patents, strategic uses are 36% and technology constraints are 25%. Market or business reasons are the sole reason in 20% of patents, strategic non-use for 17% and technology constraints for 9%. Thus, in the US overall, 62% of triadic patents are commercialized, 14% (6%) remain non-commercialized but are used for strategic holding (non-commercialized and used only for strategic holding) and 24% (32%) remain non-commercialized purely for non-strategic reasons (non-commercialized partially for non-strategic reasons). This share of strategic patents (14% in both countries), those non-commercialized but used for strategic holding, is close to that estimated by Giuri et al. (2007) for the EPO patents (19%.).

(Figures 7A, 7B)

As shown in Figure 8, blocking is more important than the prevention of inventing-around in both countries among the strategic reasons (36% vs. 16% in Japan, 32% v. 21% in the US). Moreover, in both the US and Japan, the reason of preventing inventing-around is almost always accompanied by blocking, but not vice versa. Among the reasons related to the market or the business environmental conditions of the firm, unfavorable technological or market environmental change is the most important business reason in the US (26%) and the downsizing of the business is the most important business reason in Japan (23%). Underdevelopment of the application technologies is the most important reason specific to the technology in both countries (17% in Japan and 11% in the US).

(Figure 8)

**4. Size of the bundle of patents necessary for commercialization**

Prior work suggests that the use of patents (especially cross-licensing) are related to the number of patented components incorporated into a commercial product (See, for an example, Grindley and Teece (1997), Kusunoki, Nagata and Nonaka (1998), Shapiro (2001), Cohen, Goto, Nagata, Nelson and Walsh (2002)) However, there are no systematic data available on how large a bundle of complementary patents are necessary in a technology field, although contract based studies on cross-licensing provide some indirect evidence (for an example, see Nagaoka and Kwon (2006)). Our survey has directly asked inventors how many domestically granted patents are used together with the patented invention and internally commercialized, in terms of the minimum scope of the product and the process for its commercialization, focusing on the inventions that are used internally by the applicants. As shown in Figure 9, very interestingly, the US and Japan have very similar frequency distributions of the size of the bundle of patents to be jointly used. In both countries, only around 20% of the patents can be used on a stand-alone basis. Roughly 20% (17%) of the patents require a bundle of 11 or more patents for commercial use in Japan (the US). Such share is especially high in information storage and computer peripherals, exceeding 40% in both countries.

(Figure 9)

As shown in Figures 10A and 10B, the larger the size of the bundle of patents to be jointly used, the conditional probability of cross-licensing in licensing (the incidence of cross-licensing given licensing) becomes larger. In Japan, almost 60% of the licensed inventions are cross-licensed, once the invention requires more than 100 patents for its commercialization (50% in the US). In addition, the licensing propensity per se tends to increase as the size of the bundle increases (although the pattern is cleaner in Japan than in the US, where small Ns in some categories may give unreliable estimates). This suggests that a patent thicket forces and encourages a firm to license its technology.

(Figures 10A and 10B)

**5. Appropriation Strategy**

As is pointed out by Levin, Klevorick, Nelson and Winter (1987) and the following literature, intellectual property right protection is only one, and often not the most important, instrument for a firm to appropriate the returns from its R&D. First mover advantages (*FMA*, hereafter) and complementary capabilities in manufacturing and/or sales are often more important than patents or secrecy. Our survey extends the existing literature by collecting evidence at the project level as well as by distinguishing the FMA in R&D and the FMA in commercialization, given the cumulative nature of the invention process. The patent or project level survey allows us to investigate how the structural characteristics of R&D are related to the importance of alternative appropriation measures. While follow-up research on the invention may often be a pre-condition for bringing it into the market, the importance of first mover advantages in the follow-up research would depend on the nature of the invention, in particular how upstream it is. We asked the inventors to evaluate the following eight alternative appropriation means, using a 5 point Likert scale: first mover's advantage in the follow-up development of complementary technologies and the patent portfolio (*fmvrd*), first mover's advantage in commercialization (*fmvmrk*), complementary manufacturing capabilities (*mfg*), complementary sales/service capabilities (*sales*), secrecy (*secrecy*), patent enforcement (*patenf*), collaboration with firms with complementary technologies (*collaboration*), and product/process complexity (*complexity*). Figure 11 presents the summary results based on the inventions already commercialized internally, in terms of the proportion of the responses of "very important" or "important" (the share of response 4 or 5).

(Figure 11)

Both FMAs in commercialization and R&D are the most important instruments for the appropriation in both the US and Japan, consistent with earlier studies (Levin, et al., 1987, Cohen, et al., 2002). Between the two FMAs, FMA in commercialization is more important for

US inventors relative to the FMA in R&D (74% vs. 67%), while in Japan these are equally important (85%).[13] Another salient difference between the US and Japan is that the US inventors rank enforcement of patents significantly more important relative to possessing complementary capabilities in manufacturing (63% vs. 42%), while the reverse is the case in Japan (56% vs. 72%). Although there exists a significant variation in the evaluation of patent enforcement as an appropriation instrument across technologies by US inventors (For an example, in drugs, 50% of the inventors rank patent enforcement as very important, while in biotechnology and computer hardware only 10% of the inventors rank it as very important), a significantly higher share of inventors rank patent enforcement as very important in the US than in Japan in essentially all technology sectors.

We expect that the invention characteristics such as the importance of scientific and technical literature for the conception of an invention would affect significantly the relative importance of appropriation means. In particular, the FMA in R&D would become relatively more important when the underlying research makes greater use of knowledge embodied in scientific and technical journals and involves basic research in the research scope. In order to evaluate such conjectures, we have estimated country-specific ordered-logit equations explaining the importance of each appropriation instrument, with dummies for appropriation instruments, the importance of the scientific and technical literature for the conception of an invention, a dummy representing the basic research, dummies representing the research objectives and those for the size of firm, as well as the interactions between the appropriation instruments and these other variables.[14] The use of an orderd-logit estimation provides the advantage of fully exploiting the information from the survey, in addition to the fact that it can

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[13] Assuming the binomial distribution, the standard deviation of the estimated means is less than 1.1% in Japan (*p=0.5* and n=*1900*) and less than 1.7% in the US (*p=0.5* and *n=850*).
[14] We also add two-digit NBER technology class dummies.

simultaneously control relevant factors. A major constraint in using percent high or very high share for assessing the importance of appropriation means is that it loses information provided by the inventors. For an example, the variable percent share pools the responses of 4 and 5 on the one hand and 1 to 3 on the other. The sample used for this estimation is the inventions by the inventors affiliated with firms and already commercialized by the applicants.

Figures 12A and 12B shows the summary results (see Appendix 2 for details). The base case is the estimation results for the inventions by the inventors affiliated with a large firm for new business, which does not use the scientific and technical literature and does not involve basic research. It also shows the additional effects of the use of the scientific and technical literature in R&D when such literature is given the importance of “3” (on a 0-5 scale), as well as the effect of the inclusion of basic research in R&D. The comparison between Figures 11 and 12A and 12B show that the order of the alternative means in importance is essentially the same. Figures 12A and 12B also show that as the knowledge from scientific and technical journals become more important for the underlying research, not only do most appropriation instruments tend to become more important, but also the FMA in R&D becomes more important relative to the FMA in commercialization (a statistical test suggests that the difference is highly significant in Japan, but not quite significant in the US). Also interestingly, in Japan, the use of scientific and technical journals also enhances the importance of manufacturing capability as well as that of a collaboration with the firms with complementary technology, relative to the FMA in commercialization, although we see this relation only for collaboration in the US. This is presumably because a science-intensive invention requires a non-standard production process and is more accompanied with know-how and requires new complementary technologies. We also observe a similar effect of basic research on the importance of the appropriation instruments in terms of the importance of the FMA in R&D and manufacturing relative to the

FMA in commercialization in both countries, although the statistical significance here is much weaker. One difference between the two countries is that basic research is associated with *greater* reliance on secrecy in Japan but not in the US.

(Figures 12A and 12B)

**6. Patenting reasons**

The results in the above section suggest that patent enforcement by a firm is not the most important appropriation instruments in both countries. However, a firm may apply for a patent not only for enhancing the profitability of commercializing the invention but also for other objectives such as for pure defense, for enhancing the corporate reputation and for strategic reasons such as blocking. A pure defense reason implies that a firm patents its invention only for ensuring that its use is not being blocked by others,[15] where the exclusion of the others is not the purpose of patenting. The role of a patent to enhance the corporate reputation may also be important especially for small firms (see, for an example, Gans, Hsu and Stern (2002)), since it facilitates finance, marketing and personnel recruitment of such firms. In order to comprehensively understand the patenting reasons, including these non-conventional objectives, we have asked the inventor to identify the importance of eight patenting reasons, which can be classified into the following four broad categories:

(1) *appropriation by exclusion*, which covers exclusive exploitation of the invention in product and in process (*excl*), the prevention of inventing-around (*prinvarnd*) and the blocking (*blocking*) as subcategories,

(2) *licensing*, which covers licensing for revenue (*licen*) and cross-licensing (*crlice*) as sub-categories

[15] Although defensive publications serve the same objective, patenting provides more direct protection. The European survey does not cover this motivation for patenting.

(3) *pure defense* (*defense*), ensuring that the use of one's own invention is not being blocked by others, and

(4) *reputation* for the inventor (*repinvt*) and for the firm (*repfrm*).

These four motivations are clearly different from each other. Our pre-survey interviews suggest that inventors do recognize the differences, although they often have a mixture of motivations for patenting their inventions.

