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Do grace periods promote knowledge spillover? : evidence from Japan

Sadao Nagaoka
Research Institute of Economy, Trade and Industry
/Tokyo Keizai University
Yoichiro Nishimura
Kanagawa University

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Introduction to research in Science and Innovation at RIETI

- Science is an important driver for innovation and investing in absorptive capability plays an important role for exploiting science for corporate innovation performance (Cohen and Levinthal (1989), Gambardella (1992,1995))
- Some key aspects of absorptive capability at firm and industry level:

  - Investment in human capital and basic research) (Cockburn and Henderson (1998) vs. Arora, Belenzon, Patacconi (2015))

  -Transfer of tacit knowledge embodied in human resources (Zucker, Darby, Brewer(1998)).

  -Accommodating diverse views (disagreement as a source of startups (Klepper and Thompson (2010)).
- Unique nature of the Japanese innovation system
  - relatively weak formal education at PhD level
  - low labor mobility
  - low level of new technology based start-ups and VC
- Despite of these, we see significant exploitation of science for innovations in Japan, perhaps because of the existence of compensatory or alternative mechanism (PhDs based on corporate research , secondment system etc.)
  - still room for improvement.

Introduction (continued)

- One of the key pillars of the innovation program of RIETI is to deepen our understanding of the science sources of innovations and assess the policy and institutional mechanism to strengthen the linkage in Japan.

-We have implemented a project on "Science Sources of Innovations" funded by the program of "Science of Science Policy" of the JST (Japan Science and Technology Agency) (in collaboration with Hitotsubashi University, the Office of Pharmaceutical Research and Japan Bio-industry association)

- We have been doing research on institutional infrastructure (PhD education, patent system, university and industry collaborations).

- Grace period is one important instrument of patent system to promote early interactions between the discoverer and its collaborators as well as to encourage corporate science.

Appendix Research scope of "Science Sources of Innovations" project

- Detailed case studies of 12 breakthrough drugs discovered in Japan and commercialized globally, from the middle of 70s (e.g. Statin) to 2000s (e.g. Opdivo (Nivolumab) , Nagaoka(2016))
- *A large scale survey* over the pharma discovery and development projects in Japan (the population covers more than 1000 projects with NMEs (new molecular entity) , response rate 22%)
- Biotech startup surveys
- Follow-up survey on PATVAL-Japan (RIETI), focusing on

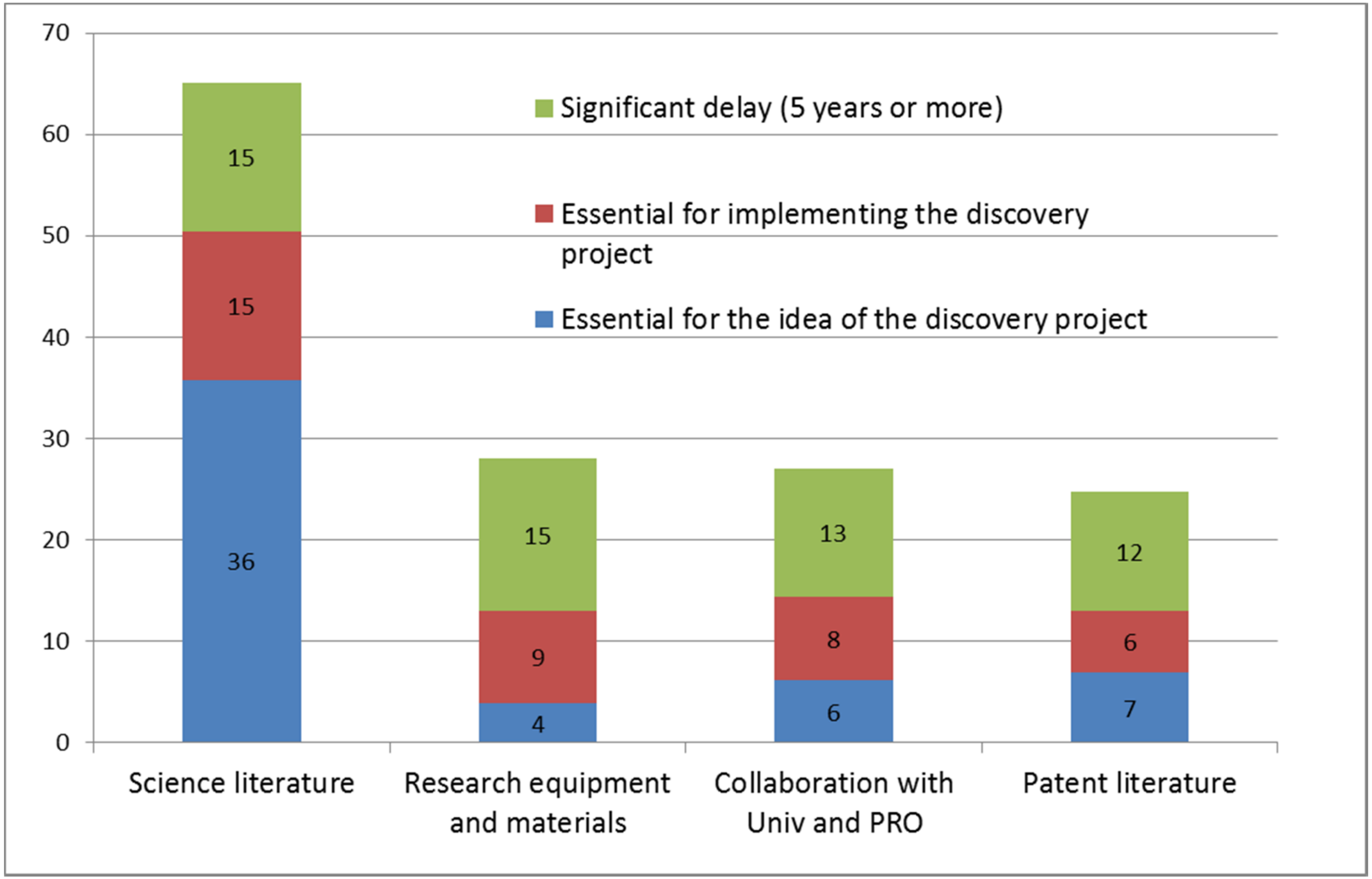
science sources of inventions as well as assessing the citation-based measures of knowledge source in light of the experience of the focal inventors

- Econometric studies on the drug launch and the efficacy of science-based drugs for longevity and hospital stays

Nature of drug discovery projects

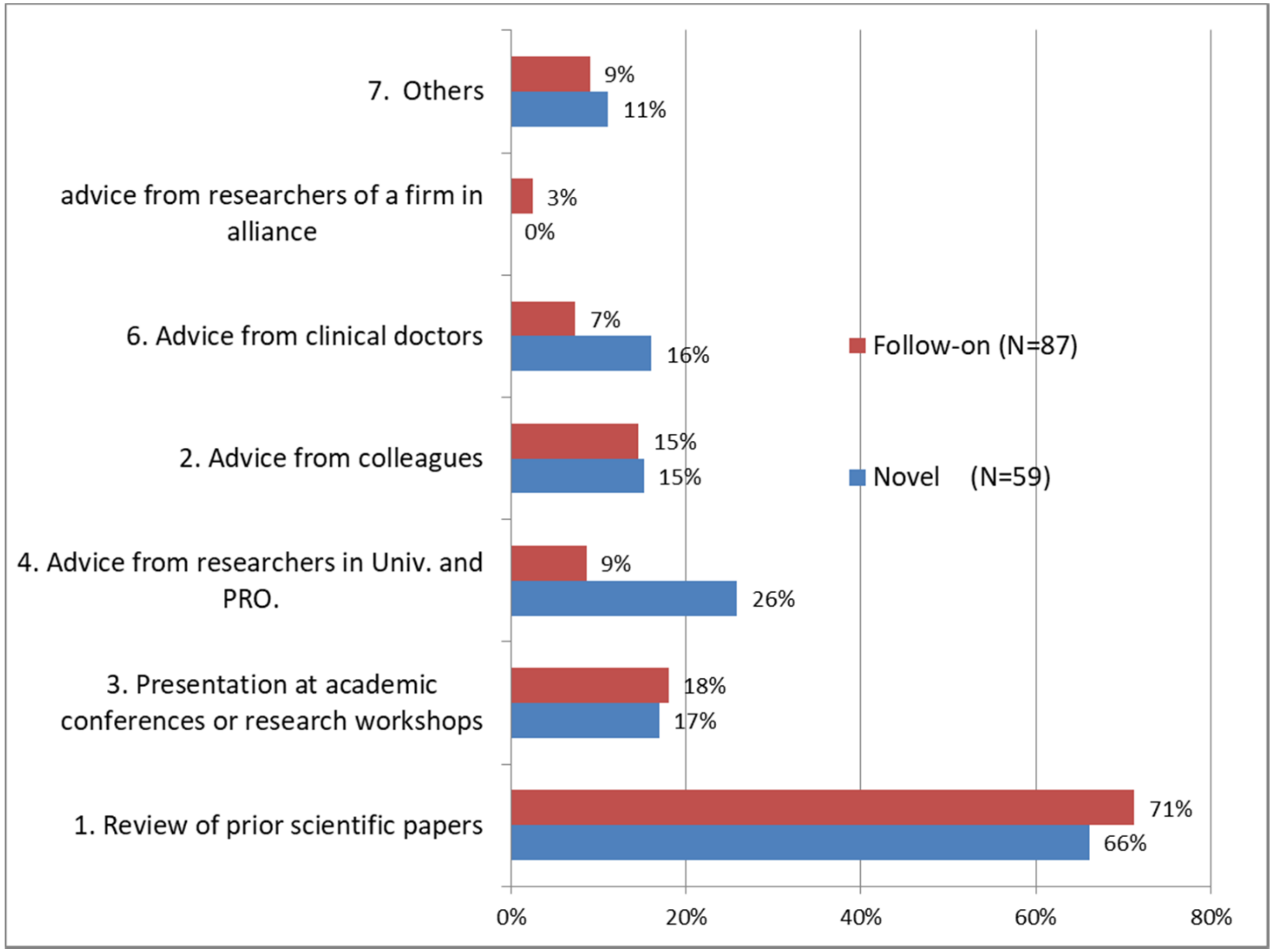
- Key findings of the nature of discovery projects
- Discovery projects were often launched when the underlying science was still quite incomplete, so that there were high uncertainty in discovery process.
- They often encountered unexpected difficulties, which could have almost led to their discontinuations.
- Science contributed to the drug discovery in multitude manners both ex-ante and ex-post: target, the animal model, finding the use et al. New drug also served as a research tool for advancing science.
- Direct human contacts played an important role for exploiting science.
- Delegation (often unauthorized hidden research project) played a key role in initiating and completing a unique but risky project .

