

Standards as a knowledge source for R&D:

A first look at their characteristics
based on inventor survey and patent bibliographic data

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Research questions

1. How important are technical standards as a knowledge source for R&D?
 - RIETI Inventor Survey

This survey was conducted in 2006-2007.

Triadic sample: 3700, non-Triadic sample: 1500,

Priority year: 1995-2001,

R&D objectives, Motivations, Knowledge sources,

Process of inventions, Use, License, Value, ... etc.

Research questions (cont.)

2. How significantly do the (backward) citations to standard documents by a patent measure such knowledge flow?
 - Triadic Patent Families database & PATSTAT database
 - We searched patents citing standard documents.
 - Frequency of citations to standard documents
 - Relationship between Inventor's recognition of standard documents and their citation behaviors in patented inventions.

3. How significantly they affect the performance of downstream R&D?
 - When standard documents are used in a R&D project as a knowledge source, do they make R&D more productive?

Data

- RIETI Inventor Survey (2007)
 - We asked inventors about their research projects yielding patents which are randomly sampled.
 - Priority application year: 1995-2001
 - Triadic patent sample & non-Triadic patent sample
 - Number of responses: About 5200 (Triadic: 3700, non-Triadic: 1500)
- OECD Triadic Patent Families Database (TPF)
 - patents applied to JPO, EPO and granted in USPTO
- EPO Worldwide Patent Statistical Database (PATSTAT, Sept. 2009)
 - Patent bibliographic data of 80 countries' patent offices
 - Citation information, Technology class, etc.

Major findings

- The information embodied in standard documents are an important knowledge source for R&D in ICT area.
- Citation to standard documents significantly implies knowledge flow.
- R&D projects using intensively standard documents tends to generate more valuable patents and more number of patents in ICT area.

Related Literatures

- There exist many related literatures,
- But no literature on knowledge spillover effects of standards upon downstream innovation activities.

Value of patents essential to technical standards

- Bekkers, Duysters and Verspagen (2002), Rysman and Simcoe (2008)

Firms involving in standard-setting process yield more essential patents.

- Gandal, Gantman and Genesove (2007), Bekkers, Bongard and Nuvolari (2011)

- Patent citations as knowledge flow
 - Trajtenberg (1990), Jaffe, Hall, Jaffe and Trajtenberg (2005), Harhoff, Narin, Scherer and Vopel (1999)
- Inventor citation vs. Examiner citation
 - Thompson (2006), Alcacer and Gittelman (2006)

Sample: RIETI Inventor Survey

Importance of standard as a knowledge source

- % of “very important”
- Only 1.6% in all the triadic sample
- Higher percentage in Telecom, IT , Audio visual area

		Literatures			Open forum		Organization, including the own firm						
		Scientific and technical lit.	Patent lit.	Standard documents	Trade fair or exhibitions	Tech. conference	Your firm excluding co-inventors	Customers or users	Suppliers	Competitors	University	Public research org.	Consulting firm
Triadic patents		17.6%	22.5%	1.6%	3.0%	3.4%	18.0%	19.8%	6.7%	13.8%	2.7%	1.4%	0.5%
Non-triadic patents		14.2%	19.7%	1.5%	2.4%	2.3%	12.9%	18.2%	4.6%	12.7%	2.1%	1.0%	0.2%
ISI class	Telecom	24.2%	18.8%	10.1%	0.6%	7.5%	17.1%	9.5%	3.2%	11.5%	1.9%	0.6%	1.3%
	Audiovisual	14.2%	16.1%	5.3%	1.8%	3.6%	23.2%	16.0%	4.7%	11.2%	0.6%	0.6%	0.0%
	IT	18.9%	12.2%	5.0%	1.9%	5.6%	17.5%	20.6%	4.3%	12.5%	3.1%	2.5%	0.6%
	Agric&Food Mach.	14.7%	18.9%	5.7%	5.4%	0.0%	20.6%	17.1%	0.0%	8.8%	2.9%	2.9%	0.0%

Sample: RIETI Inventor Survey

Whether does inventor in the survey cite standard documents in his/her patent?

- Investigating non-patent literature cited by US patents included in family of survey sample.

	Citing standard	Not citing standard	Total	#Patent families
Very important	0.14%	1.4%	1.5%	56
Important	0.19%	6.5%	6.7%	246
Other	0.38%	91.4%	91.7%	3,356
Total	0.71%	99.3%	100.0%	3,658
#Patent families	26	3,632	3,658	

- Inventors recognizing standard-documents as “important /very important” *not necessarily cite* standard-documents.
- But, half of the inventors citing standard-documents answered it as “important/very important”. $(0.14+0.19)/0.71 = 46.2\%$
- Once standards are cited, it is a significant indicator of knowledge flow.

