R&D and Patent Data for Empirical Analysis for Evidence Based Science, Technology and Innovation Policy

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Abstract

In this paper, the contribution of empirical economic analysis to evidence based science, technology and innovation policy planning is discussed based on two case studies, (1) financial supports to firm's R&D by subsidies or tax measures and (2) innovation system reform policy such as university and industry collaboration promotion. It is important to make a good balance of "theoretical rigidness", "practicality by addressing important issues" and "quality of dataset" for empirical policy analysis. In addition, the results from empirical analysis should be interpreted with substantial reservations in terms of the limitations of economic theory and datasets.

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Outline of presentation

- Framing evidence based science and technology policy (based on economics discipline)
- Example of micro analysis of S&T policy: Policy evaluation of R&D tax break
- Example of macro analysis for innovation system transformation: university and industry collaboration promotion policy
- Implications for SciREX program by Japanese government

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Framework of S&T policy analysis

Direct support of R&D (micro policy)

- Public spending of R&D for science sector
- R&D subsidy for firms
- R&D tax credit

➡ Meeting "Additionality" condition?

Innovation system reform policy (macro policy)

- University industry collaboration promotion: TLO, Baye Dole Act etc.
- Science system reform: institutional reform in science sector (incorporation of national universities), promotion of young and women researchers' activities

➡ Incorporating systemic nature of innovation players?

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Micro policy analysis

Meeting "Additionality" condition?

- Net gain can be achieved after taking into account all positive and negative impacts?
- R&D subsidy -> "Crowding out" factor should be taken into account
- R&D tax credit -> Money saved after tax measures are used for additional R&D spending (instead of other purpose of use)
- Requires behavioral model of firms to simulate changes in incentives for R&D

Example of R&D tax credit analysis
-Changes in incentive system in 2003 from "tax credit for incremental change compared to previous years" to "tax credit for all R&D spending"

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Behavioral model of firms (1)

$$f(RD_t) = \sum_{t=0}^{\infty} \frac{(1-\tau)Y_t(K_t) - \theta_t RD_t - \Phi(RD_t, K_t)}{(1+r)^{-t}}$$

$$K_t = (1-\delta)K_{t-1} + RD_t$$

$$Y_t = A \cdot K^{\alpha} \bullet \bullet$$

$$\Phi(RD_t, K_t) = \frac{1}{2\phi} \cdot \frac{RD_t^{\,2}}{K_t}$$

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Behavioral model of firms (2)

$$\frac{RD_{t+1}}{K_{t+1}} = \frac{1+r}{1-\delta}\left[\frac{RD_t}{K_t} - \frac{1}{2}\left(\frac{RD_t}{K_t}\right)^2 + \phi\left(\frac{\theta_t}{1-\tau_t} - \alpha\frac{Y_t}{K_t}\right)\right] - \phi\frac{\theta_{t+1}}{1-\tau_{t+1}}$$

$$\theta_t = P_t^{RD}(1 - T_t(\tau + ETC_t))$$

$$ETC_{i,t} = TC_t^c(B_t - \frac{1}{k}\sum_{i=1}^{k}(1+r)^{-i} B_{t+i})$$

（実証モデル）

$$rd_t = \beta_1 \cdot rd_{t-1} + \beta_2 \cdot rd_{t-1}^2 + \beta_3 \cdot y_{t-1} + \beta_4 \cdot tax_t + \beta_5 \cdot tax_{t-1}$$