Knowledge sources for drug discovery projects in Japan (%)



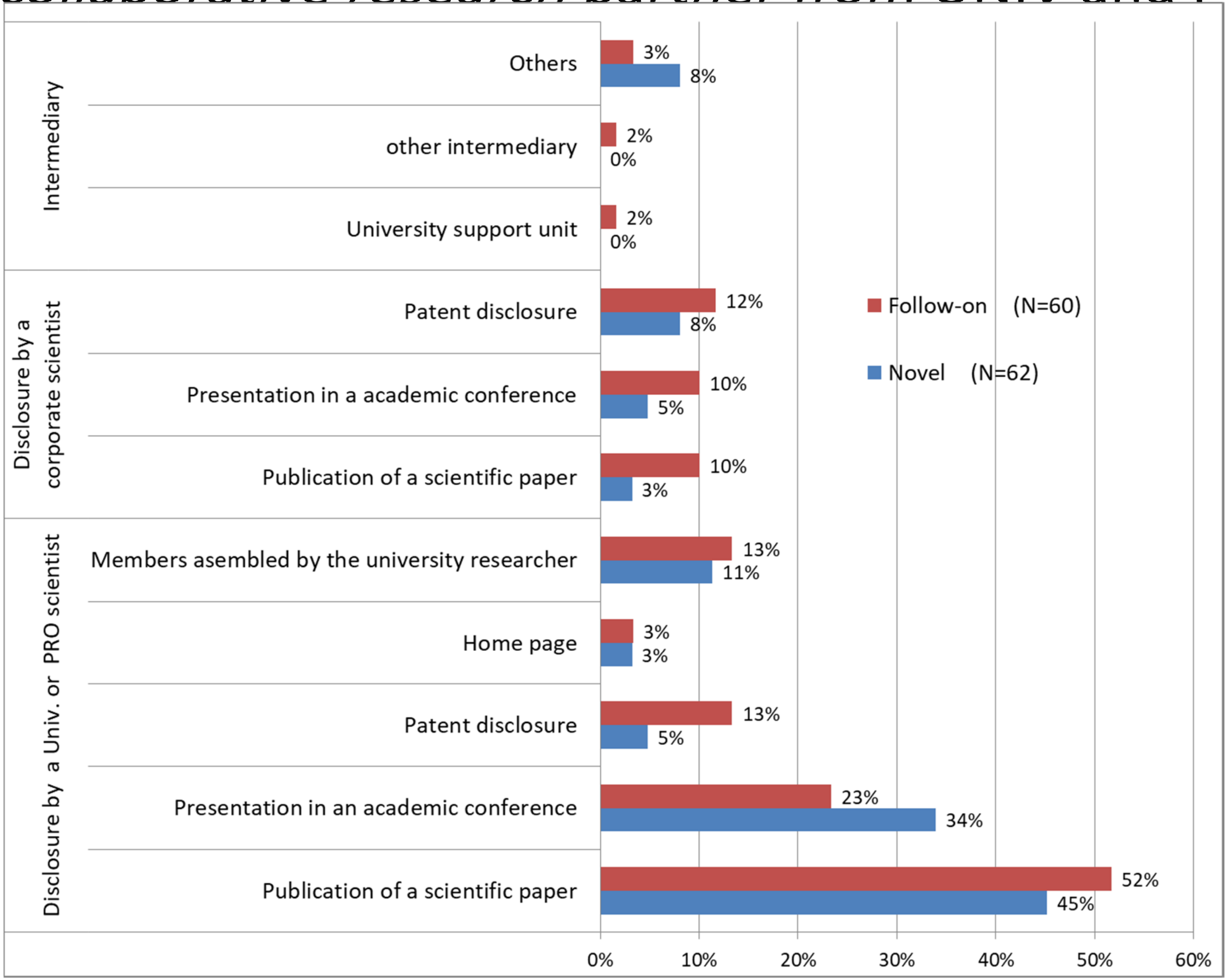
Note. N=232, the numbers in the brackets are %.
Source: Nagaoka, Nishimura and Genda (2015)

How did the corporate researcher find the key scientific literature?



Note. Novel project means those with no prior drugs available which can be used as lead compounds
Source: Nagaoka, Nishimura and Genda (2015)

How did the corporate researcher find the collaborative research partner from UNIV and PRO?



Source: Nagaoka, Nishimura and Genda (2015)

Reference

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1. Background and research objective

- The grace period allows an inventor to disclose his research output in a public environment earlier than his patent application, without destroying the latter's novelty.

-It allows the applicant to pursue both academic priority (and early interactions) and its patenting.

- In the US it is automatic for one year while there is none in Europe (except for exhibition), and in-between in Japan. One of the most important differences among the national patent systems.
- The increasing globalization of the patent applications has made the search for the best system more urgent.

- There are three views on the motivations of using the grace period:

-(1)*Acceleration* of academic disclosure (for academic competition, for searching for collaborators etc.) for a given patent application,

-(2) Applying for a patent, after the inventor's early disclosure either for academic objective or as an accident.

"Around 50% of the (European TTO) respondents say that the loss of patent protection due to premature public disclosure occurred "very often" or "fairly often"". (Edmondson et al., 2013).

-(3) *Deferral* of domestic patent filing for evaluating the merit for patenting

"The authors of published material "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))"

- This paper focuses on the first two views, because the option value of the grace period is unlikely to be important in Japan, where the inventor can use the examination request system for assessing the value of patenting an invention and the application fee is very small.

knowledge flow effect is important for welfare

- Since the applicant-inventor uses the grace period only when his private benefit is positive, the social welfare of the grace period depends on its effect on the third parties' benefits such as knowledge spillover.
- In particular, if the first view holds, the grace period accelerates knowledge flow and is likely to enhance welfare.

Research objective

This paper examines

-which of the two views are more important

as well as

-the knowledge flow effect of the grace period,

based on the comprehensive data set on the use of the grace period in Japan.

Prior research

- Prior empirical research on the grace period is very limited (Franzoni and Scellato (2010) and user surveys by the patents office), significantly due to the design of the grace period in the US and the Europe.

  - No records on the use of the grace period exist in the US, since the grace period is automatic.

  (patent-paper match attempt, but the main form of early academic disclosure is not a paper, see Table 3)

  - The grace period other than for international exhibition does not exist in Europe.

- The experience of the grace period system in Japan which requires the notification of the prior disclosure (mandatory declaration) offers a unique chance to analyze the above two views as well as knowledge flow effect.

2. Grace period system in Japan and its use

- Grace "Period": 6 months conditional on mandatory reporting of earlier disclosure
- The scope of prior disclosure allowed by the grace period significantly liberalized over time

-(1) since the 2000 reform, the use of the grace period has not constrained the patentability of the subsequent improved inventions. The reform also allowed the disclosure through internet-sites.

-(2) since the 2011 reform, almost all forms of public disclosures have been eligible for the grace period.

- Our data covers 1992-2008 period

- This paper focuses mainly on the use of the grace period for academic disclosure. Exhibitions account for around 5% of the total use of the grace periods.

- Corporations account for around a half of the use of the grace period.

Table 1　Inventions and scientific publications

	Affiliations/Types of inventiosn	Invention is also published in science or technology journal (%)	N
Affiliations	Large firm(employees with more than 500)	16%	4,056
	Small and Medium size firm	14%	725
	University and laboratories	80%	133
Types of patents	Triadic patents	20%	3,576
	Non-triadic patents (applications)	12%	1,476

(Note) The survey significantly oversamples the triadic patents.
(Source) Constructed from RIETI Inventor Survey

Table 2 Use of grace period and the science linkage of inventions at organization level in Drugs, Genetic Engineering and Biotechnology (1992-2008)

		graceperiod	sci_link	Number of patents	Number of firms
Academia		13.2%	10.1	4,575	16
Corporation	High (GP>=4%)	6.3%	6.1	7,324	32
	Low (GP<4%)	1.9%	4.2	32,785	74
	Zero (GP=0)	0	1.4	2,252	11

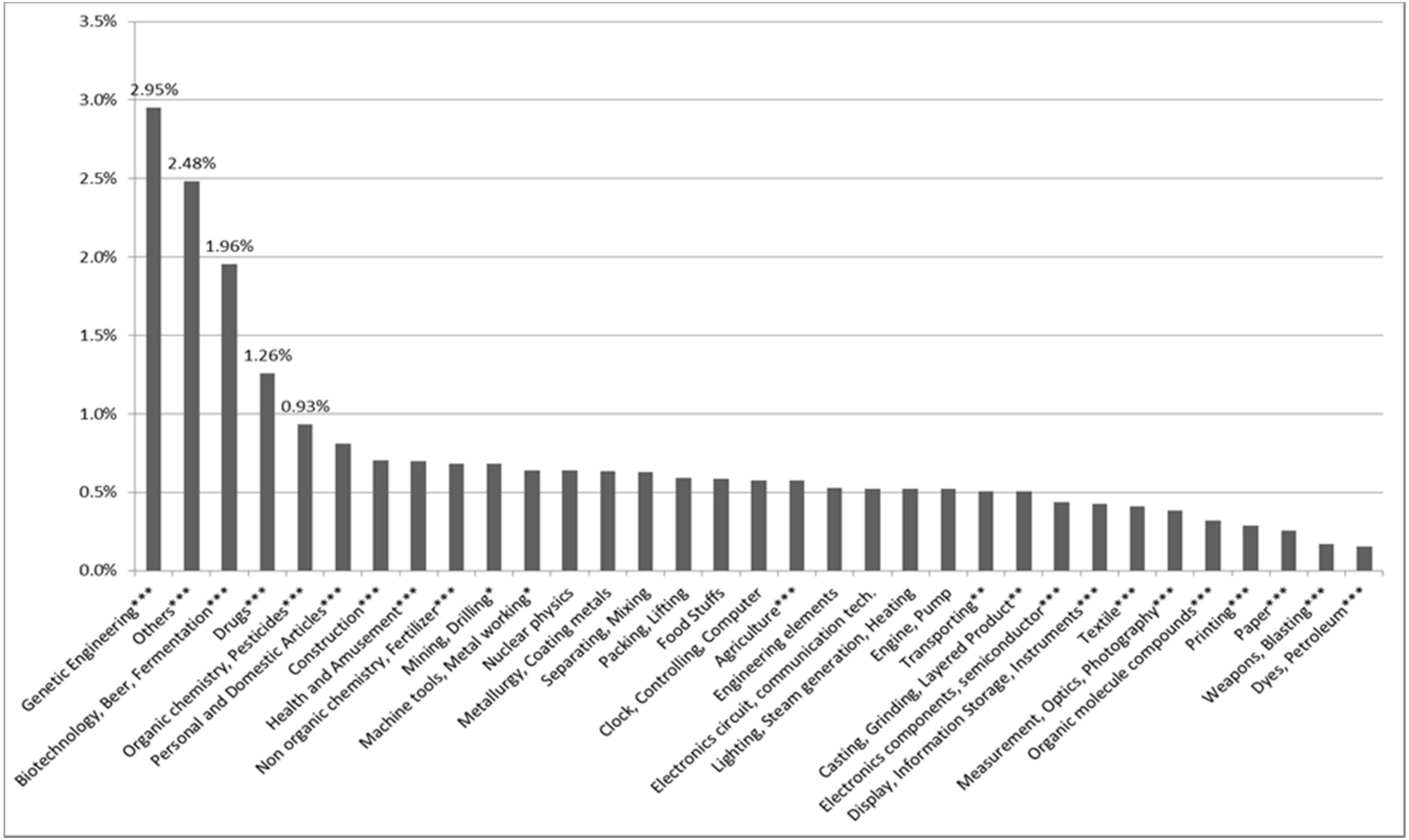
Note. These institutions are the respondents to the Survey over the Intellectual Property Activities of the JPO.

