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Use of Grace Periods and Their Impact on Knowledge Flow: Evidence from Japan[*]

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Abstract
This paper examines the determinants of the use of grace periods, as well as their effects on knowledge flow, in order to assess the economic effects based on a large scale panel data of the use of grace periods in Japan. For this purpose we discriminate which of the three views ("acceleration of disclosure," "deferral of domestic patent filing," and "promotion of domestic patenting") best explains the use of grace periods. The major findings are the following. Grace periods are used more for inventions with strong science linkages and in high technology sectors, but for those with a smaller number of claims. Science linkages matter more than the number of claims for academic inventors compared to corporate inventors in using grace periods. Their use has significantly declined in those technology areas with high level of international applications, following the Patent Cooperation Treaty (PCT) Reform in January 2004, allowing, in particular, automatic designation of all PCT contracting states. Critically, the use of grace periods significantly increased the knowledge diffusion to third parties as measured by non-self forward citations, relative to self-citations. Such effect is stronger than that of ex-post academic disclosure, following the patent application or its publication. These results show that the main motivation of the use of grace periods is the acceleration of disclosure, and that they enhance knowledge diffusion and are likely to enhance social welfare.

Keywords: Patents, Grace periods, Science linkages, Academic inventors, Knowledge flow, Harmonization of patent system
JEL classification: O34, O31, O32

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1. Introduction

Although international harmonization of patent systems has made significant progress over the past decades, especially though the implementation of the TRIPS agreement and the AIA (American Invents Act) in the United States, important national/regional differences still remain. One of the most important differences exists in the grace period[2]. In general, a patent system based on first-to-file principle requires the inventor to file the patent application prior to revealing his or her invention to the public if he or she does not want to lose the novelty of the invention. A grace period is the period before the patent application, during which the applicant can disclose his or her invention, without its novelty being lost by that disclosure. The grace period up to one year is automatic in the U.S. In fact a publication before the application may become more important in the US system for establishing priority under the AIA. On the other hand, the grace period barely exists in most European countries (disclosure only through approved exhibitions[3]). Japan stands in-between: 6 months grace period and the prior disclosures need to be reported to the Japan Patent Office (JPO).

The increasing globalization of the patent applications has made the search for

[2] The "Tegernsee Group", a consortia of national and regional patent offices, identified the following 6 issues: (1) first-inventor-to-file, (2) grace period, (3) prior user rights, (4) scope of prior art, (5) definition of novelty and non-obviousness/ inventive step, and (6) 18 months publication, as the keys to the substantive patent law harmonization process (Tegernsee Group, 2014).

[3] An un-intended disclosure as a consequence of an abuse by a third party is also covered as an exception.

the best system and the harmonization of the patent systems toward that goal more urgent. Given that an earlier disclosure in any country causes the loss of the novelty of the invention in the countries without the grace period exception, the applicant cannot use the grace period even if a home country allows it, when it wishes to obtain a patent in a foreign country with no grace period exception. That is, as Franzoni and Scellato (2010) points out, a lack of patent law harmonization is likely to cause the most restrictive law to prevail, no matter what the relative efficiency of patent system is, for such application.

There exist three quite different views regarding the use and the effects of the grace period, which may be an important cause for the heterogeneity of the views of the grace period system across the nations. The first view is that the inventor uses it because he/she would like to have academic disclosure such as presentations in workshops and conferences (for academic competition or for searching for collaborators) before the patent application which takes additional time for preparation. Grace period allows such early disclosure without destroying or constraining the patentability and the scope of the patent protection, even though there is the cost of foreign patent loss in the countries where the grace period does not exist (hereafter “foreign patent loss” for simplicity). In this case the grace period accelerates the diffusion of knowledge by enabling earlier academic disclosure. That is, if the grace period were absent, the inventor would have postponed the academic disclosure to the date of filing the patent application or, later, to the date of its publication, resulting that the disclosure of the underlying research for the invention would be delayed significantly. We call such view as “*the acceleration of disclosure view”* of the use of the grace period system.

The second view (we call it “*the deferral of domestic patent filing view*”) is that the inventor uses the grace period not for accelerating disclosure but for delaying the patent filing for a longer period of patent protection[4], even though the inventor could have applied for the patent simultaneously or even before the academic publication. Note that the count of the length of patent protection starts with the date of patent application or with its priority date. In this case the tradeoff for the inventor is between longer effective domestic patent protection and foreign patent loss. A grace period system does not enhance knowledge flow under this view, since the academic publication is not accelerated.

The third view (we call it “*the promotion of domestic patenting view*”), which is relevant to a university researcher with primary interest on academic publication as well as to an inventor who made an inadvertent academic disclosure

[4] A related view is that a grace period system allows “the authors of published material to “reserve” their inventions for a certain period of time without the inconvenience or cost of filing a patent” (de Saint-Georges and van Pottelsberghe de la Potterie, 2013).

before the patent application, is that the inventor uses the grace period for obtaining a domestic patent, after the inventor's early disclosure either for academic objective or as an accident. A grace period system under this view does not enhance additional knowledge flow either if the disclosure of patent publication system does not have significant effect on knowledge flow. Its use is recorded if the applicant perceives the net gain of applying for the domestic patent at the end of the grace period, while the academic disclosure and foreign patent loss are predetermined.

One of the central objectives of our study is to identify which of the three views most adequately explains the use of the grace period in Japan. This is substantially important because the economic role of the grace period system crucially depends on which view is correct. Since the inventors gain from the option of using the grace period, its welfare effect depends on the effect on the third parties. In this respect, the early knowledge spillover serves as an important part. In particular, if the first view holds, the grace period is likely to enhance welfare by accelerating knowledge spillover from a scientific discovery to the third parties[5]. If the second view is correct, it may harm a third party by providing a longer patent protection.

For this purpose we will undertake two empirical tasks. First, we will assess the

[5] Disclosure of the invention can destroy the value of the R&D project of a competitor (business stealing effect). Still, early disclosure would help such competitor to reduce such loss by avoiding duplicative R&D and by implementing a new R&D based on such disclosure. The consumers will gain from accelerated technological progress or from diversification of R&D.

determinants of the use of the grace period. In particular, this paper will examine how globalization of patent applications, science intensity of the inventions and the value of patenting affect the use of the grace period. Since the above three views have different implications on the types of inventions using the grace period, this econometric examination will help us in assessing the importance of those three views. In particular, foreign patent loss should matter only under the first two views, while the invention with more patenting value uses less the grace period under the first view and more under the third view. Given the endogeneity of an international patent application decision with respect to the use of the grace period, we will exploit an exogenous policy change (PCT reform in 2004), which has enabled a single PCT application to gives its applicant a bundle of options to apply for a patent in any number of countries within 30 months from the priority date, as a measure of globalization of patent applications.

In the second part, we investigate whether the use of a grace period enhances the knowledge flow to the third parties. This investigation also allows us to discriminate *the acceleration of disclosure view* from *the deferral of domestic patent filing view*. For this part of our analysis, we adopt the difference in differences approach, using self-citation flows from the focal patent as control events which are not affected by the use of the grace period, in order to control for the endogeneity of the use of the grace period due to unobserved heterogeneity of invention quality. Furthermore, we compare the effect of *ex-ante* academic disclosure using the grace period and that of *ex-post* academic disclosure following a patent filing (typically after the patent publication), in order to assess the net effect of accelerated disclosure.

The rest of the paper is organized as follows. Section 2 briefly reviews prior literature and Section 3 develops hypotheses based on three alternative views on the effects of the grace period. In section 4, we present descriptive statistics on the data that we use for testing hypotheses and provide the estimation strategy. Section 5 presents the empirical results and section 6 concludes and discusses policy implications.

2. Prior Literature

To the best of our knowledge, an economic analysis of the use and the effects of the grace period system is very rare. There exists substantial body of theoretical analysis of disclosure in the context of cumulative innovations (see Scotchmer (2004); (Scotchmer and Green, 1990) for a comprehensive analysis). One key message from this theoretical analysis is that if ideas are scarce, disclosure increases the probability in each period that there will be an idea for further advance by expanding the existing public knowledge stock. From this perspective, if the grace period accelerates the disclosure by inventors who are willing to do so, it will promote technical progress. The main empirical question, then, is whether the grace period accelerates the disclosure significantly.

Existing empirical research on the grace period is very limited, significantly due to the design of the current grace period system. No records on the use of the grace period exist in the US, since the grace period begins automatically after an inventor reveals his or her invention. Such records also do not exist in Europe, where the grace period other than the one for an exhibition barely exists. However, Japan is an exception, since it has a 6 months grace period system and it requires the notification of the specific disclosure to JPO made by the applicant from which the application does not wish to lose its priority.

An important exception in empirical analysis of the grace period system is Franzoni and Scellato (2010). They developed the data set of patent-publication pairs (through inventor- author matching and through patent document-scientific article matching), in order to assess how often the grace period exception is used in the U.S. and how significantly the patent-publication lags vary between the U.S. and Europe. Their study does not cover the academic disclosures in academic meetings, which are actually perceived as the main channels of academic disclosures in Japan until recent years. In addition, its sample size is very small (299 for the U.S. and 62 for Europe). They estimated that the grace period exception is used by nearly one third of academic inventors in the U.S., even though there is a substantial risk of international extensions being denied. They also found that an extension abroad from the U.S. increases publication delay, as does the presence of a firm among the assignees, for the patents which do not use the grace period. Furthermore, they found that the publication lags are shorter when priority of the patent is claimed in the U.S. than in Europe, which shows that the absence of the grace period in Europe makes Europe-based researchers less competitive in obtaining scientific priority, according to their interpretation.

One major gap of existing literature is that the impact of the grace period system on knowledge flow has not been analyzed, which is critical for assessing the economic role of the grace period system. While the above study by Franzoni and Scellato (2010) analyzed the patent-publication delay, it is important to note that such delay itself does not necessarily inform us of the effect that the grace period might have on knowledge flow. Consider an example where an European researcher publicly discloses his research just after the patent filing, while a US researcher files for an patent in one year from the date of disclosure of the research, using the grace period. In this case, the patent-publication delay is 0 for the European researcher while it is – 12 months for the US researcher, so that it looks as though the grace period accelerated knowledge spillover. However, if the US researcher simply delayed his patent filing by 12 months, indicating that he takes advantage of the grace period, there will be no such acceleration effect. This example clearly reveals that it is important for us to directly assess the knowledge flow effect of the grace period, to deeply understand its economic role, which is one of our central objectives.

There are a number of informative surveys on the grace period. One of the most recent surveys was done by "Tegernsee Group" (TegernseeGroup et al., 2014), the respondents of which were the applicants (412 respondents to the JPO survey, 194 to the USPTO survey and 134 to the European surveys). The survey results sharply differed among the regions, depending on whether the resident country of the respondents has the grace period system or not. In Japan and the U.S., the large majority of the respondents supported the grace period system, while only a slim majority favored the grace period in Europe as a whole[6]. As for the implications of a grace period, a large fraction of the respondents in Japan and the US think that the grace period is either user-friendly for SMEs (Japan 40%, the U.S. 70%), or it encourages early publication of

[6] The survey done by Europe Economics commissioned by the Economic and Scientific Advisory Board (ESAB) of the EPO in 2014 (820 responses) gave similar results Europe Patent Office, 2014. Economic Analysis of the Grace Period, commissioned by the Economic and Scientific Advisory Board (ESAB) of the EPO, http://documents.epo.org/projects/babylon/eponet.nsf/0/c4a001f6453f3d48c1257e0b0034cb2b/$FILE/europe_economics_esab_grace_period_20112014_en.pdf..

inventions for public interest (Japan 46%, the U.S. 65%). Only minority of the European respondents appreciates these positive impacts (37% for the SME and 28% for the public interest). On the other hand, Europe respondents think that a grace period system may undermine the legal certainty of the patent system (61%), while such respondents are minorities in Japan (14%) and in the US (30%).

There is another recent survey on the views of the technology transfer professionals of European research universities toward grace period (Edmondson et al., 2013). According to the survey, two third of the respondents replied that European patent system should adopt a grace period. As for the reasons, 49% of them points out “[b]ecause it enhances academic freedom to speak early about discoveries,” which indicates the importance of the disclosure acceleration. Another 45% of the respondents points out “[t]o avoid potential economic loss and social benefits from a patent.” Around 50% of the respondents reported that the loss of patent protection due to premature public disclosure occurred “very often” or “fairly often”. On the other hand, among the minority respondents against a grace period, 59% of them mentioned that: “it would create unnecessary uncertainty about patent priority” as a reason for objection.

The report by the European Commission (2002) states that publication delays do occur in Europe which does not have the grace period, but less so (less than 20%)

with more experienced users of the patent system (Owen-Smith and Powell, 2001). The survey covers public and commercial researchers in the genetic engineering. According to the survey, there was a clear preference in the academic sector for a grace period in order to avoid and/or minimize any delays of publication of research results that may be the subject of a patent application. Based on the review of this survey as well as other survey evidence, Geuna and Nesta (2006) argues that the introduction of a grace period in Europe is likely to have a considerable impact in reducing the conflict between scientific publication and patenting for exploitation, especially in those disciplines where the distinction between basic and applied sciences is more blurred (e.g. biotechnology).

While there is a grace period for one year in the US, there exist views that such exception should be further expanded. Grushcow (2004) argues that scientists who seek patents are often secretive, withholding publication or presentation of their data so as not to jeopardize patentability. It recommends increasing the rewards for early data sharing while providing an explicit experimental disclosure exception. Bagley (2008) emphasizes the importance of globalizing the grace period.

