Role of public research institutes in Japan's National Innovation System:
The case of AIST, RIKEN, JAXA

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Objective of this paper

- We focus on three major PRIs in Japan:
  - The National Institute of Advanced Industrial Science and Technology (AIST)
  - The Institute of Physical and Chemical Research (RIKEN)
  - The Japan Aerospace Exploration Agency (JAXA).

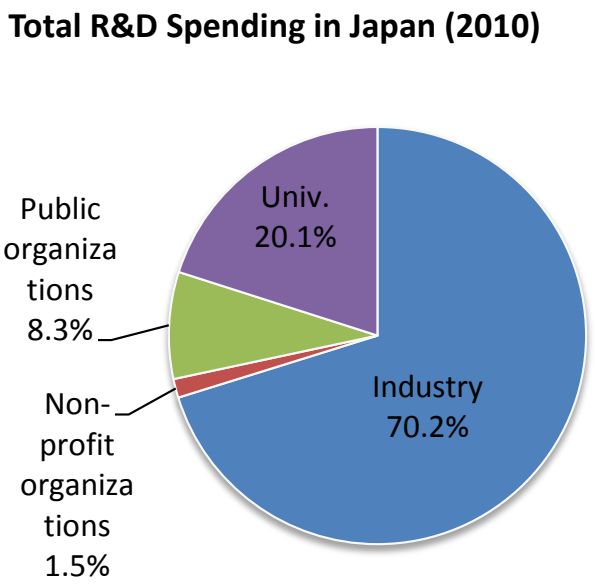
- We investigate their role in helping Japan's industry by examining their patents.
  - Performance measures drawn from patents data
  - Effects of research collaborations with private sector

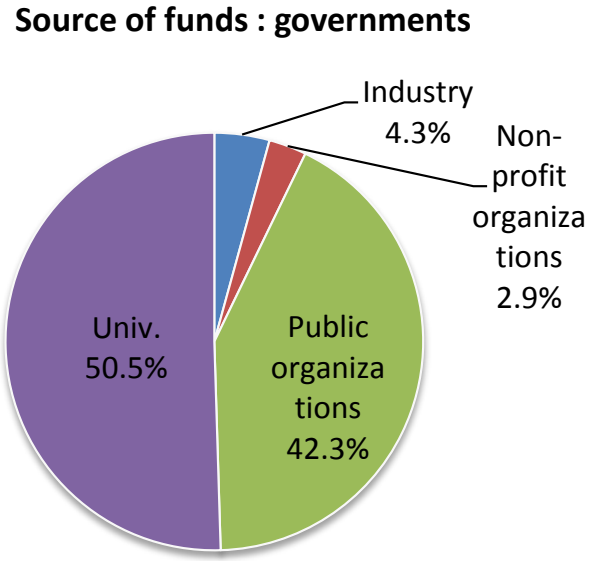
Background

- Historically, PRIs played an important role in conducting research related to the Japanese government's missions in defense, space exploration, health care, agriculture, and industrial technology.
- PRIs that aimed to help industry played a significant role during the catch-up period.
- However, throughout the 1970s and 1980s, as Japanese firms acquired new technological capabilities and crossed technological frontiers with increasing financial resources, the firms' reliance on PRIs as a source of advanced technology decreased.
- At present, discussions are underway regarding the role and rationale of PRIs in Japan's innovation system.

Background

- Public organizations uses 40% of government R&D





- Public organizations employ 32,422 researchers (3.8% of total researchers in Japan, firms: 58.2%, universities: 37.0%)
- PRI researchers spent more R&D per researcher

Literature review

- Ample research has addressed the function of universities in the National Innovation System. However, research on the role of PRIs in the NIS is scarce.
- Much of that research focuses on the PRI's role in developing countries' NIS.

- Notable exceptions include Rush et al. (1996), whose chapters examined PRIs in Germany, the United Kingdom, and the United States, among others.
- Jaffe (1997) used patent statistics to evaluate NASA's support of industry technology.

Data construction

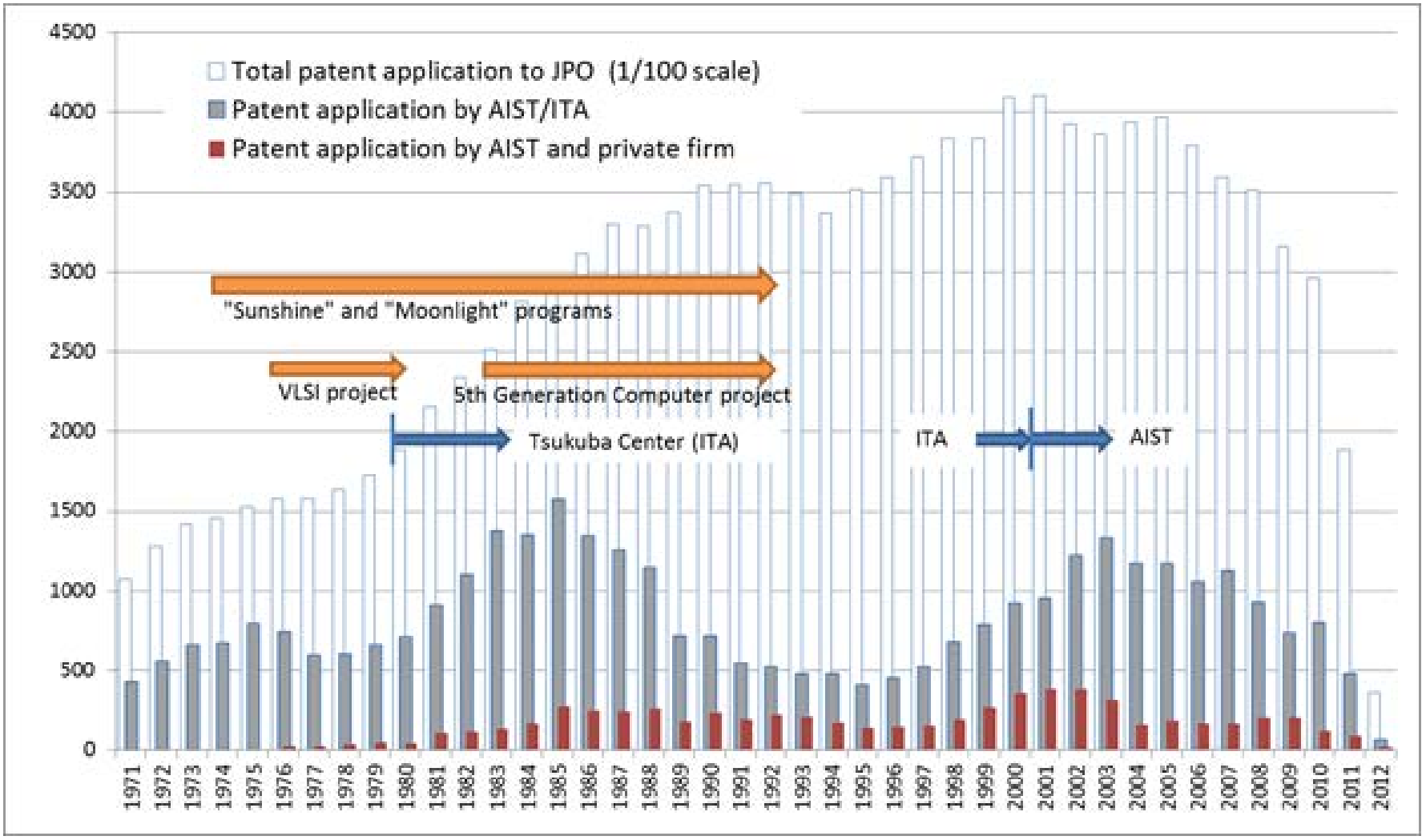
- Data source:
  - IIP patent database (Institute of Intellectual Property)
  - Inventor's citations database (Artificial Life Laboratory Inc.)
  - Worldwide Patent Statistical Database 2013April (European Patent Office)