Table 3 Types of academic disclosures applied for the use of the grace period in Japan

Academic meetings	Journal articles	Research reports	News paper	Other news related articles	Internet
44%	5%	19%	12%	9%	4%
Exhibition (International)	Exhibition (Domestic)	Catalogue	Unknown		
3%	2%	2%	1%		

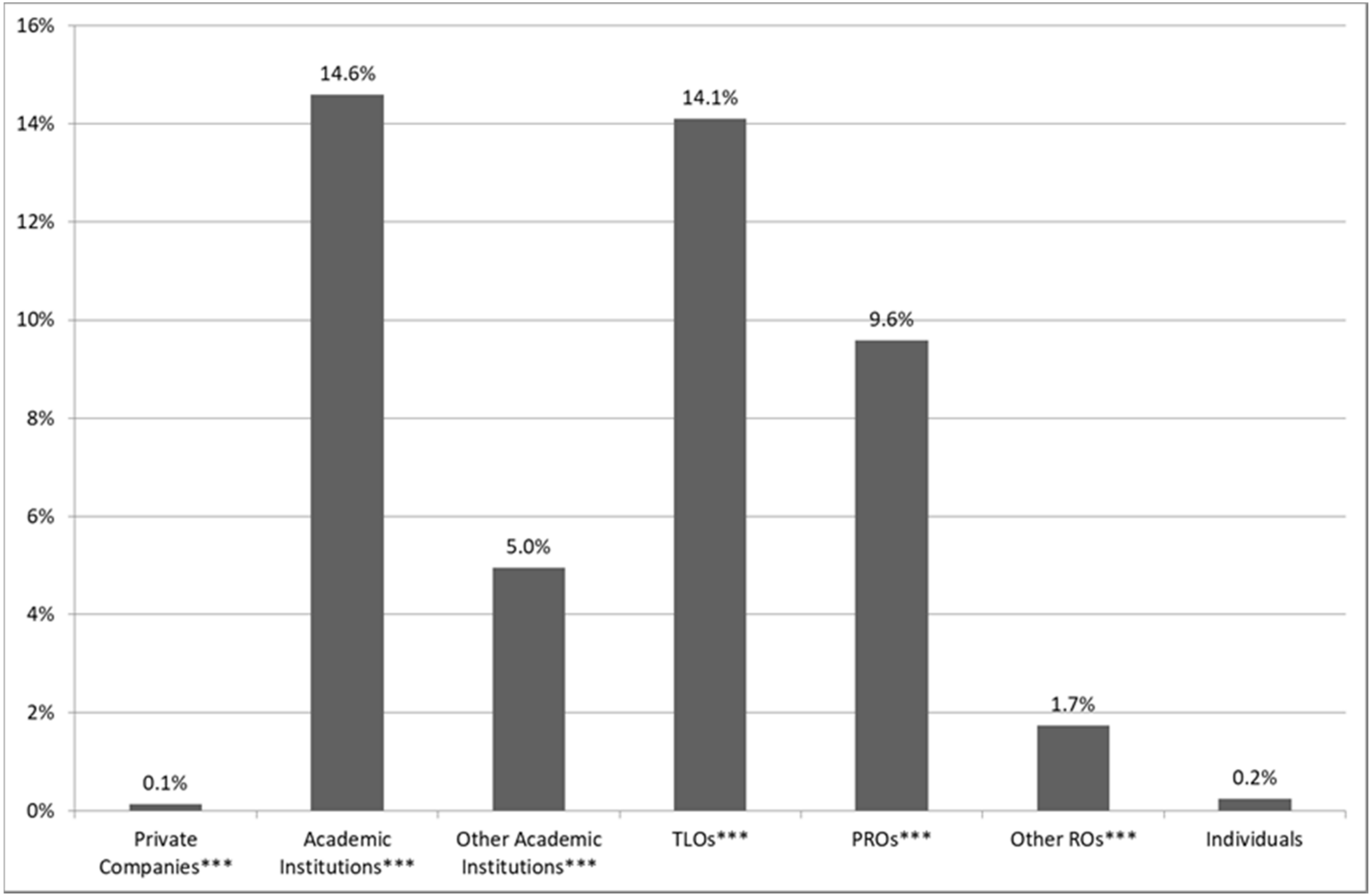
Note) 1380 patent applications which are randomly selected from all patent applications using the grace period from 1996 to 2005.

Figure 2 Technology field and use of grace period



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

Figure 3. the intensity of the use of grace period by applicant type



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

Figure 4 Share of the patent applications using grace period across the type of institutions

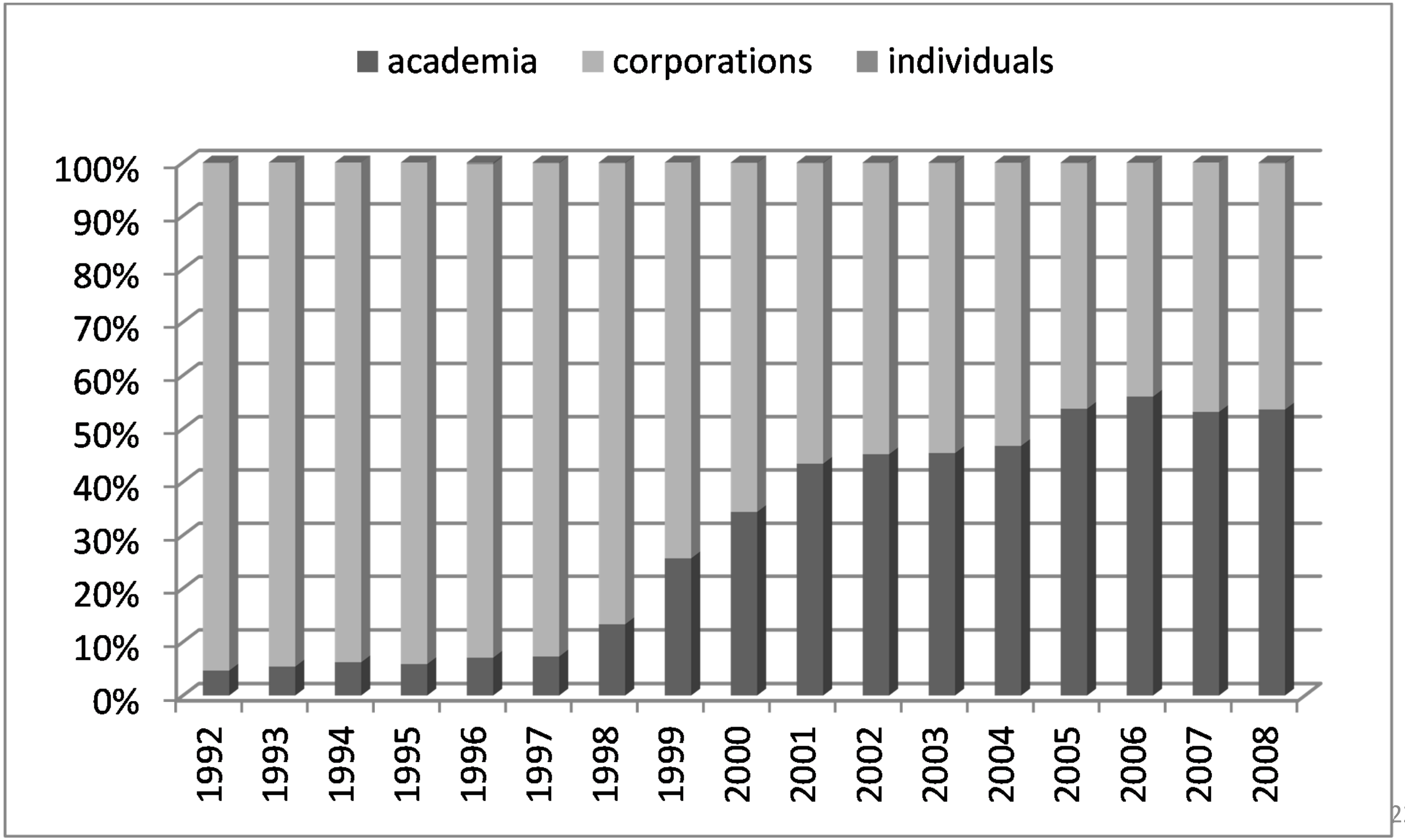
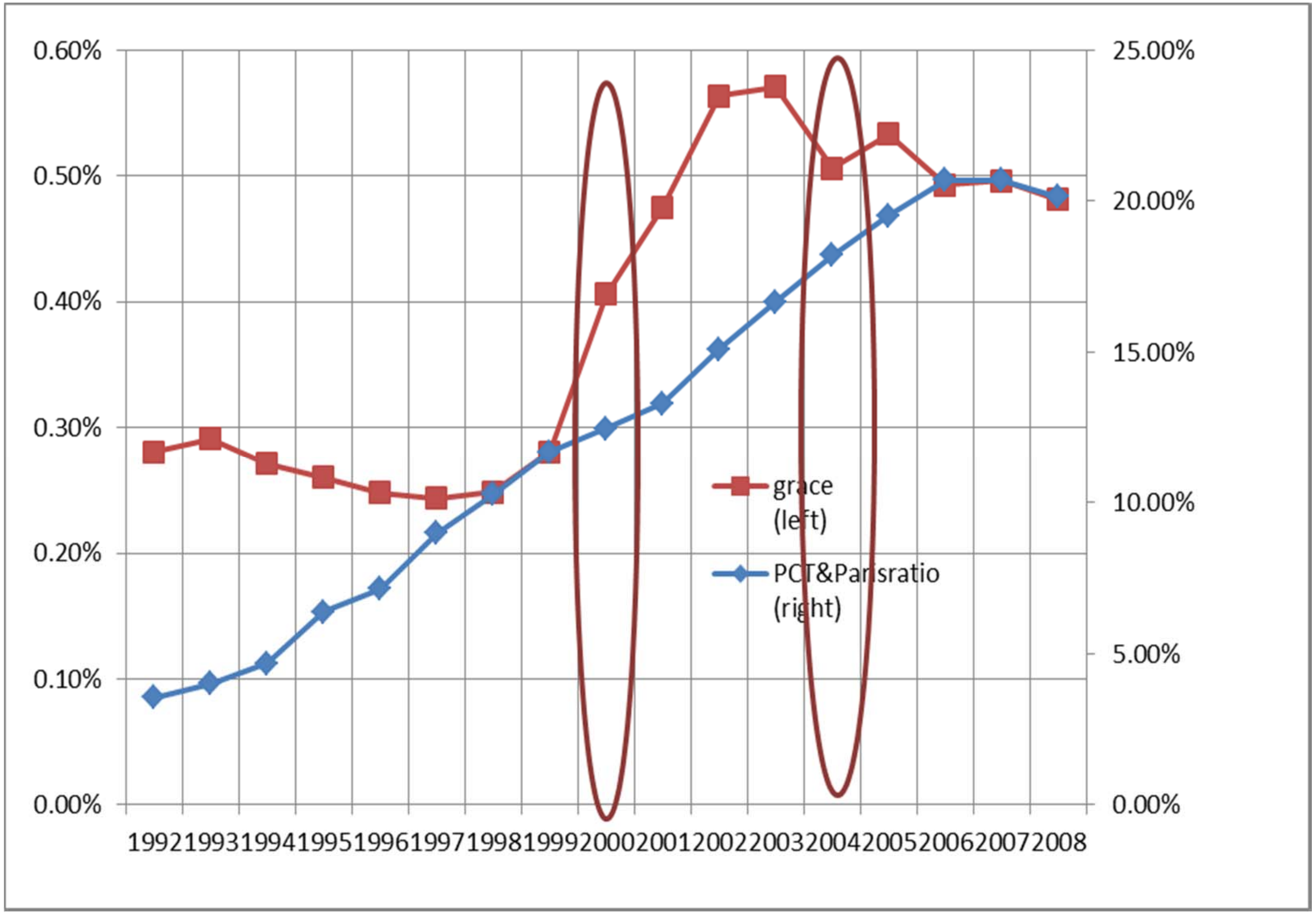


Figure 5 Use of grace period over time in patent applications and the share of the patents with international applications in Japan



Two policy changes

(1) Domestic reform in 2000, which removed the risk of the applicant's academic disclosure barring its subsequent improved patent application based on inventive step ground

(2) PCT reform of 2004, which abolished designation-of-states rule for PCT filing system and allowed more time for priority filing in 2004

(A PCT application gives its applicant a bundle of options to apply for a patent in any number of countries within 30 months from the priority date).