3. Three views on the effects of the grace period and hypotheses

3.1 Three views on the effects of the grace period

The three views have different implications on knowledge flow. According to "the acceleration of disclosure view", the grace period exception promotes the early disclosure of the scientific research: In Figure 1, it accelerates the academic disclosure (white dot) from point B to point A in calendar timeline. According to "the deferral of domestic patent filing view", the grace period allows the applicant to postpone the filing of the patent application for a longer period of patent protection. If such view holds, the grace period system has no effect of accelerating the disclosure, since a firm (or a university) would have simultaneously filed for a patent application with the academic disclosure, if there were no grace period. The use of the grace period resulted in the patent filing delay as indicated by the shift from point A to point B for patent filing (black dot) in Figure 1. The first and the second view have quite different implications on the effect of grace period on knowledge spillover to the third parties as well as on what type of inventions are applied for grace period exception.

(Insert Figure 1 about here)

According to "the promotion of domestic patenting view", the grace period allows such researcher to obtain the patent on the invention based on the scientific research, resulting in the promotion of domestic patent filing. In Figure 1, a patent filing happens in grace-period regime (with black dot) whereas it does not happen in no-grace-period regime (with no black dot). In this case the grace period system has no effect of accelerating the disclosure, since the academic disclosure would have happened regardless of whether the grace period exists or not, and the potential benefit from the grace period is the promotion of commercializing the invention with the patent.

3.2 Simple models for the use of the grace period

We consider a decision made by an academic or corporate researcher regarding whether it would apply for the grace period exception in the county where such exception exists. Under "the acceleration of disclosure view", the researcher faces the tradeoff between early academic disclosure and foreign patent loss, given the additional time necessary to prepare a patent application. Thus, the benefit from using the grace period is a larger chance to establish scientific priority by an early disclosure of the research to the scientific research community (we call it "*Benefit from priority in science*", denoted as α). Such benefit is larger when the research project generates an important scientific discovery. We assume that such chance increases with the science linkage (θ) of the research project, that is, how intensively the invention exploits the scientific knowledge sources. In the disciplines where the science linkage of the invention is strong (e.g. biotechnology), the research more often belongs to "Pasteur" quadrant (Stokes, 1997) and the distinction between basic research and applied research is blurred (Geuna and Nesta, 2006), so that a patentable invention and a scientific discovery are more likely to be jointly produced.

The cost of using the grace period on the basis of academic disclosure is the foreign patent loss: loss of patenting opportunities in those countries with no grace period exception on that basis (we call it "Cost from foreign patent loss"). We assume that such cost rises with the (average) patenting value in the foreign countries (v_f) subtracted by the foreign patent application cost (c_f). Given these benefits and costs are linearizing the benefit function, the researcher will seek a grace period exception for the invention (i), iff

$$\mathit{Benefit\ from\ priority\ in\ science}_i = \alpha\theta_i > \mathit{Cost\ from\ foreign\ patents\ loss}_i = v_{f_i} - c_{f_i} \qquad (1)$$

Under "the deferral of domestic patent filing view", the researcher faces no constraint in preparing the patent application before the academic disclosure so that the patent application does not constrain the pursuit of priority by academic disclosure. The benefit from using the grace period is to delay the patent application for enjoying a longer protection of the invention in the country with such exemption ($vd\_d_i, value\ from\ deffered\ application\ in\ a\ domestic\ market$), which rises with the commercial value of patenting in the domestic market. The cost of using the grace period is foreign patent loss. Thus, the researcher will seek a grace period exception for an invention (i), iff

$$Benefit\ from\ deferral\ of\ domestic\ patent\ filing_i = vd\_d_i >$$

$$Cost\ from\ foreign\ patent\ loss_i = v\_f_i - c_{f_i} \qquad (2)$$

s.t. the existence of some minimal academic output from the research project.

Under *the promotion of domestic patenting view*, the benefit from the grace period (v_d_i) is to enable a university researcher or an inventor who made an early academic disclosure or who made a disclosure inadvertently to have the extra time for a patent application in the domestic market. The cost is the domestic patenting cost c_d_i. Thus, the researcher will seek the grace period iff

$$Beneifit\ from\ domestic\ patenting = v\_d_i > Domestic\ patenting\ cost = c\_d_i$$

s.t. the existence of some minimal academic output (3)

The above framework provides the following testable comparative statics implications on the use of the grace period among the patent applications. First, the effects of globalization of the domestic patent applications, driven by the exogenous policy change, vary across three views. More chances to apply patents to those countries with no grace period for lower marginal cost and with longer time window affect only in the above equation (1) and (2). Thus, we have the following result.

Comparative statics result 1 (Effects of more chances to make patent applications to the countries with no grace period under three views)

More chances to make patent applications to those countries with no grace period reduce the use of grace period and do so more in those technology fields with high global patent applications, when the effect of grace period is either the acceleration of disclosure or the deferral of domestic patent filing. On the other hand, they do not affect the use of grace period if the effect of the grace period system is the promotion of domestic patenting of the disclosed invention.

We will use the PCT reform introduced in 2004 as an exogenous change to test this prediction. We will also assess whether more chances of using global applications do not affect the use of the grace period for an exhibition as a placebo test, since the period on the basis of exhibitions is widely recognized internationally, so that more chances to make global patent applications would not affect the use of the grace period on the basis of exhibitions.

When the focal invention uses scientific knowledge intensively either for the idea for the R&D or for the implementation of the R&D, it is more likely that the patent is associated with a scientific discovery and there will be an opportunity for using the grace period under any of the three views. Furthermore, high science intensive project is more likely to generate a high quality scientific output, which is worthy of early academic disclosure. This latter effect influences the decision on the use of the grace period under "the acceleration of disclosure view", where the tradeoff is between the cost of foreign patent loss and the value of early academic disclosure. The enhanced value of early academic disclosure affects the use of the grace period under the other two views only through increasing the probability of the existence of some minimal academic output. Since the last condition is likely to be met for even a modest research project, we hypothesize that the science intensity of the research project affects the use of the grace period only marginally when the science intensity is already very high. Thus, we have the following comparative statics result.

Comparative statics result 2 (Effects of science linkage under three views)

The use of the grace period increases monotonically with its science linkage under

the acceleration of disclosure view, unless the value of early academic disclosure begins to dominate the foreign patent loss. On the other hand, the effect of higher science linkage becomes insignificant under the other two views (the deferral of domestic patent filing view and the promotion of domestic patenting view), once the inventor has the minimal academic output.

Higher commercial value of patenting the invention increases the cost of foreign patent loss due to the use of the grace period and increases the incentive for domestic patenting. Thus, it reduces the use of the grace period under the acceleration of disclosure view, where the tradeoff is between the cost of foreign patent loss and the value of the academic disclosure. On the other hand it increases its use under "the promotion of domestic patenting view", where the tradeoff is between domestic filing cost and the gain from domestic patenting. It increases both the value of deferring a domestic patent filing as well as the cost of foreign patent loss so that its effect on the use of the grace period is ambiguous under "the deferral of domestic patent filing view".

Comparative statics result 3 (Effects of the commercial value of patenting the

invention under three views)

Higher commercial value of patenting, the invention reduces the use of the grace period under the acceleration of disclosure view, while it increases such use under the promotion of domestic patenting view. On the other hand, its effect is ambiguous under the deferral of domestic patent filing view.

These comparative statics results are summarized in the Table 1. It helps us to identify which of the three alternative views best explains the motivations of using the grace period, as stated in the following Hypothesis 1.

(Insert Table 1 about here)

Hypothesis 1 (Use of the grace period under three views)

If more chances to make patent applications to those countries with no grace period and higher value of patenting the invention reduce its use, "the promotion of domestic patenting view" does not explain the use of the grace period. If the use increases more significantly for the inventions with very high science linkage, "the deferral of domestic patent filing view" does not explain its use.

Academic researchers recognize more benefit from getting priority in science than corporate or industrial researchers. Furthermore, they recognize less the foreign patent loss due to the use of the grace period and the gain from postponing the patent application. Thus, the equation (1) under “the acceleration of disclosure view” indicates that the use of the grace period by the academic researchers is more likely to respond to the science-intensity of the project than to the patenting value, relative to corporate inventors. Since an academic inventor is expected to have some academic output accompanying his/her invention, the condition of the existence of the academic output is likely to be no-binding under the second and the third view for academic inventors. Thus, under “the deferral of domestic patent filing view” and “the promotion of domestic patenting view”, we expect that the use of the grace period is less likely to respond to the science-intensity of the project than to the patenting value for academic inventors, compared to the pattern for corporate inventors.

Hypothesis 2 (Use of the grace period by academic and corporate inventors)

If the acceleration of disclosure view holds, the use of the grace period is more likely to respond to the science intensity of the project than to the patenting value, relative to the corporate inventors. If the other two views hold, we will observe the opposite pattern.

3.3 The impact of grace period exception on knowledge flow

"The acceleration of disclosure view" suggests that those inventions subject to grace period exception become revealed earlier to the public through academic disclosure, relative to those inventions without the grace period, the disclosure of which comes only later than the date of domestic filing (typically in 18 months after the domestic filing). On the other hand, according to "the deferral of domestic patent filing view", the adoption of grace period is used only to delay the filing but not to accelerate the academic disclosure. "The promotion of domestic patenting view" implies that the adoption of grace period does not accelerate the disclosure either, although we cannot measure that effect since we do not have data on academic disclosure without domestic patent filing.

Hypothesis 3 (Knowledge flow effects under *the acceleration of disclosure view* and under *the deferral of domestic patent filing view*)

A grace period accelerates the knowledge flow to the third parties, according to the acceleration of disclosure view, but it does not under the deferral of domestic patent filing view.

Note again that we cannot directly assess the knowledge flow effects of the third view, since we observe only the patent applications with or without the use of the grace period. The alternative to the use of the grace period under the third view is the academic publication with no patent application, such events of which we cannot observe.

4. Data and estimation strategy

4.1 Data

We constructed our main dataset of the patent applications filed from 1992 to 2008, matched with three sources of database: (1) the data on the individual use of the grace period as reported to the JPO, (2) the patent bibliographic data such as non-patent literature reference data, and (3) the applicant data. The comprehensive data on the individual use of the grace period as reported to the JPO were made available from the JPO for this research. We have collected the patent bibliographic data from the IIP patent database compiled by IIP[7] and the databases developed by Jinko Seimei Kenkyujo. In particular, we used the non-patent inventor references data extracted by Jinko Seimei Kenkyujo from the patent documents to measure the science linkage for

[7] See Goto, A., Motohashi, K., 2007. Construction of a Japanese Patent Database and a first look at Japanese patenting activities. Research Policy 36, 1431-1442.

each individual patent. Lastly, both Japanese company name dictionary data developed by the NISTEP and the SIPRA data provided by the JPO were used as applicant data and were merged with the above individual patent data.

To control for the timing of the knowledge flow accurately, the divisional applications and the applications based on domestic priorities were removed from our dataset in the econometric analysis for knowledge flow. As a consequence, our sample patents cover roughly 77% of the entire domestic patent applications during the period between 1992 and 2008.

In addition to this main dataset, we also constructed the subset of the dataset, matched with RIETI inventor survey on the patent applications from 1995 to 2001[8]. This survey asked whether the inventor disclosed the invention in academic publications. We can assess whether the earlier disclosure using the grace period (ex-ante academic disclosure) generates more knowledge spillover than the late disclosure without using the grace period (ex-post academic disclosure). In the sample (N=4648), 15 % of the patent applications have the ex-post publication of the invention in scientific or technical journals (see Appendix Table 2)

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[8] This RIETI inventor survey, which is part of the RIETI project titled "The Structural Characteristics of Research and Development by Japanese Companies, and Issues for the Future," was undertaken from January to June in 2007 by RIETI and amassed nearly 5,300 responses. For more information about this survey, please see Nagaoka, S., Tsukada, N., 2007. The Innovation in Japan: Major findings from the RIETI inventor survey (Hatsumeisha kara mita Nihon no Innovation Process: RIETI inventor survey no kekka gaiyo in Japanese), RIETI Discussion Paper Series 07-J-046..

4.2 Descriptive statistics

First, we would like to show how the propensity that applicants use grace period exception varies significantly across technology sectors and across applicant types. The probability that grace period exception was employed by applicants in Japan varies significantly across technologies, from 3.02% (genetic engineering) to 0.23% (dyes, petroleum products) (Appendix Figure 1, note that those values shown in this figure are the estimated values and its reference industrial sector is Agriculture at 0.64%), controlling for invention characteristics. The average use of the grace period per application varies significantly across applicant types (see Appendix Figure 2, note that those values shown in this figure are the estimated values and its reference applicant type is commercial firms at 0.46%): Academic institutions (universities) (14.9%), Technology Licensing Organizations (14.4%), Public Research Organizations (9.9%) and commercial firms[9] (0.5%), after controlling for technology sectors. Furthermore the commercial firms account for around a half of the patent applications using the grace period, due to their large number of patent applications (see Appendix Figure 3). When we focus on the firm size, we found that SMEs have higher level of using grace

[9] Commercial firms cover all sectors: manufacturing, trade, finance and service firms.

period exception (0.31%) than large firms (0.24%) (see Appendix table 1).

Figure 2 shows the variation over time of the use of grace period (%) and of the PCT application propensity (%) in Japan. As we have anticipated, there was a major surge in the use of the grace period exceptions since 2000, driven by the 2000 reform of grace period rule which allowed the use of internet for academic disclosures. Furthermore, the use of the grace period showed a decline since 2004 (the year when the designation-of-state rule for PCT filing was abolished) and then became flat. On the other hand, there has been a continued rise of the share of PCT applications from around 3 % in 1992 to 17 % in 2008.