- Identification of patent applications of public research institutes, universities, private firms:
  - Applicant name, Inventor's address includes name of a focal organization.

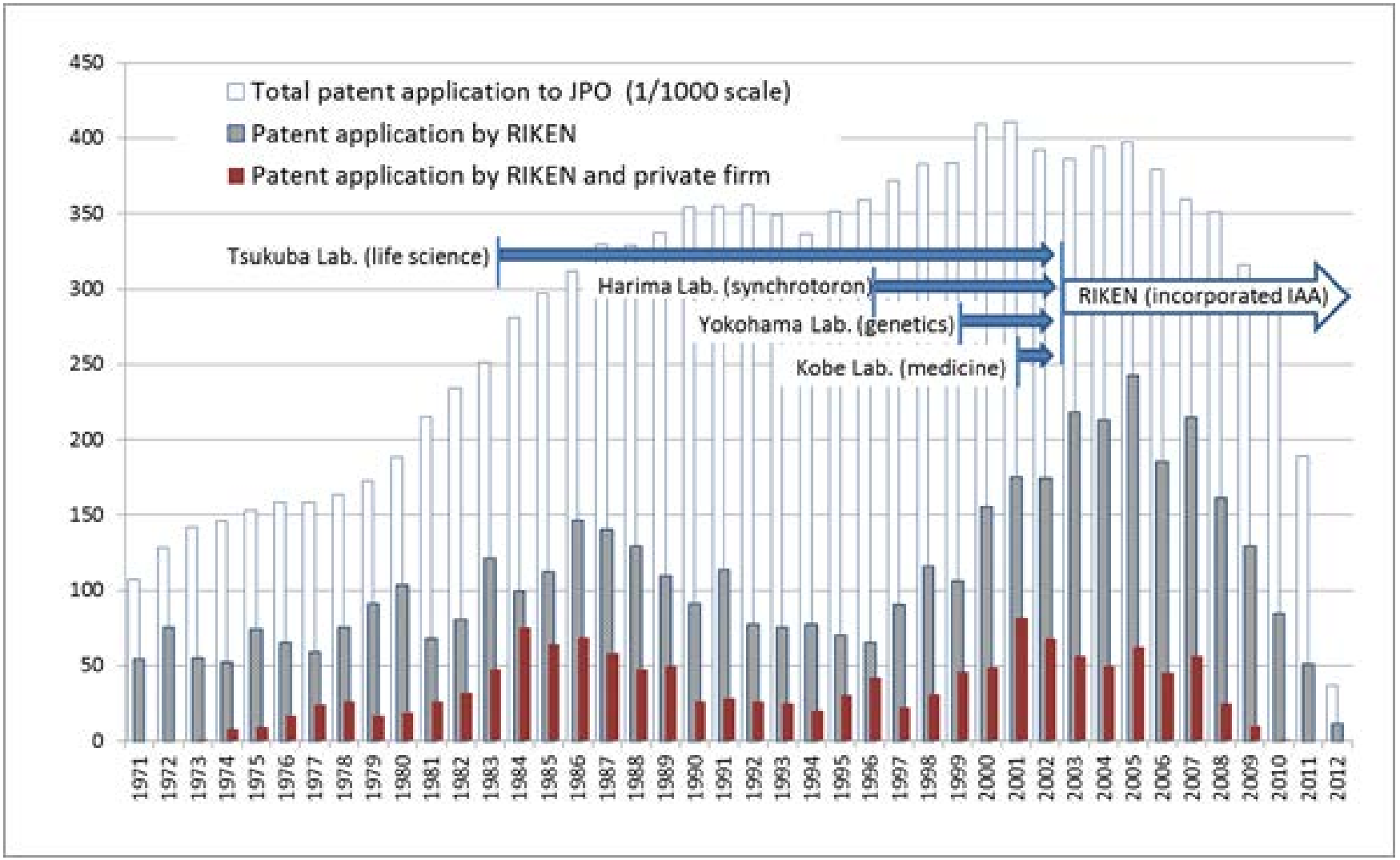
  - AIST ⇒ **35,042 patent applications**
  - RIKEN ⇒ **4,295 patent applications**
  - JAXA ⇒ **1,768 patent applications**

  - Universities ⇒ **61,619 patent applications**
  - Private firms: **1/100 random sampling ⇒ 97,279 patent applications**