As shown in Figure 13, the order of the importance of the patenting reasons in terms of percent "high" (4 or 5 on a 0-5 scale) are very similar between the two countries, although the reason of enhancing the exclusive commercial exploitation is by far the most important one in the US, unlike in Japan, consistent with the fact that US inventors regard the enforcement of the patent right relatively more important than the Japanese inventors, as pointed out above. While more than 80% of the inventors in each country regard this motivation as either very important or important (%high), less than half of the US inventors regard the second most important reason (blocking) as that important (the statistical difference can be confirmed by the following statistical analysis). This result is consistent with the characterization of the US patent system as emphasizing exclusion, relative to that of Japan (Ordover (1991)). In both countries, blocking and pure defense reasons come next to exclusive use and are ranked relatively high. Licensing and cross-licensing follow after strategic patenting. Corporate reputation is also ranked high in the US, at about a similar level as licensing. Although individual reputation reasons is ranked low in both countries, it is ranked relatively high by the inventors belonging to the small or very small firms in both countries, especially in the US, as shown in the following analysis (perhaps due to the higher mobility of small firm inventors).

(Figure 13)

In order to assess how the invention and organizational characteristics affect the patenting reasons, we again estimated country-specific ordered-logit equations, using the sample of the inventions by corporate inventors, and using blocking as the base of comparison across patenting reasons (see Appendix 2 for analytical details). The results are summarized in Figures 14A and 14B. If we focus on the base case (invention by a large firm for creating a new business, which does not use the knowledge embodied in the science and technical literature and involves no basic research), the order of the importance of patenting reasons is broadly similar to that in Figure 13. However, the blocking motivation is found to be significantly more important than pure defense in both countries, once we take full account of the ranking information given by the inventors.

(Figures 14A and 14B)

In both countries, as the knowledge in the scientific and technical literature becomes important, most patenting reasons (excluding blocking) are also enhanced, perhaps reflecting the increase of the value of an invention. In Japan the reasons for licensing, cross licensing and reputations become especially more important (if we focus on the difference from the effect on the exclusion reason, there exists a highly statistically significant difference only for a licensing reason). In the US, we also see licensing, cross-licensing and inventor reputation being especially important reasons to patent in the presence of the importance of scientific literature, although none are significantly more affected than is exclusion. On the other hand, in Japan, the inclusion of basic research in the scope of research is associated with significantly stronger reasons only for exclusive use and licensing, relative to blocking, the prevention of inventing around, defense and cross-licensing. In the US, only licensing and inventor reputation are significantly enhanced (compared to blocking) in the presence of basic research. Figures 14A and 14B also shows the salient characteristics of the patenting reasons of the very small firms (less than 100 employees), relative to large firms. In both countries, the smallest firms appreciate significantly more the corporate reputation reason and significantly less the cross license reason. The latter finding is consistent with Nagaoka and Kwon (2007), which has found that the incidence of cross-licensing increases with the firm size of the partners and their symmetry. On the other hand, in the US, but not in Japan, licensing becomes significantly more important for very small firms. Market exclusivity is also significantly more important for very small firms in the US. Finally, in both countries, when the invention is from an R&D project for the existing business of the firm, the licensing and cross-licensing reasons become significantly lower, especially relative to defense or blocking reasons.

**7. Conclusions**

Based on the newly implemented inventor survey in Japan and the US, we have examined the commercialization and other uses of triadic patents. Major findings are the follows. Although the two countries have a similar overall level of commercialization (60% of the patents), the structure is different: in Japan, we see a higher incidence of in-house use relative to the overall level of commercialization, but simultaneously more inventions being used non-exclusively though licensing and less used for startups in Japan. In both countries, the in-house utilization rate and the licensing rate of an invention tend to decline as firm size increases. At the same time, the share of the inventions the commercialization of which are under investigation increases with firm size and the willingness to license does not decline with firm size, indicating that a large firm has relatively more inventions difficult to commercialize. Licensing plays a relatively larger role for commercializing the inventions from R&D targeted to other than existing business: especially new business in the US and especially those from R&D targeted to new technology in Japan. Startups based on the inventions from large firms are equally rare in both countries and the key difference is a high incidence of the inventions of university researchers being used for startups in the US. Perhaps closely related with this, the use of patents for startups in the US is most likely for high-tech sectors, while in Japan, the most startup intensive areas are much less R&D intensive technology classes.

Strategic holding (or the use of a patent for blocking and the prevention of inventing around) is one of the major reasons of non-commercialized patents. In Japan, market and business constraints, strategic holding and technology constraints specific to the invention is partially or wholly responsible for 46%, 40% and 37% of non-commercialized patents respectively. The rates in the US are broadly similar: 41% (market), 36% (strategic) and 25% (technology). Only half of the patents serving strategic purposes are held purely for strategic reasons in both countries, meaning that the firm is willing to commercialize either internally or through license as opportunities arise.

Only 20% of the patents can be used on a stand-alone basis in both countries, indicating the potential importance of patent thicket. The incidence of cross-license conditional on license increases with the size of the bundle of the patents to be jointly used with that invention. Once the size of the bundle exceeds a certain level, the incidence of licensing itself becomes larger, indicating that the patent thicket forces and encourages a firm to license its technology.

The first mover advantages (FMA) in commercialization and in R&D are the most important means for appropriation in both US and Japan. The FMA in R&D becomes more important relative to that in commercialization as the underlying R&D for the invention involves more use of scientific knowledge (especially in Japan). Although collaboration with firms with complementary technology is not regarded as an important appropriation strategy on average, more use of scientific knowledge significantly enhances such importance in both countries. Manufacturing capabilities also become more important for such invention in Japan, presumably because such science-intensive inventions require non-standard production processes and are more accompanied with know-how. The US inventors rank patent enforcement significantly higher than possessing complementary capability, while the reverse is the case for Japanese inventors. Finally, as for patenting reasons, the reason of enhancing the exclusive commercial exploitation is the most important one in both countries, but it is by far the most important in the US. A licensing reason is more highly valued in Japan and such reason becomes especially more important as the underlying R&D for the invention involves more use of scientific knowledge. Non-conventional patenting reasons are also important. Blocking and pure defense are at least as important as licensing reason in both countries. A pure defense reason is more important for the inventions from R&D targeting the existing business of the firm. Corporate reputation is an important reason for the patenting by small firms in both countries, especially in the US.

Thus, we see substantial similarities between the two countries in their commercialization and the use patterns of their patented inventions. In particular, the commercialization rates are quite similar, as is its relationship with R&D project type and firm size, the size of the bundle of patents used in a product, and the relation between this bundle and the use of licensing and cross-licensing. Strategic patenting as well as pure defensive patenting are also important in each country (only second to the exclusive use in both countries) and occur at about the same rate in each country. We also see important differences, especially in the use of licenses and startups. In Japan, licensing is more common. In particular, while licensing is important for the inventions from the projects targeted toward existing businesses in Japan, we find that in the US licensing and startups are most important for the inventions from new businesses, and inventions from existing business are much less likely to be licensed (or used as startups).

The above findings poses a number of future research questions as well as managerial and policy implications. We will discuss three of them. First, they provide interesting contrasts which would allow us to investigate how the patent protection of the exclusive right affects the commercialization of inventions. Overall, exclusive use of a technology is more valued by the US inventors, perhaps due to stronger patent protection in the US. US inventors rate patents as more important for appropriating returns to their inventions and they rate exclusive use as a more important reason for patenting. Similarly, the rate of commercializing the patent purely in-house is relatively higher in the US, while in Japan firms are more likely to license the patents that they are also commercializing themselves. Furthermore, in the US, we find exclusive licensing more common among small firms and universities, compared to Japan (although the overall rate of one licensee patents is slightly higher in Japan, once we include patents used in house by large firms). At the same time, the US inventions are more likely to be licensed or for startups if they are not used in house. Overall, licensing is higher in Japan, as is cross-licensing, especially for technologies they are commercializing themselves. Together, these results suggest higher rates of multiple users of a given technology (and its complements) in Japan and more single uses in the US. Since in-house and external uses in the US are more additive than in Japan, we might expect overall use (any commercialization) to be higher in the US. However, there can be offsetting effects of exclusivity on the commercialization of patents. On the one hand, exclusivity gives the owner (or his designate) the incentives to exploit the technology, because of greater potential appropriability (which is one of the main justifications for the patent system). On the other hand, a strong emphasis on exclusivity could retard use by creating patent thickets (Shapiro, 2001, Heller and Eisenberg, 1998) or by losing the advantages of multiple lines of attack on technical problems and diversity of paths of exploitation (Nelson and Winter, 1982). In fact, we observe little difference in the overall rate of commercialization of the patents in the two countries, suggesting that there may not be a clear net effect of the differences on the overall rate in the two systems. However, further, more systematic work is needed to test the welfare implications of these differences in the commercialization processes in the two countries.

Secondly, as a related point, we see significant differences in the contributions of university-based inventors, with US university researchers much more likely to use their inventions for startups, and more likely to grant a single license for their licensed inventions. Further work on the institutional contexts in each country may help explain some of these differences. Thirdly, licensing is important for expanding the scope of research by a firm toward exploratory research creating new business or enhancing the technology base. Since the social return from such research is likely to be large, we need to nurture the development of the technology market. Open innovation strategy will become more important as a firm pursues more the strategy of engaging in exploratory research.

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## Appendix 1. Japan and US inventor survey

### A.1 Basics of the survey

The survey in Japan was conducted by RIETI (Research Institute of Economy, Trade and Industry) between January and May in 2007. It collected 3,658 triadic patents[16], with priority years from 1995 to 2001. The survey in the US was conducted by Georgina Tech between June and November 2007, in collaboration with RIETI, and collected 1,919 patents, with 2000-2003 priority years. The survey used both mail and web (post-mail out and response by post or web) and the response rate was 20.6% (27.1% adjusted for undelivered, ineligible, etc.) in Japan and 24.2% (31.8% adjusted for the deceased, undeliverable, etc.) in the US.