(Insert Figure 2 about here)

Figure 3 shows the variation over time of the use of grace period on the basis of academic disclosure in science intensive sectors (Drugs, Organic chemistry, Pesticides, Biotechnology, Beer, Fermentation and Genetic Engineering) and that on the basis of exhibition in exhibition intensive sector (Personal and Domestic Articles and Packing, Lifting), together with the aggregate use in the overall sectors. The level of the use of the grace period in science intensive sectors is significantly higher than that in the overall sectors (the former level (3-5.5%) is ten times larger than the latter one (0.3-0.55%). Furthermore, the variation over time of the use of the grace period in science intensive sectors is very similar to that in the overall sectors. The use of the grace period on the basis of exhibition does not show so strong changes as its use on the basis of academic disclosure. This stable use of the grace period based on the basis of exhibition disclosure is consistent with our expectation, since the grace period rule on the basis of exhibition has been accepted globally, suggesting that cost from foreign patent loss due to the use of grace period should not be affected by more opportunities for international applications.

(Insert Figure 3 about here)

Figure 4 illustrates the variation over time of the incidence of the use of the grace period by four types of applicants: academia, corporations, individuals and the others. Figure 4 provides us that academia most frequently uses the grace period exception, (7%~16%). In contrast, corporations use much less frequently, as we would expect (around 0.2%~0.3 %).

(Insert Figure 4 about here)

Figure 5 shows the variation over time of the use of the grace period by intensity of the use of PCT applications across sectors. This figure shows that if a technology field is highly globalized, the inventions in those fields use more the grace period, even though such inventions cannot have patent protection in European countries. Moreover, the sharp decline is shown in the sectors with high PCT propensity after the 2004 reform as to a PCT filing rule. A similar tendency can be observed in Figure 6, which shows the use of the grace period by technology sectors categorized by the level of science linkage. It shows us that higher science linkage is associated with more use of grace period exception.

(Insert Figure 5 and Figure 6 about here)

4.3 Estimation strategy

(1) Determinants of the use of the grace period

We use the panel data covering the period from 1992-2008 and 33 technology fields. The estimation is implemented at an individual patent level, using the decision on the use of the grace period as the dependent variable and the invention characteristics as independent variables. We estimate the following basic equation for the use of the grace period.

$$\mathrm{GRACE}_{i,j,f,t,k} = \beta_0 + \beta_1 \cdot \ln\left(\mathrm{SCIENCE}_{i,j,f,t,k} + 1\right) + \beta_2 \cdot \ln\left(\mathrm{INV}_{i,j,f,t,k}\right) + \beta_3 \cdot \ln\left(\mathrm{CLAIM}_{i,j,f,t,k}\right) + \beta_4 \cdot \mathrm{PCT}_{k-f,t-1} + \beta_5 \cdot \mathrm{PCT}_{k-f,t-1} \times \mathrm{REFORM\_PCT}_t + \sum_j \beta_j \mathrm{APPLICANT}_{i,j} + \sum_k \beta_k \mathrm{TECHNOLOGY}_{i,k} + \sum_t \beta_t \mathrm{YEAR}_{i,t} + \epsilon_{i,j,f,t,k}$$

(4)

A patent is denoted by *i*, firm by *f*, applicant type by *j*, technology sector by *k* and year by *t* respectively. The dependent variable, GRACE, is a binary variable that takes a value equal to 1 if the applicant files a patent application with a grace period exception and a value of zero otherwise.

We use the following five major explanatory variables. SCIENCE is the number of backward citations to non-patent literature (mainly science and technical journals and publications, including proceedings). This variable measures the science intensity of the R&D project and indicates the probability that the invention is accompanied with scientific output. We expect that its coefficient is positive under any view. INV is the number of inventors who generated the patented inventions. When a more number of inventors are involved, it is more likely that at least one of them has a scientific output associated with the invention, so that we expect a positive coefficient for this variable. CLAIM is the number of claims and measures the commercial value from patenting the invention. We expect that it has a negative coefficient under the first view and a positive coefficient under the third view[10].

For the purpose of measuring the globalization of domestic patent filing, we do not use the international patent filing data of the focal patent unlike the previous study

[10] Admittedly, CLAIM is likely to be an imperfect measure of the patenting value, so that SCIENCE and INV tend to capture a part of such value. As a result, the coefficients of these variables tend to be biased. In particular, these effects tend to show us the positive effect for SCIENCE under the acceleration of disclosure view.

(Franzoni and Scellato, 2010), since this variable is clearly an endogenous variable (if a particular patent uses the grace period exception, its foreign extension is constrained). Instead, we use the exogenous policy shock in 2004 (REFORM_PCT) interacted with the past intensity of the use of PCT applications at a sector level (PCT) and introduce this interaction term as the explanatory variable. REFORM_PCT is the PCT reform dummy and is set to 1 after 1st January 2004 and to a value of zero before this date. From 1st January 2004, all PCT contracting states are automatically designated for a national or regional patent office if the applicant files the PCT patent application afterward. As a result, a single PCT application gives its applicant a bundle of options to apply for a patent in any number of countries if it is done within 30 months from the international filing date. We use this variable as an exogenous policy shock enhancing the benefit of preserving the option of making foreign patent applications to those countries with no grace period, by actually not using the grace period. PCT is given by the ratio of the total count of PCT patent applications (excluding the number of PCT applications made by the focal institution) relative to domestic patent (JP) applications (excluding the number of JP applications made by the focal institution) in each technology k in each year t-1. Since we introduce fixed effects for technology sectors, the PCT variable itself essentially measures the effect of the time variation of the globalization of patent filings, lagged by one year.

Other important control variables are dummy variables: APPLICANT classifies applicant types into 7 categories (Academic Institutions, Other Academic Institutions, Technology Licensing Organizations (TLOs), Public Research Organizations (PROs), Other Research Organizations, Individuals, and Commercial Companies; the base type is commercial companies). TECHNOLOGY are the sets of technology dummy variables based on WIPO statistical reports (33 technology fields; the base technology is Agriculture). We also introduce YEARs, which are the patent application years (1992-2008; the base year is 1992). We estimate equation (4) based on the pooled sample as well as individually for academic inventions and corporate inventions.

In order to assess whether the use of the grace period rises with the level of the science linkage of the invention even at very high level, we introduce SCI_P95 into our models, which is a dummy variable for the inventions at the top 5% level of science linkage. We add the interaction term between $\ln\left(\mathrm{SCIENCE}_{i,j,f,t,k}+1\right)$ and SCI_P95 as additional explanatory variable to basic equation (4).

(2) Effect of grace period on knowledge flow

Earlier academic disclosure will accelerate knowledge spillover from the academic disclosure to the subsequent inventions as well as to the subsequent scientific research. We focus on the first channel (non-self inventor forward citations), since the spillover to science is more difficult to assess, partly because a significant part of the disclosures occur in the conference and the other academic meetings, and the disclosures through journal papers is only a minor part. We split our sample into two subgroups for our estimation: corporate inventor sample and an academic researcher sample, given that the two types of inventors are likely to have different motivations and face different constraints.

Following the prior studies to capture knowledge flow, we use patent citation data (Alcácer and Gittelman, 2006; Alcácer et al., 2009; Henderson et al., 2005; Jaffe et al., 2000a; Jaffe et al., 2000b; Jaffe et al., 1993; Thompson, 2006; Thompson and Fox-Kean, 2005). However there is an endogeneity issue: a more science-based intention has high knowledge spillover and simultaneously more likely to use the grace period. We control such endogeneity due to unobserved heterogeneity by the combination of taking the difference between the non-self forward citations and the self forward citations (difference in logarithmic terms to control for unobserved heterogeneity in invention quality) and by introducing the level of science linkage of each invention as a control, as will be explained in more detail later.

We will estimate the following specification for examining the impact of a grace period system on the knowledge flow. We use the logarithm of inventor non-self forward citation flows ($\text{OTHER\_FORWARD}_{i,j,f,t,k}$) in order to assess the effects of early disclosure of the invention in academic conferences or through publications. Given that it is likely that there is a unobserved selection effect (that is, those inventions using the grace period are likely to be higher spillover inventions ($\mu_{i,j,f,t,k}$), embodying scientific discoveries, but cannot be fully measured by bibliographic indicators such as science linkage), we adopt a "difference in differences" approach, with the logarithm of self -citation flows ($\text{SELF\_FORWARD}_{i,j,f,t,k}$) as a control, given that self-citation flow would not be affected by the early disclosure of its own patented invention, whereas citation flow made by other parties would be affected by the early disclosure of the invention. We assume that unobserved invention quality affects the self forward citations and other forward citations in terms of percentage to the same extent:

$$\text{SELF\_FORWARD}_{i,j,f,t,k} = \beta_{SELF,0} + \beta_{SELF} \cdot \text{X}_{i,j,f,t,k} + \mu_{i,j,f,t,k} + \epsilon_{SELF,i,j,f,t,k} \quad , \quad (6)$$

$$\text{OTHER\_FORWARD}_{i,f,t,k} = \beta_{OTHER,0} + \beta_{OTHER} \cdot \text{X}_{i,j,f,t,k} + \mu_{i,j,f,t,k} + \alpha \cdot gd_{i,j,f,t,k} + \epsilon_{OTHER,i,j,f,t,k}, \quad (7)$$

By subtracting the first equation from the second equation, we will gain the following equation to be estimated.

$$\text{OTHER\_FORWARD}_{i,j,f,t,k} - \text{SELF\_FORWARD}_{i,j,f,t,k} = (\beta_{OTHER,0} - \beta_{SELF,0}) + (\beta_{OTHER} - \beta_{SELF}) \cdot \text{X}_{i,j,f,t,k} + \alpha \cdot gd_{i,j,f,t,k} + (\epsilon_{OTHER,i,j,f,t,k} - \epsilon_{SELF,i,j,f,t,k}) \quad , \tag{8}$$

In the above equations, $\text{OTHER\_FORWARD}_{i,j,f,t,k}$ represents the logarithm of citation flow to the third parties and $\alpha \cdot gd_{i,j,f,t,k}$ denotes the effect of early academic disclosure of the invention on the third parties, where $gd_{i,j,f,t,k}$ is a dummy variable representing whether the grace period is used or not. $\varepsilon_{*,i,j,f,t,k}$ represents exogenous stochastic term. We control for the nature of invention (CLAIM, SCIENCE and INV), technology area, applicant type, and application year:

$$\text{OTHER\_FORWARD}_{i,j,f,t,k} - \text{SELF\_FORWARD}_{i,j,f,t,k} = \gamma_0 + \gamma_1 \cdot \text{GRACE}_{i,j,f,t,k} + \beta_1 \cdot \ln(\text{CLAIM}_{i,j,f,t,k}) + \beta_2 \cdot \ln(\text{SCIENCE}_{i,j,f,t,k} + 1) + \beta_3 \cdot \ln(\text{INV}_{i,j,f,t,k}) + + \sum_j \beta_j \text{APPLICANT}_{i,j} + \sum_k \beta_k \text{TECHNOLOGY}_{i,k} + \sum_t \beta_t \text{YEAR}_{i,t} + \epsilon_{i,j,f,t,k}. \tag{9}$$

The above equations would be estimated by an ordinary least square regression (OLS). We estimate equation (9) individually for corporate inventions and academic inventions.

5. Estimation Results

5.1 The determinants of the use of grace period exception

The following Table 2a and Table2b provide the estimation results on the determinants of applying for a grace period exception, using an OLS model and a probit model. Model 1 to 4 of Table 2a pool all the samples which cover patent applications with the grace period exceptions based on academic disclosure as well as those based on exhibition by both corporate and academic inventors. In model 1, we introduce patent attributes (SCIENCE, CLAIM, INV), application year dummies of the patent (YEAR), technology field dummies of the patent (TECHNOLOGY), and applicant type dummies of the patent (APPLICANT). Model 2 adds the following variables to those in model 1: the cross term between PCT ratio (PCT) and the time dummy of PCT reform (REFORM_PCT) to examine the impact of the PCT reform on the use of grace period. In order to assess whether the use of the grace period increases with science linkage even at very high level of science linkage, a dummy variable for the top 5 percentile level of science linkage (SCI_P95) is introduced in model 3. Since the dependent variable (GRACE) is a binary variable regarding whether an applicant applies for a grace period exception upon filing a patent application or not, a Probit model is also used for our estimation (model 4) for a robustness check (the marginal effects are presented). The findings based on Probit model are qualitatively the same as those from the OLS model (model 3).

(Insert Table 2a about here)

Regarding the effect of globalization on the use of grace period, we find evidence strongly supporting that more chances of using global applications reduced the use of grace period exception more in those technology fields with higher global patent applications. The coefficient of the cross term of PCT ratio with the PCT reform dummy (REFORM_PCT) is negative and statistically significant at 1% level. This tendency holds even after we control for science linkage more tightly in model 3. Namely, the negative impact of PCT reform on the use of the grace period is higher for the sectors which had extensive use of PCT applications. The result shows that the relationship as observed in Figure 5 is robust to statistical testing. The estimated effect is very large: one standard deviation increase of the PCT share (7.75%) results in the decrease of the use of the grace period by 0.21% points, which is roughly a half of the average probability of the use of the grace period during this period (0.40%).

The second major finding is that SCIENCE has a positive and highly significant effect on the use of the grace period, with no sign of its diminishing effect as the science intensity of the project increases. Considering that the average probability of using grace period is 0.40%, the estimated impact of this variable for SCIENCE=2 references is very strong (2.94%). As shown in model 3, the cross-term between the science linkage and top 5% status of the invention in terms of science linkage has a significantly positive coefficient.