Sample: TPF

How many triadic patents cite standard documents

- Search method:
 - Full-text search against citation information in patent bibliographic data
 - See appendix A in our paper about the MySQL command.

Sample: TPF

Number of patent families citing standard documents by technology sectors

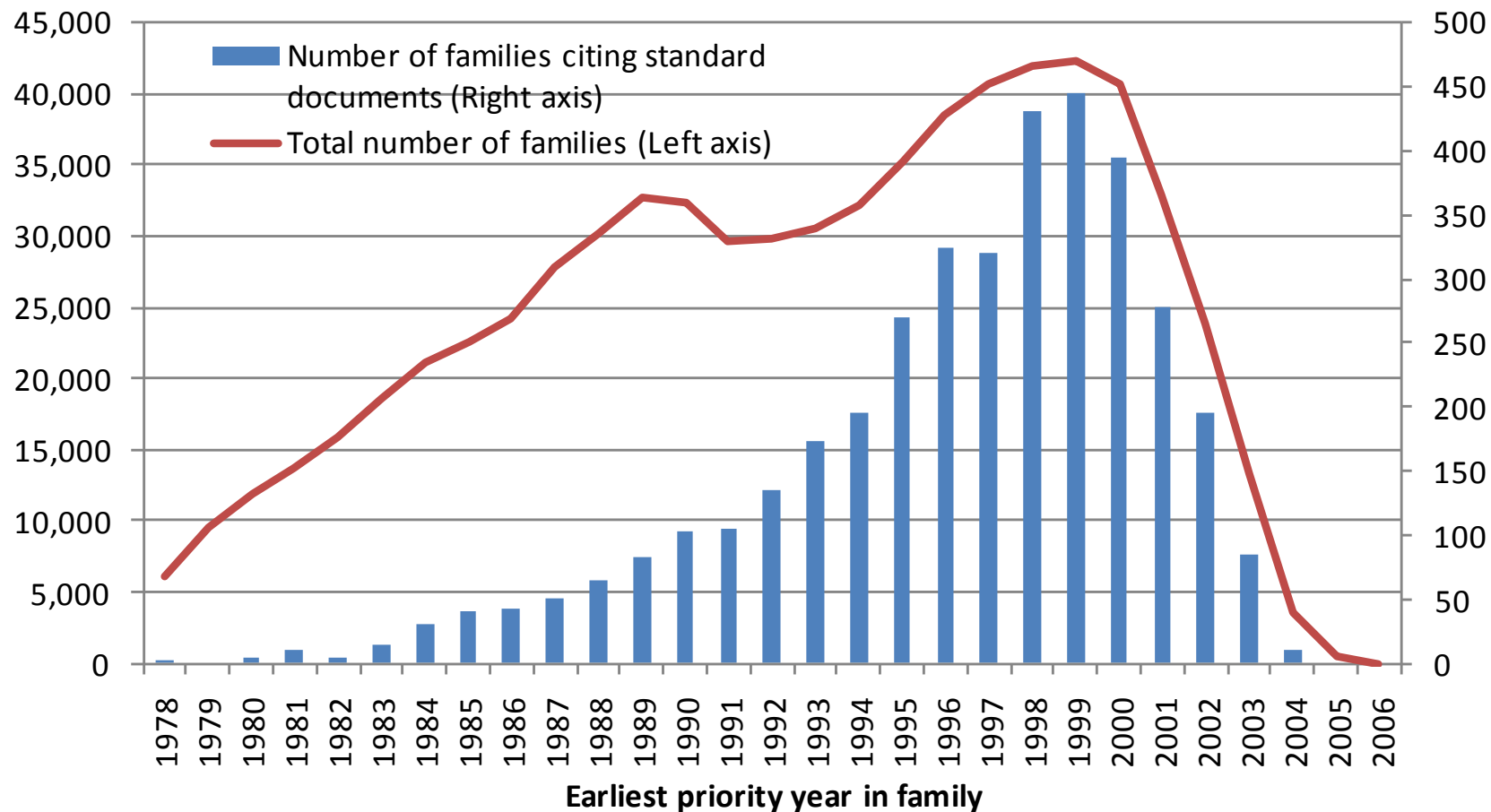
ISI area	Num. of families	%	Total
Telecom	964	4.8%	20,110
IT	680	3.6%	19,027
Analysis/Measurement/	122	0.8%	15,774
Audiovisual	63	0.8%	7,804
Electr/Energy	56	0.3%	20,255
Polymers	48	0.4%	11,003
MedicalTechn	37	0.3%	13,361
Pharmaceuticals/Cosme	36	0.2%	15,468
SurfaceTechn	36	0.3%	10,570
Optical	26	0.2%	14,900
Other	228	0.2%	116,521
Total	2,296	0.9%	264,793
(Earliest pyear: 1995-2001)			

- Telecom and IT are the most frequently citing area in all the Triadic patent families.