### A.2. The questionnaire

The questionnaire consists of the following six sections: (1) Inventor's Personal Information; (2) Inventor's Education; (3) Inventor's Employment and Mobility; (4) Objective and Scope of R&D and the Invention Process; (5) Inventor's Motivations; (6) Use of invention and the patent.

### A.3 The sampling strategy and procedure

The sampling frame used for the survey is the OECD's Triadic Patent Families (TPF patents) database (OECD, 2006) which includes only those patents whose applications are filed in both the Japanese Patent Office and the European Patent Office and granted in the United States Patent and Trademark Office. There are both practical and theoretical advantages to using the TPF patents. Practically, we could utilize the enormous databases provided by all three patent offices. Particularly, we could extract from the EPO database the addresses of the U.S. inventors, which are not available from the USPTO. We could use the extensive citation information available from the USPTO, to assess the backward and forward citation structure of the Japanese inventions. Also, the reduced home country bias and relatively homogenized value distribution of

[16] The survey also covers 1501 non-triadic patents as well as a small number of important patents.

patents enhances the comparability of patented inventions between patents as well as among nations (Criscuolo, 2006; Dernis and Khan, 2004). Furthermore, focusing on triadic patents can avoid sending most questionnaires to economically unimportant patents, given the highly skewed nature of the value of patents, since filing in multiple jurisdictions works as a threshold. The number of basic patents (first priority patent) of TPFs account for only 3% of the domestic applications in Japan. One caveat here is that this characteristic of TPF may favor large and multinational firms.[17]

The survey population of Japan is the TPF patents filed between 1995 and 2001 (first priority application) and having at least one applicant with a Japanese address and at least one inventor with a non-alphabetical name (i.e. the name consists of Chinese characters and hiragana), given that the Japanese survey questionnaire was in Japanese. The population satisfying these requirements amounted to 65,000 patents. We randomly selected 17,643 patents for the final mail out, stratified by 2-digit NBER technology class[18] (Hall, Jaffe, and Trajtenberg, 2001), with oversampling for the technology sectors such as biotechnology with a relatively small number of patent applications[19]. In order to increase the response rate by reducing the respondent burden, we sent a maximum of two questionnaires to the same inventor of triadic patents and a maximum of 150 questionnaires to one establishment. We updated the inventor address based on the patent documents information of the JPO, to take into account the mobility of inventors across the establishments within a firm. The survey population for the U.S. is the TPF patents filed between 2000 and 2003 inclusive (first priority application) and having at least one U.S.-addressed inventor. We sampled 9,060 patents, stratified by NBER technology class

[17] Since the Japanese survey also covered non-triadic patents, we could compare the characteristics of triadic and non-triadic patents (See Nagaoka and Tsukada (2007)). The differences in terms of applicant structure are often small. For an example, the share of small firms (with 250 employment or less) account for 10.2% of non-triadic patents and 8.7% of triadic patents.

[18] We separated computer hardware and software.

[19] The simple averages and the averages reflecting the sampling weight give essentially identical results.

(Hall, Jaffe, and Trajtenberg, 2001). Then, for the first U.S. inventor of each patent we collected U.S. street addresses, mostly from the EPO database but supplemented by other sources such as the USPTO application database or phone directories. If no address was available, we take the next U.S. inventor. After removing 18 patents that are either withdrawn or for which we could not find any U.S. inventor address, we had 9,042 patents in our sample. Taking the first available U.S. inventor as a representative inventor of each patent, we have 7,933 unique inventors. In order to increase response rate and reduce respondent burden, we only surveyed one (randomly chosen) patent from each inventor. The final mail out sample was, thus, a set of 7,933 unique U.S. patents/inventors.

Using the patent-based indicators for all patents in the sample, we tested response bias, in terms of application year, the number of assignees, the number of inventors, the number of claims, and the number of different International Patent Classes. There are some differences in application year in both countries (the responses have newer application dates by 1 month in Japan and by 0.3 months in the US on average, both significant at 5%), the number of claims in Japan (the responses have smaller number of claims by 0.37, significant at 5%) and the number of inventors in the US (the responses have smaller number of co-inventors by 0.07 persons on average, significant at 10%). These test results show that there do not exist very significant response biases.

Because the distribution of patents by technology class varies significantly between the US and Japan, we constructed a set of weights to represent the observed distribution relative to the population distribution across the two countries, and applied these weights when calculated country-level means for comparisons (for example, the mean percent of patents that were commercialized). However, weighted and unweighted means produced essentially the same results.

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Appendix 2 Ordered logit equations for the importance of appropriation instruments and patenting reasons

The dependent variable $y_{i,j}$ is the score given by the inventor of invention *j* to attribute *i* of invention j (here, the importance of the appropriation instruments and the importance of the reasons for patenting). The explanatory variables are the dummies representing the attribute ( $x_{i,j}$ ) such as the first mover advantage in commercializing the invention, which is equal to 1 if the score is for attribute *i* and zero otherwise. We use collaboration (blocking) as the base of the estimation for the appropriation instruments (patenting reasons). In addition, we introduce the following explanatory variables: the importance of the scientific and technical literature for the conception of an invention (*cncpt_sci*) (range from 0 to 5), a dummy indicating the existence of basic research (*basic*), the business objectives of the research (e*xisting business*, *technology base* and *other*, with *new business* as the base), the size of the firm (*medium*, *small* and *very small*, with *large* with the base), and the interactions between the attribute variables and these additional explanatory variables (their interactions with a set of the variables $z_{L,j}$ (L≥1)) . We also introduce the US technology class dummies in terms of two digit NBER classes.

The logit probability distributions, the parameters of which we estimate, are

$$\Pr(y_{i,j} = \gamma) = f(\alpha_0 + \Sigma_j \alpha_{1,i} x_{i,j} + \Sigma \alpha_{2,j} z_{L,j} + \Sigma_{L,j} \beta_{L,i} z_{L,j} x_{i,j}; \gamma)$$

where $\gamma$ indicates the value of the score (integers from 1 to 5). We use the inventions made only by the inventors affiliated with firms for the estimation sample. We also limit the sample to those inventions internally commercialized by the applicants for the estimation of the importance of the appropriation instruments.

The estimation results are shown in the following tables A-2A and A2B. The standard errors are robust.

Table A-2. Ordered-logit estimations for appropriation instruments and patenting reasons (Japan)