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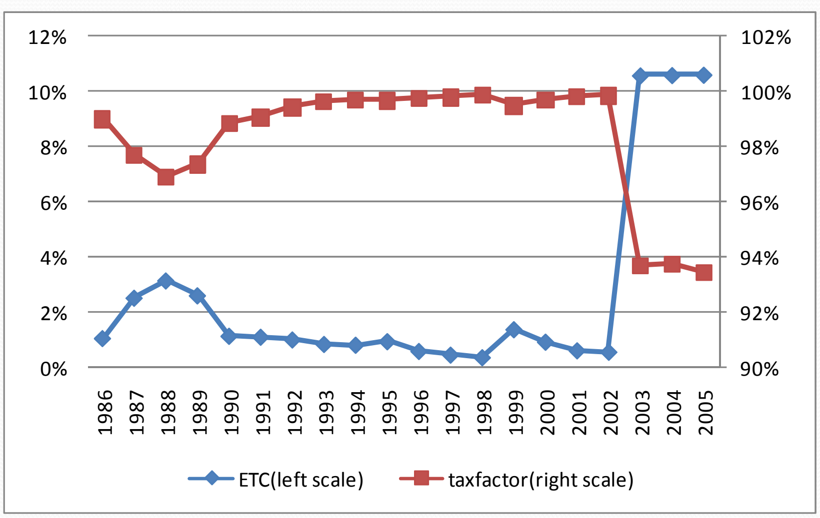
Effective tax credit ratio (ETC) and tax factor (θ)



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Results of Empirical analysis

	(1) OLS	(2) FE	(3) FE	(4) SYS-GMM	(5) SYS-GMM
rd(t-1)	0.757 (79.54)**	0.545 (46.44)**	0.540 (46.17)**	0.909 (28.89)**	0.877 (30.56)**
rd2(t-1)	-0.283 (28.49)**	-0.143 (12.68)**	-0.138 (12.28)**	-0.423 (9.04)**	-0.377 (9.31)**
y(t-1)	0.0001 (10.49)**	0.0003 (13.72)**	0.0003 (13.39)**	0.0001 (1.73)	0.0001 (1.78)
taxfactor(t)	-0.971 (35.78)**	-0.848 (32.71)**	-0.990 (35.62)**	-0.693 (3.17)**	-0.515 (3.14)**
taxfactor(t-1)	0.382 (13.71)**	0.295 (10.44)**	0.361 (12.46)**	0.373 (2.63)**	0.277 (2.55)*
debtratio			-0.032 (6.33)**		-0.032 (3.71)**
cashr			-0.019 (3.72)**		0.012 (0.71)
Constant	0.915 (36.12)**	0.869 (35.47)**	1.005 (38.49)**	0.484 (3.23)**	0.387 (3.38)**
Observations	14957	14981	14904	14957	14915
# of groups	-	1244	1223	1244	1223
Industry dummy	yes	-	-	yes	yes
Year dummy	yes	yes	yes	yes	yes
R-squared	0.68	0.58	0.58	-	-
Hansen-J	-	-	-	0.108	0.026

Absolute value of t statistics in parentheses
* significant at 5%; ** significant at 1%

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Interpretation of results

- Decrease in tax factor (by stronger R&D tax system) induces R&D investing in next year (-0.692 or -0.515), but decrease R&D (+0.373 or +0.277) in 2 years after.
- A long term effect will be -0.319(-0.692+0.373) or -0.238 (-0.515+0.277).
- Tax factor deceases by 6% from 2002 to 2003, then the effect of change on R&D will be 1.5% - 2.0%.

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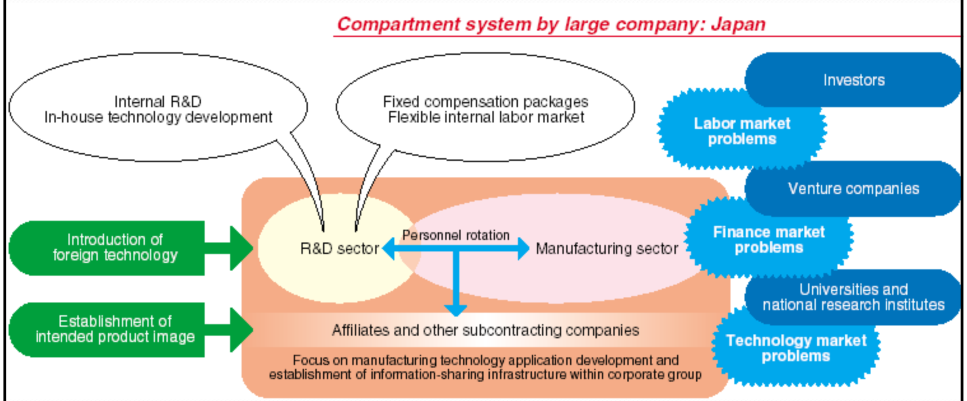
Macro policy analysis
-Reforms of Japan's National Innovation System-