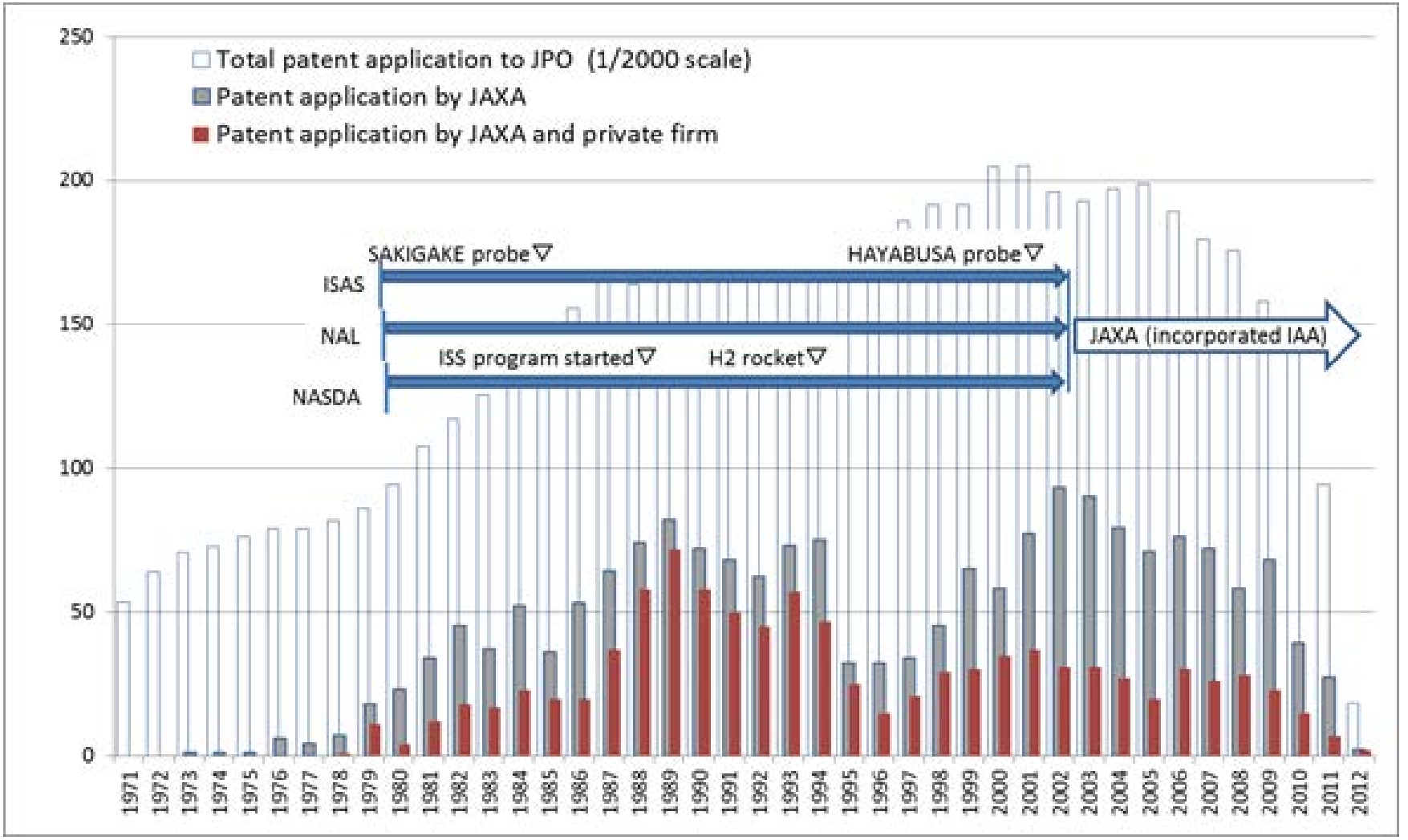
Trends of AIST's patent applications



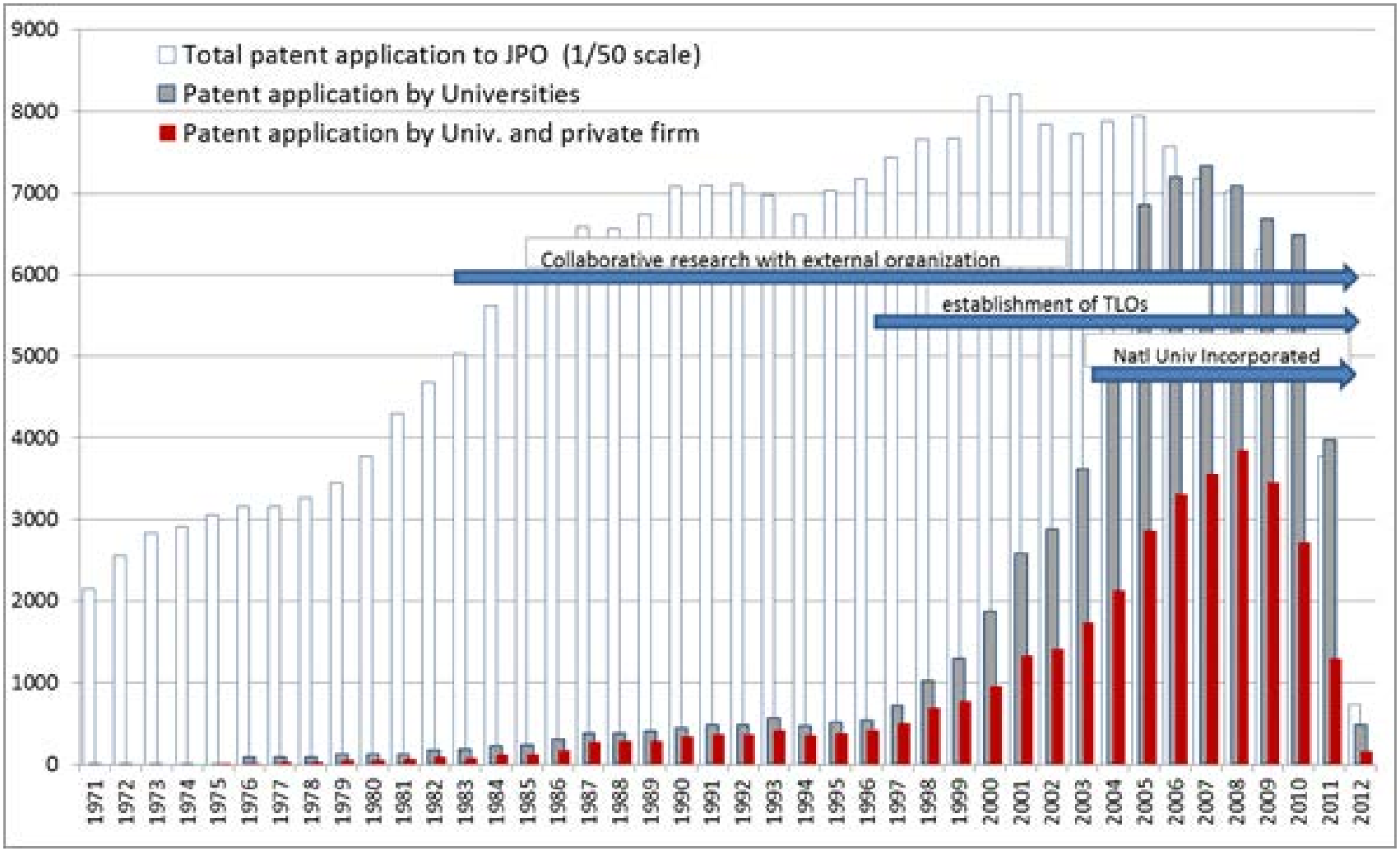
Trends of RIKEN's patent applications



Trends of JAXA's patent applications



Trends of universities' patent applications



Statistical analysis

- Four measures drawn from patent data to describe PRI performance:
  - ① *Technological value*: Inventor forward citations with 5-year window
  - ② *Exclusionary value*: Examiner forward citations with 5-year window
  - ③ *Expected market value*: Family size of patent
  - ④ *Knowledge spillover*: Generality index

- Following factors, which might be related to the characteristics of research projects
  - *Joint patent* : Joint patent application with private firms
  - *Inventor backward citations:* Backward citations to patents
  - *Science linkage:* Backward citations to non-patent literatures
  - *Team size* : No. of inventors