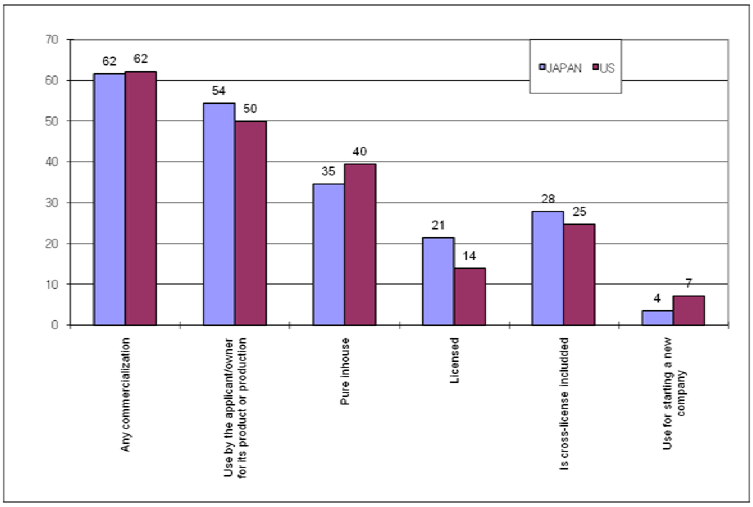
| | Ologit for the appropriation measures | | | | | Ologit for the patenting reasons | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Number of obs = 14482<br>Log pseudo-likelihood = −17464.825<br>Pseudo R2 = 0.0849 | | | | | Number of obs = 20942<br>Log pseudo-likelihood = −27813.001<br>Pseudo R2 = 0.0985 | | | |
| | Covariates | | Coef. | Robust Std. Err. | | Covariates | | Coef. | Robust Std. Err. | |
| appropriation measures (or patenting reasons) | fmvrd | | 2.35 | 0.20 | *** | excl | | 0.87 | 0.16 | *** |
| | fmvmrk | | 2.59 | 0.20 | *** | licen | | −0.81 | 0.17 | *** |
| | mfg | | 1.64 | 0.21 | *** | crlice | | −0.75 | 0.16 | *** |
| | sales | | 1.45 | 0.21 | *** | defense | | −0.38 | 0.17 | ** |
| | patenf | | 1.17 | 0.19 | *** | prinvarnd | | −1.19 | 0.15 | *** |
| | secrecy | | 1.32 | 0.21 | *** | repinvt | | −2.83 | 0.15 | *** |
| | complexity | | −0.04 | 0.19 | | repfrm | | −1.97 | 0.16 | *** |
| importance of the scientific and technical literature for the conception | cncpt_sci | | 0.19 | 0.03 | *** | cncptsci | | 0.00 | 0.02 | |
| | interactions with cncpt_sci | fmvrd | −0.03 | 0.04 | | interactions with cncptsci | excl | 0.09 | 0.03 | *** |
| | | fmvmrk | −0.12 | 0.04 | *** | | licen | 0.18 | 0.03 | *** |
| | | mfg | −0.01 | 0.04 | | | crlice | 0.15 | 0.03 | *** |
| | | sales | −0.06 | 0.04 | | | defense | 0.06 | 0.03 | * |
| | | patenf | −0.10 | 0.04 | *** | | prinvarnd | 0.08 | 0.03 | *** |
| | | secrecy | −0.05 | 0.04 | | | repinvt | 0.13 | 0.03 | *** |
| | | complexity | −0.08 | 0.04 | ** | | repfrm | 0.14 | 0.03 | *** |
| the basic research | basic | | 0.12 | 0.12 | | basic | | −0.02 | 0.09 | |
| | interaction with basic | fmvrd | 0.19 | 0.17 | | interaction with basic | excl | 0.50 | 0.14 | *** |
| | | fmvmrk | −0.08 | 0.17 | | | licen | 0.51 | 0.14 | *** |
| | | mfg | 0.18 | 0.17 | | | crlice | 0.06 | 0.13 | |
| | | patenf | −0.18 | 0.17 | | | defense | −0.15 | 0.14 | |
| | | sales | 0.06 | 0.18 | | | prinvarnd | −0.06 | 0.13 | |
| | | secrecy | 0.20 | 0.18 | | | repinvt | 0.12 | 0.12 | |
| | | complexity | −0.20 | 0.16 | | | repfrm | 0.14 | 0.13 | |
| business objective of research | existing business | | −0.12 | 0.12 | | existing business | | 0.13 | 0.09 | |
| | interaction (additional effects) | fmvrd | 0.01 | 0.16 | | interaction (additional effects) | excl | −0.08 | 0.13 | |
| | | fmvmrk | −0.01 | 0.16 | | | licen | −0.55 | 0.13 | *** |
| | | mfg | 0.04 | 0.17 | | | crlice | −0.31 | 0.13 | ** |
| | | sales | −0.22 | 0.17 | | | defense | 0.17 | 0.13 | |
| | | patenf | 0.05 | 0.15 | | | prinvarnd | −0.16 | 0.12 | |
| | | secrecy | −0.04 | 0.17 | | | repinvt | −0.17 | 0.12 | |
| | | complexity | 0.07 | 0.15 | | | repfrm | 0.09 | 0.13 | |
| | new tech | | 0.40 | 0.28 | | new tech | | −0.57 | 0.17 | *** |
| | interaction (additional effects) | fmvrd | −0.96 | 0.39 | ** | interaction (additional effects) | excl | −0.46 | 0.24 | * |
| | | fmvmrk | −0.78 | 0.37 | ** | | licen | 0.28 | 0.25 | |
| | | mfg | −0.07 | 0.41 | | | crlice | 0.53 | 0.23 | ** |
| | | sales | −0.52 | 0.39 | | | defense | 0.08 | 0.24 | |
| | | patenf | −0.60 | 0.38 | | | prinvarnd | 0.13 | 0.23 | |
| | | secrecy | −0.49 | 0.38 | | | repinvt | 0.51 | 0.23 | ** |
| | | complexity | −0.31 | 0.36 | | | repfrm | 0.76 | 0.24 | *** |
| | other | | 0.28 | 0.41 | | other | | 0.03 | 0.37 | |
| | interaction (additional effects) | fmvrd | −0.78 | 0.61 | | interaction (additional effects) | excl | −0.48 | 0.47 | |
| | | fmvmrk | −0.73 | 0.52 | | | licen | 0.77 | 0.58 | |
| | | mfg | −0.93 | 0.56 | * | | crlice | −0.35 | 0.56 | |
| | | sales | −0.80 | 0.51 | | | defense | −0.49 | 0.59 | |
| | | patenf | −0.49 | 0.58 | | | prinvarnd | 0.20 | 0.57 | |
| | | secrecy | −1.04 | 0.58 | * | | repinvt | 0.20 | 0.47 | |
| | | complexity | −0.26 | 0.53 | | | repfrm | 0.30 | 0.53 | |
| the size of organization | medium | | −0.03 | 0.18 | | medium | | 0.22 | 0.13 | |
| | interaction (additional effects) | fmvrd | −0.17 | 0.25 | | interaction (additional effects) | excl | −0.36 | 0.19 | * |
| | | fmvmrk | 0.20 | 0.26 | | | licen | −0.85 | 0.20 | *** |
| | | mfg | 0.22 | 0.25 | | | crlice | −1.29 | 0.19 | *** |
| | | sales | 0.29 | 0.27 | | | defense | −0.05 | 0.20 | |
| | | patenf | −0.03 | 0.24 | | | prinvarnd | −0.08 | 0.19 | |
| | | secrecy | 0.21 | 0.26 | | | repinvt | −0.11 | 0.18 | |
| | | complexity | 0.14 | 0.25 | | | repfrm | 0.34 | 0.20 | * |
| | small | | −0.26 | 0.22 | | small | | 0.35 | 0.20 | * |
| | interaction (additional effects) | fmvrd | −0.15 | 0.32 | | interaction (additional effects) | excl | −0.44 | 0.28 | |
| | | fmvmrk | 0.18 | 0.30 | | | licen | −1.11 | 0.28 | *** |
| | | mfg | 0.19 | 0.33 | | | crlice | −1.45 | 0.27 | *** |
| | | sales | 0.45 | 0.35 | | | defense | −0.29 | 0.31 | |
| | | patenf | 0.36 | 0.30 | | | prinvarnd | −0.04 | 0.27 | |
| | | secrecy | 0.45 | 0.35 | | | repinvt | −0.29 | 0.25 | |
| | | complexity | 0.64 | 0.30 | ** | | repfrm | 0.40 | 0.29 | |
| | very small | complexity | −0.34 | 0.25 | | very small | | 0.29 | 0.16 | * |
| | interaction (additional effects) | fmvrd | −0.45 | 0.27 | * | interaction (additional effects) | excl | −0.44 | 0.24 | * |
| | | fmvmrk | −0.44 | 0.26 | * | | licen | −0.29 | 0.26 | |
| | | mfg | −0.28 | 0.28 | | | crlice | −1.00 | 0.23 | *** |
| | | sales | 0.13 | 0.27 | | | defense | −0.05 | 0.25 | |
| | | patenf | −0.43 | 0.26 | * | | prinvarnd | 0.24 | 0.22 | |
| | | secrecy | −0.20 | 0.28 | | | repinvt | 0.20 | 0.23 | |
| | | | 0.51 | 0.19 | *** | | repfrm | 0.74 | 0.23 | *** |
| | cutoff points | _cut1 | −2.38 | 0.20 | | | _cut1 | −3.18 | 0.17 | |
| | | _cut2 | −1.10 | 0.20 | | | _cut2 | −1.89 | 0.17 | |
| | | _cut3 | 0.89 | 0.20 | | | _cut3 | −0.43 | 0.17 | |
| | | _cut4 | 3.29 | 0.20 | | | _cut4 | 1.74 | 0.17 | |

Note The coefficients for the technology class dummies are not reported.

Table A-2. Ordered-logit estimations for appropriation instruments and patenting reasons (US)