Figure 9 Science intensity and grace period

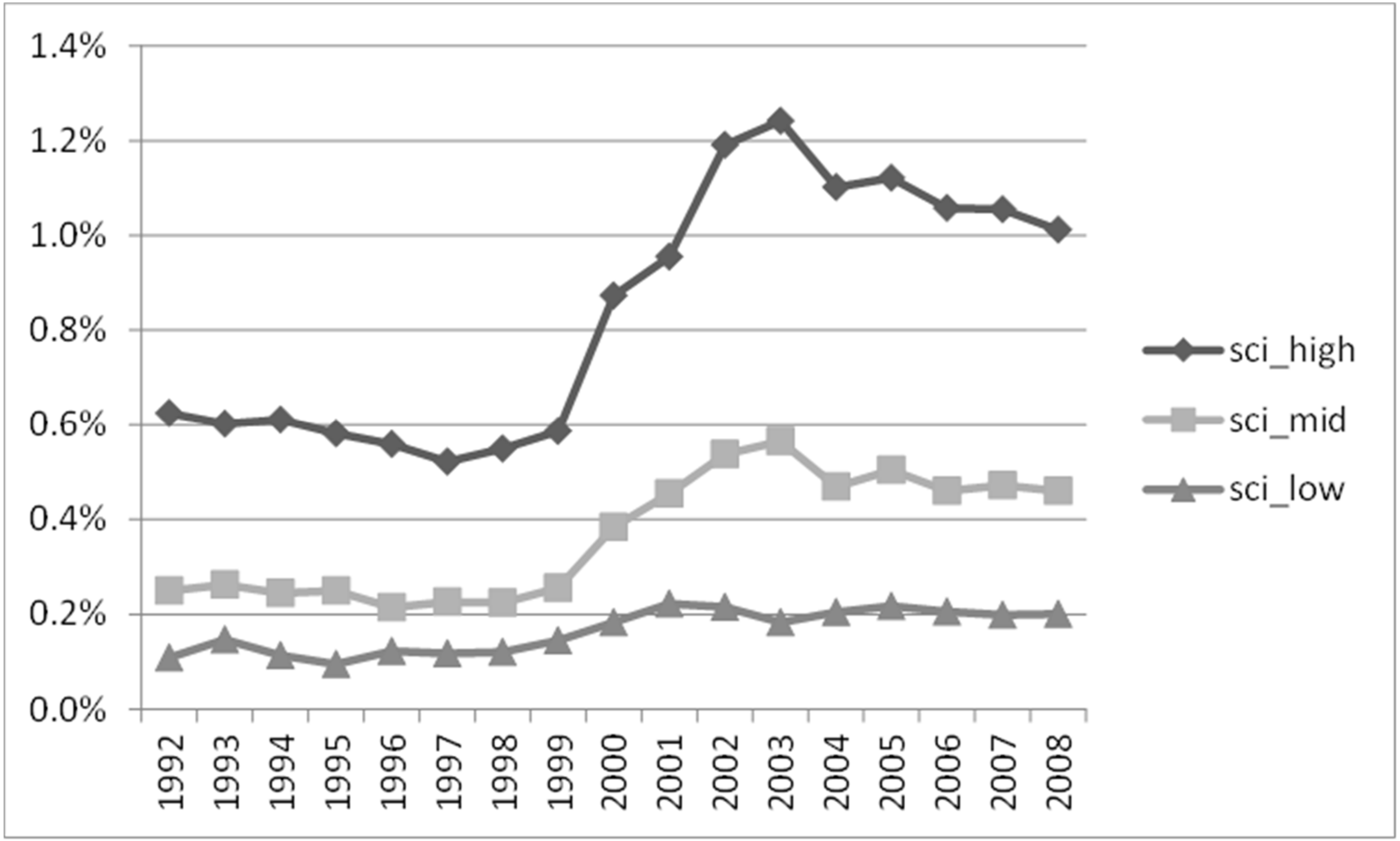
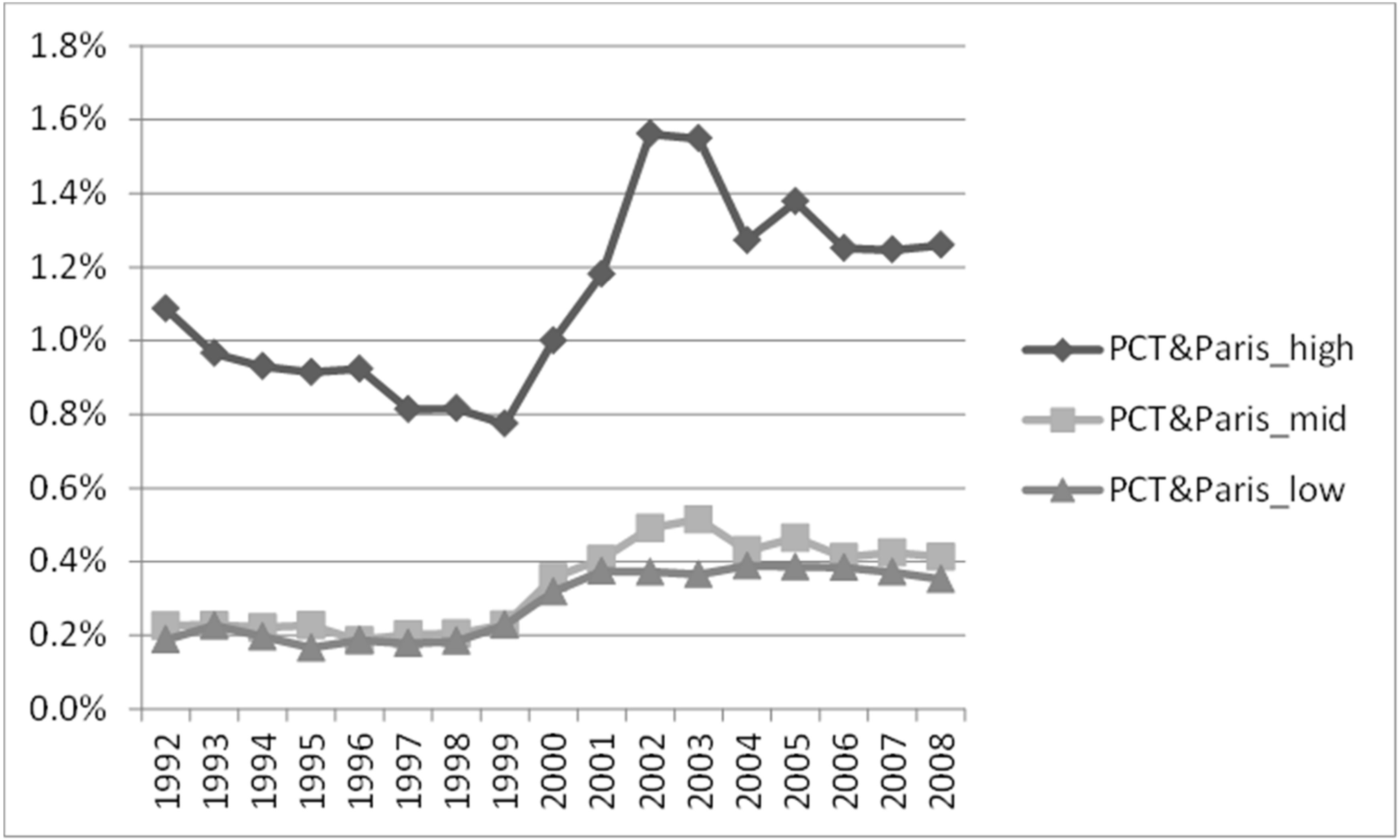