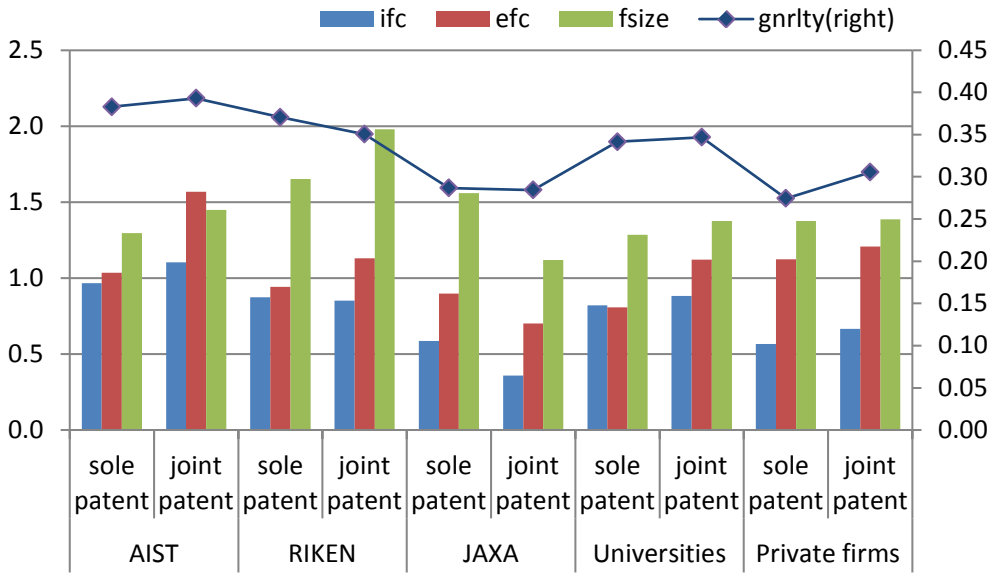
- Sample for statistical analysis:
  - Application year: 1992-2005, Observations: 78,866 patents (33,823 patents)

Average performance measures by organization and collaboration structure

- Technological value (inventor forward citations) of AIST' and universities' joint patents is slightly higher than their sole patents.

- Business value (examiner forward citations, family size) of joint patents are higher than sole patents, as for patents of AIST, RIKEN and universities.

- Generality of patents of AIST, RIKEN and universities is broad, compared to firms' patents.

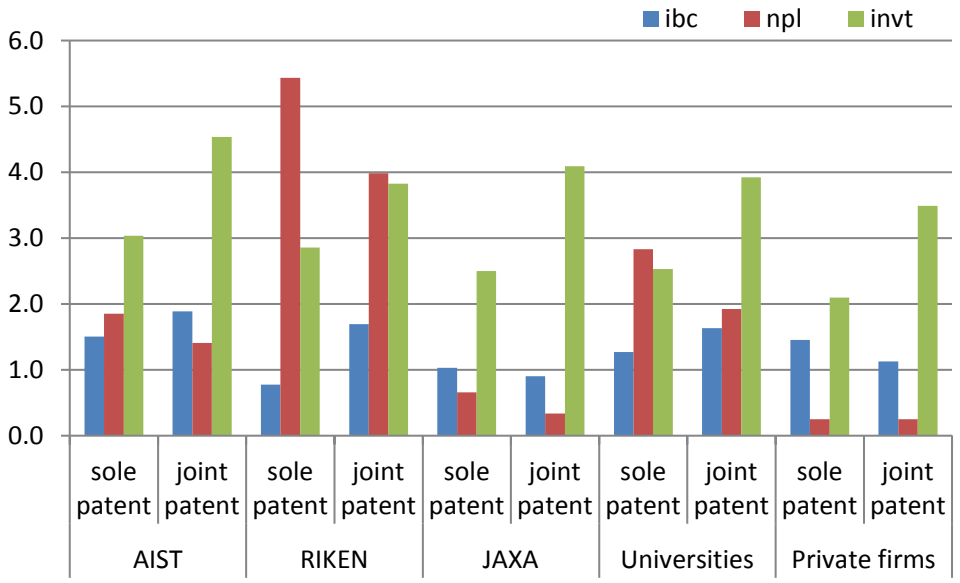


Average input measures by organizations and collaboration structure

- Science linkage of RIKEN's patents is high.
- Science linkage of joint patents are lower than that of sole patents, as for PRIs and universities.

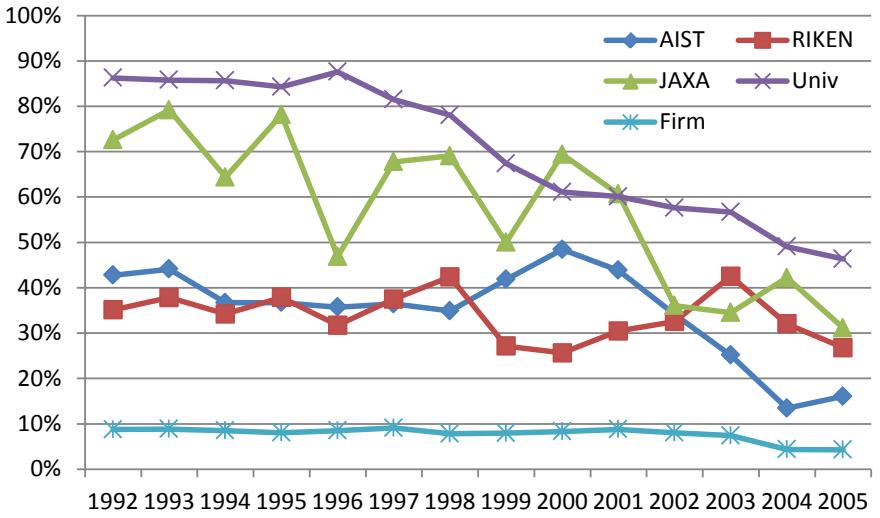
- Inventor backward citations are higher than that of sole patents, as for PRIs and universities.

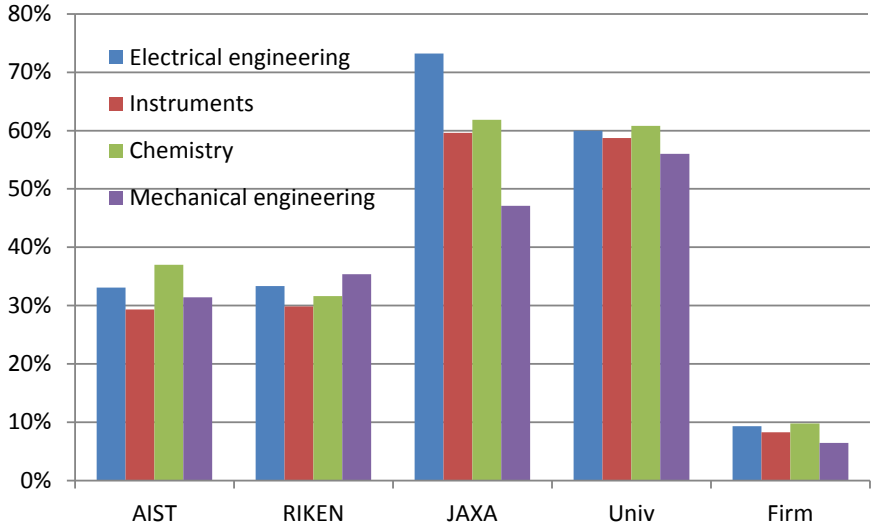
- Team size of joint patents are larger than sole patents.