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Ologit for appropriation measure | | | | | Ologit for Reasons for Patent | | | |
| | | | Number of obs = 5249 | | | | | Number of obs = 11865 | | |
| | | | Log pseudolikelihood = -7667.6026 | | | | | Log pseudolikelihood = -16848.521 | | |
| | | | Pseudo R2 = 0.0804 | | | | | Pseudo R2 = 0.0902 | | |
| | | | Coeff. | Robust Std. Error | | | | Coeff. | Robust Std. Error | |
| Appropriation | FMVRD | | 2.977406 | 0.2979313 | *** | Com.exploit | | 1.844546 | 0.1925486 | *** |
| Measures (Re | FMVMRK | | 3.372926 | 0.2984308 | *** | Licensing | | -1.254432 | 0.1888224 | *** |
| asons for Pat | MFG | | 1.941076 | 0.3058948 | *** | CR_licens | | -1.255606 | 0.1835453 | *** |
| enting) | SALES | | 2.09838 | 0.3112664 | *** | Defense | | -0.191699 | 0.1834859 | |
| | PATENT | | 2.773502 | 0.2872415 | *** | Prvtarnd | | -1.726664 | 0.1863302 | *** |
| | SECRET | | 1.887917 | 0.3051512 | *** | RepInvt | | -2.213928 | 0.1853876 | *** |
| | COMPLEX | | 2.011627 | 0.3026127 | *** | RepFrm | | -1.117024 | 0.1715165 | *** |
| Importance | SciLit | | 0.27226 | 0.046637 | *** | SciLit | | -0.009453 | 0.0272034 | |
| of Scientific | Interaction | FMVRD | -0.118966 | 0.0590751 | ** | Interaction | Com.exploit | 0.1059289 | 0.0394538 | *** |
| and Technical | with SciLit | FMVMRK | -0.180686 | 0.0595001 | *** | with SciLit | Licensing | 0.1658314 | 0.0405982 | *** |
| Literature for | | MFG | -0.192995 | 0.0632668 | *** | | CR_licens | 0.1142231 | 0.03956 | *** |
| Suggeting the | | SALES | -0.295758 | 0.0638632 | *** | | Defense | -0.001981 | 0.0392048 | |
| Invention | | PATENT | -0.147492 | 0.0594219 | ** | | Prvtarnd | 0.0731156 | 0.0396639 | * |
| | | SECRET | -0.191917 | 0.0629421 | *** | | RepInvt | 0.1179996 | 0.0389814 | *** |
| | | COMPLEX | -0.217111 | 0.0593931 | *** | | RepFrm | 0.0735051 | 0.0365419 | ** |
| Basic | Basic | | 0.1751473 | 0.17286 | | Basic | | 0.0109831 | 0.1007321 | |
| Research | Interaction | FMVRD | 0.0696474 | 0.2212975 | | Interaction | Com.exploit | 0.1078251 | 0.1503668 | |
| | with Basic | FMVMRK | -0.210223 | 0.2252665 | | with Basic | Licensing | 0.3827177 | 0.1452775 | *** |
| | | MFG | 0.0487321 | 0.236651 | | | CR_licens | 0.1010509 | 0.144026 | |
| | | SALES | -0.245542 | 0.2374646 | | | Defense | -0.098076 | 0.143591 | |
| | | PATENT | -0.114507 | 0.2261804 | | | Prvtarnd | 0.2138043 | 0.1467555 | |
| | | SECRET | -0.085579 | 0.2342027 | | | RepInvt | 0.3693638 | 0.1422397 | *** |
| | | COMPLEX | -0.062007 | 0.2218789 | | | RepFrm | 0.1405164 | 0.1355701 | |
| Business | Exist | | -0.484833 | 0.2139229 | ** | Exist | | 0.0681351 | 0.119195 | |
| Objective of | Interaction | FMVRD | -0.012282 | 0.2807203 | | Interaction | Com.exploit | -0.591533 | 0.1821717 | *** |
| Research | (Additional | FMVMRK | 0.3470012 | 0.2815477 | | (Additional | Licensing | -0.53708 | 0.1744915 | *** |
| | effects) | MFG | 0.2837084 | 0.2850696 | | effects) | CR_licens | -0.277139 | 0.169082 | |
| | | SALES | 0.4691063 | 0.2908299 | | | Defense | 0.2071235 | 0.171188 | |
| | | PATENT | 0.3566417 | 0.2754283 | | | Prvtarnd | 0.2441429 | 0.1725461 | |
| | | SECRET | 0.3796244 | 0.2895206 | | | RepInvt | 0.1441961 | 0.1708111 | |
| | | COMPLEX | 0.3784425 | 0.2845879 | | | RepFrm | 0.2058494 | 0.1612621 | |
| | Base | | 0.0816643 | 0.2545805 | | Base | | 0.0840201 | 0.1405251 | |
| | Interaction | FMVRD | -0.068409 | 0.335846 | | Interaction | Com.exploit | -1.149208 | 0.210159 | *** |
| | (Additional | FMVMRK | -0.278597 | 0.3373195 | | (Additional | Licensing | -0.122755 | 0.1995926 | |
| | effects) | MFG | -0.277464 | 0.3535942 | | effects) | CR_licens | 0.1944594 | 0.1958665 | |
| | | SALES | -0.194771 | 0.3582582 | | | Defense | 0.2720687 | 0.2008237 | |
| | | PATENT | 0.0958973 | 0.3314739 | | | Prvtarnd | 0.3784161 | 0.2015837 | * |
| | | SECRET | 0.0162709 | 0.3456023 | | | RepInvt | 0.5653503 | 0.1981298 | *** |
| | | COMPLEX | 0.2270659 | 0.333767 | | | RepFrm | 0.4019543 | 0.1874683 | ** |
| | Other | | 0.362205 | 0.538732 | | Other | | -0.609096 | 0.2944403 | ** |
| | Interaction | FMVRD | 0.1728795 | 0.698812 | | Interaction | Com.exploit | 0.1225443 | 0.4816497 | |
| | (Additional | FMVMRK | -0.576236 | 0.6394798 | | (Additional | Licensing | 1.071985 | 0.4459013 | ** |
| | effects) | MFG | -0.179302 | 0.628989 | | effects) | CR_licens | 0.5373016 | 0.4508161 | |
| | | SALES | 0.0768844 | 0.7033976 | | | Defense | 0.5353387 | 0.4487629 | |
| | | PATENT | -0.294972 | 0.6815475 | | | Prvtarnd | 0.1396024 | 0.4624197 | |
| | | SECRET | 0.0640797 | 0.682171 | | | RepInvt | 0.8243829 | 0.5063685 | |
| | | COMPLEX | -0.062759 | 0.6851819 | | | RepFrm | 0.6572682 | 0.4339471 | |
| Size of the | Med | | -0.210711 | 0.3311295 | | Med | | 0.1149484 | 0.2396431 | |
| Organization | Interaction | FMVRD | -0.042555 | 0.4795971 | | Interaction | Com.exploit | -0.035158 | 0.344179 | |
| | (Additional | FMVMRK | -0.128826 | 0.4448035 | | (Additional | Licensing | -0.564794 | 0.3318952 | * |
| | effects) | MFG | 0.1171605 | 0.4822916 | | effects) | CR_licens | -0.990167 | 0.3241361 | *** |
| | | SALES | 0.1166762 | 0.486209 | | | Defense | -0.513253 | 0.3553106 | |
| | | PATENT | 0.124832 | 0.442056 | | | Prvtarnd | 0.0595524 | 0.344777 | |
| | | SECRET | 0.3324214 | 0.4806226 | | | RepInvt | -0.086202 | 0.3243174 | |
| | | COMPLEX | -0.234722 | 0.4095933 | | | RepFrm | 0.1759176 | 0.3200828 | |
| | Small | | 0.130738 | 0.4718301 | | Small | | 0.0120106 | 0.2575525 | |
| | Interaction | FMVRD | -0.341319 | 0.6262439 | | Interaction | Com.exploit | 0.4201589 | 0.4233051 | |
| | (Additional | FMVMRK | 0.5633883 | 0.5745874 | | (Additional | Licensing | -0.262826 | 0.475734 | |
| | effects) | MFG | 0.9918763 | 0.6174846 | | effects) | CR_licens | -0.725955 | 0.3753745 | * |
| | | SALES | 0.7181334 | 0.6264982 | | | Defense | -0.108067 | 0.4186692 | |
| | | PATENT | -0.158658 | 0.6394521 | | | Prvtarnd | -0.374845 | 0.4513422 | |
| | | SECRET | 0.0495513 | 0.6398327 | | | RepInvt | -0.021776 | 0.3999878 | |
| | | COMPLEX | -0.004996 | 0.5561925 | | | RepFrm | 0.1913198 | 0.3937994 | |
| | Smallest | | 0.4326267 | 0.2344683 | * | Smallest | | -0.158941 | 0.1511931 | |
| | Interaction | FMVRD | -0.412422 | 0.3016313 | | Interaction | Com.exploit | 0.6454796 | 0.2352532 | *** |
| | (Additional | FMVMRK | -0.260641 | 0.3084823 | | (Additional | Licensing | 0.9812022 | 0.2332685 | *** |
| | effects) | MFG | -0.582345 | 0.3198921 | * | effects) | CR_licens | -0.3743 | 0.2206623 | * |
| | | SALES | 0.0594827 | 0.315244 | | | Defense | -0.021246 | 0.2150555 | |
| | | PATENT | -0.31259 | 0.3095357 | | | Prvtarnd | 0.0092144 | 0.2171531 | |
| | | SECRET | -0.679762 | 0.3054102 | ** | | RepInvt | -0.23112 | 0.2251298 | |
| | | COMPLEX | -0.785039 | 0.3084263 | ** | | RepFrm | 0.3658426 | 0.2150949 | * |
| | Cut Point | CUT 1 | 0.8683938 | 0.2473712 | | Cut Point | CUT 1 | -1.470598 | 0.1491132 | |
| | | CUT 2 | 1.732148 | 0.2485277 | | | CUT 2 | -0.800392 | 0.1483557 | |
| | | CUT 3 | 2.732574 | 0.2496914 | | | CUT 3 | 0.088473 | 0.1480996 | |
| | | CUT 4 | 3.985848 | 0.2513722 | | | CUT 4 | 1.169514 | 0.1488498 | |

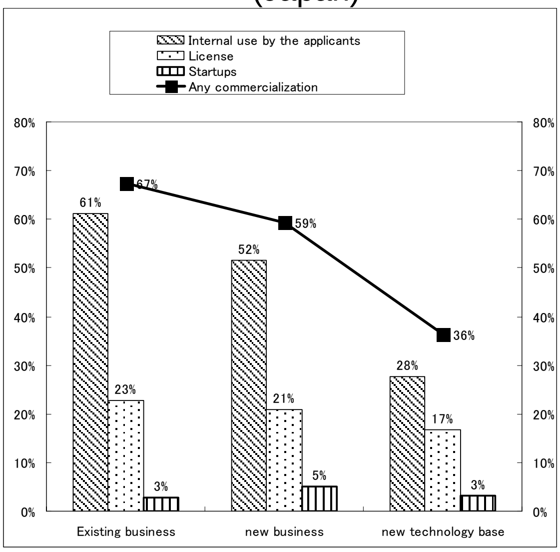
## Figure 1. Commercialization of the inventions




Note. pure in-house= used by the applicant/owner only for its internal use (neither license nor the use through a startup), based on the common technology class weights.



## Figure 2A. Commercialization patterns by business objectives (Japan)




Note: This figure depends on the sample of the inventions for which the inventors respond to all questions on the use of the inventions.