TPF + PATSTAT

Number of families citing standard documents

- 0.25% in 1989 \Rightarrow 1.05% in 1999



Sample: TPF

Number of patent families citing standard documents by Standard-Setting Organizations

- Most cited standard documents are those of ISO

SSO	Num. of families
ISO	1022
IEC	664
IETF	596
ITU	536
ANSI	439
IEEE	385
ETSI	353
DIN	257
JIS	221
EI/TIA	101
Others	222
Total	3817
* There exist duplications.	

Sample: TPF

Inventor citations vs. Examiner citations

- US patents granted after 2001 disclosed information whether a citation is added by inventors or by examiners.
- % of inventor citations and examiner citations
(Data: All the triadic US patents granted in 2001)

	Average number of citations	Share of inventor citations	Share of examiner citations
Patent literatures	16.80 (100%)	12.04 (71.65%)	4.77 (28.35%)
Non-patent literatures	10.34 (100%)	10.01 (96.86%)	0.32 (3.14%)
Standard documents	0.019 (100%)	0.018 (98.27%)	0.001 (1.73%)

- Almost all the citations of standard documents are added by inventors
⇒ Knowledge flow

Patent citing standard documents is essential patent of standard?

- Number of essential patent families of MPEG, DVD, and WCDMA citing standard related documents

	MPEG	DVD	WCDMA
Number of essential patent families	86	153	28
ISO	21	4	0
IEC	21	1	0
ITU	1	0	0
IETF	2	0	0
ANSI	0	0	0
IEEE	0	0	0
ETSI	0	0	0
DIN	0	0	0
JIS	0	1	0
EIATIA	0	0	2

Geography of citations

- Number of patent families including JP/US/DE inventor and citing standard documents of each SSO.

	All	Including JP inventor		Including US inventor		Including DE inventor	
Triadic all	264,772	75,307	28.4%	93,345	35.3%	38,951	14.7%
ISO	490	116	23.7%	231	47.1%	61	12.4%
ITU	392	111	28.3%	144	36.7%	29	7.4%
ANSI	216	19	8.8%	169	78.2%	3	1.4%
JIS	113	95	84.1%	16	14.2%	2	1.8%
DIN	119	7	5.9%	21	17.6%	75	63.0%
ETSI	287	36	12.5%	64	22.3%	34	11.8%
IETF	501	87	17.4%	321	64.1%	18	3.6%
IEEE	181	47	26.0%	113	62.4%	5	2.8%

(Earliest priority year: 1995-2001)

Two estimations

- How significantly they affect the performance of downstream R&D?
 1. Estimation using sample of RIETI Inventor Survey
 2. Estimation using sample of TPF
- Period: 1995-2001

Estimation: RIETI Inventor Survey

- Dependent variables:
 1. Economic value of the patent (4point likert scale)
 2. Number of granted patents generated in the R&D project (6point likert scale)
 3. Whether the patent is used by own firm or not
 4. Whether the patent is licensed or not
- Independent variable:
 - Importance of standard documents (5point likert scale)
- Control variables:
 - Importance of scientific literatures, Importance of patent literatures
 - R&D man-month, PhD inventor dummy
 - Organization type dummies
- Estimation method: Ordered Logit, or Probit