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Impact of university-industry collaboration promotion policy

Evolution of Japan's UIC policy.

1998	Formulation of the Act on the Promotion of Technology Transfer from Universities to Private Industry (the TLO Act) → Promoted the establishment of TLOs (Technology Licensing Organizations) Amendment of the Law for Facilitating Governmental Research Exchange → Made it possible to use government-owned land at low cost for joint university–industry research
1999	Creation of the Small Business Innovation Research Program ("Japanese SBIR") Formulation of the Act on Special Measures for Industrial Revitalization → Japanese version of the Bayh–Dole Act/licensing fee halved for approved TLOs Establishment of the Japan Accreditation Board for Engineering Education (JABEE)
2000	Formulation of the Industrial Technology Enhancement Act → Enabled gratis use of national university facilities by approved/certified TLOs, allowed university researchers to serve concurrently as TLO directors, board directors of companies commercializing research results, and statutory auditors of stock corporations
2001	"Hiranuma Plan" announced "Plan for 1000 university-originated ventures in three years"
2002	Revision of the Ministry of Finance Property Administration Bureau Notification No. 1 → Allowed university-originated ventures to use national university facilities Revision of the TLO Law Notification → Made it easier for businesses to start approved TLOs
2003	Formulation of the Intellectual Property Basic Act → Obligated universities to voluntarily and actively seek to develop human resources, research activities, and disseminate research results Amendment of the School Education Law → Created special emphasis graduate school systems, increased flexibility in establishing university faculties/departments
2004	Implementation of the National University Corporation Law → Status of university researchers: "non-civil servant type," capital contributions to approved TLOs Implementation of the Act for Partial Revision of the Patent Act → revision of patent-related charges relating to universities and TLOs.

(Motohashi and Muramatsu, 2012)

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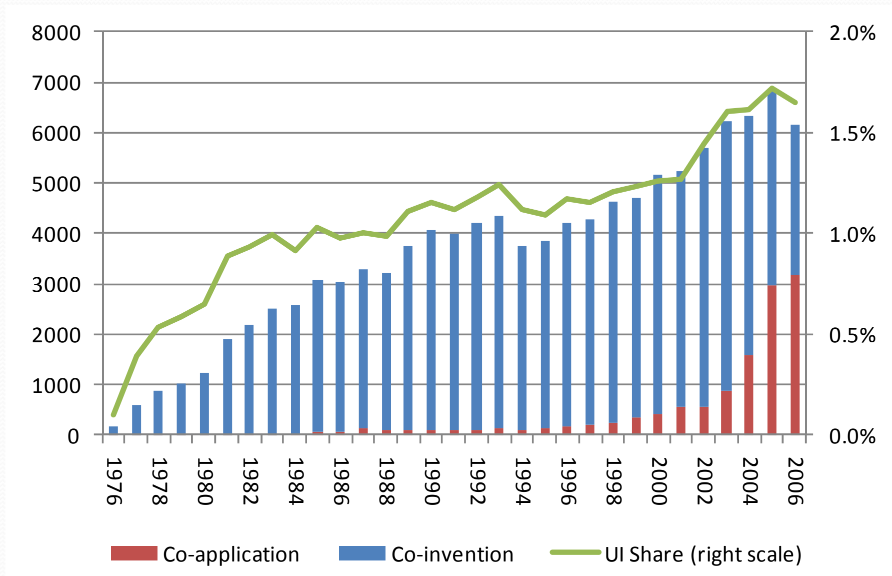
Trend of UI patents



