

China's Patent Quality in International Comparison

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SEEK, Mannheim, October 9th

Motivation

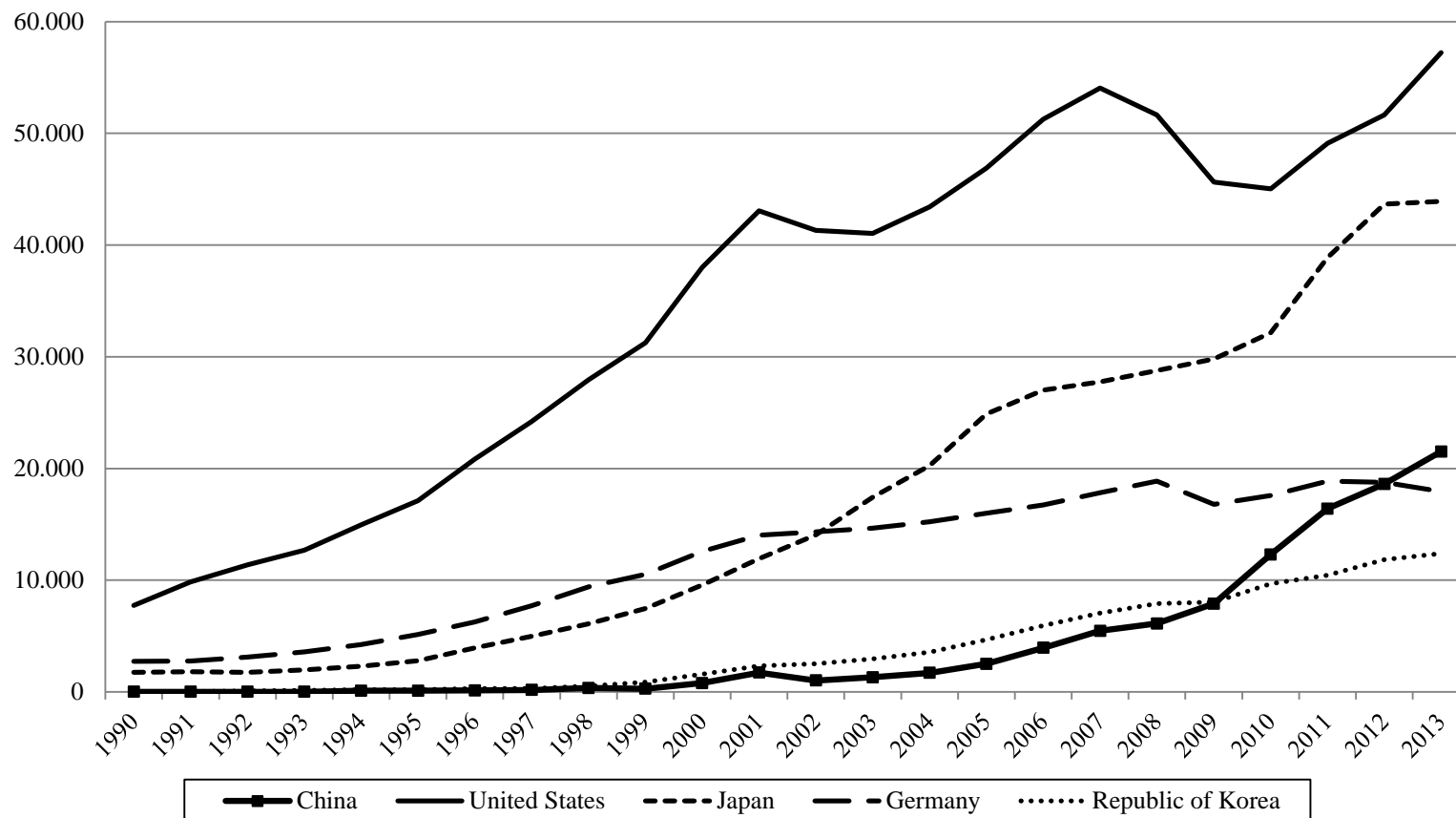
- Global shift of R&D and patents towards China (OECD 2014)
 - GERD to GDP intensity above EU-28 level
 - China contributes 20% to global GERD
 - SIPO leading in residential applications