Estimation results: RIETI Inventor Survey

		(1)		(2)		(3)		(4)	
		Ordered logit		Probit		Probit		Ordered logit	
		Economic value of the patent	(Marginal effect)	Used by own firm	(Marginal effect)	Licensed	(Marginal effect)	#Patents from the R&D project	(Marginal effect)
Importance as knowledge source	Standard related documents	0.065** (0.026)	0.009** (0.004)	0.067*** (0.014)	0.027*** (0.006)	0.074*** (0.017)	0.019*** (0.004)	0.045** (0.021)	0.0005** (0.0002)
	Scientific and technical	0.094*** (0.025)	0.013*** (0.004)	-0.092*** (0.013)	-0.037*** (0.005)	-0.062*** (0.016)	-0.016*** (0.004)	0.103*** (0.020)	0.0011*** (0.0003)
	Patent literatures	-0.073*** (0.027)	-0.01*** (0.004)	-0.036** (0.014)	-0.014** (0.006)	0.003 (0.016)	0.001 (0.004)	0.038* (0.021)	0.0004* (0.0002)
ln(R&D man-month)		0.228*** (0.028)	0.032*** (0.004)	0.067*** (0.015)	0.027*** (0.006)	0.055*** (0.017)	0.015*** (0.005)	0.475*** (0.024)	0.0051*** (0.0007)
Phd		0.475*** (0.115)	0.068*** (0.016)	-0.277*** (0.068)	-0.11*** (0.027)	-0.079 (0.081)	-0.02 (0.02)	0.257*** (0.099)	0.0031** (0.0014)
Triadic dummy		0.590*** (0.081)	0.078*** (0.01)	0.390*** (0.042)	0.155*** (0.017)	0.346*** (0.052)	0.086*** (0.012)	0.254*** (0.063)	0.0026*** (0.0007)
Constant				-0.066 (0.078)		-1.066*** (0.091)			
Observations		2920		4502		4415		4515	
Pseudo R-Squared		0.03		0.04		0.03		0.06	
Log Likelihood		-3573.06		-2997.66		-2081.96		-5747.45	

Note: We also introduce the organization dummies and application year dummies, but not reported.

Standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%

Estimation: TPF sample

- Dependent variable:
 - Number of forward citations
- Independent variables:
 - Dummy of citing standard documents, or
 - Three dummies classified by type of standard-setting organizations

	Global scope	National or regional scope
Public	International public standards (ISO, IEC, ITU)	National/regional public standards (ANSI, JIS, DIN, BSI, CEN, ETSI)
Private	Private international standards (IETF, W3C, IEEE, Ecma international, EIA/TIA, JEDEC)	

Estimation: TPF sample (cont.)

- Control variables
 - Number of non-patent literatures cited
 - Number of citations to standard documents are excluded.
 - Number of patent literatures cited
 - Number of inventors
 - Patent family size
 - Dummy including US inventors (to control differences of citation-propensity)
 - Dummies for technology by grant-year
- Negative binomial regression

Estimation results : TPF sample

Negative binomial regression

		Number of forward citations to family						
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
Knowledge source	National/regional standards dummy			0.450*** (0.054)	0.203*** (0.051)	0.156*** (0.050)	0.152*** (0.051)	0.117** (0.050)
	International public standards dummy	0.701*** (0.028)	0.356*** (0.027)	0.221*** (0.044)	0.013 (0.042)	-0.052 (0.041)	0.002 (0.041)	-0.058 (0.041)
	Private international forum standards dummy			0.959*** (0.041)	0.577*** (0.039)	0.506*** (0.038)	0.574*** (0.039)	0.508*** (0.038)
	ln(Non-patent literatures cited + 1)		0.182*** (0.006)		0.182*** (0.006)	0.170*** (0.006)	0.181*** (0.006)	0.169*** (0.006)
	ln(Patent literatures cited + 1)		0.381*** (0.007)		0.379*** (0.007)	0.216*** (0.008)	0.364*** (0.007)	0.209*** (0.008)
ln(Number of inventors)			0.205*** (0.008)		0.204*** (0.008)	0.186*** (0.008)	0.205*** (0.008)	0.187*** (0.008)
ln(US domestic family size)						0.572*** (0.014)		0.555*** (0.014)
ln(Number of patent offices applied)							0.233*** (0.013)	0.183*** (0.013)
US inventor dummy		0.737*** (0.011)	0.465*** (0.011)	0.730*** (0.011)	0.461*** (0.011)	0.457*** (0.011)	0.472*** (0.011)	0.467*** (0.011)
Constant		2.610*** (0.160)	1.768*** (0.149)	-0.040 (1.201)	-0.317 (1.130)	-0.162 (1.109)	-0.600 (1.127)	1.753*** (0.146)
Observations		46433	46433	46433	46433	46433	46433	46433
Pseudo R-Squared		0.08	0.10	0.08	0.10	0.10	0.10	0.10
Log Likelihood		-145340	-142200	-145272	-142158	-141214	-142001	-141114

Why does private international standard have more significant positive effect on the downstream R&D?

- Patent families citing private international standards have high science linkage, shorter citation lag, more number of backward citations.
- ⇒ Private international standards might adopt quickly science-based new technology

	Families citing national/regional public standards (ANSI, JIS, DIN, etc.)	Families citing international public standards (ISO, IEC, ITU)	Families citing private international forum standards (IETF, W3C, IEEE, Ecma., etc)	Triadic all
Lag years of backward patent citations	5.51	5.78	5.08	6.56
Backward patent citations	19.39	20.24	30.83	11.72
Non-patent Literature citations	6.2	6.73	10.09	2.52
Num. of inventors	2.49	2.4	2.58	2.38

RIETI Inventor Survey:

Importance of foreign/international standards

- Relative importance of foreign knowledge sources, compared with domestic that of domestic sources.