The third major finding is that CLAIM has a significantly *negative* coefficient, while INV (inventor team size) has a significantly positive coefficient, in addition to SCIENCE. In our estimation model, CLAIM is an indicator of the patenting value of the invention. The negative coefficient for CLAIM suggests that the invention with high patenting value uses less the grace period exception, in consistent with the promoting of domestic patenting view and the disclosure acceleration view.

Model 5 and model 6 of Table 2b separates the grace period exception on the basis of academic disclosure and that on the basis of exhibition in the estimation. The samples are also correspondingly different: the sectors with high science linkage for the first dependent variable and the exhibition intensive sectors for the second dependent variable. Consistent with our placebo testing strategy, the cross term between the PCT ratio (PCT) and the PCT reform dummy (REFORM_PCT) is negative and statistically significant only in model 5.

(Insert Table 2b about here)

Model 7 and model 8 of Table 2b separates the sample of science intensive sector into those for academic inventors and those for corporate inventors for the use of the grace period with respect to academic disclosure. The size of the estimated coefficients for SCIENCE is twice as much larger for academic inventors than for corporate inventors, while that of the number of claims is similar for academic inventors and for corporate inventors. Thus, these results support the acceleration of disclosure view according to Hypothesis 2. The coefficient of PCT reform in 2004 is significant in neither model 7 nor model 8, since there exist only small variations of the use of the PCT among the science intensive sectors.

5.2 Impacts of grace period exception in Japan on knowledge flow

Our main dependent variable is the difference between a logarithm of the citations made by third parties (other than the applicant and the examiner) and a logarithm of the self-forward citations, as explained in section 4. All the models introduce the same set of explanatory and control variables except for PCT-related variables: grace period dummy (GRACE), the number of claims (CLAIM), the number of science literature backward citations (SCIENCE), the number of inventors (INV), application year dummies (YEAR), technology class dummies (TECHNOLOGY) and applicant type dummies (APPLICANT). First, we split our whole sample into two subgroups, depending on applicant type (corporations and academia). The estimation results are shown respectively in Table 3a and 3b (corporate inventions and academic inventions). For each subsample, we separately estimate three models (model 1a to model 4a in the case of Table 3a) employing the following four types of citation flows from the focal patent: (a) the count of citations received from the patent applications by all applicants (model 1a), (b) those received from Japanese large firms (model 2a), (c) those received from the patent applications of Japanese SMEs, which are mostly small firms (model 3a), and (d) those received from the patent applications of academia (universities, TLOs and PROs) (model 4a). Moreover, we also estimate the total citation flows before taking the difference, so as to understand the source of the impact of GRACE: self-forward citations (model 1a-1) and forward citations (model 1a-2).

(Insert Table 3a about here)

Regarding the difference between the forward citations by the others and self forward citations with respect to a corporate invention, the estimated coefficient for the variable, GRACE, is positive and statistically significant in all models from (1a) to (4a), as we expect from Hypothesis 3 when *the acceleration of disclosure view* holds. This implies a positive knowledge spillover effect: the estimated coefficient for GRACE is 6.3% for the entire citations, 5.7% for large firms, 3.6% for small firms and 5.6% for academia respectively in corporation inventions sample. Even academia such as universities, TLOs and PROs benefits from knowledge spillover for corporate inventions. These findings indicate that earlier academic disclosure before the domestic patent filing enhances the knowledge flow to the other firms.

Model 1a-1 and 1a-2 in Table 3a show the estimation results for self-forward citations and forward citations by the others separately, corresponding to model 1a. The results show that the number of non self-citations is significantly higher with the use of the grace period (3.1%), but that of self-citations is significantly lower (-3.1%). Our desirable interpretation of this asymmetric result for the coefficients of the grace period is that since the invention using a grace period is often an invention from basic research, the internal follow-up inventions increase only slowly, while at the same time there is a large spillover to the other firms due to large potential opportunities of developing such invention, so that the external follow-up inventions increase fast. Furthermore, the results show that both self-citations and non-self-citations increase significantly and to a similarly extent (the estimated coefficients are close) with science linkage, while non-self-citations increase more with the number of claims and the number of inventors.

The estimation results for academic inventions are qualitatively very similar to those of corporate inventions, as shown in Table 3b (here the sample is academic inventions). The estimated effect of grace period is highly significant and positive, although the size of coefficient (4.0 % for the total citations) is a bit smaller than that in the case of corporate inventions (6.3%). This may again reflect the fact that the nature of academic discoveries is more basic than corporate discoveries.

(Insert Table 3b about here)

Table 3c shows the estimation results for the sectors of high degree of science intensive sectors and for the sectors of low degree of science intensity. The grace period coefficient is significantly larger in the former sectors (7.0 %) than in the latter sectors (3.9%). The impact of the use of the grace period is significantly larger in the high degree of science intensive sectors.

(Insert Table 3c about here)

Finally, Table 4 compares the impacts of *ex-ante* disclosure using the grace period versus *ex-post* disclosure for corporate inventions from 1995-2001. The upper table shows the results for the impact of the *ex-ante* disclosure for the patent applications from 1995 to 2001. The use of the grace period (ex-ante disclosure during grace period) is associated with 8.46% increase of the non-self forward citations, relative to the self citations, and the coefficient is highly significant. On the other hand, the *ex-post* disclosure is associated with 4.41% increase of the non-self forward citations (ex-post disclosure by scientific lit.), relative to the self citations, and the coefficient is not significant. Thus, *ex-ante* disclosure is accompanied with more spillovers, suggesting that the grace period system promotes knowledge spillover by accelerating disclosure.

6. Conclusions and discussions

This paper first featured three views on the role of the grace period. According to the first view (*the acceleration of disclosure view*), the grace period allows earlier academic disclosure (either for academic competition or for searching for collaborators) without losing the opportunity to apply for the domestic patenting right, given that it takes time for a researcher to prepare a patent application. In this case the tradeoff for the inventor-researcher in using the grace period is between early academic disclosure and foreign patent loss, and the use of the grace period accelerates the diffusion of knowledge. In this view, science linkage matters rather than the number of claims more for academic inventors than for corporate inventors. According to the second view (*the deferral of domestic patent filing view*), the inventor uses the grace period for delaying the patent filing for the purpose of enjoying a longer period of patent protection or for testing the invention. In this case the tradeoff for the inventor is between longer effective domestic patent protection and foreign patent loss, and it does not accelerate academic disclosure. According to the third view (*the promotion of domestic patenting view*), the inventor uses the grace period for obtaining a domestic patent, after the inventor's early disclosure either for a purpose (by a researcher with predominant interest on research competition) or as an accident. In this case the tradeoff for the inventor is between the value of domestic patenting and the domestic patenting cost, since his earlier academic disclosure and foreign patent loss are predetermined. As a consequence, the grace period does not accelerate academic disclosure. Under the second and third view, the number of claims matters rather than science linkage for academic inventors more than for corporate inventors, given that academic inventors are very likely to have some academic output accompanying their inventions.

This paper examined what determined the use of the grace period (by corporate and academic inventors) as well as its effects on knowledge flow, based on the data of the use of the grace period in Japan. Furthermore, we also identified which of these three views best explains the pattern of the use of the grace period and therefore its economic effects.

Major findings are the following. The grace period is more used for the inventions with strong science linkage and in high technology sectors, but less used for those with a large number of claims (the invention with high patenting value). Science linkage matters rather than the number of claims for academic inventors more than for corporate inventors in using the grace period. The PCT reform in January 2004 had a significantly negative impact on the use of the grace period in those sectors with high shares of PCT applications. The PCT reform in 2004 has enabled an applicant to obtain a bundle of options to apply for a patent in any number of countries when it is done within 30 months from the international filing date, by a single PCT application. The combination of these evidences clearly suggests that *the promotion of domestic patenting view* cannot explain the use of the grace period and *the acceleration of academic disclosure* is likely to be the main driver of the use of the grace period in Japan.

In the second econometric exercise we have also found that the use of the grace period increased significantly knowledge diffusion to third parties as measured by non-self forward citations, relative to self-citations. This knowledge flow effect to the third parties is 6.3% during the 1992-2008 period for corporate inventions (the control group is the other corporate inventions) and it is 4.0% for academic inventions (the control group is the other academic inventions). The knowledge diffusion effect of the grace period is larger for the sectors with high science linkage but it also remains significant for the sectors with low science linkage. Furthermore, the effect of *ex-ante* disclosure using the grace period (that is, the disclosure before the patent application) is larger than that of *ex-post* disclosure (that is, the disclosure after the patent application). These findings show that the main motivation of the use of grace period is the acceleration of disclosure and therefore the grace period enhances knowledge diffusion.

Given that the applicant has the choice of using the grace period and that the third parties are likely to gain from early knowledge disclosure (the competitor can avoid inventing duplicated R&D and consumers can gain from the acceleration and diversification of research), these results also suggest that the grace period system is likely to enhance innovation and social welfare. Moreover, the global introduction of the grace period system has become more important, given that the increasing opportunities for global patent applications facilitated by the PCT applications have started to significantly hinder the use of the grace period, as the experience of Japan suggests.

There are a number of important policy design issues for the grace period system, such as the mandatory notification of the earlier disclosure to the patent office, international extension (grace period counted from priority date or from the application date), early publication of the patent application reliant on the grace period and prior user right. This study does not address directly these issues, but some features of the grace period system in Japan may explain why the acceleration of academic disclosure is its main effect. First, the system of notification of the earlier disclosure (mandatory declaration system) as required in Japan provides an important mechanism to ensure that such disclosure is genuine academic disclosure with the scientific merit which has the potential of external knowledge diffusion. In addition, a relatively short grace period in Japan (6 months) may make using the grace period for longer patent protection unattractive, in addition to the possibility that the patents for science based inventions are often not maintained for a long period.

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Figure 1 Three views on the effects of grace period

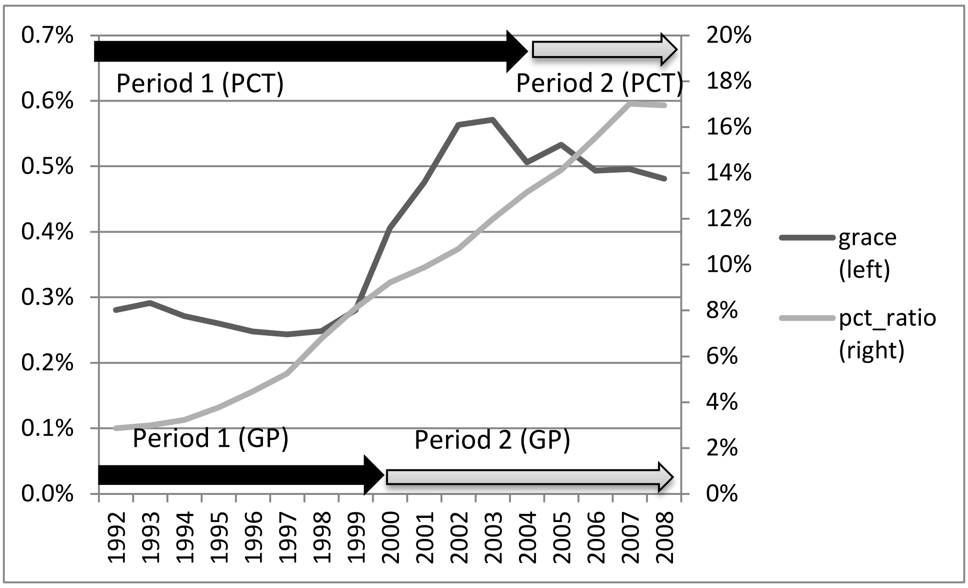
Several Views on the effect of grace period	**Use of grace period**	**Timing** (A ○———○ B →)	**Knowledge diffusion to the third party begins at**	**Effect of grace period on knowledge spillover**
Acceleration of disclosure view	Yes	△○− − −→● 6 months	A	YES
	No	△− − − − −→●○	B	
Deferral of domestic patent filing view	Yes	△○− − −→● 6 months	A	NO
	No	△●○	A	
Promotion of domestic patenting view	Yes	△○− − −→● 6 months	A	NO
	No	△○	A	

△: Invention Completed, ○: Academic disclosure, ●: patent filing

Table 1 Implications of three views of the grace period

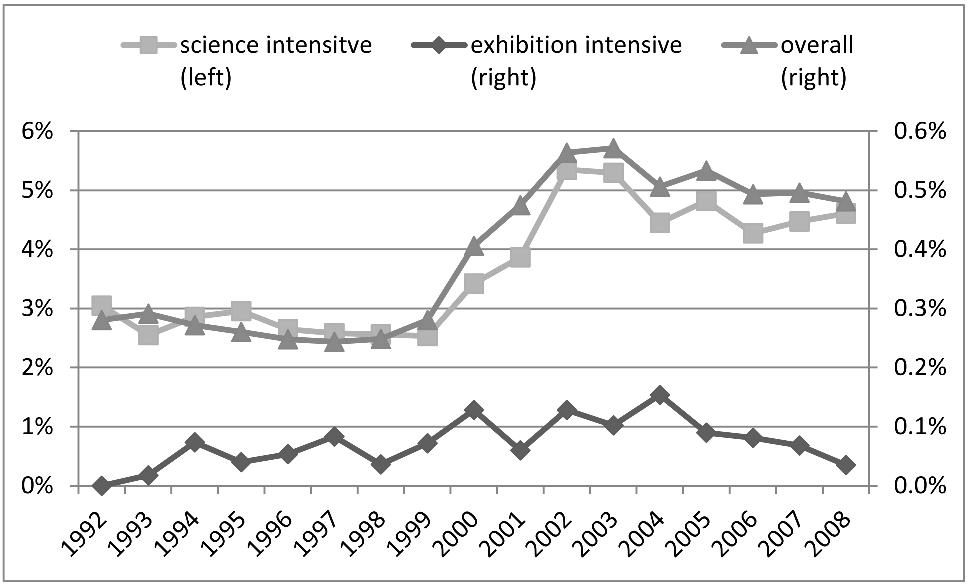
Three Views on the effect of grace period	**Effects on the use of the grace period**		
	More chances to make patent applications to the countries with no grace period	High science linkage	High private value from patenting
Acceleration of disclosure view	Minus	Plus	Minus (foreign patent loss)
Deferral of domestic patent filing view	Minus	Initially plus but may become insignificant	Ambiguous (longer domestic protection) less (foreign patent loss)
Promotion of domestic patenting view (after an intentional or accidental disclosure)	None	Initially plus but may become insignificant	Plus (domestic patent gain)