Trends of share joint patents by organization, and share by technology sector

- Share of AIST's joint patents was decreasing after 2001
- Share of universities' joint patents was decreasing after 1997.





As for AIST, RIKEN and universities, shares of joint patents do not differ by technology sectors

Estimation①

- Patent level estimation:

- Dependent variable: Four performance measures
  - ① Technological value
  - ② Exclusionary value
  - ③ Expected market value
  - ④ Knowledge spillover

- Estimation method
  - ①②: Negative binomial, ③:Poisson, ④:OLS

Estimation②

- Independent variables:
  - Organization dummies, Joint-patent dummy, Aft2001 dummy
  - Organization dummy × Joint-patent dummy
  - Organization dummy × Aft2001 dummy

  (⇒ Baseline: private firms' sole patents before 2000)

  - Other input measures:
    - Inventor backward citations to patents
    - Science linkage (Backward citations to non-patent literature)
    - Team size (No. of inventors)

- Control variables:
  - Dummies of technology class (WIPO 33 ITC class)

Estimation results

explanation	variable	(1) NB Tech value ifc	(2) NB Exclsinry value efc	(3) Poisson Expctd mrkt val fsize	(4) OLS Kwldg spillover gnrlty
AIST	dum_aist	0.440***	-0.137***	-0.101***	0.068***
		(0.043)	(0.031)	(0.018)	(0.008)
RIKEN	dum_riken	0.410***	-0.067	0.131***	0.049***
		(0.099)	(0.072)	(0.036)	(0.017)
JAXA	dum_jaxa	-0.169	-0.355***	0.090	0.019
		(0.168)	(0.115)	(0.060)	(0.028)
Univ.	dum_univ	0.277***	-0.138***	-0.083***	0.071***
		(0.043)	(0.030)	(0.017)	(0.007)
Joint patent	joint_pat	0.165***	0.044	-0.015	0.025***
		(0.040)	(0.028)	(0.015)	(0.007)
After 2001	aft2001	0.382***	-0.098***	0.104***	-0.015***
		(0.022)	(0.015)	(0.008)	(0.004)
PRI x Joint patent interaction term	dum_aist * joint_pat	-0.160***	0.264***	0.089***	-0.026**
		(0.059)	(0.042)	(0.024)	(0.010)
	dum_riken * joint_pat	-0.396***	0.032	0.164***	-0.050**
		(0.122)	(0.090)	(0.043)	(0.022)
	dum_jaxa * joint_pat	-0.595***	-0.307**	-0.331***	-0.031
		(0.175)	(0.123)	(0.065)	(0.031)
	dum_univ * joint_pat	-0.184***	0.143***	0.045**	-0.035***
		(0.049)	(0.035)	(0.019)	(0.009)

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Estimation results (cont.)

explanation	variable	ifc	efc	fsize	gnrlty
PRI x After2001 interaction term	dum_aist * aft2001	-0.189***	0.095***	-0.075***	-0.005
		(0.049)	(0.035)	(0.020)	(0.009)
	dum_riken * aft2001	-0.084	0.042	-0.109***	0.052***
		(0.115)	(0.085)	(0.041)	(0.020)
	dum_jaxa * aft2001	0.186	0.240**	-0.025	0.002
		(0.175)	(0.121)	(0.064)	(0.030)
	dum_univ * aft2001	-0.177***	-0.164***	-0.114***	-0.021***
		(0.042)	(0.029)	(0.016)	(0.007)
Number of inventors	ln_invt	0.222***	0.183***	0.102***	0.011***
		(0.014)	(0.010)	(0.006)	(0.003)
Inventor bkwd citation	ln_ibc	0.311***	0.116***	0.048***	0.009***
		(0.011)	(0.008)	(0.005)	(0.002)
Science linkage	ln_npl	0.150***	0.026***	0.054***	0.006**
		(0.013)	(0.010)	(0.005)	(0.002)
	Constant	-1.484***	-0.689***	0.064**	0.221***
		(0.078)	(0.059)	(0.030)	(0.014)
Technology field contro	itc2 - itc33	Yes	Yes	Yes	Yes
	Observations	78866	78866	78866	33823
	(Pseudo) R-Squared	0.02	0.01	0.01	0.08
	Log Likelihood	-83397.43	-111592.73	-105972.14	

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

Estimation results

- PRIs' sole patents vs. Firms' sole patents
  - Positive performance:
    - AIST: Technology value, Knowledge spillover
    - RIKEN: Technology value, Expected market value, Knowledge spillover
    - Universities: Technology value, Knowledge spillover
- PRIs' joint patents vs. Firms' joint patents
  - Positive performance:
    - AIST: Technology value, Exclusionary value, Knowledge spillover
    - RIKEN: Expected market value
    - Universities: (Technology value), (Exclusionary value), Knowledge spillover

Significance of difference b/w PRI's and firm's joint patents

	Before 2000				After 2001			
	ifc	efc	fsize	gnrlty	ifc	efc	fsize	gnrlty
AIST's joint patents vs. firms' joint patents	++	++	−−−	+++		++	−−−	
RIKEN's joint patents vs. firms' joint patents			+++				+++	
JAXA's joint patents vs. firms' joint patents	−−−	−−−	−−−		-	−−−	−−−	-
Univ's joint patents vs. firms' joint patents	++	++	−−−	+++		−−−	−−−	

* Number of + or − means significance, +: significant at 10%, ++: significant at 5%, +++: significant at 1%

** + or - means sign of coefficient

Discussions①

- Contribution to pool of public knowledge by creating patents with high technological value
  - Sole patents of AIST, RIKEN, Universities
  - AIST's (and universities') joint patents with private sectors

- Contribution to supporting firms activities by creating patents with high business value
  - RIKEN's sole and joint patents
  - AIST's and universities' joint patents