Figure 2B. Commercialization patterns by business objectives (US)

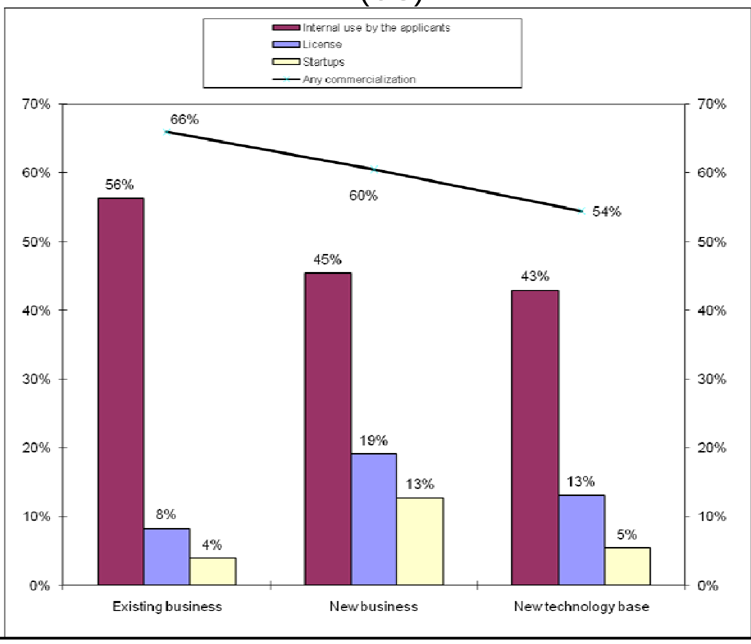
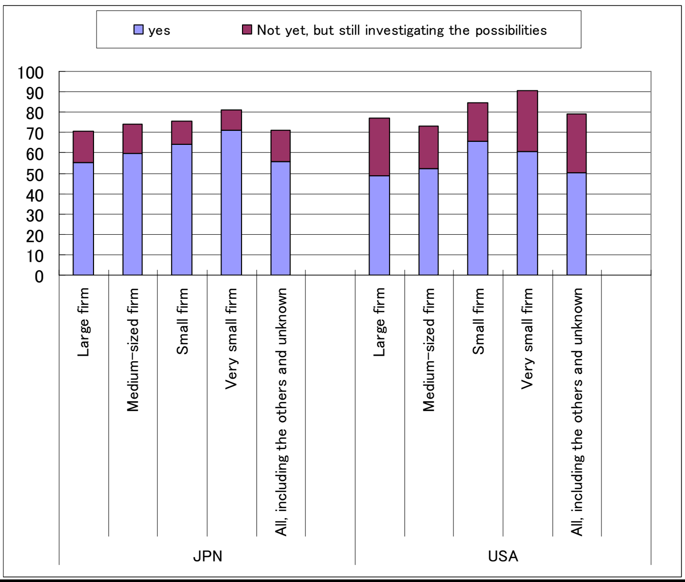
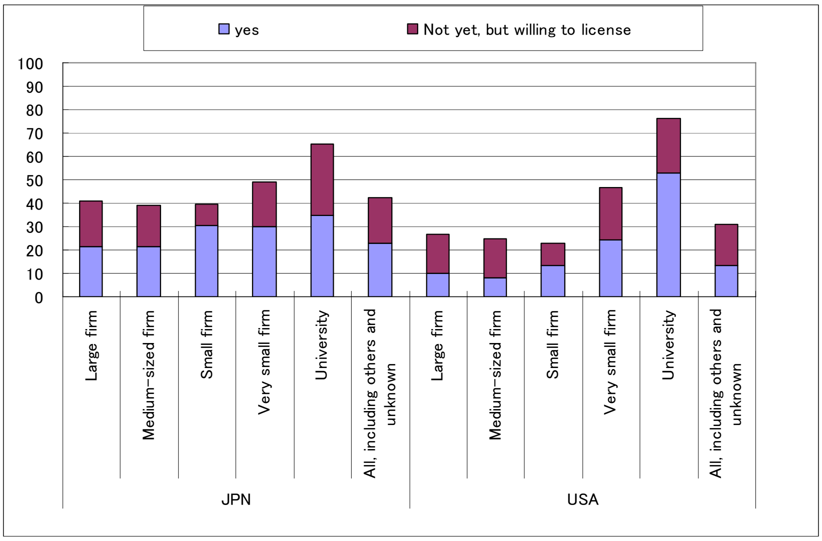



Figure 3. Proportion of the inventions internally commercialized by organization type (%)



# Figure 4. Licensing rate by organization type






# Figure 5. Use of inventions by startups by the organizational affiliation of the inventors (% )

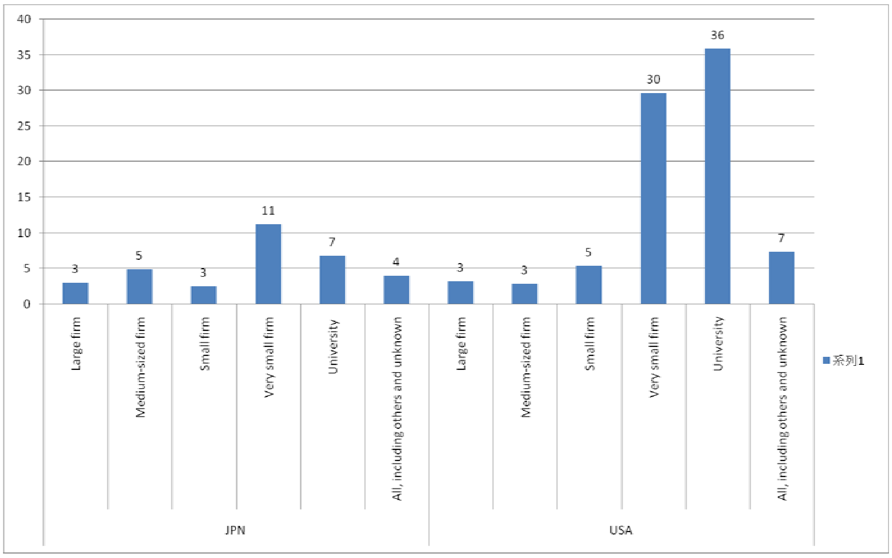


Figure 6A. Strategic holding of the patents by the business objective of the R&D projects yielding these inventions (Japan)

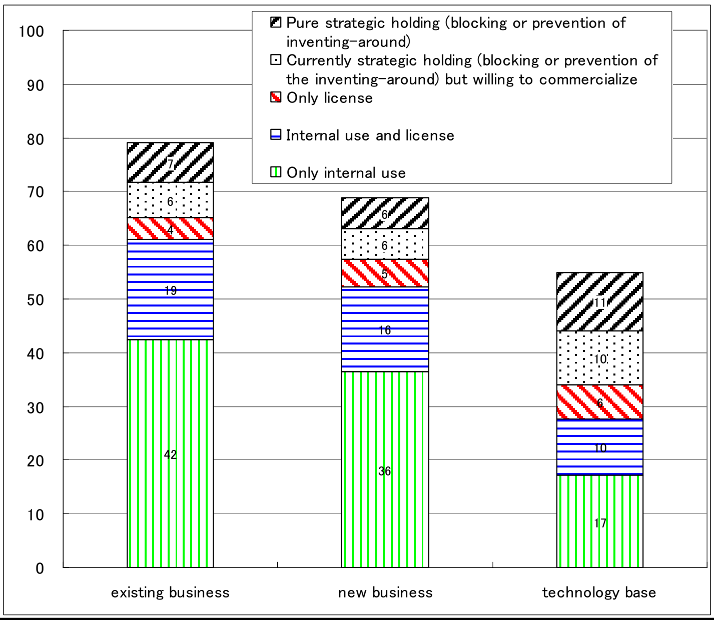



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Figure 6B. Strategic holding of the patents by the business objective of the R&D projects yielding these inventions (US)

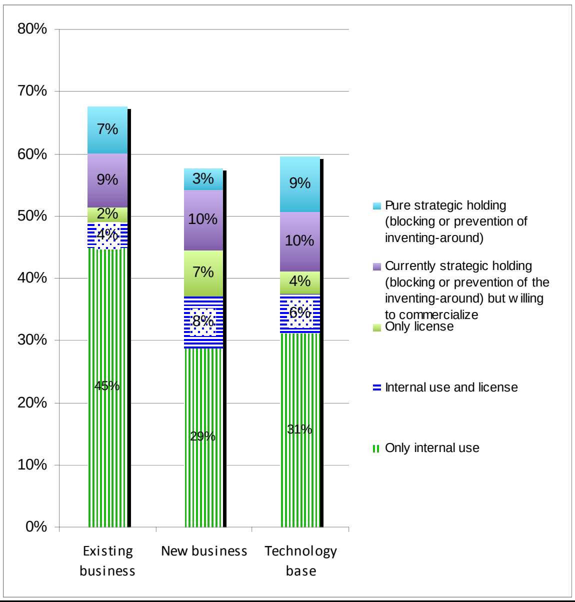

Figure 7A. Technology, Market or business and strategic reasons for non-commercialized inventions (Japan)