Figure 2 Use of grace period and the share of PCT applications in Japanese patent applications



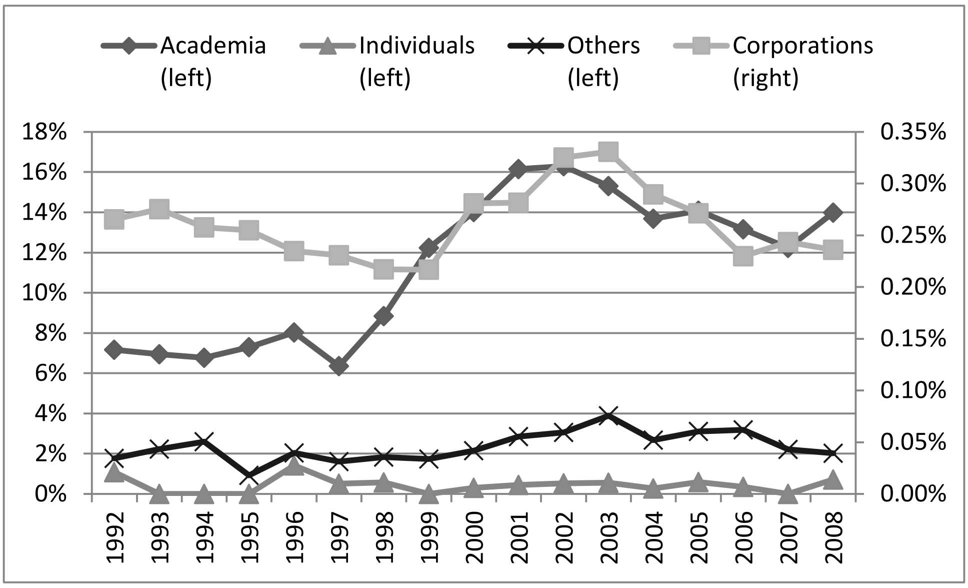
Note: Designation-of-states rule for PCT filing system was abolished in 2004. Internet form of disclosure for grace period exception in Japan was permitted in 2000.

Figure 3 Grace period on the basis of academic disclosures and that on the basis of exhibitions



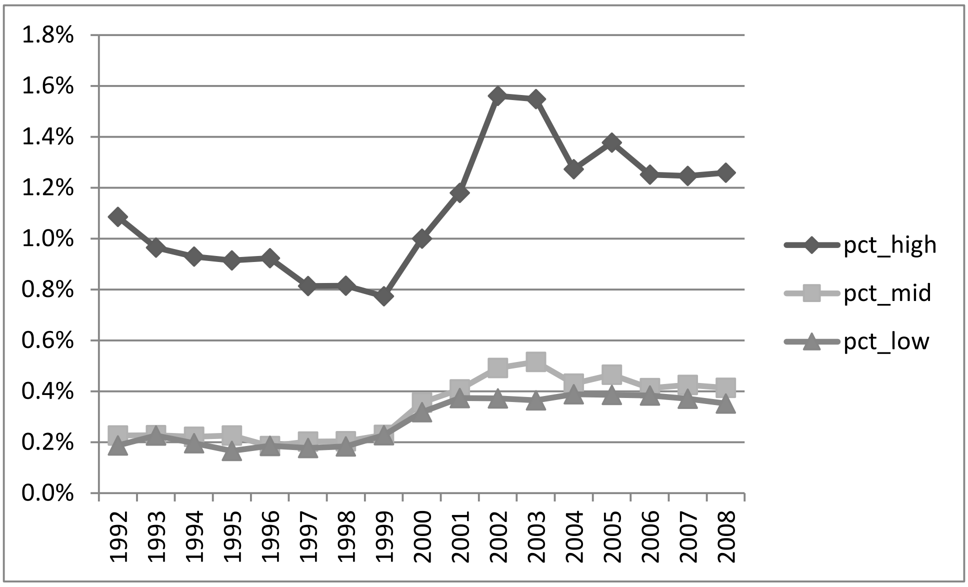
Note: Science intensive technology sectors include Drugs (5), Organic chemistry, Pesticides (13), Biotechnology, Beer, Fermentation (16) and Genetic Engineering (17). Exhibition intensive technology sectors comprise Personal and Domestic Articles (3) and Packing, Lifting (11). Figures in the blanket are sectorial ID.

Figure 4 Applicant type and the frequency of reliance on grace period



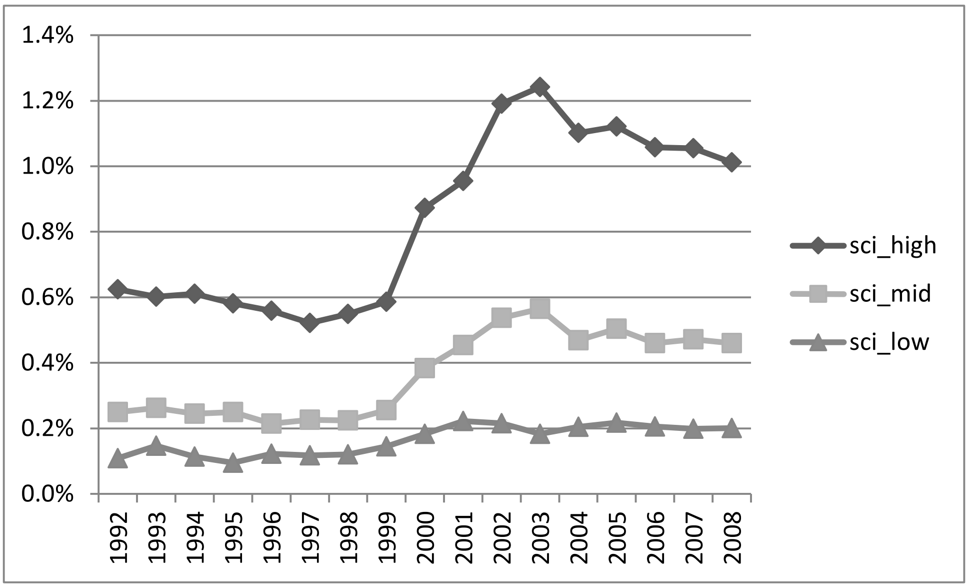
Note: "Academia" denotes Academic Institutions, TLOs and PROs, "Corporations" denotes Commercial Companies, "Individuals" for Individuals and Others for "Other Academic Institutions and Other ROs. Graphs with a left Y-axis are Academia, individuals and others and Graph with a right Y-axis is Corporations.

Figure 5 Use of the grace period by intensity of the use of PCT



Note: Classification of sectors by the intensity of PCT applications is as follows: PCT high intensive technology sectors are Health&Amusement, Drugs, Organic chemistry&Pesticides, Organic molecule compounds, Dyes&Petroleum, Biotechnology&Beer&Fermentation, Genetic Engineering, Paper, Weapons&Blasting, and Others; PCT middle intensive sectors are Food Stuffs, Separating&Mixing, Casting&Grinding&Layered Product, Non organic chemistry&Fertilizer, Metallurgy&Coating metals, Textile, Engine&Pump, Clock&Controlling&Computer, Display&Information Storage&Instruments, Electronics components&semiconductor, and Electronics circuit&communication tech; PCT low intensive sectors are Agriculture, Personal and Domestic Articles, Machine tools&Metal working, Printing, Transporting, Packing&Lifting, Construction, Mining&Drilling, Engineering elements, Lighting&Steam generation&Heating, Measurement&Optics&Photography, and Nuclear physics.

Figure 6 Science linkage and grace period



Note: Classification of the extent of science linkage is listed as follows: high science linkage technology sectors are Drugs, Organic chemistry&Pesticides, Organic molecule compounds, Dyes&Petroleum, Biotechnology&Beer&Fermentation, Genetic Engineering, Measurement&Optics&Photography, and Others; middle science linkage technology sectors are Agriculture, Food Stuffs, Health and Amusement, Separating&Mixing, Non organic chemistry&Fertilizer, Metallurgy&Coating metals, Paper, Clock&Controlling&Computer, Display&Information Storage&Instruments, Nuclear physics, Electronics components&semiconductor, and Electronics circuit&communication tech; low science linkage technology sectors are Personal and Domestic Articles, Machine tools&Metal working, Casting&Grinding&Layered Product, Printing, Transporting, Packing&Lifting, Textile, Construction, Mining&Drilling, Engine&Pump, Engineering elements, Lighting&Steam generation&Heating, and Weapons&Blasting.

Table 2a The determinants of the use of grace period exception (Pooled sample)

GRACE is a binary variable that takes a value equal to 1 if the applicant files a patent application with grace period exception on the basis of the other disclosure and a value of zero otherwise.

	(1)	OLS				(2)	OLS			
dependent variable=GRACE	Coef.	Std. Err.	t	P>|t|	significance	Coef.	Std. Err.	t	P>|t|	significance
ln(SCIENCE+1)	2.93	0.00883	332	0	***	2.94	0.00884	333	0	***
ln(INV)	0.205	0.00513	39.9	0	***	0.202	0.00513	39.4	0	***
ln(CLAIM)	-0.142	0.00543	-26.2	0	***	-0.142	0.00543	-26.3	0	***
PCT						-0.253	0.182	-1.39	0.163	
REFORM_PCT*PCT						-2.56	0.109	-23.4	0	***
CONSTANT	0.196	0.0329	5.96	0	***	0.142	0.033	4.31	0	***
TECHNOLOGY sector dummies		YES						YES		
APPLICANT type dummies		YES						YES		
application YEAR dummies		YES						YES		
Number of observations		4,207,325					4,207,325			
Adj R-squared		0.0729					0.0731			

	(3)	OLS				(4)	Probit			
dependent variable=GRACE	Coef.	Std. Err.	t	P>|t|	significance	Coef.	Std. Err.	t	P>|t|	significance
ln(SCIENCE+1)	0.331	0.0211	15.7	0	***	0.629	0.00519	121	0	***
ln(SCIENCE+1)*SCI_P95	3.04	0.0223	136	0	***					
ln(INV)	0.218	0.00512	42.5	0	***	0.241	0.0049	49.2	0	***
ln(CLAIM)	-0.132	0.00541	-24.3	0	***	-0.0957	0.00494	-19.4	0	***
PCT	-0.324	0.181	-1.79	0.07	*	-0.779	0.0896	-8.7	0	***
REFORM_PCT*PCT	-2.72	0.109	-24.9	0	***	-0.52	0.0477	-10.9	0	***
CONSTANT	0.128	0.0329	3.89	0	***	0.404	0.00284	142	0	***
TECHNOLOGY sector dummies		YES						YES		
APPLICANT type dummies		YES						YES		
application YEAR dummies		YES						YES		
Number of observations		4,207,325					4,207,325			
Adj R-squared		0.0772				Pseudo R2	0.332			

Note: * significance at 10%; ** significance at 5%;*** significance at 1%.

All of the coefficients and standard errors are multiplied by 100.

The explanatory variables are SCIENCE, which is the number of patent backward citations, SCI_P95, which is a dummy variable for the top 5% level of science linkage and INV, which is the number of inventors for the patent. The variable PCT is the ratio of the count of PCT patent applications to domestic patent (JP) applications in each technology *k* in each year *t*-1, REFORM_PCT which takes 1 after 1st January 2004 and a value of zero before this date, when all PCT contracting states are automatically designated for a national or regional patent if the applicant files the PCT patent application afterward and the interaction term of both variables. Dummy variables, APPLICANT, where we classify applicant types into 7 categories (Academic Institutions, Other Academic Institutions, Technology Licensing Organizations(TLOs), Public Research Organizations (PROs), Other Research Organizations, Individuals and Commercial Companies; its reference type is commercial companies), TECHNOLOGY, which are sets of technology dummy variables based on WIPO statistical reports (33 technologies, the base technology is Agriculture) and YEAR, which are sets of application year when the applicant filed the patent document (its reference year is 1992). Science intensive technology sectors include Drugs (5), Organic chemistry, Pesticides (13), Biotechnology, Beer, Fermentation (16) and Genetic Engineering (17). Exhibition technology sectors comprise Personal and Domestic Articles (3) and Packing, Lifting (11). Those patented inventions which were solely disclosed by exhibition have been dropped from the sample in equation (5), (7) and (8). The sample of equation (6) is only limited to the patented inventions which were solely disclosed by exhibition when an inventor used grace period.

Table 2b The determinants of the use of grace period exception (By sector)

GRACE is a binary variable that takes a value equal to 1 if the applicant files a patent application with grace period exception on the basis of the other disclosure and a value of zero otherwise. We exclude the sample of exhibition disclosure by grace period exception in model (5), (7) and (8).