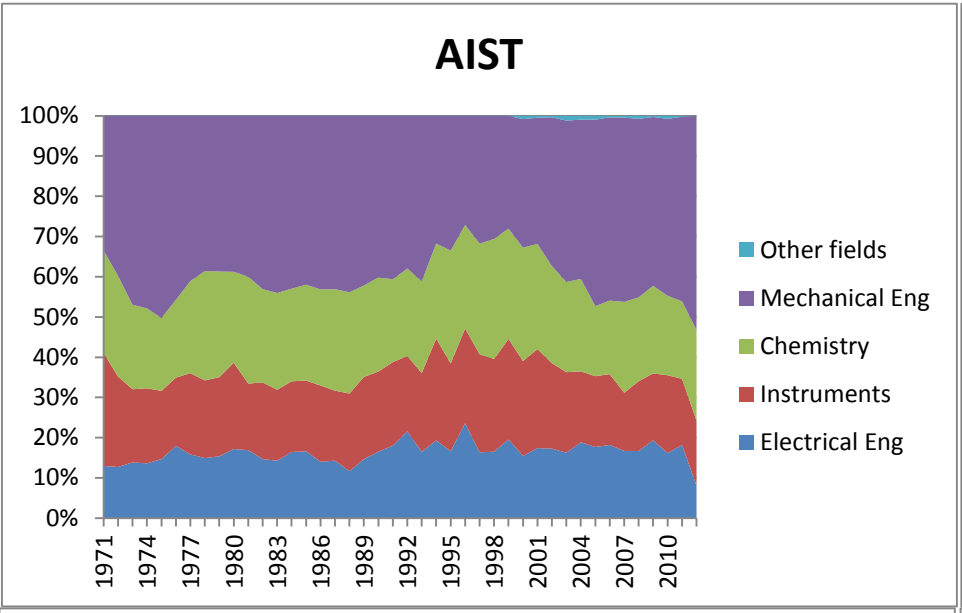
- Contribution to Knowledge spillover in the economy
  - AIST's, RIKEN's and universities' sole patents
  - AIST's and universities Joint patents

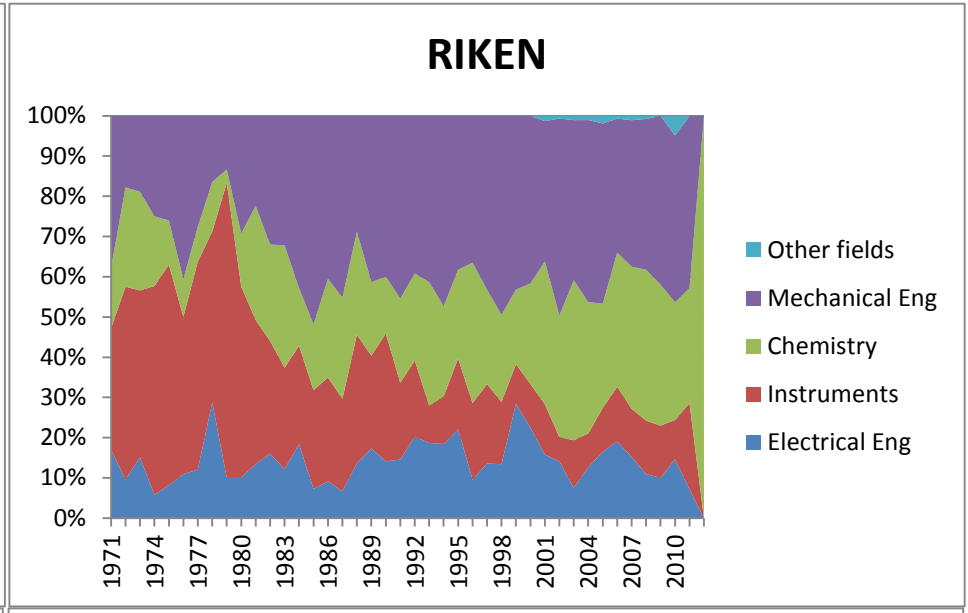
Discussion ②

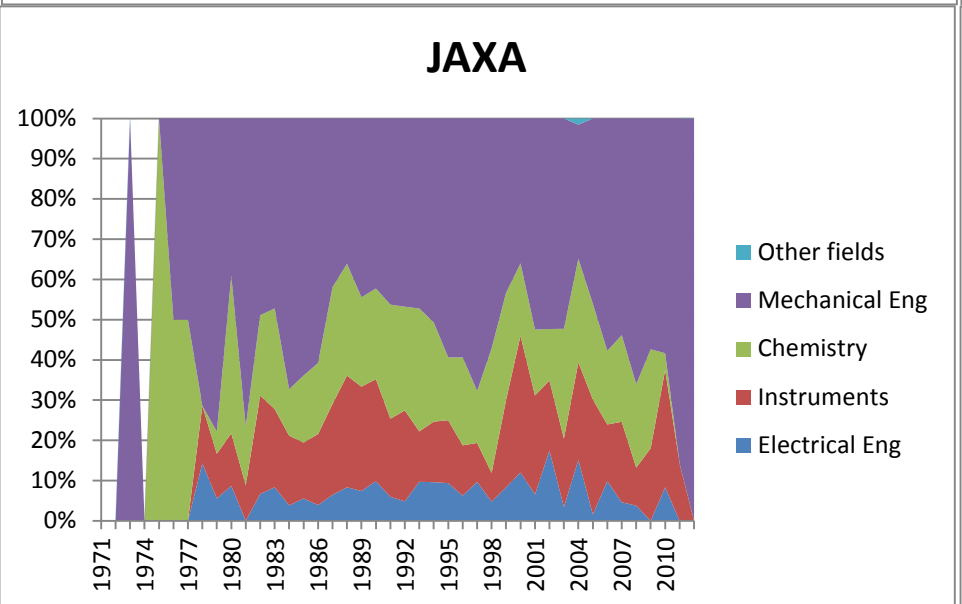
- As for JAXA, their sole patents have lower business value than private firms' sole patents. JAXA's joint patents tended to have even lower technological and business value compared to joint patents of firms.
- These results are considered to be the consequences of JAXA's R&D activity, which is deeply integrated with the small number of firms that have specific missions. Such technological knowledge might not be versatile and is cited rarely.

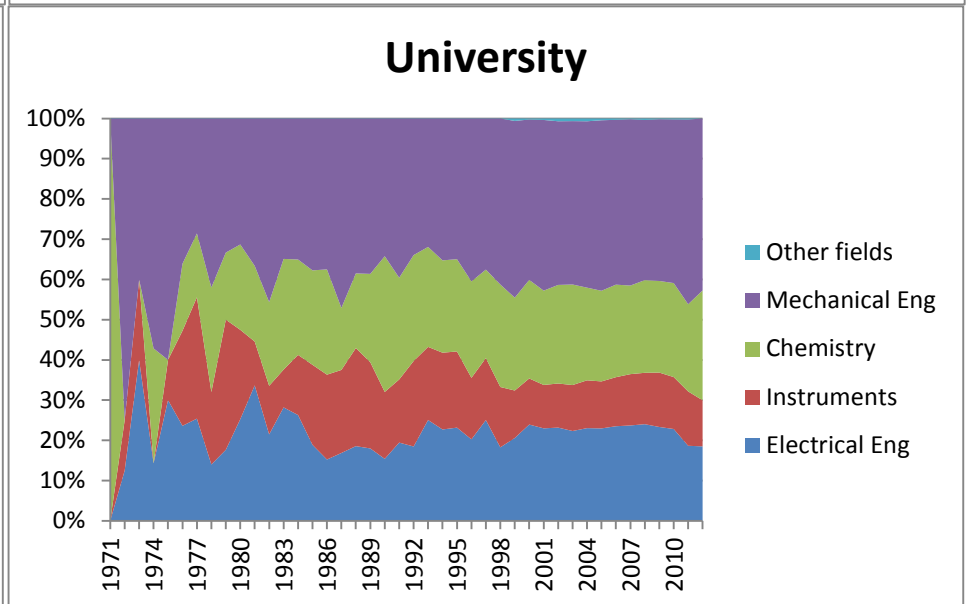
- Fundamental scientific knowledge (represented by the science linkage), accumulated technological knowledge (represented by inventor backward citation), and team size (represented by the number of inventors), are factors associated with PRI's and universities research performance.