Figure 8 Use of the grace period by intensity of the use of PCT& Paris route

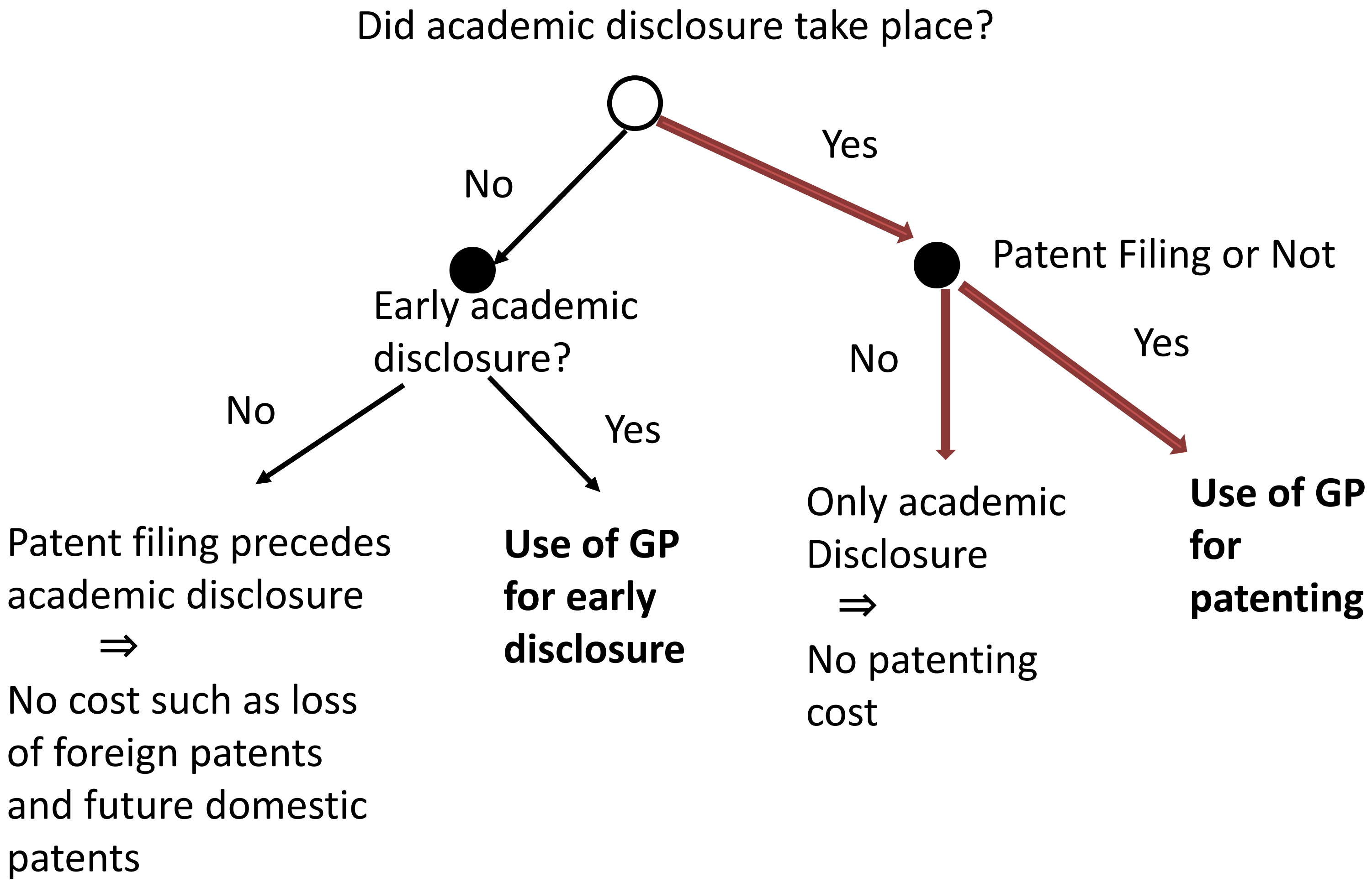


3. A model for early disclosure vs. patenting

- There are essentially two types of the use of grace period: one for a*cceleration of disclosure and another for Promotion of domestic patenting.*

-In the first case early disclosure is a choice, so that the grace period promotes early disclosure.
-In the second case early disclosure is predetermined, so that the grace period promotes only domestic patenting.

Choices for using grace period



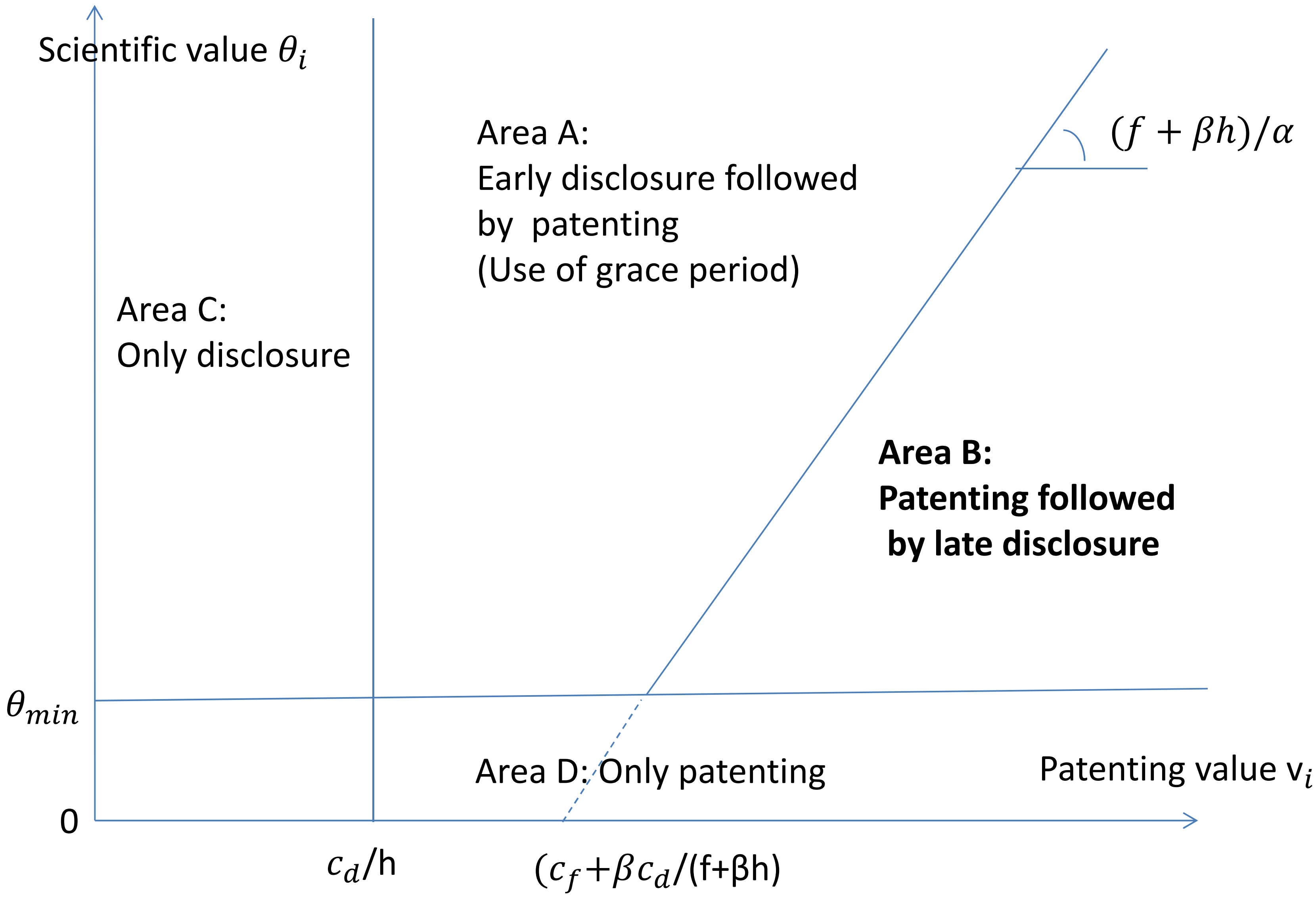
Assessing the significance of the choice for early disclosure

- We can use the following comparative statistics result:
- **Proposition 1**: Only if the grace period is used significantly for accelerating early disclosure, its use increases with lower β (less constraint on patenting of the subsequent improvement inventions) and declines with larger f (more loss of foreign patenting).

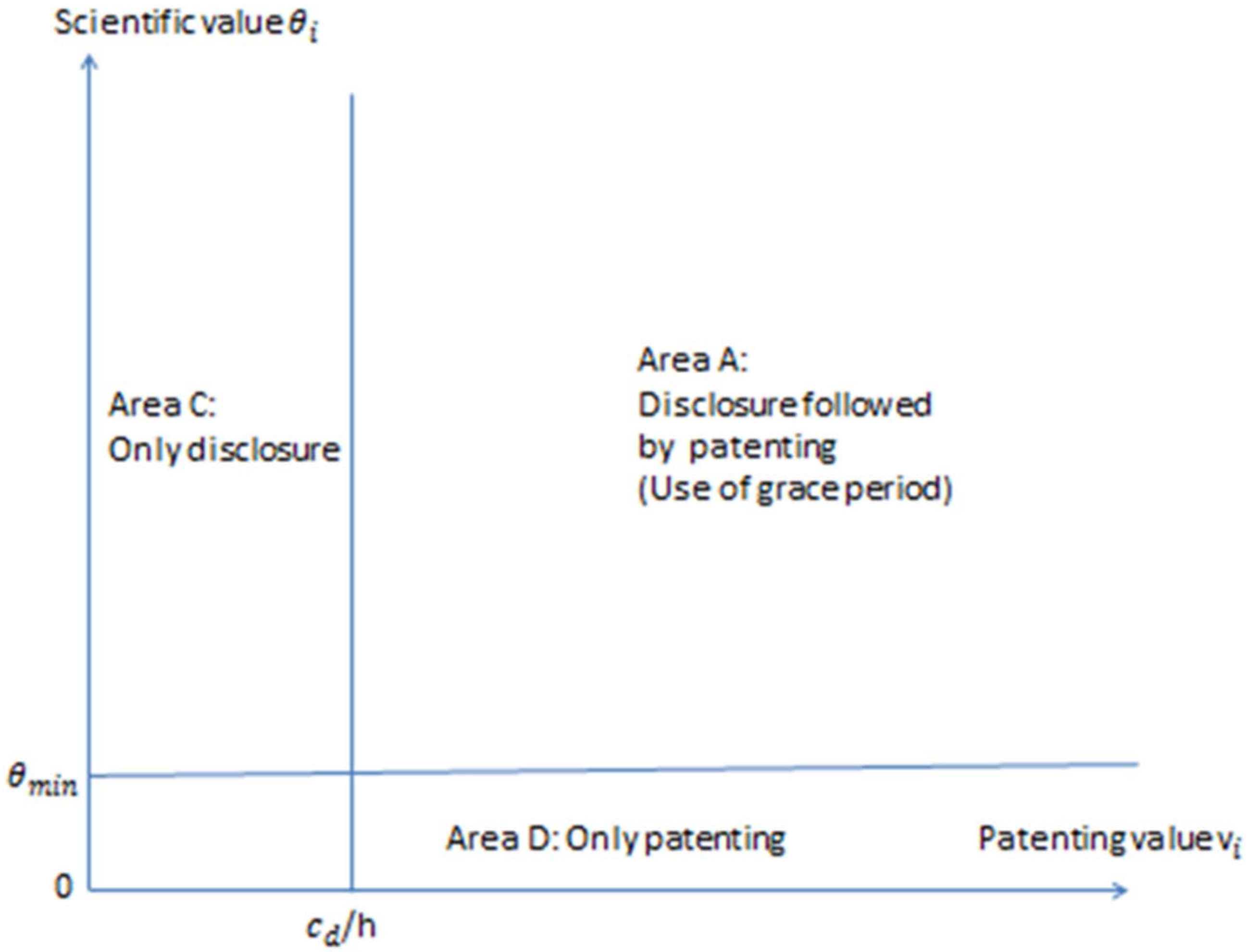
- **Proposition 2**: The use of the grace period declines with higher patenting value (v_i), controlling for scientific value, if the grace period is used significantly for accelerating early disclosure. The increase will be observed if it is used for patenting.

Figure 1 Choice sets for the use of the grace period

A. Case where the choice of the timing of scientific choice is relevant



B. Case where late disclosure is not a viable choice



Empirical Predictions

	Effects on the use of the grace period		
	lower β (less constraint on patenting of the subsequent improvement inventions)	larger f (more loss of foreign patenting)	Larger v_i (High private value from patenting)
Acceleration of disclosure view	Plus	Minus	Minus (foreign patent loss)
Promotion of domestic patenting view(after an intentional or accidental disclosure)	None	None	Plus (domestic patent gain)

4. Estimation model and results
4.1 Use of the grace period

- Linear probability model for the use of the grace period
- Controls for

-the endogeneity caused by the changes of technological and market opportunities: the application year dummies interacted with 33 technology class dummies

-the endogeneity caused by firm and institutional heterogeneity (e.g. strongly profit oriented firm seek more claims and constrain its researchers to publish) : firm fixed effects

-science intensity: number of backward citations made by the focal patent to science and technical literature

- We focus on the short-run (within 6 months) effects of the policy changes which would vary by the characteristics of technology sectors:

- Science linkage, and

- Share of the patent applications seeking for international protection("INTERNATIONAL")

Major findings

- The domestic reform in 2000 is associated with a significantly more use of the grace period especially in science intensive sectors.