- Global shift away from triadic region (USPTO, JPO, EPO) and increase in PCT between 1995 and 2013 (OECD 2015)
 - annual global applications increased from 1 to 2.4 million
 - share filed within triadic region declined from 69% to 49%
 - triadic families increased by 43%, PCT applications by 414%

- In 2013, Chinese PCT applications overtook German ones and now rank third behind the US and Japanese (OECD 2014)

- Patent expansion follows quantitative gov. targets
 - since 1999 provincial and sub-provincial subsidy programs (Li 2012)
 - since 2009 central gov. subsidies for granted PCTs (Ministry of Finance 2009)₂

PCT Applications by Country of Origin



Source: WIPO 2014

Priority Year

Challenges for Measuring Patent Quality

- Citations preferred measure for patent quality
 - good proxy for economic & technological value (Harhoff et al 1999, Trajtenberg 1990)
 - different national examination standards, citations not disclosed by SIPO
- International comparisons suffer from selection biases
 - comparison between domestic and international applications
 - patent offices tend to cite prior art from home country (Michel & Bettels 2001)
- Other quality measures endogenous to policy
 - positive relation between patent subsidies and expansion (Li 2012)
 - claims per applicant remain constant, claims per patent decrease after increase in subsidies (Lei et al. 2012)
 - grant rates (stable, increasing) and renewals potentially endogenous to policy

ISR Index

ISR index 1

- Non-self citation $i_{i,j}$: = 1 if application i is cited by application j
- c : country of the applicant
- t : priority year
- m : technology

$$quality\ index_{t',m',c'} = \frac{\left(\frac{\sum_{i=1}^I \mathbb{1}_{i \in t=t', m=m', c=c'} \sum_{j=1, c_i \neq c_j}^I \text{non-self citation}_{i,j}}{N_{t',m',c'}} \right)}{\left(\frac{\sum_{k=1}^I \mathbb{1}_{k \in t=t', m=m', c \neq c'} \sum_{j=1, c_k \neq c_j}^I \text{non-self citation}_{k,j}}{N_{t',m',c \neq c'}} \right)}$$

ISR index 2: allow for citations from own country

ISR index 3: additionally allow for self-citations

ISR Index

- 3-year time window
 - high correlation of 0.91 between information from 3 and 5 years
- SIPO is the only Receiving Office and International Search Authority for Chinese firms
- Technologies defined at 3-digit IPC level
- Index of 100% signifies quality equal to international benchmark
- Upper bound of language bias against Chinese prior art: 11%

Data

- PCT applications from PATSTAT, October 2013
 - time period 2001-2009
 - country of origin determined according to country of first applicant

- Match with firms listed on mainland stock markets
 - 1,743 firms covered, 228 firms with PCT patent applications
 - firm data from Datastream, Compustat, WIND, RESSET

- Firms' filing strategies focus on domestic and PCT applications
 - 109,769 domestic applications (94%)
 - 5,186 PCT applications (4%)
 - 951 international applications outside PCT system (1%)

ISR Index for Chinese PCT Population

Year	ISR Index 1	ISR Index 2	ISR Index 3	Obs.
<i>Considered Citations</i>				
<i>Applicant country</i>	<i>excluded</i>	<i>included</i>	<i>included</i>	
<i>Self-cites</i>	<i>excluded</i>	<i>excluded</i>	<i>included</i>	
2001	0.478	0.390	0.375	793
2002	0.373	0.338	0.313	1,060
2003	0.403	0.362	0.327	1,368
2004	0.349	0.281	0.323	1,948
2005	0.429	0.403	0.459	3,321
2006	0.315	0.430	0.523	4,649
2007	0.290	0.558	0.732	5,799
2008	0.299	0.768	1.138	6,159
2009	0.335	0.904	1.536	9,641
Total	0.335	0.626	0.913	34,738

Note: Analysis at patent level. Mean values of variables displayed.

ISR Index for Listed Firms with Positive PCT Stock

Year	ISR Index 1	ISR Index 2	ISR Index 3	Obs.
<i>Considered Citations</i>				
<i>Applicant country</i>	<i>excluded</i>	<i>included</i>	<i>included</i>	
<i>Self-cites</i>	<i>excluded</i>	<i>excluded</i>	<i>included</i>	
2001	0.608	0.859	0.949	53
2002	0.576	0.574	0.692	102
2003	0.429	0.538	0.492	159
2004	0.844	0.810	0.704	195
2005	0.580	0.731	0.588	347
2006	0.586	0.650	0.702	429
2007	0.507	0.834	1.164	710
2008	0.252	0.705	1.668	871
2009	0.220	0.727	1.877	2,318
Total	0.360	0.727	1.441	5,184

Note: Analysis at patent level. Mean values of variables displayed.