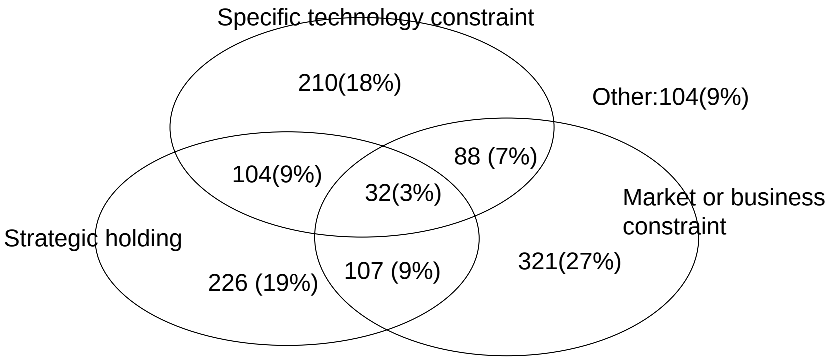


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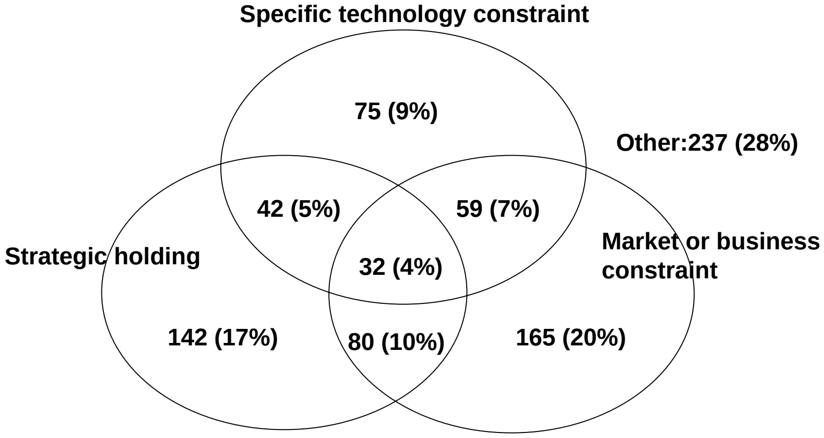
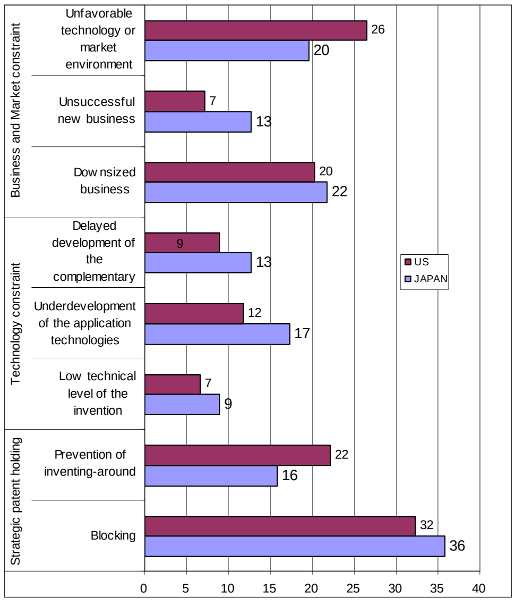
Figure 7B. Technology, Market or business and strategic reasons for non-commercialized inventions (US)



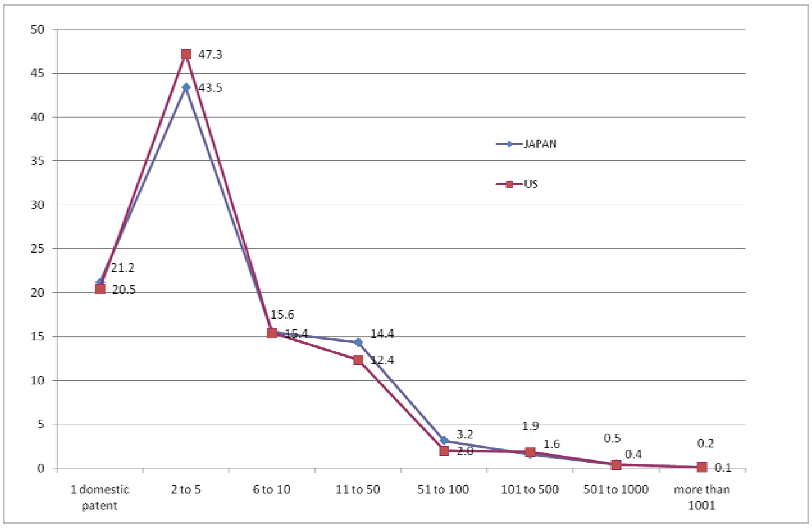
# Figure 8. Reasons for not Commercializing Invention




Note. Unknown reasons are not included in the denominator, based on common technology –class weight.



Figure 9. Estimated Number of Patents jointly used in Commercializing the Invention (own and others)




Note: based on common technology class weight

Figure 10A. Size of the bundle of the patents jointly used and the licensing patterns, Japan

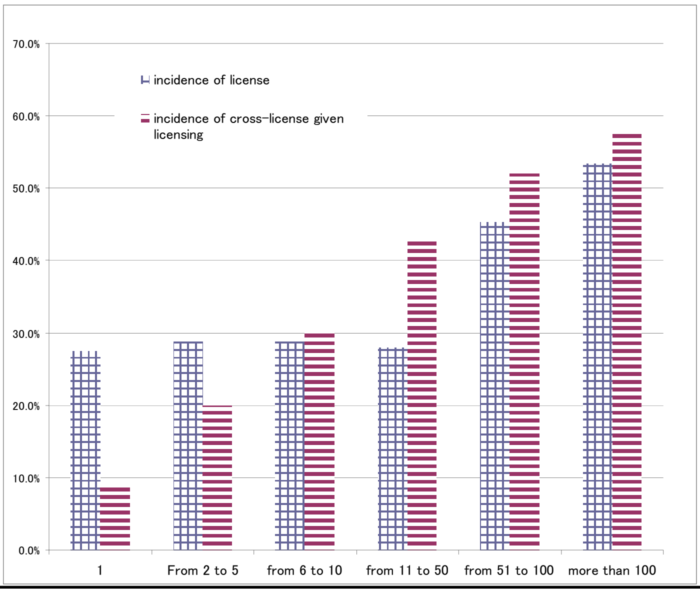



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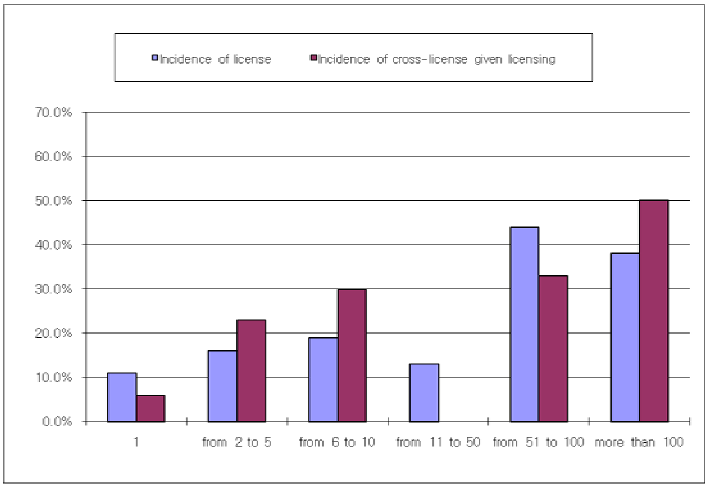
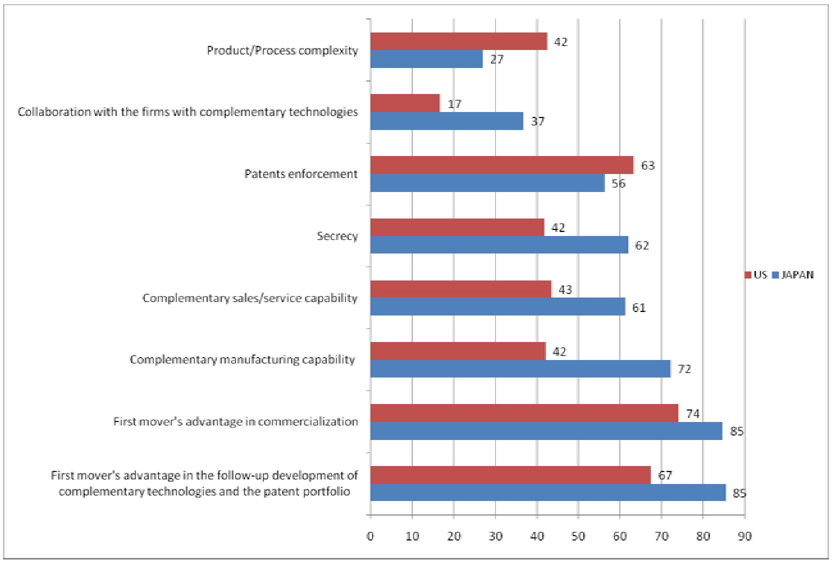
Figure 10B. Size of the bundle of the patents jointly used and the licensing patterns, US



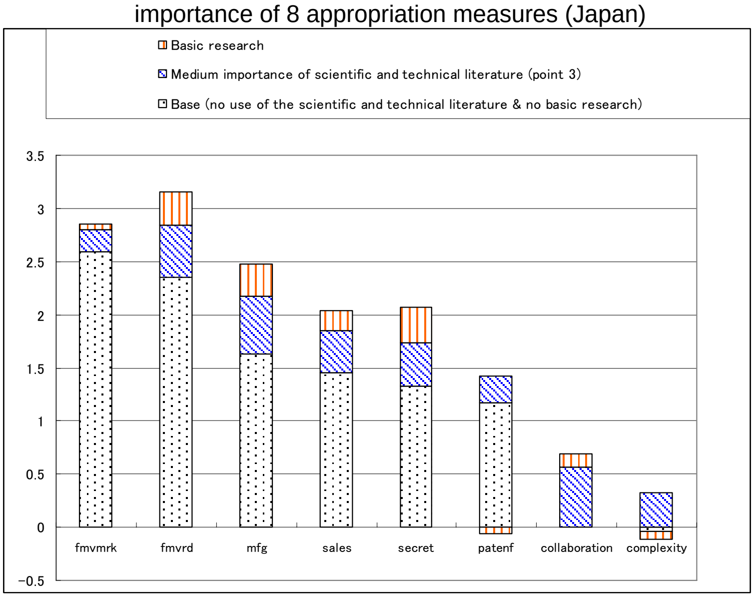
## Figure11. Appropriation Strategies (% high)




Note: Based on the sample of the inventions already commercialized internally and on common technology class weight

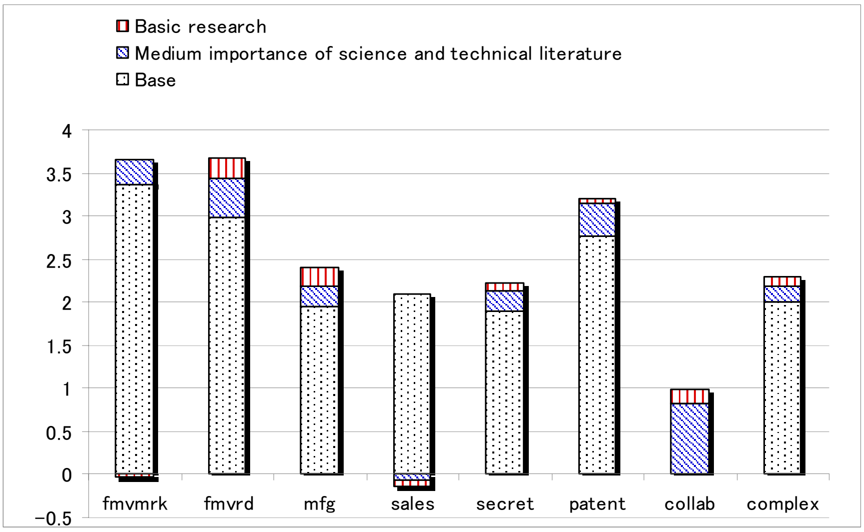


## Figure 12A. Scientific and technical literature, basic research and the importance of 8 appropriation measures (Japan)




Note. The coefficients are given in the ordered-logit estimation explaining the importance of each appropriation measure (the sdv of the distribution is 1). The estimated standard deviation of each coefficient is roughly 0.20. The cut points estimated are -2.4 (between 1 and 2), -1.1 (between 2 and 3), 0.9 (between 3 and 4) and 3.3 (between 4 and 5).