Existing Studies

- Trajtenberg et al. (1997): University patents have greater generality (index), in a sense of spillover effect of wider technological fields.
- Henderson et. al (1998): After Baye-Dole Act, the quality of US university patents decrease over time
- Sampat et al. (2003): Not really, Henderson et. al (1998) used too short time scope for patent citation analysis
- Mowery and Ziedonis (2002): Looked at the patent quality by universities and found no quality decline in top universities, but it was found in new comers in patent filings.
- Thursby and Thursby (2002): Increasing patent applications and licensing by universities does not come from changes of university research focus, but from activating licensing functions there.
- Mowrey and Sampat (2005): US Bale Dole style policy action has been taken in many other OECD countries, but in different institutional settings of university system

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Results (1): How about quality?

Variable	Mean difference UIC-matched	Wilcoxon signed rank test
Overall sample		(obs=162303)
Numbers of claims	-0.321	+++
Number of inventors	1.553	+++
Number of forward citations	0.201	+++
Number of forward self-citations	-0.007	---
Number of forward nonself-citations	0.223	+++
Generality index	0.021	+++
application year ~1999		(obs=102489)
Numbers of claims	-0.030	+++
Number of inventors	1.622	+++
Number of forward citations	0.240	+++
Number of forward self-citations	-0.032	---
Number of forward nonself-citations	0.293	+++
Generality index	0.022	+++
applied after 2000		(obs=59814)
Numbers of claims	-0.825	
Number of inventors	1.446	+++
Number of forward citations	0.142	+++
Number of forward self-citations	0.037	++
Number of forward nonself-citations	0.103	+++
Generality index	0.009	

Note:
+: UIC>matched, +++: 1% level, ++: 5% level, +: 1% level statistically significant
-: UIC<matched, ---: 1% level, --: 5% level, -: 1% level statistically significant

Results (2): SF more quality upgrade?

Variable	Mean difference small-large	Mann-Whitney U-test
Overall sample		
Numbers of claims	0.192	--
Number of inventors	0.108	+++
Number of forward citations	-0.079	---
Number of forward self-citations	-0.131	---
Number of forward nonself-citations	0.052	++
Generality index	0.004	
application year ~1999		
Numbers of claims	0.354	+++
Number of inventors	0.225	+++
Number of forward citations	0.000	
Number of forward self-citations	-0.170	---
Number of forward nonself-citations	0.170	+++
Generality index	0.011	
applied after 2000		
Numbers of claims	0.289	--
Number of inventors	0.073	+++
Number of forward citations	-0.128	---
Number of forward self-citations	-0.117	---
Number of forward nonself-citations	-0.012	
Generality index	-0.038	

Note:
+: small>large, +++: 1% level, ++: 5% level, +: 1% level statistically significant
-: small<large, ---: 1% level, --: 5% level, -: 1% level statistically significant

Results (3): Co-invention vs co-application?

Variable	Mean difference inv-apply	Mann-Whitney U-test
Overall sample		
Numbers of claims	0.332	
Number of inventors	0.185	+++
Number of forward citations	0.204	+++
Number of forward self-citations	0.010	++
Number of forward nonself-citations	0.204	+++
Generality index	0.027	

Note:

+: inv>apply, +++: 1% level, ++: 5% level, +: 1% level statistically significant

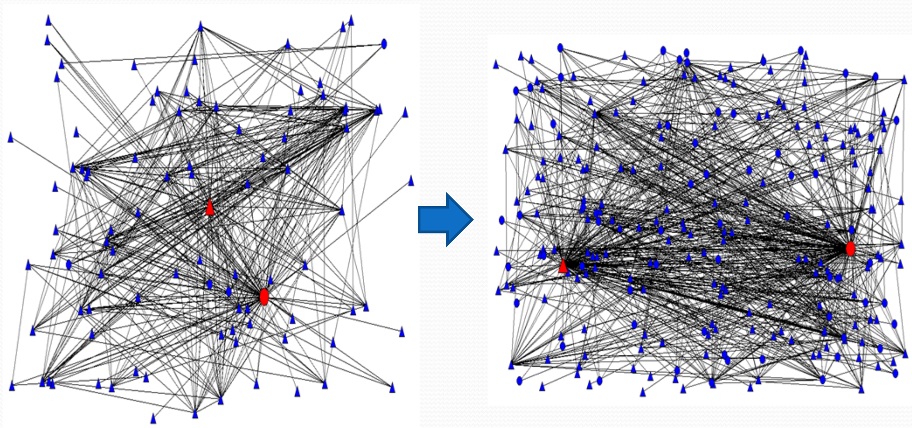
-: inv<apply, ---: 1% level, --: 5% level, -: 1% level statistically significant

Summary of findings

- UI reforms: stimulated knowledge spillover from university to industry (both quantity and quality)
- SME premium over LE in a sense of innovativeness of UI results disappears (lower UI hurdle for SMEs?)
- University's ownership affected firm's incentives for UI activities

Additional results (on-going research)

-Difference of network structure of UI co-applications-



1995-1999 2000-2004

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Difference Social Network Indicators

	1995-99	2000-04
N. of patents	1615	4758
N. of applicants	1645	3118
N. of Corporations	1124	2404
N. of Universities	521	714
N. of Components	249	299
Size of Largest Component [a]	955 (58.1%)	2336 (74.9%)
Size of 2[nd] Largest Component [a]	12 (0.7%)	24 (0.8%)
N. of single cooperation (2-nodes component) [b]	150 (60.2%)	197 (65.9%)
Density	0.002	0.0014
Mean degree [c]	2.991	3.44
Average distance (reachable) [c]	6.473	4.982
Compactness [c d]	0.062	0.128

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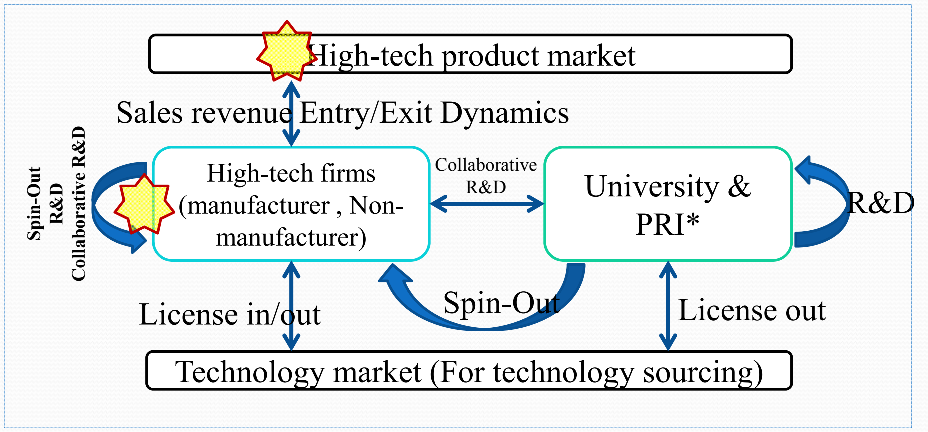
Agent Based Simulation on J-NIS



competition * Public Research Institute

(Kwon and Motohashi, on-going)

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Implications for evidence based S&T policy

- Importance of data: NISTEP innovation database platform (connection of S-T-I data, say, academic papers, patents, firm level database etc.)
- Keep in mind boundaries associated with modeling social events, so that it is important to have different analytical works for one issues. Again, the analysis based on common database facilitates cross fertilization of empirical research works
- Who can be an interpreter from “evidence” to “policy planning”? Human resource development program are on-going under SciRex program.

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