Quality Determinants at the Firm-level

	ISR Index 1	ISR Index 2	ISR Index 3
<i>Considered Citations</i>			
<i>Applicant Country</i>	<i>excluded</i>	<i>included</i>	<i>included</i>
<i>Self-cites</i>	<i>excluded</i>	<i>excluded</i>	<i>included</i>
ln(R&D stock)	0.180***	0.039	-0.004
PCT patent stock /'000 employees	0.239***	0.085**	0.055*
Domestic patent stock/'000 employees	-0.006***	-0.001	-0.001
ln(employees)	0.252	0.206	0.221**
ln(age)	-0.827	-0.144	-0.022
Private ownership	0.825	-0.113	-0.052

Note: Analysis at firm-year level. The dependent variable is the average quality index of the annual patent applications. Tobit analysis with standard errors clustered at the firm level. Reference category for year is 2001 and for region it is Coast. Industry dummies included. *** sig. level < 1%, ** sig. level < 5%, * sig. level < 10%.

Quality Determinants at the Firm-level

	ISR Index 1	ISR Index 2	ISR Index 3
2002	-1.587	-1.211	-0.809
2003	-2.611	-2.128	-1.376
2004	-0.559	-1.410	-0.354
2005	-2.147	-2.163	-1.261
2006	-2.272	-1.367	-0.346
2007	-3.300	-1.658	-0.518
2008	-3.340	0.168	0.827
2009	-4.198*	-0.392	1.706*
Observations (firms)	451 (228)	451 (228)	451 (228)
Log pseudo likelihood	-348.87	-550.58	-615.78

Note: Analysis at firm-year level. The dependent variable is the average quality index of the annual patent applications. Tobit analysis with standard errors clustered at the firm level. Reference category for year is 2001 and for region it is Coast. Industry dummies included. *** sig. level < 1%, ** sig. level < 5%, * sig. level < 10%.