	(5)	OLS	Science intensive sectors			(6)	OLS	Exhibition intensitve sectors		
dependent variable=GRACE	Coef.	Std. Err.	t	P>|t|	signi ficance	Coef.	Std. Err.	t	P>|t|	signi ficance
ln(SCIENCE+1)	3.69	0.0759	48.5	0	***	0.322	0.057	5.65	0	***
ln(INV)	0.561	0.115	4.88	0	***	-0.00989	0.0104	-0.95	0.343	
ln(CLAIM)	-0.704	0.111	-6.36	0	***	-0.035	0.0118	-2.98	0.003	***
PCT	5.16	1.86	2.77	0.01	***	-6.45	2.16	-2.98	0.003	***
REFORM_PCT*PCT	-6.63	2.3	-2.88	0	***	3.97	4.72	0.84	0.399	
CONSTANT	0.205	0.82	0.25	0.8		0.253	0.0772	3.27	0.001	***
TECHNOLOGY sector dummies	YES					YES				
APPLICANT type dummies	YES					YES				
application YEAR dummies	YES					YES				
Number of observations		86,731					202,197			
Adj R-squared		0.0783					0.0007			

	(7)	OLS	Academia Science intensive sectors			(8)	OLS	Corporations Science intensive sectors		
dependent variable=GRACE	Coef.	Std. Err.	t	P>|t|	signi ficance	Coef.	Std. Err.	t	P>|t|	signi ficance
ln(SCIENCE+1)	6.7	0.442	15.2	0	***	3.31	0.0679	48.7	0	***
ln(INV)	0.405	0.776	0.52	0.6		0.696	0.101	6.92	0	***
ln(CLAIM)	-0.613	0.724	-0.85	0.4		-0.598	0.0972	-6.15	0	***
PCT	14.3	9.98	1.43	0.15		-1.26	1.85	-0.68	0.498	
REFORM_PCT*PCT	-13.6	10.2	-1.34	0.18		-0.973	2.36	-0.41	0.68	
CONSTANT	-6.19	5.72	-1.08	0.28		4.02	0.844	4.76	0	***
TECHNOLOGY sector dummies			YES					YES		
Large firm dummy			NO			-1.51	0.172	-8.75	0	***
application YEAR dummies			YES					YES		
Number of observations		7,531					77,756			
Adj R-squared		0.0354					0.0381			

Table 3a Grace period and knowledge flow (forward citations) for corporations

(1a) dependent variable is based on forward citations received from all firms

ln(others)-ln(self)	Coef.	Std. Err.	t	P>|t|	significance
GRACE	6.31	0.595	10.6	0	***
ln(CLAIM)	4.47	0.053	84.4	0	***
ln(SCIENCE+1)	-0.235	0.0896	-2.62	0.009	***
ln(INV)	1.63	0.0501	32.5	0	***
CONSTANT	6.02	0.322	18.7	0	***
TECHNOLOGY sector dummies		YES			
APPLICANT type dummies		NO			
application YEAR dummies		YES			
Number of observations		4,135,183			
Adj R-squared		0.0278			

(4a) dependent variable is based on forward citations received from academia

ln(others)-ln(self)	Coef.	Std. Err.	t	P>|t|	significance
GRACE	5.58	0.359	15.5	0	***
ln(CLAIM)	-1.72	0.032	-53.9	0	***
ln(SCIENCE+1)	-2.42	0.0541	-44.8	0	***
ln(INV)	-2.27	0.0303	-75	0	***
CONSTANT	-9.3	0.195	-47.8	0	***
TECHNOLOGY sector dummies		YES			
APPLICANT type dummies		NO			
application YEAR dummies		YES			
Number of observations		4,135,183			
Adj R-squared		0.0135			

(2a) dependent variable is based on forward citations received from large firms

ln(others)-ln(self)	Coef.	Std. Err.	t	P>|t|	significance
GRACE	5.69	0.562	10.1	0	***
ln(CLAIM)	3.83	0.0501	76.5	0	***
ln(SCIENCE+1)	-0.507	0.0847	-5.98	0	***
ln(INV)	1.24	0.0474	26.3	0	***
CONSTANT	-1.36	0.304	-4.48	0	***
TECHNOLOGY sector dummies		YES			
APPLICANT type dummies		NO			
application YEAR dummies		YES			
Number of observations		4,135,183			
Adj R-squared		0.0215			

(1a-1) dependent variable is self-forward citations

ln(self)	Coef.	Std. Err.	t	P>|t|	significance
GRACE	-3.19	0.351	-9.07	0	***
ln(CLAIM)	2.2	0.0313	70.4	0	***
ln(SCIENCE+1)	3.63	0.0529	68.6	0	***
ln(INV)	2.51	0.0296	84.7	0	***
CONSTANT	9.51	0.19	50	0	***
TECHNOLOGY sector dummies		YES			
APPLICANT type dummies		NO			
application YEAR dummies		YES			
Number of observations		4,135,183			
Adj R-squared		0.018			

(3a) dependent variable is based on forward citations received from SMEs

ln(others)-ln(self)	Coef.	Std. Err.	t	P>|t|	significance
GRACE	3.6	0.375	9.6	0	***
ln(CLAIM)	-2	0.0334	-60	0	***
ln(SCIENCE+1)	-3.77	0.0565	-66.7	0	***
ln(INV)	-2.24	0.0316	-70.8	0	***
CONSTANT	-6.14	0.203	-30.2	0	***
TECHNOLOGY sector dummies		YES			
APPLICANT type dummies		NO			
application YEAR dummies		YES			
Number of observations		4,135,183			
Adj R-squared		0.0126			

(1a-2) dependent variable is non self-forward citations

ln(others)	Coef.	Std. Err.	t	P>|t|	significance
GRACE	3.12	0.541	5.77	0	***
ln(CLAIM)	6.67	0.0482	138	0	***
ln(SCIENCE+1)	3.4	0.0815	41.7	0	***
ln(INV)	4.13	0.0456	90.7	0	***
CONSTANT	15.5	0.293	53	0	***
TECHNOLOGY sector dummies		YES			
APPLICANT type dummies		NO			
application YEAR dummies		YES			
Number of observations		4,135,183			
Adj R-squared		0.0595			

Note: * significance at 10%; ** significance at 5%;*** significance at 1%. All of the coefficients and standard errors are multiplied by 100. The patented inventions which were disclosed at exhibition are dropped from the sample.

Table 3b Grace period and knowledge flow (forward citations) for academia

(1b) dependent variable is based on forward citations received from all firms

ln(others)-ln(self)	Coef.	Std. Err.	t	P>|t|	significance
GRACE	4.01	0.949	4.23	0	***
ln(CLAIM)	4.95	0.534	9.27	0	***
ln(SCIENCE+1)	-0.096	0.409	-0.23	0.815	
ln(INV)	2.59	0.526	4.92	0	***
CONSTANT	23.4	3.64	6.42	0	***
TECHNOLOGY sector dummies		YES			
APPLICANT type dummies		YES			
application YEAR dummies		YES			
Number of observations		41,349			
Adj R-squared		0.0825			

(4b) dependent variable is based on forward citations received from academia

ln(others)-ln(self)	Coef.	Std. Err.	t	P>|t|	significance
GRACE	3.19	0.623	5.11	0	***
ln(CLAIM)	1.38	0.351	3.92	0	***
ln(SCIENCE+1)	-0.208	0.269	-0.77	0	***
ln(INV)	-1.1	0.346	-3.19	0	***
CONSTANT	1.84	2.47	0.75	0	***
TECHNOLOGY sector dummies		YES			
APPLICANT type dummies		YES			
application YEAR dummies		YES			
Number of observations		41,349			
Adj R-squared		0.0135			

(2b) dependent variable is based on forward citations received from large firms

ln(others)-ln(self)	Coef.	Std. Err.	t	P>|t|	significance
GRACE	3.77	0.891	4.24	0	***
ln(CLAIM)	4.44	0.501	8.86	0	***
ln(SCIENCE+1)	0.409	0.384	1.06	0.287	
ln(INV)	2.21	0.494	4.48	0	***
CONSTANT	11.1	3.42	3.23	0.001	***
TECHNOLOGY sector dummies		YES			
APPLICANT type dummies		YES			
application YEAR dummies		YES			
Number of observations		41,349			
Adj R-squared		0.0691			

(1b-1) dependent variable is self-forward citations

ln(self)	Coef.	Std. Err.	t	P>|t|	significance
GRACE	-1.84	0.488	-3.77	0	***
ln(CLAIM)	0.354	0.275	1.29	0.198	
ln(SCIENCE+1)	1.62	0.211	7.71	0	***
ln(INV)	0.84	0.271	3.1	0.002	***
CONSTANT	1.4	1.87	0.75	0.454	
TECHNOLOGY sector dummies		YES			
APPLICANT type dummies		YES			
application YEAR dummies		YES			
Number of observations		41,349			
Adj R-squared		0.0167			

(3b) dependent variable is based on forward citations received from SMEs

ln(others)-ln(self)	Coef.	Std. Err.	t	P>|t|	significance
GRACE	1.68	0.536	3.14	0.002	***
ln(CLAIM)	0.00523	0.302	0.02	0.986	
ln(SCIENCE+1)	-1.64	0.231	-7.08	0	***
ln(INV)	-0.312	0.297	-1.05	0.294	
CONSTANT	3.44	2.06	1.67	0.094	*
TECHNOLOGY sector dummies		YES			
APPLICANT type dummies		YES			
application YEAR dummies		YES			
Number of observations		41,349			
Adj R-squared		0.0124			

(1b-2) dependent variable is non self-forward citations

ln(others)	Coef.	Std. Err.	t	P>|t|	significance
GRACE	2.17	0.879	2.47	0.013	**
ln(CLAIM)	5.3	0.495	10.7	0	***
ln(SCIENCE+1)	1.53	0.379	4.03	0	***
ln(INV)	3.43	0.488	7.04	0	***
CONSTANT	24.8	3.37	7.35	0	***
TECHNOLOGY sector dummies		YES			
APPLICANT type dummies		YES			
application YEAR dummies		YES			
Number of observations		41,349			
Adj R-squared		0.1106			

Note: * significance at 10%; ** significance at 5%;*** significance at 1%. All of the coefficients and standard errors are multiplied by 100.
The patented inventions which were disclosed at exhibition are dropped from the sample.

Table 3c Grace period and knowledge flow (forward citations) for high science intensive technology sectors and low science intensive technology sectors

High technolgy sectors

(1c) dependent variable is based on forward citations received from all firms

ln(others)-ln(self)	Coef.	Std. Err.	t	P>|t|	significance
GRACE	6.98	0.8730	8	0	***
ln(CLAIM)	5.06	0.1370	36.9	0	***
ln(SCIENCE+1)	-3.42	0.1490	-23	0	***
ln(INV)	1.82	0.1310	14	0	***
CONSTANT	20.1	41100.0000	0	1	
TECHNOLOGY sector dummies		YES			
APPLICANT type dummies		YES			
application YEAR dummies		YES			
Number of observations		780,198			
Adj R-squared		0.0273			

(2c) dependent variable is based on forward citations received from large firms

ln(others)-ln(self)	Coef.	Std. Err.	t	P>|t|	significance
GRACE	6.93	0.834	8.31	0	***
ln(CLAIM)	4.41	0.131	33.7	0	***
ln(SCIENCE+1)	-3.73	0.142	-26.3	0	***
ln(INV)	1.42	0.125	11.4	0	***
CONSTANT	18.3	39225.95	0	1	
TECHNOLOGY sector dummies		YES			
APPLICANT type dummies		YES			
application YEAR dummies		YES			
Number of observations		780,198			
Adj R-squared		0.018			

(3c) dependent variable is based on forward citations received from SMEs

ln(others)-ln(self)	Coef.	Std. Err.	t	P>|t|	significance
GRACE	5.71	0.572	9.98	0	***
ln(CLAIM)	-2.04	0.0899	-22.6	0	***
ln(SCIENCE+1)	-5.01	0.0975	-51.4	0	***
ln(INV)	-2.08	0.0857	-24.3	0	***
CONSTANT	-10.6	26924.52	0	1	
TECHNOLOGY sector dummies		YES			
APPLICANT type dummies		YES			
application YEAR dummies		YES			
Number of observations		780,198			
Adj R-squared		0.0127			

(3c) dependent variable is based on forward citations received from academia

ln(others)-ln(self)	Coef.	Std. Err.	t	P>|t|	significance
GRACE	9.04	0.562	16.1	0	***
ln(CLAIM)	-1.75	0.0884	-19.8	0	***
ln(SCIENCE+1)	-4.08	0.0958	-42.6	0	***
ln(INV)	-2.33	0.0842	-27.6	0	***
CONSTANT	-12.5	26455.63	0	1	
TECHNOLOGY sector dummies		YES			
APPLICANT type dummies		YES			
application YEAR dummies		YES			
Number of observations		780,198			
Adj R-squared		0.0147			

Low technology sectors

(5c) dependent variable is based on forward citations received from all firms

ln(others)-ln(self)	Coef.	Std. Err.	t	P>|t|	significance
GRACE	3.87	1.24	3.13	0.002	***
ln(CLAIM)	3.26	0.0947	34.4	0	***
ln(SCIENCE+1)	2.42	0.271	8.96	0	***
ln(INV)	1.19	0.0834	14.28	0	***
CONSTANT	17.2	18800	0	0.999	
TECHNOLOGY sector dummies		YES			
APPLICANT type dummies		YES			
application YEAR dummies		YES			
Number of observations		1,330,666			
Adj R-squared		0.0199			