		Importance of foreign standard, compared with domestic					
		Not important	Less important	Same	Important more	Far more important	Total
Importance of standard documents	Important	15.9%	6.3%	38.9%	27.8%	11.1%	100%
	Very important	15.7%	0.0%	23.5%	9.8%	51.0%	100%

- Inventors strongly recognized the importance of exploitation of foreign or international standard, when standard related documents are very important for the research projects.

Conclusion (1)

- Technical information embodied in standard and related documents are an important knowledge source for R&D (especially in ICT area).
 - Inventor survey suggests that standard-documents are often important for the conception of R&D.
 - Number of backward citations to standards suggests that it becomes increasingly important in recent year.
- Citation to standard documents significantly implies knowledge flow, although the reverse is not the case
 - Half of the inventors citing standard documents recognize standard as important or very important.
 - Standard documents are cited predominantly by inventors (not by examiners).

Conclusion (2)

- R&D projects using intensively standard documents tends to generate more valuable patents and more number of patents.
 - These patents have high economic values (used, licensed) and tends to be cited more by future patents.
- Private international forum standards enhance downstream R&D more.
 - Quickness in adopting new technology

Implications

- Standards might promote downstream innovations
 - It is important for standard organizations to archive standard documents properly and to establish clear disclosure rule, so that firms can make use of such information and patent office can examine standard based invention as proper prior art.
- This analysis has shown “going for global” and quick adoption of new technology enhance value of the standards.
 - It suggests that efforts of national standard organizations to accommodate new technology and to be open to international members would make sense.

Appendix

Estimation results (B-7) : TPF sample

		Number of forward citations to family						
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
National/regional standards	ANSI	0.600*** (0.099)	0.586*** (0.098)	0.141 (0.093)	0.126 (0.092)	0.049 (0.092)	0.131 (0.092)	0.056 (0.092)
	JIS	0.686* (0.412)	0.631 (0.408)	0.150 (0.388)	0.122 (0.386)	-0.079 (0.387)	0.095 (0.386)	-0.077 (0.387)
	DIN	0.373 (0.294)	0.449 (0.291)	-0.068 (0.272)	-0.009 (0.271)	-0.140 (0.267)	-0.099 (0.271)	-0.198 (0.268)
	CEN	0.065 (0.241)	0.018 (0.239)	0.037 (0.222)	0.006 (0.220)	0.067 (0.216)	-0.032 (0.221)	0.037 (0.216)
	ETSI	0.315*** (0.072)	0.339*** (0.071)	0.171** (0.068)	0.187*** (0.067)	0.156** (0.066)	0.126* (0.067)	0.111* (0.066)
International public standards	ISO	0.232** (0.109)	0.206* (0.108)	-0.071 (0.115)	-0.067 (0.115)	-0.083 (0.112)	-0.087 (0.115)	-0.094 (0.112)
	IEC	0.057 (0.116)	0.077 (0.116)	0.145 (0.123)	0.145 (0.122)	0.080 (0.120)	0.156 (0.122)	0.087 (0.119)
	ITU	0.161** (0.063)	0.157** (0.062)	-0.037 (0.058)	-0.036 (0.058)	-0.085 (0.057)	-0.046 (0.058)	-0.091 (0.057)
Private international forum standards	IETF	1.208*** (0.053)	1.171*** (0.052)	0.738*** (0.049)	0.727*** (0.049)	0.696*** (0.048)	0.727*** (0.049)	0.697*** (0.048)
	W3C	1.057*** (0.150)	1.046*** (0.148)	0.522*** (0.139)	0.514*** (0.138)	0.410*** (0.136)	0.533*** (0.137)	0.425*** (0.136)
	IEEE	0.690*** (0.101)	0.681*** (0.100)	0.164* (0.096)	0.145 (0.096)	0.086 (0.095)	0.153 (0.095)	0.096 (0.095)
	EIA/TIA	0.746*** (0.179)	0.665*** (0.177)	0.133 (0.166)	0.146 (0.165)	0.052 (0.163)	0.115 (0.165)	0.032 (0.164)
	JEDEC	0.447 (0.380)	0.380 (0.376)	0.430 (0.350)	0.393 (0.348)	0.327 (0.343)	0.452 (0.348)	0.376 (0.343)
	Ecma international	0.896*** (0.192)	0.901*** (0.190)	0.839*** (0.178)	0.839*** (0.177)	0.467*** (0.174)	0.775*** (0.177)	0.437** (0.174)