  - not only for large firms but also for academia

- The PCT reform of 2004 is associated with a significantly more negative effect for sectors with more international applications for large firms as well as for SMEs.

- A patent with higher patenting value as measured by a number of the claims is associated with less use of the grace period

  - not only for large firms but also for academia

Additional findings

- Grace period is significantly more used for the invention with high science linkage, as expected.
- No significant effect of the 2000 domestic reform and the patenting value for the grace period based on exhibitions (Placebo test)
- Overall, the results strongly support that the acceleration of disclosure drives both large firms and academic researchers for using the grace period system.

Table 4 The determinants of the use of grace period exception (%, Pooled sample, linear probability model)

dependent variable=GRACE	Academia	Large Firms	SMEs	Exhibition
	(1)	(2)	(3)	(4)
ln(SCIENCE+1)	13.97***	2.25***	2.30***	0.37***
	(67.38)	(283.69)	(71.16)	(6.56)
ln(INV)	1.72***	0.16***	0.39***	0.02
	(6.10)	(35.13)	(18.03)	(1.48)
ln(CLAIM)	-2.04***	-0.07***	0.00	-0.01
	(-7.20)	(-15.20)	(0.18)	(-0.97)
REFORM_PCT*INTERNATIONAL	3.04	-1.58***	-3.08***	52.15***
	(0.64)	(-5.19)	(-3.72)	(3.08)
REFORM_DOMESTIC*ln(SCIENCE+1)	5.04***	0.51***	-0.16	-0.37
	(4.48)	(11.43)	(-0.90)	(-0.95)
REFORM_PCT	-2.47*	0.13***	0.27**	-3.47***
	(-1.73)	(3.38)	(2.11)	(-3.12)
REFORM_DOMESTIC	0.46	0.11	-0.22	-0.01
	(0.12)	(1.55)	(-1.14)	(-0.00)
CONSTANT	6.20	-0.00	-0.25	0.10
	(1.32)	(-0.09)	(-1.40)	(0.06)
Application Year Dummy	YES	YES	YES	YES
Technology Sector Dummy	YES	YES	YES	YES
Technology Sector x Application Year Dummy	YES	YES	YES	YES
Quarterly Dummy	YES	YES	YES	YES
Firm Fixed Effect	YES	YES	YES	YES
Number of observations	41,349	3,864,203	270,984	202,197
Adj R-squared	0.102	0.023	0.006	-0.014

4.2 Knowledge flow

- We use inventor non-self forward citations to the focal patent, in order to assess the effect of the grace period upon the knowledge flow to the third parties.
- There is a potential endogeneity issue due to *unobserved heterogeneity* (μ) of the patent application characteristics:

-an applicant is more likely to use the grace period for a science intensive invention, which has high spillover.

-an applicant may not choose to use the grace period for an invention with a potential for subsequent improvements, in order to preserve its first mover advantage in developing subsequent inventions.

- We control such endogeneity by taking the difference between the non-self forward citations and the self forward citations.

- Grace period (gd_i) affects only the knowledge flow to third parties.
- We also introduce the level of science linkage of each patent as a control over μ_i

$$\text{SELF\_FORWARD}_i = \beta_{SELF,0} + \beta_{SELF} \cdot \mathrm{X}_i + \mu_i + \epsilon_{SELF,i}, \quad (5)$$

$$\text{OTHER\_FORWARD}_i = \beta_{OTHER,0} + \beta_{OTHER} \cdot \mathrm{X}_i + \mu_i + \alpha \cdot gd_i + \epsilon_{OTHER,i}, \quad (6)$$

Ex-ante vs. ex-post academic disclosure

- In order to validate this approach, we assess the effect of ex-post disclosure (publication of science paper without using the grace period).
- Ex-post disclosure will not have a strong knowledge flow effect, given that it typically occurs after the publication of the patent application.
- Thus, if taking the difference is effective for controlling unobserved heterogeneity of an patent application, we will find that such disclosure does not significantly promote knowledge flow.
- The sample from the RIETI inventor survey is used for assessing the impact of the ex-post disclosure

Ex-ante vs. ex-post disclosure : Corporate inventions, 1995-2001

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

ln(others)-ln(self)	Coef.	Std. Err.	t	P>|t|	significance
GRACE	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			

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

5. Conclusions

- We have found significant evidence that both corporate and academic inventors use the grace period for early disclosure

-The use of the grace period has significantly expanded with the reform removing the risk of domestic patent loss especially in science intensive sector

- It significantly declined with reduced cost for international applications

-The grace period is less used for the inventions with high patenting value.

5. Conclusions (continued)

- Moreover, the use of grace period is significantly associated with more knowledge spillover to the third party relative to the internal spillover, while the ex-post scientific publication is not.

- Thus, the grace period enhances knowledge diffusion and likely to enhance welfare, given that the use of the grace period is voluntary. It will promote early interactions between the discoverer and its collaborators as well as encourage corporate science.

- Implications and Limitations
  - Harmonization has become important.
  - Design issues for the grace period, such as notification of the earlier disclosure for transparency, international extension (grace period counted from priority date) , early publication of the patent application which used the grace period, prior user right

Selected References

- de Saint-Georges, M., van Pottelsberghe de la Potterie, B., 2013. A quality index for patent systems. Research Policy 42, 704-719
- Edmondson, G., Holmes, J., Henschel, R.F., McCollam, S., 2013. A Grace Period for Patents: Could it help European universities innovate? The Science|Business.
- Franzoni, C., Scellato, G., 2010. The grace period in international patent law and its effect on the timing of disclosure. Research Policy 39, 200-213.

Appendix) Detailed results on knowledge flow from the patents using the grace period

- The level of forward citations, both self (3.63%) and non-self (3.40%), increases with the science linkage of the invention (to a similar degree, in the next 2 slides).
- The level of non-self forward citations of the invention using the grace period is significantly higher than that of the invention without the grace period, relative to the corresponding difference of the self-citations.
- This knowledge flow effect to the third parties is larger for corporate inventions than for academic inventions.

  - corporate inventions: 6.3% (in the next slide)

  - academic inventions: 4.0% (in the next 3 slides)

Table 5a Impact of using grace period on knowledge spillover : the difference for corporate inventions (%, 1992-2008)

(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	0.59	10.6	0	***
ln(CLAIM)	4.47	0.05	84.4	0	***
ln(SCIENCE+1)	-0.23	0.09	-2.6	0.009	***
ln(INV)	1.63	0.05	32.5	0	***
CONSTANT	6.02	0.32	18.7	0	***
TECHNOLOGY sector dummies		YES			
APPLICANT type dummies		NO			
application YEAR dummies		YES			
Number of observations		4,135,428			
Adj R-squared		0.0278			

Grace period coefficients for separate estimations for spillovers to large firms (5.7% in equation (2a)) , SMEs (3.6% in equation (3a)) and academia (5.6 % in equation (4a)).

Table 5a Separate estimations for self and non-self citations (corporate inventions) (%, 1992-2008)

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

ln(self)	Coef.	Std. Err.	t	P>|t|	significance
GRACE	-3.19	0.35	-9.1	0	***
ln(CLAIM)	2.20	0.03	70.4	0	***
ln(SCIENCE+1)	3.63	0.05	68.6	0	***
ln(INV)	2.51	0.03	84.7	0	***
CONSTANT	9.51	0.19	50.0	0	***
TECHNOLOGY sector dummies		YES			
APPLICANT type dummies		NO			
application YEAR dummies		YES			
Number of observations		4,135,428			
Adj R-squared		0.018			

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

ln(others)	Coef.	Std. Err.	t	P>|t|	significance
GRACE	3.12	0.54	5.8	0	***
ln(CLAIM)	6.67	0.05	138.4	0	***
ln(SCIENCE+1)	3.40	0.08	41.7	0	***
ln(INV)	4.13	0.05	90.7	0	***
CONSTANT	15.53	0.29	53.0	0	***
TECHNOLOGY sector dummies		YES			
APPLICANT type dummies		NO			
application YEAR dummies		YES			
Number of observations		4,135,428			
Adj R-squared		0.0595			

Table 5b Impact of using grace period on knowledge spillover : the difference for academic inventions (%, 1992-2008)

(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)	-0.10	0.409	-0.23	0.815	
ln(INV)	2.59	0.526	4.92	0	***
CONSTANT	23.38	3.642	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			

Grace period coefficients for separate estimations for spillovers to large firms (3.8%), SMEs (1.7%) and academia (3.2 %).

Table 5b Separate estimations for self and non-self citations (academic inventions, % 1992-2008)

(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)	0.35	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	1.40	1.874	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			

(1b-2)	dependent variable is non self-forward citations				
ln(others)	Coef.	Std. Err.	t	P>|t|	significance
GRACE	2.17	0.88	2.47	0.013	**
ln(CLAIM)	5.30	0.49	10.72	0	***
ln(SCIENCE+1)	1.53	0.38	4.03	0	***
ln(INV)	3.43	0.49	7.04	0	***
CONSTANT	24.78	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			

End

Disclosure ex-ante (with using the grace period) vs. ex post (without using the grace period)

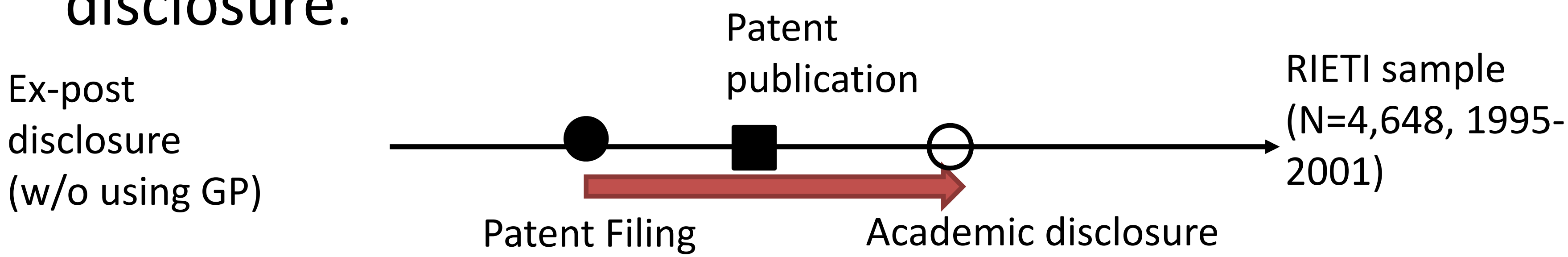
- The sample based on the RIETI inventor survey for assessing the impact of ex-post disclosure

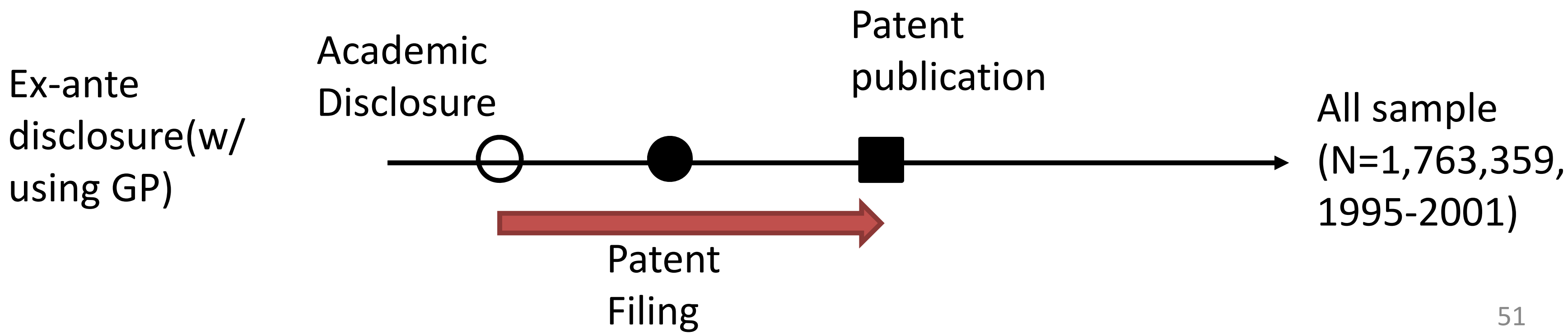
The inventors was asked whether he published the invention in a professional journal.