(6c) dependent variable is based on forward citations received from large firms

ln(others)-ln(self)	Coef.	Std. Err.	t	P>|t|	significance
GRACE	4.1	1.17	3.52	0	***
ln(CLAIM)	2.66	0.0893	29.8	0	***
ln(SCIENCE+1)	1.56	0.255	6.13	0	***
ln(INV)	0.868	0.0786	11.1	0	***
CONSTANT	9.19	17700	0	1	
TECHNOLOGY sector dummies		YES			
APPLICANT type dummies		YES			
application YEAR dummies		YES			
Number of observations		1,330,666			
Adj R-squared		0.0144			

(7c) dependent variable is based on forward citations received from SMEs

ln(others)-ln(self)	Coef.	Std. Err.	t	P>|t|	significance
GRACE	1.26	0.808	1.56	0.118	
ln(CLAIM)	-2.29	0.0619	-37	0	***
ln(SCIENCE+1)	-3.32	0.177	-18.8	0	***
ln(INV)	-2.07	0.0545	-38	0	***
CONSTANT	-4.39	12300	0	1	
TECHNOLOGY sector dummies		YES			
APPLICANT type dummies		YES			
application YEAR dummies		YES			
Number of observations		1,330,666			
Adj R-squared		0.0118			

(8c) dependent variable is based on forward citations received from academia

ln(others)-ln(self)	Coef.	Std. Err.	t	P>|t|	significance
GRACE	2.17	0.771	2.81	0.005	***
ln(CLAIM)	-2.31	0.0591	-39.2	0	***
ln(SCIENCE+1)	-2.74	0.169	-16.2	0	***
ln(INV)	-2.22	0.052	-42.7	0	***
CONSTANT	-7.81	11700	0	0.999	
TECHNOLOGY sector dummies		YES			
APPLICANT type dummies		YES			
application YEAR dummies		YES			
Number of observations		1,330,666			
Adj R-squared		0.014			

Note: 1)* significance at 10%; ** significance at 5%;*** significance at 1%. All of the coefficients and standard errors are multiplied by 100.

2)The patented inventions which were disclosed at exhibition are dropped from the sample.

3)High science linkage technology sectors are Drugs, Organic chemistry&Pesticides, Organic molecule compounds, Dyes&Petroleum, Biotechnology&Beer&Fermentation, Genetic Engineering, Measurement&Optics&Photography, and Others.

4)Low science linkage technology sectors are Personal and Domestic Articles, Machine tools&Metal working, Casting&Grinding&Layered Product, Printing, Transporting, Packing&Lifting, Textile, Construction, Mining&Drilling, Engine&Pump, Engineering elements, Lighting&Steam generation&Heating, and Weapons&Blasting.

Table 4 *Ex-ante* academic disclosure, using the grace period versus *ex-post* academic disclosure: Corporations inventions, 1995-2001

(1) *Ex-ante* disclosure, using the grace period: dependent variable is based on forward citations received from all firms

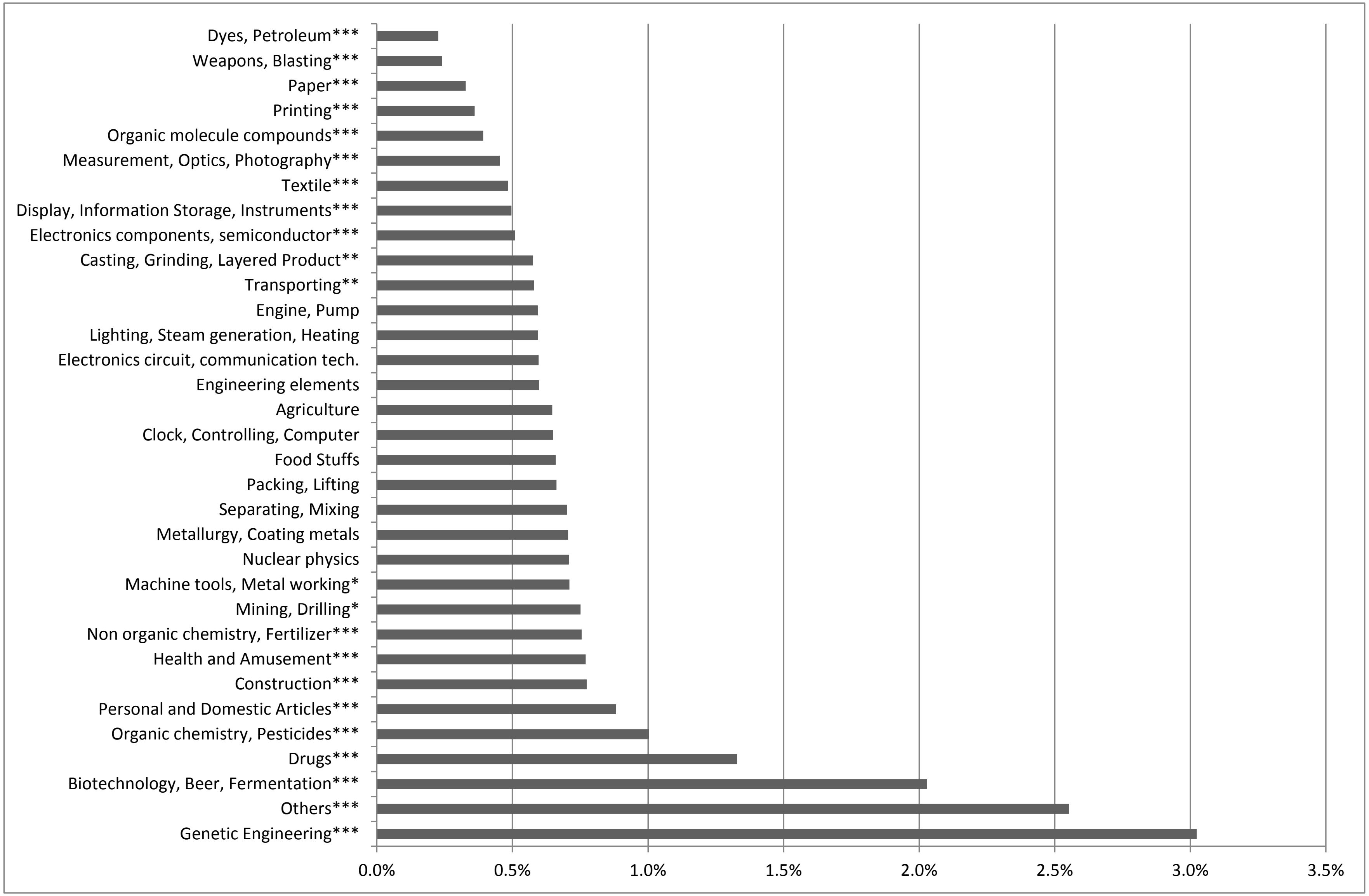
ln(others)-ln(self)	Coef.	Std. Err.	t	P>|t|	significance
ex-ante disclosure during gp	8.46	1.04	8.11	0	***
ln(CLAIM)	5.75	0.0876	65.62	0	***
ln(SCIENCE+1)	-0.224	0.166	-1.35	0.177	
ln(INV)	2.47	0.0858	28.85	0	***
CONSTANT	0.955	0.495	1.93	0.053	*
TECHNOLOGY sector dummies		YES			
APPLICANT type dummies		NO			
application YEAR dummies		YES			
Number of observations		1,763,359			
Adj R-squared		0.0109			

(2) *Ex-post* disclosure: dependent variable is based on forward citations received from all firms

ln(others)-ln(self)	Coef.	Std. Err.	t	P>|t|	significance
ex-post disclosure by scientific lit.	4.41	6.85	0.64	0.52	
ln(CLAIM)	9.99	3.28	3.05	0.002	***
ln(SCIENCE+1)	-6.12	4.73	-1.29	0.196	
ln(INV)	0.0498	3.19	0.02	0.988	
CONSTANT	12.6	16.5	0.76	0.445	
TECHNOLOGY sector dummies		YES			
APPLICANT type dummies		NO			
application YEAR dummies		YES			
Number of observations		4,648			
Adj R-squared		0.0328			

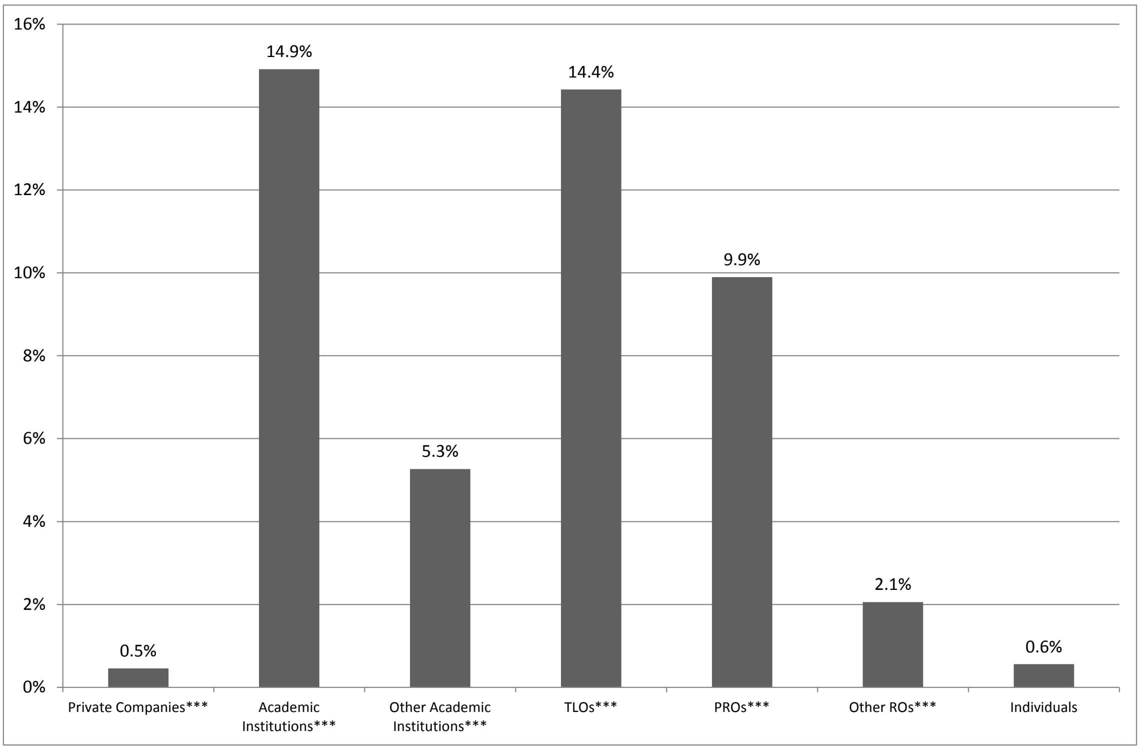
Note: Triadic and non-triadic patents are merged using, the sampling probability.

Appendix Figure 1 Technology field and use of grace period exception



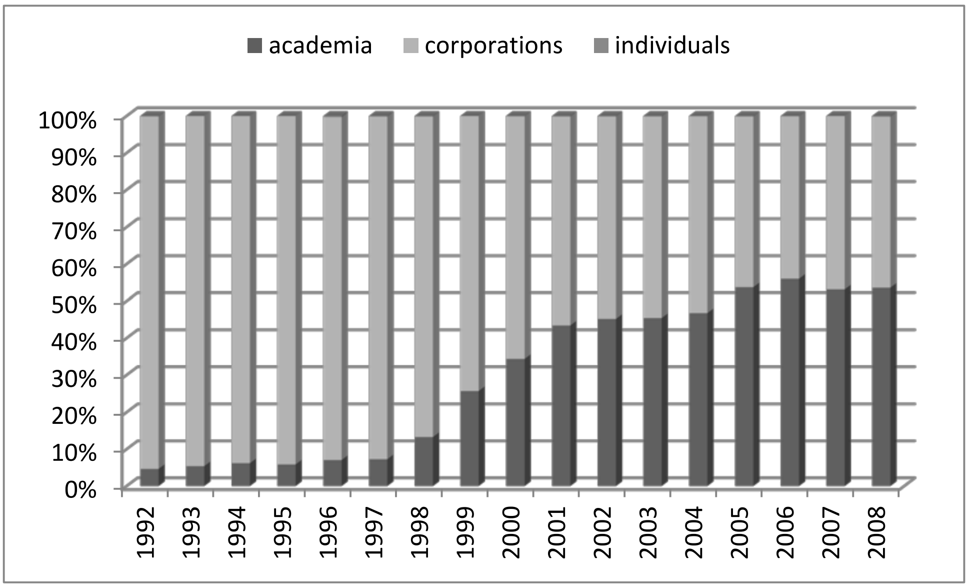
Note: * significance at 10%; ** significance at 5%;*** significance at 1%.

Appendix Figure 2 Applicant type and the intensity of the use of grace period exception



Note: * significance at 10%; ** significance at 5%;*** significance at 1%. Those values shown in this figure are the estimated values and its reference applicant type is commercial firms at 0.46%.