Trends of application share by ITC sec.









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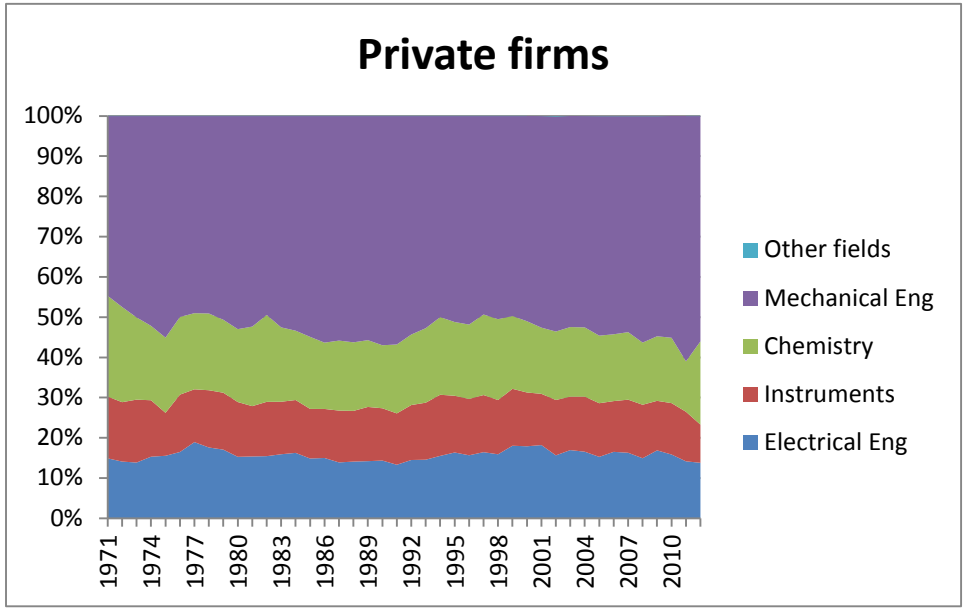
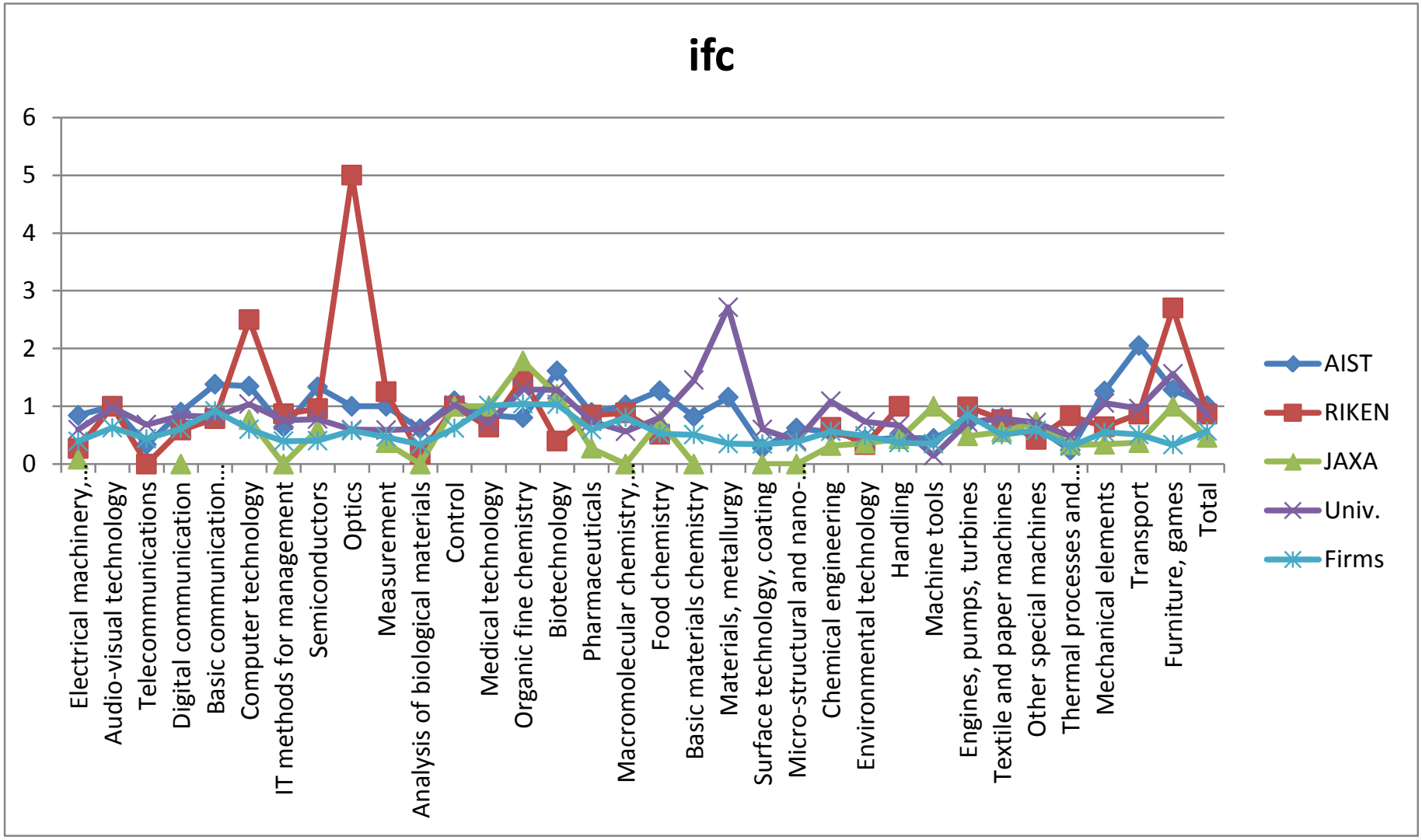