- The patents covered by the survey has two samples:
- Triadic patent (N=3311)
- Non-triadic patent (N=1337)
- 15% of these patents were disclosed through academic journals ex-post, that is, without using the grace period.
- Sample period: 1995-2001
- We compare the results with the ex-ante disclosure (the patents which used the grace period)

Two samples to be examined

- Two samples are examined to assess the ex ante disclosure effect by grace period, relative to ex-post disclosure.





Identification of the effect

- The acceleration effect on the knowledge flow to the third party can be assessed by using the patent citations.

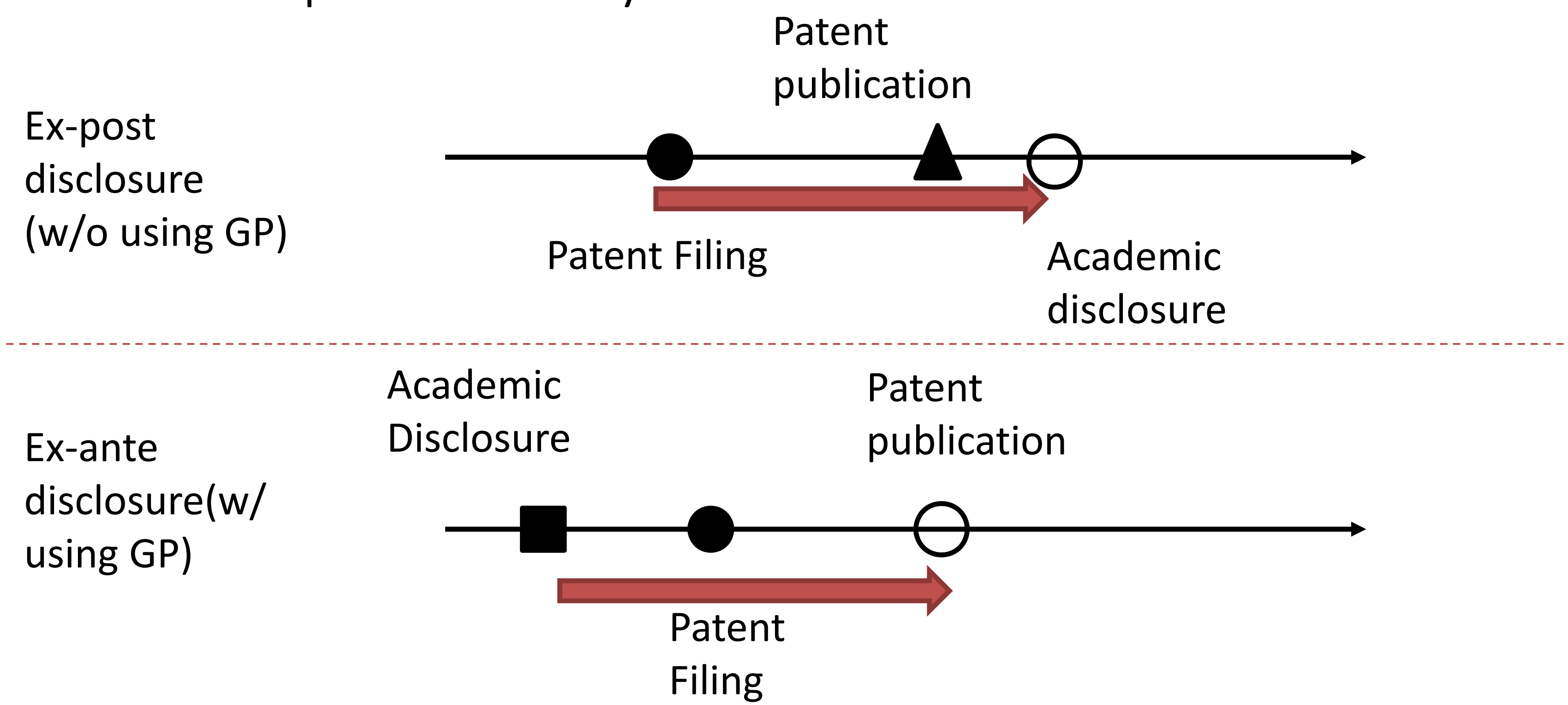
 - Early academic disclosure will accelerate the citations by the third parties to the patent with such disclosure, while it does not directly affect the self-citation flows.

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

Grace period

- If you disclose earlier (such as talk in academic conference) than your patent application, you cannot get a patent in Europe. You need to postpone academic disclosure after filing of the patent in Europe or you need to give up the patenting
- You can get a patent in the US even if you do academic disclosure earlier but file a patent within a year.



Descriptives (1)

- 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_pct1	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						grace==0					grace==1				
Variable	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
graceperiod	41349	0.134	0.341	0	1	35793	0	0	0	0	5556	1	0	1	1
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
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
ratio_pct1	41349	0.204	0.184	0.0116	0.754	35793	0.201	0.181	0.0116	0.754	5556	0.226	0.198	0.0123	0.754
reform_pct	41349	0.534	0.499	0	1	35793	0.534	0.499	0	1	5556	0.532	0.499	0	1

corporation						grace==0					grace==1				
Variable	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
graceperiod	4135183	0.00246	0.0495	0	1	4125006	0	0	0	0	10177	1	0	1	1
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
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
ratio_pct1	4135183	0.089	0.0746	0.0113	0.755	4125006	0.0889	0.0742	0.0113	0.755	10177	0.146	0.154	0.0116	0.754
reform_pct	4135183	0.274	0.446	0	1	4125006	0.274	0.446	0	1	10177	0.262	0.44	0	1

Descriptives (2)

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

All sample						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)	4206667	0.2	0.601	-5.87	6.53	4190292	0.2	0.6	-5.87	6.53	16375	0.277	0.676	-4.13	4.91
ln(other_cit received from large firm+1)-ln(self_cit+1)	4206667	0.146	0.566	-5.87	6.52	4190292	0.146	0.566	-5.87	6.52	16375	0.209	0.637	-4.13	4.84
ln(other_cit received from smes+1)-ln(self_cit+1)	4206667	-0.0884	0.375	-7.03	5.48	4190292	-0.0884	0.375	-7.03	5.48	16375	-0.0933	0.387	-5.74	2.64
ln(self_cit+1)	4206667	0.113	0.352	0	7.03	4190292	0.113	0.352	0	7.03	16375	0.128	0.359	0	5.74
ln(other_cit+1)	4206667	0.313	0.556	0	7.1	4190292	0.313	0.555	0	7.1	16375	0.404	0.632	0	4.91
graceperiod	4206667	0.00389	0.0623	0	1	4190292	0	0	0	0	16375	1	0	1	1
ln_claim_jpo	4206667	1.62	0.606	0	6.91	4190292	1.62	0.606	0	6.91	16375	1.76	0.616	0	5
ln_sci_link	4206667	0.102	0.364	0	5.08	4190292	0.097	0.353	0	5.08	16375	1.3	0.774	0	4.82
ln_invs_jpo	4206667	0.587	0.598	0	3.43	4190292	0.585	0.598	0	3.43	16375	1.03	0.577	0	3
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

Descriptives (3)

- Appendix Table 2 RIETI control sample (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
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
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
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
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
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
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
sample_a	4,648	0.152	0.359	0	1	3,942	0	0	0	0	706	1	0	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
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
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

Descriptives (4)

- Appendix Table 2 All control sample (ex-post academic disclosure + ex-ante academic disclosure)

	Corporations	1995<=ayear<=2001					grace==0					grace==1				
	Variable	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
[1]	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
[2]	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
[3]	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
[4]	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
[5]	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
[6]	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
[7]	graceperiod	1,763,359	0.00231	0.0481	0	1	1,759,278	0	0	0	0	4,081	1	0	1	1
[8]	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
[9]	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
[10	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

Figure 6 Grace period on the basis of academic disclosures and that on the basis of exhibitions