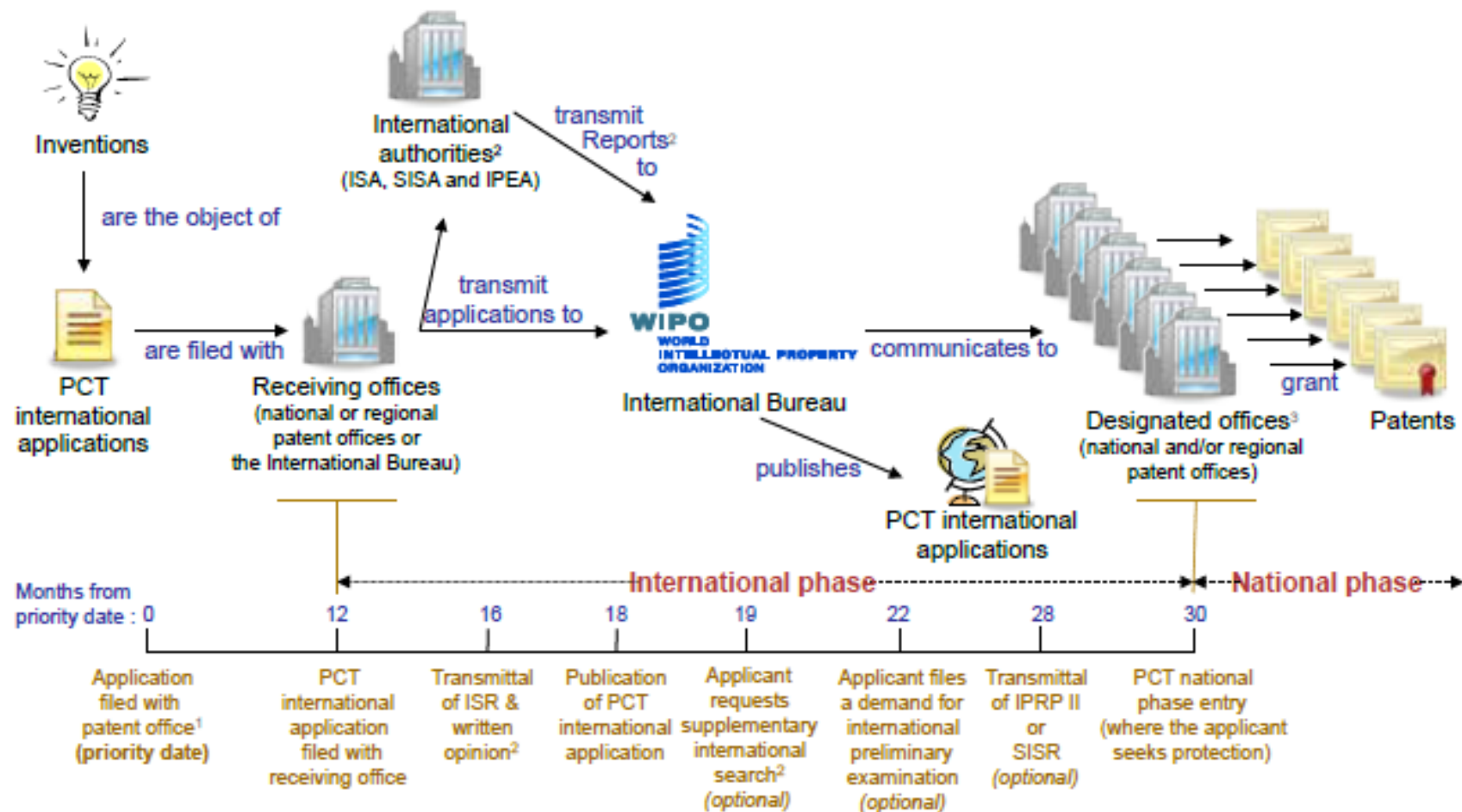
Conclusion

Based on ISR index 1

- (1) Chinese PCT applications achieve 34% of the international quality level
 - (2) Quality is decreasing over time
 - (3) Patent quality of firms increases in R&D stocks but decreases with the introduction of PCT subsidies
- ✓ *China's PCT expansion was achieved to the detriment of quality*

Back-Up

Citations Generated by PCT Applications



Source: WIPO (2014)

Measuring Patent Quality

- Citations are a good proxy for economic and technological value
(Harhoff et al. 1999, Trajtenberg 1990)
- Closer relationship to value than references, claims, or family size
(Gambardella et al. 2008)
- Renewal fees or oppositions not applicable for intern. comparison
- For using citations, details matter a lot (Michel and Bettels 2001)
 - self-citation vs. non-self citation
 - applicants (not) required to provide citations
 - rules about what should be cited differ by patent office

International Search Reports

- Common standard of Receiving Offices for prior art search (WIPO 2014, § 15.63-15.67)
 - cite only most relevant documents
 - cite documents in language of application (if available)
- PCT applications are filed with competent Receiving Office
- International phase has duration of 30 months after priority
- Designated International Search Authority publishes the International Search Report 18 months after priority
 - ISR contains citations to prior art
 - we exclusively use ISR citations for quality measure

Global PCT Applications

- Applications mainly from high-income countries
 - 87% from high-income countries
 - 12% from upper-middle-income countries (10% China)
 - 1% from lower-middle-income countries

- Search by 17 International Search Authorities (ISA) but more than 90% of the work is distributed among the five leading ISAs
 - European Patent Office: 38%,
 - Japan: 21%,
 - Republic of Korea: 15%,
 - China: 12%,
 - USA: 8%

Chinese Language Bias

- Examiners follow detailed guidelines to ensure search quality
- Applications follow WIPO's minimum documentation standard
- English translation of title, abstract, international search report, and any text relating to figures available for all PCT applications not published in English (Rule 48.3 (c), WIPO 2014b)
 - 9% of PCT filings with Chinese origin published in EN, remaining CN
 - for additional 47% of filings EN equivalent available at PCT publication date
- Keyword search of patent examiners identifies prior art in Chinese

Chinese Language Bias

- English translation of main parts gives good guidance to examiner whether document is relevant
- Examiners at EPO and at other ISAs can ask colleagues who are native speakers of Chinese for immediate help
- If document is relevant examiners can request human translation
- Since 2012 machine translation available to examiners at EPO
- Examiners can obtain full access to prior art in Chinese