Average ifc （Sample for estimation）



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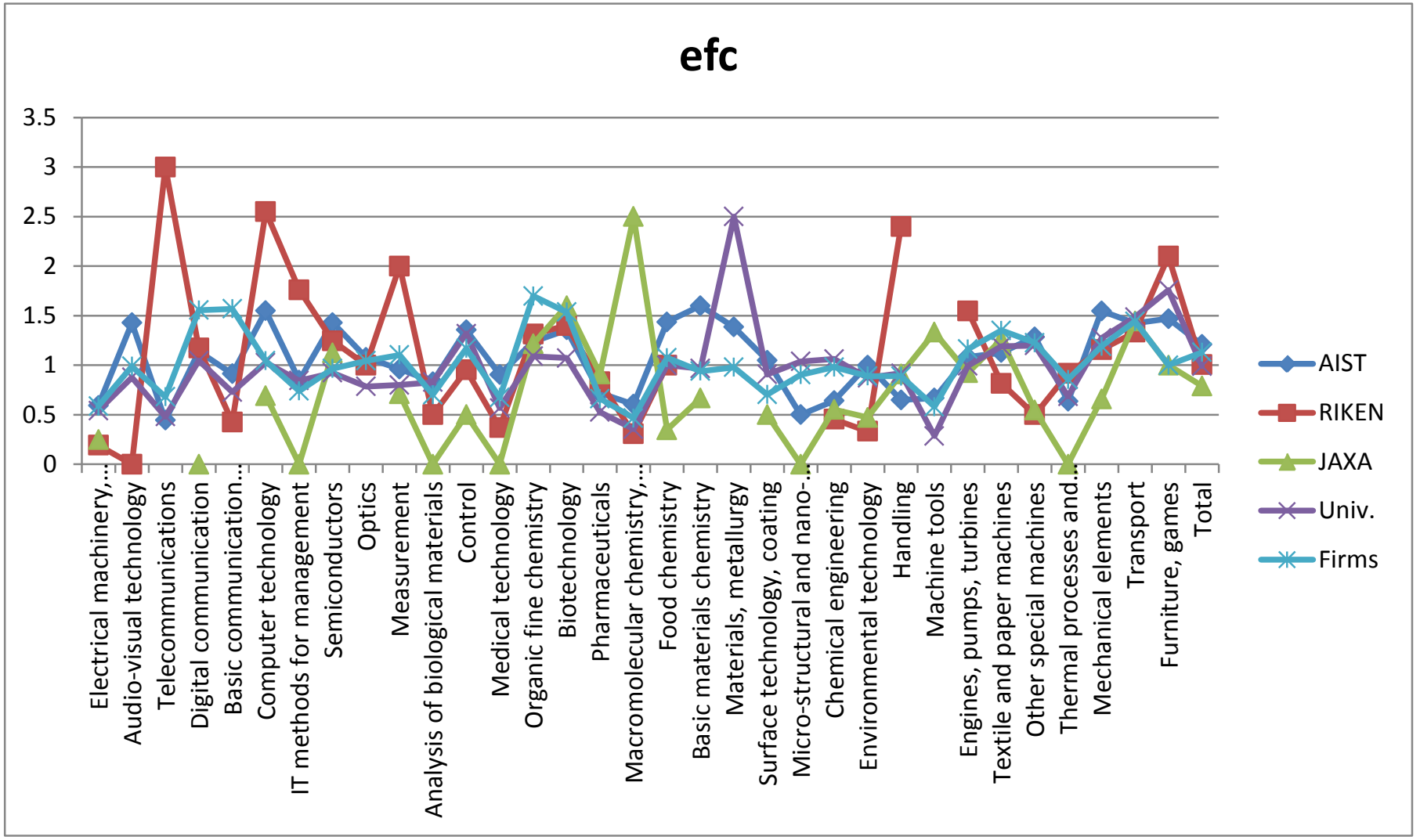
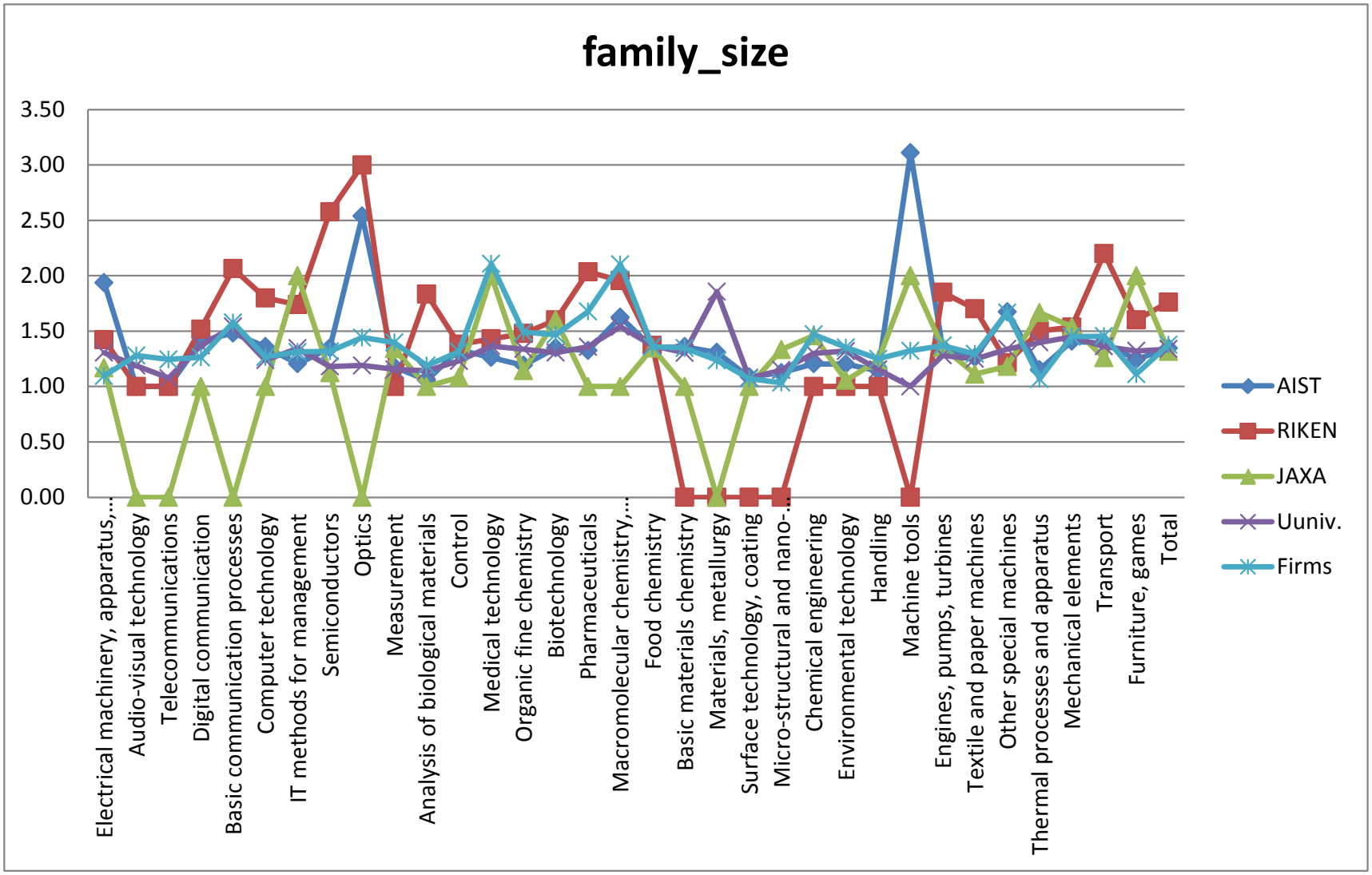


Average fsize (Sample for estimation)



Average gnrlty （Sample for estimation）