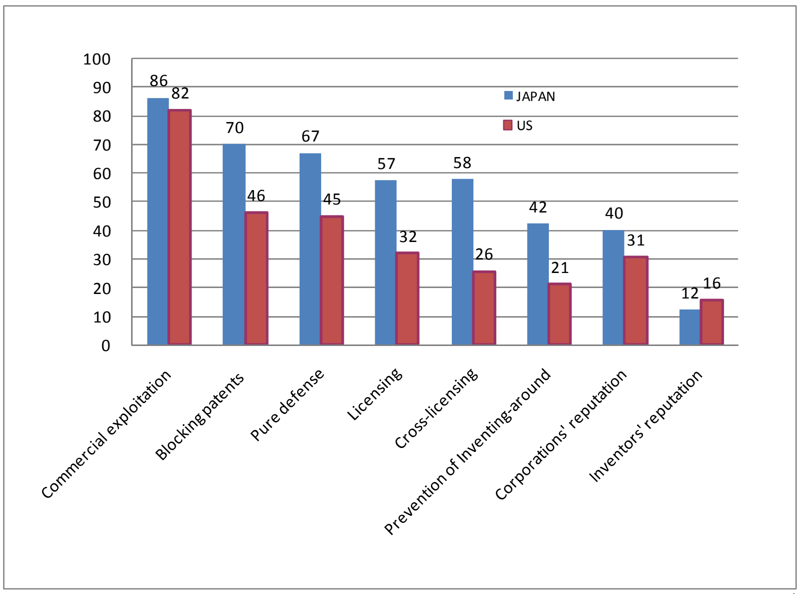
Figure 12B. Scientific and technical literature, basic research and the importance of 8 appropriation measures (US)




Note. The coefficients are given in the ordered-logit estimation explaining the importance of each appropriation measure (the sdv of the distribution is 1). The estimated standard deviation of each coefficient is roughly 0.30. The cut points estimated are 0.9 (between 1 and 2), 1.7 (between 2 and 3), 2.7 (between 3 and 4) and 4.0 (between 4 and 5).

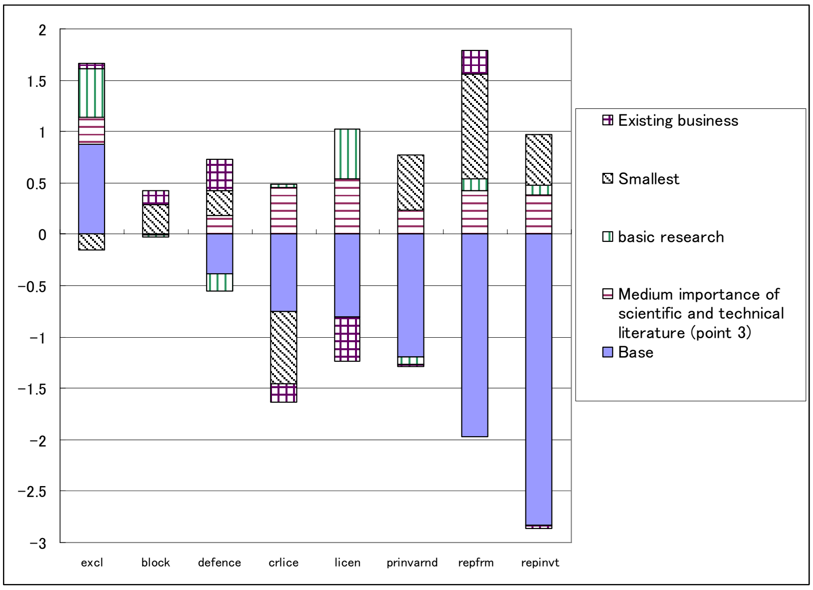


Figure13. Reasons for patenting (%high)




Note: Based on common technology class weight

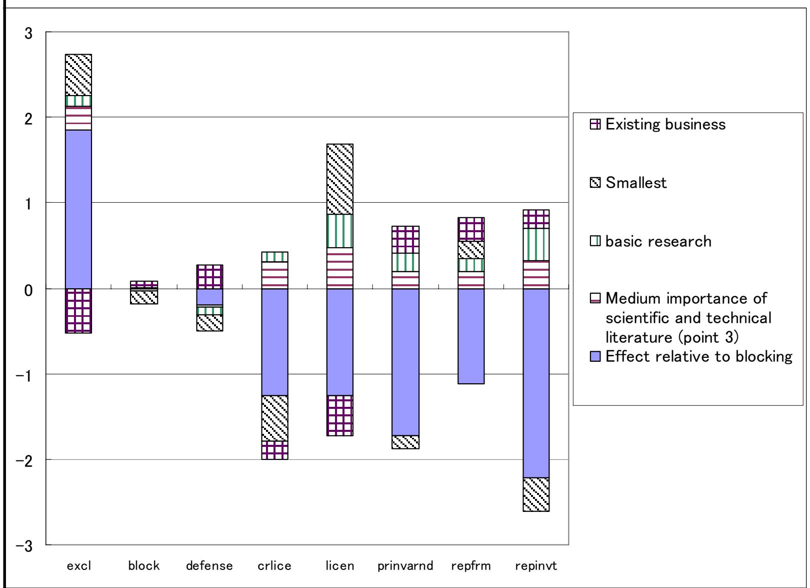
## Figure 14A. Reasons for patenting (Japan)




The coefficients are given in the ordered-logit estimation explaining the importance of each patenting reason (the sdv of the distribution is 1). The estimated standard deviation of each coefficient is roughly 0.16. The cut points estimated are -3.2 (between 1 and 2), -1.9 (between 2 and 3), -0.43 (between 3 and 4) and 1.7 (between 4 and 5).

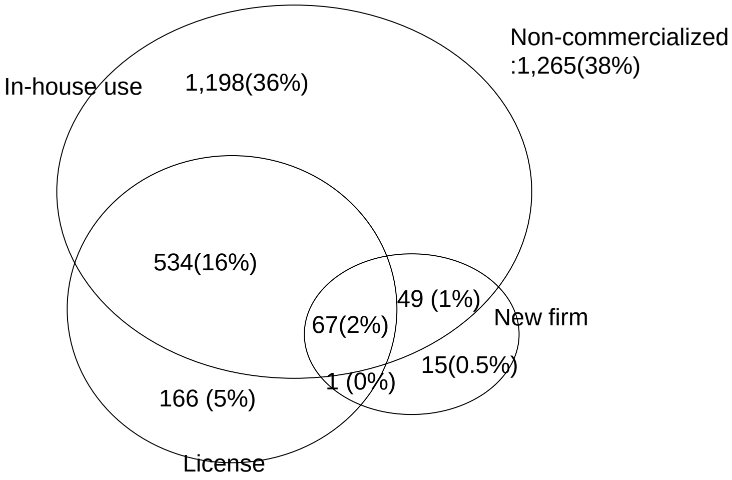


## Figure 14B. Reasons for patenting (US)




The coefficients are given in the ordered-logit estimation explaining the importance of each patenting reason (the sdv of the distribution is 1). The estimated standard deviation of each coefficient is roughly 0.19. The cut points estimated are -1.4 (between 1 and 2), -0.0 (between 2 and 3), 0.1 (between 3 and 4) and 1.5 (between 4 and 5).

Appendix Figure A-1A. Internal use, license and new firm (Japan)

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Appendix Figure A-1B. Internal use, license and new firm (US)

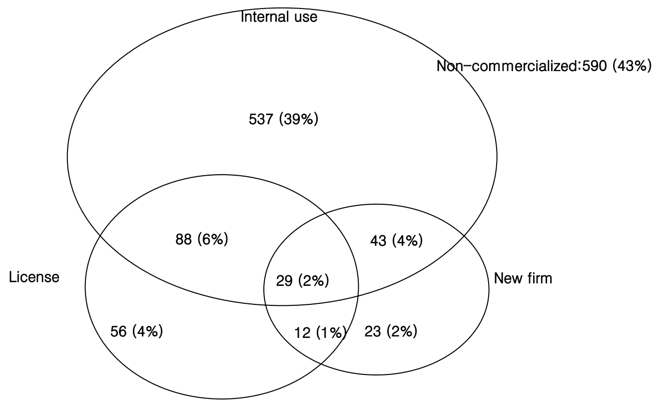


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Figure A-2. The incidence of a single licensee (%)