Potential Biases Against Citing Prior Art in Chinese

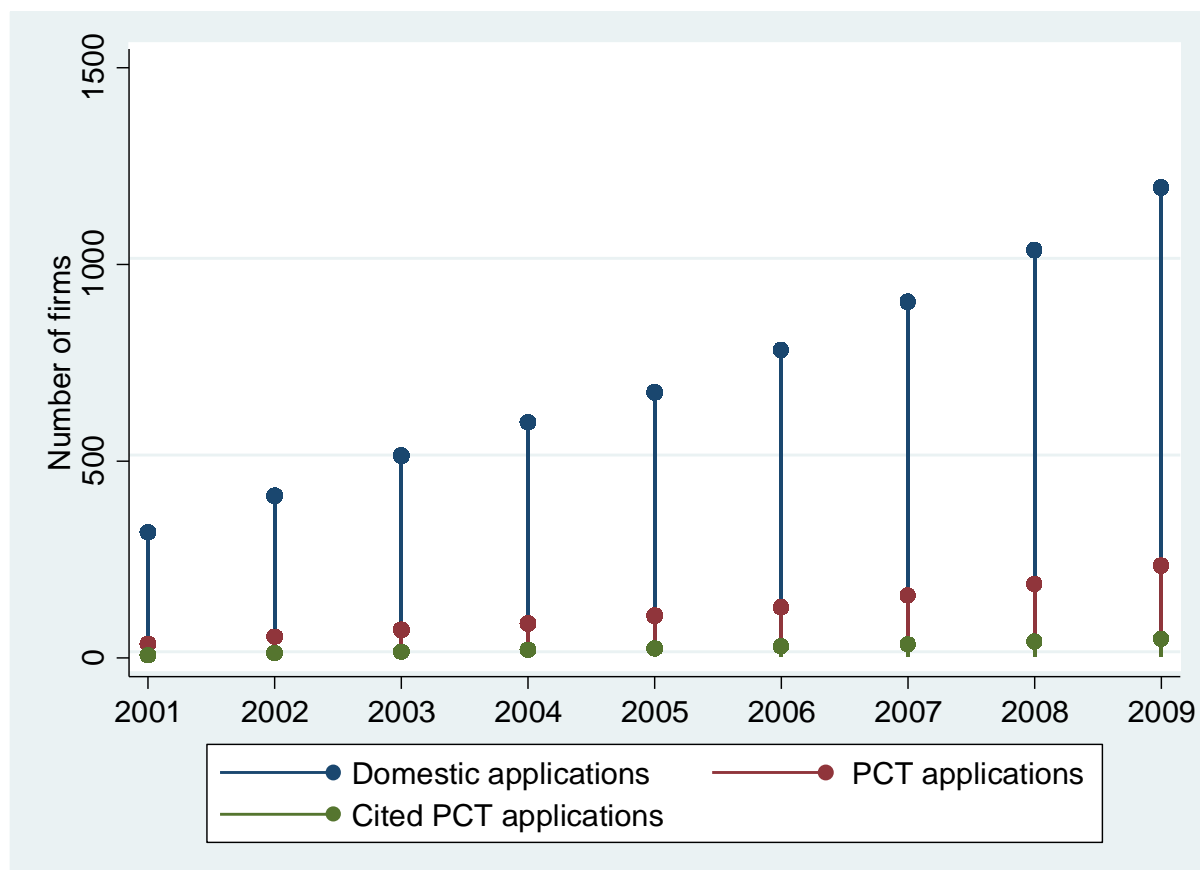
Insights from interviews with patent examiners

- Trying to find equivalent document in EN when document in CN identified by keyword search
- No discrimination
 - with respect to the size of the firm / degree of familiarity with the firm
 - with respect to the country of the applicant
- Not more likely to cite applications in CN because technological sophistication of Chinese firms has increased
- Lower probability of citing prior art in CN possible for older examiners or under time pressure
- *Examiners make great effort to identify the relevant prior art*