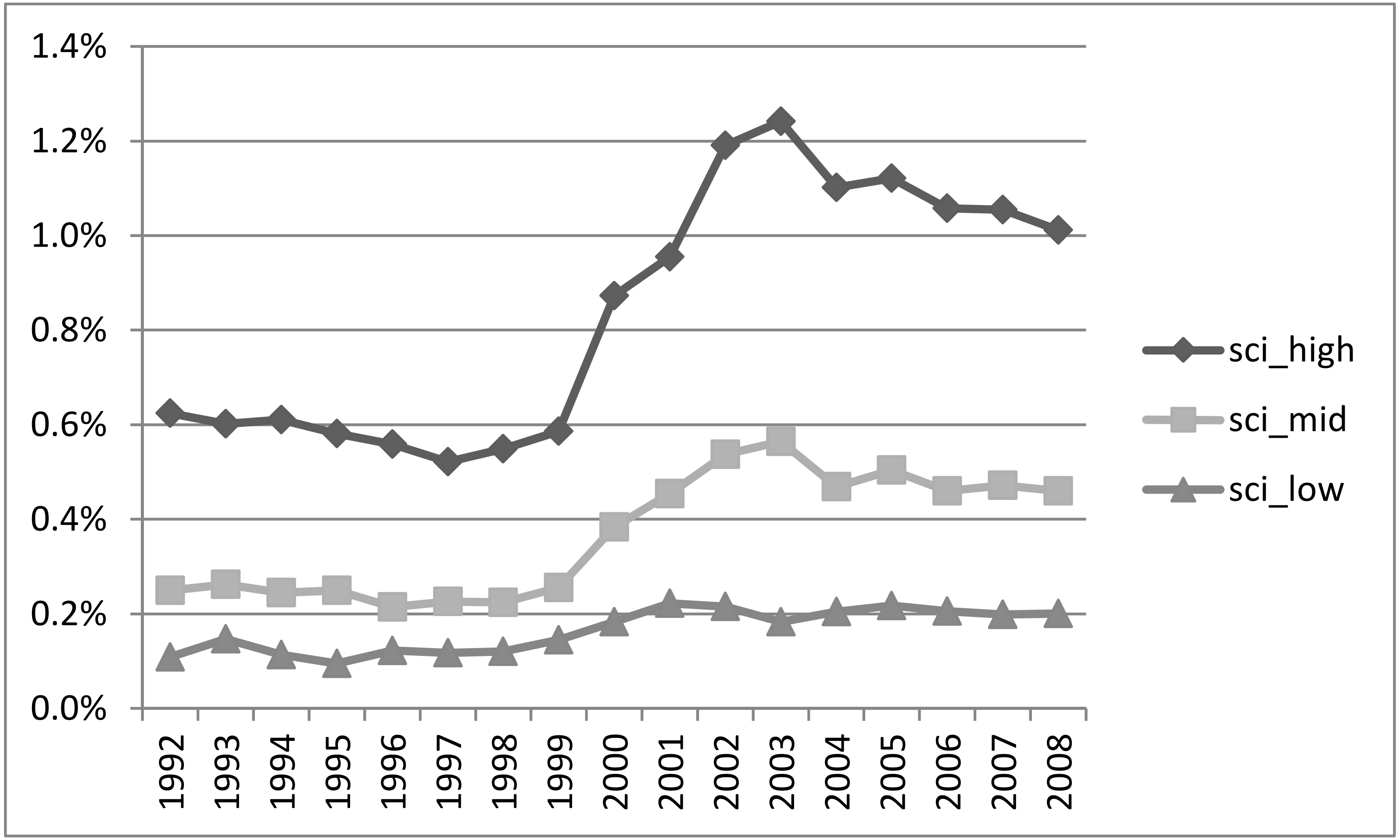
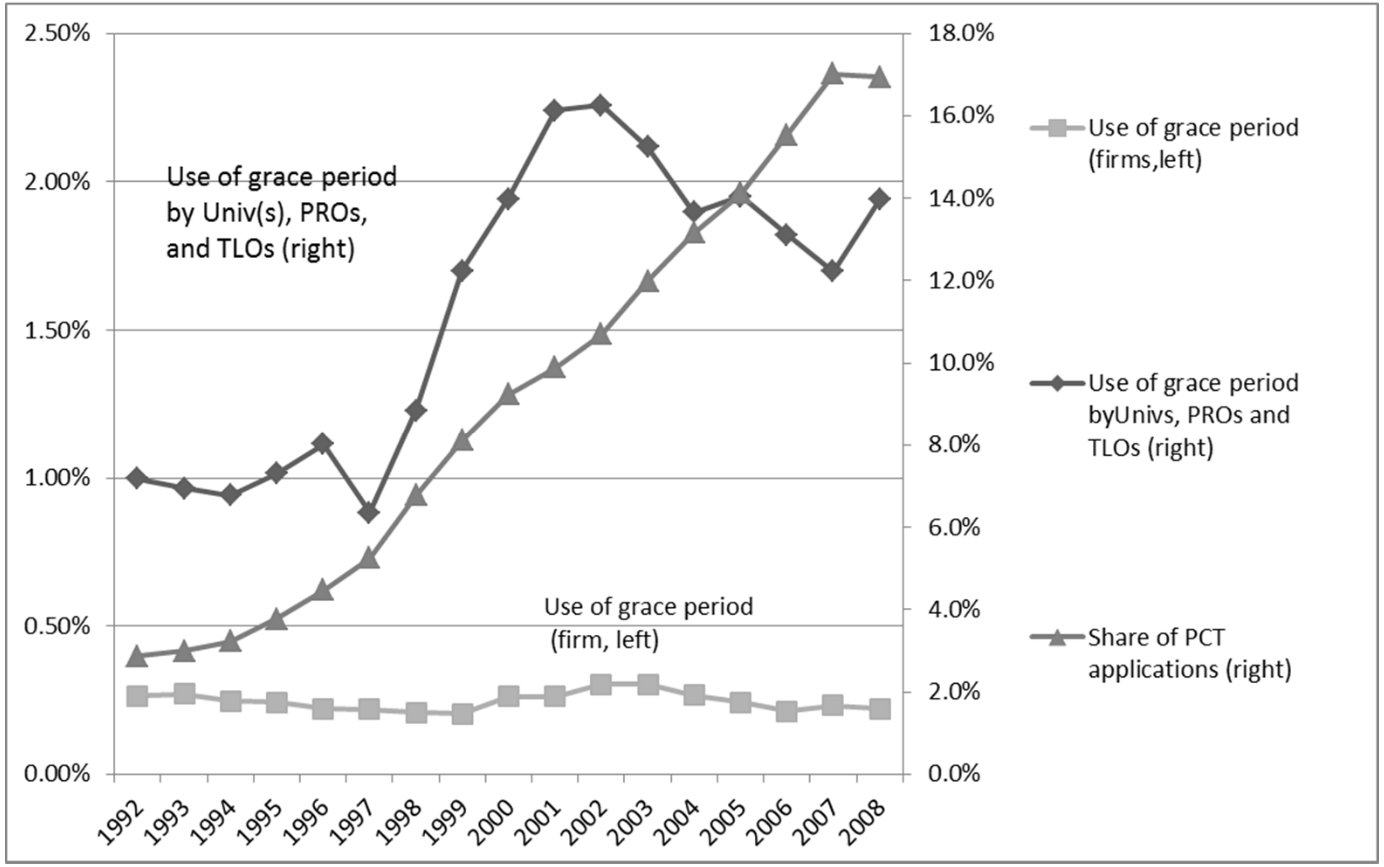


Figure 2 Use of grace period and the share of PCT applications in Japanese patent applications



Nagaoka Sadao and Yoichiro Nishimura (2015), "Use of grace period and its impact on knowledge flow: evidence from Japan," RIETI Discussion Paper Series 15-E-072

Table 2b The determinants of the use of grace period exception (%, Academia vs, Corporations)

	(7)	OLS	Academia			(8)	OLS	Corporations		
dependent variable=GRACE	Coef.	Std. Err.	t	P>|t|	signi ficance	Coef.	Std. Err.	t	P>|t|	signi ficance
ln(SCIENCE+1)	13.95	0.20	69.3	0	***	2.21	0.01	300.89	0	***
ln(INV)	0.69	0.27	2.53	0.01	**	0.21	0.00	50.11	0	***
ln(CLAIM)	-1.65	0.28	-5.94	0	***	-0.10	0.00	-22.6	0	***
PCT	11.67	5.70	2.05	0.04	**	-1.72	0.15	-11.38	0	***
REFORM_PCT*PCT	-4.72	1.89	-2.5	0.01	**	-1.12	0.09	-11.86	0	***
CONSTANT	2.57	1.90	1.36	0.18		0.15	0.03	5.43	0	***
TECHNOLOGY sector dummies			YES					YES		
Large firm dummy			NO			-0.04421	0.01001	-4.42	0	***
application YEAR dummies			YES					YES		
Number of observations		41,349					4,135,183			
Adj R-squared		0.1146					0.0273			

Figure 6 Grace period on the basis of academic disclosures and that on the basis of exhibitions

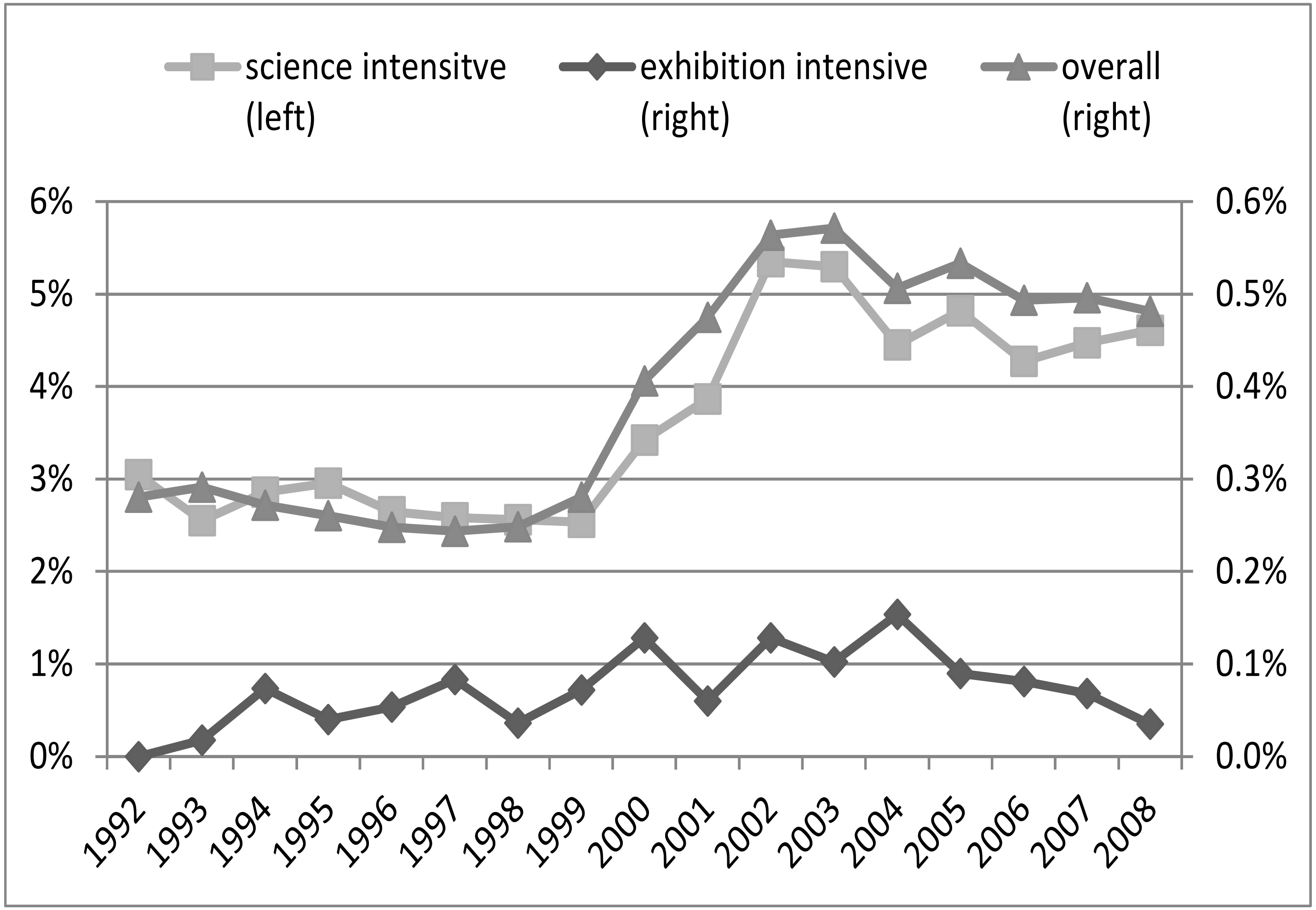


Figure 7 Applicant type and the frequency of the use of grace period