Appendix Figure 3 Share of the patent applications using grace period across the type of institutions



Appendix Table 1 Descriptive Statistics of the determinants of using grace period

all						grace==0					grace==1				
Variable	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
graceperiod	4207325	0.00405	0.0635	0	1	4190292	0	0	0	0	17033	1	0	1	1
ln_sci_link	4207325	0.102	0.364	0	5.08	4190292	0.097	0.353	0	5.08	17033	1.25	0.797	0	4.82
ln_invs_jpo	4207325	0.587	0.598	0	3.43	4190292	0.585	0.598	0	3.43	17033	1.01	0.581	0	3
ln_claim_jpo	4207325	1.62	0.606	0	6.91	4190292	1.62	0.606	0	6.91	17033	1.75	0.614	0	5
ratio_pct	4207325	0.0903	0.0775	0.0113	0.755	4190292	0.0899	0.0767	0.0113	0.755	17033	0.171	0.173	0.0116	0.754
reform_pct	4207325	0.277	0.448	0	1	4190292	0.277	0.448	0	1	17033	0.358	0.48	0	1
academic&science						grace==0					grace==1				
Variable	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
graceperiod	7531	0.162	0.368	0	1	6311	0	0	0	0	1220	1	0	1	1
ln_sci_link	7531	1.55	1.03	0	4.82	6311	1.47	1.04	0	4.81	1220	1.96	0.874	0	4.82
ln_invs_jpo	7531	1.02	0.542	0	2.77	6311	1.02	0.545	0	2.77	1220	1.02	0.527	0	2.64
ln_claim_jpo	7531	1.95	0.639	0.693	4.6	6311	1.94	0.64	0.693	4.6	1220	2.01	0.633	0.693	3.91
ratio_pct	7531	0.559	0.13	0.161	0.754	6311	0.556	0.132	0.161	0.754	1220	0.572	0.122	0.161	0.754
reform_pct	7531	0.561	0.496	0	1	6311	0.566	0.496	0	1	1220	0.534	0.499	0	1
corporation&science						grace==0					grace==1				
Variable	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
graceperiod	77756	0.0235	0.151	0	1	75932	0	0	0	0	1824	1	0	1	1
ln_sci_link	77756	0.658	0.855	0	5.08	75932	0.633	0.842	0	5.08	1824	1.68	0.766	0	4.72
ln_invs_jpo	77756	0.93	0.542	0	2.89	75932	0.926	0.54	0	2.89	1824	1.1	0.565	0	2.64
ln_claim_jpo	77756	1.59	0.604	0	4.73	75932	1.59	0.603	0	4.73	1824	1.66	0.626	0.693	3.81
ratio_pct	77756	0.412	0.161	0.16	0.755	75932	0.412	0.16	0.16	0.755	1824	0.411	0.174	0.16	0.754
reform_pct	77756	0.236	0.425	0	1	75932	0.237	0.425	0	1	1824	0.192	0.394	0	1

corporation	Large firms					SMEs				
Variable	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
graceperiod	3864203	0.0024	0.0491	0	1	270980	0.0031	0.0560	0	1
ln_sci_link	3864203	0.0939	0.3440	0	5.075	270980	0.0963	0.3659	0	4.575
ln_invs_jpo	3864203	0.5863	0.5993	0	3.434	270980	0.5239	0.5525	0	3.332
ln_claim_jpo	3864203	1.6264	0.6071	0	6.908	270980	1.5503	0.5740	0	6.908
ratio_pct	3864203	0.0876	0.0730	0.011	0.755	270980	0.1096	0.0919	0.011	0.75
reform_pct	3864203	0.2722	0.4451	0	1	270980	0.3033	0.4597	0	1

Appendix Table 2 Descriptive Statistics of the knowledge flow effects of using grace period

2-1 Sample of all sectors

Academia						grace==0					grace==1				
Variable	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
ln(other_cit+1)-ln(self_cit+1)	41349	0.244	0.644	-2.71	5.42	35793	0.238	0.642	-2.71	5.42	5556	0.28	0.651	-2.3	4.2
ln(other_cit received from large firm+1)-ln(self_cit+1)	41349	0.184	0.6	-2.71	5.27	35793	0.178	0.598	-2.71	5.27	5556	0.223	0.61	-2.3	4.09
ln(other_cit received from smes+1)-ln(self_cit+1)	41349	-0.0768	0.351	-3.44	3	35793	-0.0772	0.354	-3.44	3	5556	-0.0742	0.329	-2.48	1.85
ln(self_cit+1)	41349	0.108	0.32	0	4.54	35793	0.108	0.323	0	4.54	5556	0.103	0.301	0	2.48
ln(other_cit+1)	41349	0.351	0.606	0	5.42	35793	0.346	0.603	0	5.42	5556	0.382	0.621	0	4.79
graceperiod	41349	0.134	0.341	0	1	35793	0	0	0	0	5556	1	0	1	1
ln_claim_jpo	41349	1.86	0.608	0	4.6	35793	1.85	0.609	0	4.6	5556	1.9	0.601	0	4.06
ln_sci_link	41349	0.772	0.909	0	4.82	35793	0.661	0.869	0	4.81	5556	1.49	0.826	0	4.82
ln_invs_jpo	41349	0.973	0.589	0	3.33	35793	0.97	0.594	0	3.33	5556	0.989	0.558	0	3

Corporations						grace==0					grace==1				
Variable	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
ln(other_cit+1)-ln(self_cit+1)	4135183	0.199	0.6	-5.59	6.53	4125006	0.199	0.599	-5.59	6.53	10177	0.28	0.686	-4.13	4.91
ln(other_cit received from large firm+1)-ln(self_cit+1)	4135183	0.145	0.565	-5.59	6.52	4125006	0.145	0.565	-5.59	6.52	10177	0.205	0.648	-4.13	4.84
ln(other_cit received from smes+1)-ln(self_cit+1)	4135183	-0.0885	0.375	-7.03	5.48	4125006	-0.0884	0.375	-7.03	5.48	10177	-0.0995	0.408	-5.74	2.64
ln(self_cit+1)	4135183	0.113	0.352	0	7.03	4125006	0.113	0.352	0	7.03	10177	0.137	0.379	0	5.74
ln(other_cit+1)	4135183	0.313	0.555	0	7.1	4125006	0.312	0.555	0	7.1	10177	0.416	0.635	0	4.91
graceperiod	4135183	0.00246	0.0495	0	1	4125006	0	0	0	0	10177	1	0	1	1
ln_claim_jpo	4135183	1.62	0.605	0	6.91	4125006	1.62	0.605	0	6.91	10177	1.67	0.612	0	4.22
ln_sci_link	4135183	0.0941	0.346	0	5.08	4125006	0.0913	0.34	0	5.08	10177	1.2	0.725	0	4.72
ln_invs_jpo	4135183	0.582	0.597	0	3.43	4125006	0.581	0.596	0	3.43	10177	1.05	0.588	0	2.83

2-2 Sample for the sectors by science intensity

high sci						grace==0					grace==1				
Variable	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
ln(other_cit+1)-ln(self_cit+1)	780198	0.222	0.68	-5.41	6.53	773702	0.221	0.68	-5.41	6.53	6496	0.264	0.68	-3.33	4.25
ln(other_cit received from large firm+1)-ln(self_cit+1)	780198	0.163	0.647	-5.46	6.52	773702	0.163	0.647	-5.46	6.52	6496	0.195	0.64	-3.33	4.25
ln(other_cit received from smes+1)-ln(self_cit+1)	780198	-0.116	0.443	-7.03	3.83	773702	-0.117	0.443	-7.03	3.83	6496	-0.0885	0.398	-3.33	2.64
ln(self_cit+1)	780198	0.145	0.423	0	7.03	773702	0.145	0.424	0	7.03	6496	0.131	0.366	0	3.33
ln(other_cit+1)	780198	0.367	0.637	0	7.1	773702	0.367	0.637	0	7.1	6496	0.395	0.64	0	4.84
graceperiod	780198	0.00833	0.0909	0	1	773702	0	0	0	0	6496	1	0	1	1
ln_claim_jpo	780198	1.68	0.602	0	5.36	773702	1.68	0.602	0	5.36	6496	1.77	0.625	0.693	5
ln_sci_link	780198	0.234	0.569	0	5.08	773702	0.223	0.554	0	5.08	6496	1.52	0.822	0	4.82
ln_invs_jpo	780198	0.68	0.601	0	3.14	773702	0.677	0.6	0	3.14	6496	1.04	0.558	0	2.64

low sci						grace==0					grace==1				
Variable	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
ln(other_cit+1)-ln(self_cit+1)	1330666	0.157	0.567	-5.87	6.45	1328496	0.156	0.567	-5.87	6.45	2170	0.224	0.645	-2.2	4.09
ln(other_cit received from large firm+1)-ln(self_cit+1)	1330666	0.105	0.533	-5.87	6.45	1328496	0.105	0.533	-5.87	6.45	2170	0.156	0.602	-2.2	3.97
ln(other_cit received from smes+1)-ln(self_cit+1)	1330666	-0.0937	0.369	-5.93	4.44	1328496	-0.0937	0.369	-5.93	4.44	2170	-0.0991	0.386	-2.56	1.79
ln(self_cit+1)	1330666	0.116	0.349	0	6.06	1328496	0.116	0.349	0	6.06	2170	0.13	0.36	0	2.56
ln(other_cit+1)	1330666	0.273	0.508	0	6.58	1328496	0.273	0.508	0	6.58	2170	0.354	0.58	0	4.79
graceperiod	1330666	0.00163	0.0403	0	1	1328496	0	0	0	0	2170	1	0	1	1
ln_claim_jpo	1330666	1.5	0.555	0	6.91	1328496	1.5	0.555	0	6.91	2170	1.57	0.544	0	4.06
ln_sci_link	1330666	0.0296	0.185	0	4.44	1328496	0.0281	0.18	0	4.44	2170	0.933	0.648	0	4.34
ln_invs_jpo	1330666	0.591	0.593	0	3.33	1328496	0.591	0.592	0	3.33	2170	0.984	0.636	0	2.77

2-3 Sample for assessing *ex-post* academic disclosure

Corporations	all (1995-2001)					No academic publications					Academic publications				
Variable	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
ln(other_cit+1)-ln(self_cit+1)	4,648	0.251	0.848	-5.38	4.51	3,942	0.241	0.825	-5.38	4.5	706	0.304	0.967	-3.22	4.51
ln(other_cit received from large firm+1)-ln(self_cit+1)	4,648	0.16	0.818	-5.38	4.5	3,942	0.155	0.795	-5.38	4.5	706	0.186	0.939	-3.22	4.5
ln(other_cit received from smes+1)-ln(self_cit+1)	4,648	-0.28	0.657	-5.38	2.89	3,942	-0.257	0.631	-5.38	1.95	706	-0.407	0.775	-3.53	2.89
ln(other_cit received from academia+1)-ln(self_cit+1)	4,648	-0.317	0.647	-5.38	1.1	3,942	-0.294	0.617	-5.38	1.1	706	-0.446	0.785	-3.64	1.1
ln(self_cit+1)	4,648	0.334	0.645	0	5.38	3,942	0.308	0.616	0	5.38	706	0.48	0.772	0	3.64
ln(other_cit+1)	4,648	0.585	0.768	0	5.61	3,942	0.55	0.729	0	4.87	706	0.784	0.931	0	5.61
ex-post disclosure by scientific lit.	4,648	0.152	0.359	0	1	3,942	0	0	0	0	706	1	0	1	1
ln_claim_jpo	4,648	1.78	0.65	0.693	4.44	3,942	1.75	0.635	0.693	4.44	706	1.97	0.698	0.693	4.23
ln_sci_link	4,648	0.156	0.471	0	3.83	3,942	0.122	0.408	0	3.83	706	0.344	0.7	0	3.83
ln_invs_jpo	4,648	0.77	0.617	0	3.04	3,942	0.734	0.609	0	2.71	706	0.97	0.621	0	3.04

2-4 Sample for assessing *ex-post* academic disclosure + *ex-ante* academic disclosure

Corporations	all (1995-2001)					grace==0					grace==1				
Variable	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
ln(other_cit+1)-ln(self_cit+1)	1,763,359	0.261	0.66	-5.59	6.45	1,759,278	0.26	0.66	-5.59	6.45	4,081	0.365	0.754	-4.13	4.91
ln(other_cit received from large firm+1)-ln(self_cit+1)	1,763,359	0.191	0.624	-5.59	6.45	1,759,278	0.191	0.624	-5.59	6.45	4,081	0.263	0.712	-4.13	4.78
ln(other_cit received from smes+1)-ln(self_cit+1)	1,763,359	-0.104	0.416	-6.71	4.33	1,759,278	-0.104	0.415	-6.71	4.33	4,081	-0.111	0.455	-5.74	2.64
ln(other_cit received from academia+1)-ln(self_cit+1)	1,763,359	-0.125	0.397	-6.71	2.48	1,759,278	-0.125	0.397	-6.71	2.48	4,081	-0.0983	0.462	-5.74	1.79
ln(self_cit+1)	1,763,359	0.137	0.388	0	6.71	1,759,278	0.137	0.388	0	6.71	4,081	0.162	0.418	0	5.74
ln(other_cit+1)	1,763,359	0.398	0.61	0	7.1	1,759,278	0.397	0.61	0	7.1	4,081	0.527	0.687	0	4.91
ex-ante disclosure during gp	1,763,359	0.00231	0.0481	0	1	1,759,278	0	0	0	0	4,081	1	0	1	1
ln_claim_jpo	1,763,359	1.61	0.592	0	6.91	1,759,278	1.61	0.592	0	6.91	4,081	1.67	0.599	0	3.81
ln_sci_link	1,763,359	0.0793	0.317	0	4.98	1,759,278	0.0768	0.312	0	4.98	4,081	1.12	0.746	0	4.72
ln_invs_jpo	1,763,359	0.585	0.594	0	3.43	1,759,278	0.584	0.593	0	3.43	4,081	1.03	0.594	0	2.77