Quantification of Language Bias

- 91% of PCTs with Chinese origin published in Chinese
- Only 44% of PCTs with Chinese origin without English full text at time of publication (equivalent document or original publication)
 - 2/3 of those obtain EN equivalent, on average after 1.5 years, half citation window
 - 1/3 of those do not obtain EN equivalent during our sample period
- Citations from outside China before/ after EN equivalent available
 - Share increases from 31% to 69% (difference is 38%)
- Adjustment of citations
 - No adjustment for PCTs with EN full text
 - Adjustment of $\frac{1}{2} * 38\%$ for PCTs obtaining EN equivalent
 - Adjustment of 38% for PCTs not obtaining EN equivalent
- Weighted adjustment factor for language bias is 11%

Expansion of Patent Ownership









Avg. annual growth rates:

- Listed firms: 5.6%
- Firms with domestic applications: 18.6%
- Firms with PCT applications: 30.8%
- Firms with cited PCT applications: 34.8%







Note: Analysis at firm level.

Quality of largest PCT applicants

Main technology area	Firm		PCT stock	CN stock	ISR index
Electrical engineering	ZTE		3,084	13,942	0.237
Instruments	Tsinghua Tongfang		64	781	1.073
Chemistry	Sinopec		117	3,770	0.471
Process engineering	Sany		75	542	0.849
Mechanical engineering	Gree		69	1,013	0
Consumer goods and construction	Haier		35	2,497	0.700

Note: Analysis at patent level.

Quality of technology leaders

Main technology area	Firm	PCT stock	CN stock	ISR index
Electrical engineering	Irtouch 	13	32	1.912
Instruments	Tsinghua Tongfang 	64	781	1.073
Chemistry	OTIC 	7	6	3.32
Process engineering	Sany 	75	542	0.849
Mechanical engineering	Longyuan Power 	8	42	1.713
Consumer goods and construction	Hisense 	7	1,682	2.014

Note: Analysis at patent level. To ensure a minimum size of the PCT stock, technology leaders are required to have a PCT stock > 5.

Industry Distribution

Industry	Number of firms with at least one ...			
	... PCT application	%	... cited PCT application	%
Chemistry & pharma	70	30.6	24	40.0
Electronics	15	6.6	5	8.3
Metal & non-metal	25	10.9	5	8.3
Machinery & instruments	52	22.7	11	18.3
Remaining manufacturing	18	7.9	6	10.0
Information technology	18	7.9	3	5.0
Remaining industries	31	13.5	6	10.0
Total	229	100	60	100

Technology Distribution

Main technology area	Number of firms with at least one ...			
	... PCT application	%	... cited PCT application	%
Electrical engineering	47	20.5	10	16.7
Instruments	21	9.2	4	6.7
Chemistry	90	39.3	32	53.3
Process engineering	29	12.7	6	10.0
Mechanical engineering	26	11.4	4	6.7
Consumer goods & construction	16	7.0	4	6.7
Total	229	100	60	100

Citation Rate for PCT Applications of Listed Firms

Citations received	Number PCT applications	Percent PCT applications	Cumulative percent
0	4,714	90.90	90.90
1	349	6.73	97.63
2	70	1.35	98.98
3	25	0.48	99.46
4	13	0.25	99.71
5 / 6	7	0.14	99.85
7 – 9	4	0.08	99.92
≥ 10	4	0.08	100.00
Total	5,186	100.00	

Descriptive Statistics – Firm Characteristics

Variable	Mean	Median	Std. Dev.	Min	Max	Obs.
R&D stock (million RMB)	487.89	30.45	2183	0	25,000	451
PCT stock/ '000 employees	3.442	0.825	8.443	0.005	100	451
Domestic stock/ '000 employees	55.26	8.589	217.1	0	2,920	451
Employees	20,237	3,126	68,679	10	539,168	451
Firm age	11.49	11	5.057	1	29	451
Private ownership	0.417	0	0.494	0	1	451

Note: Statistics based on firms with at least one PCT application.

Future Research

- (1) ISR Index may be applied to Chinese non-PCT patents
- (2) ISR Index works at patent, micro, and macro levels
- (3) ISR Index can be refined by using second-order citations

Policy Implications

- (1) High number of patents will not contribute to real economic gains if the quality of underlying inventions is low (Boeing et al. forthcoming)
- (2) Patent subsidies should be abandoned, PCT subsidies only for SMEs (since 2012) seems reasonable
- (3) Avoid clogging of international patent system by low quality applications – lesson learned from SIPO