The organization of science and innovation in Japan and the US: 25 year retrospective

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Introduction

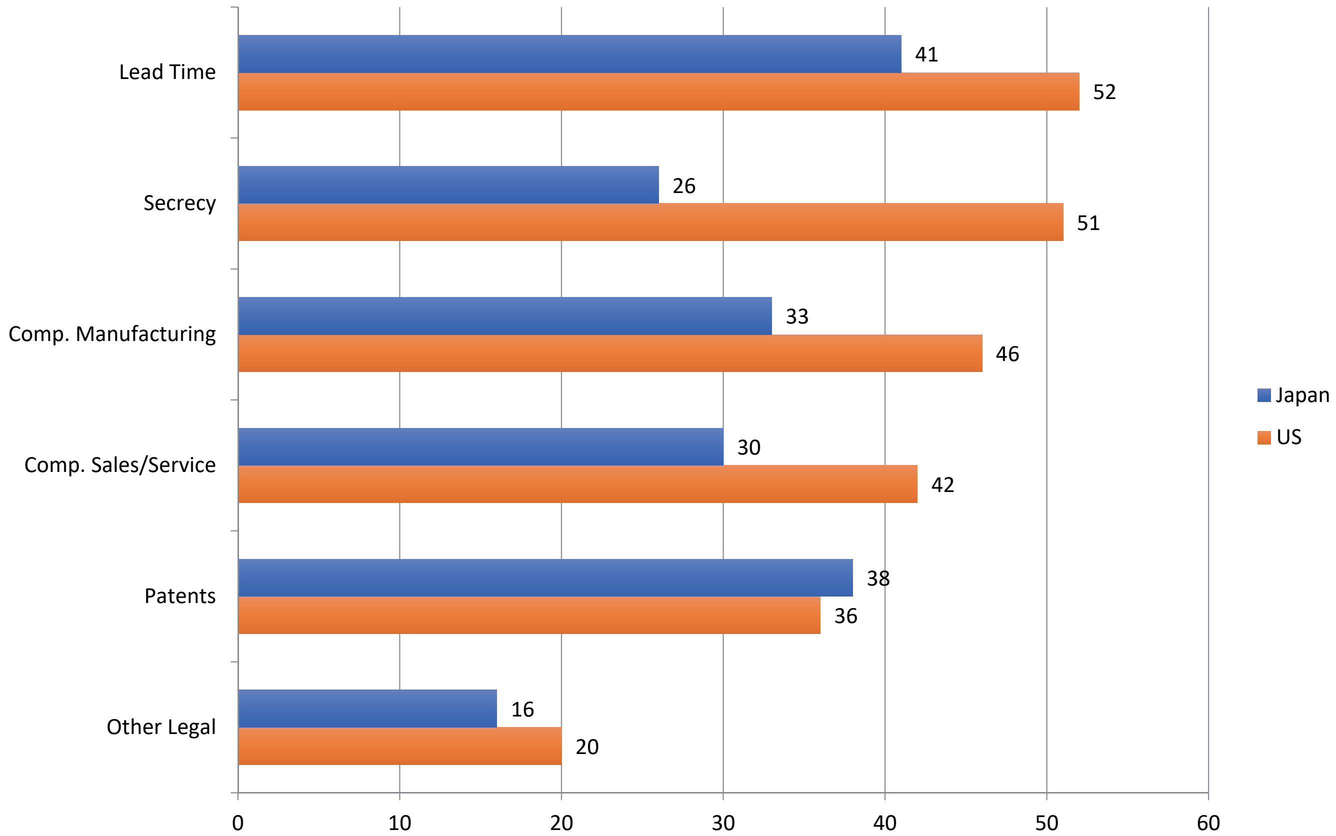
- Innovation is key to economic growth, and scientific progress is a key underpinning of innovation.
- One important question is, how are such innovations and scientific advances produced?
- Review several large scale surveys of science and innovation in Japan and the US
  - Focusing on the organization of science and innovation.
- Highlight key findings related to similarities and differences in the organization of science and innovation in each country

I. NISTEP-CMU R&D and Appropriability Survey (Goto, Nagata, Cohen, Nelson & Walsh) (1994)

- Surveyed R&D unit managers from manufacturing firms in the U.S. and Japan (Japan=593; US=826)

- 2002. Cohen, WM, A Goto, A Nagata, R Nelson and J Walsh. "R&D spillovers, patents and the incentives to innovate in Japan and the United States." Research Policy 31:1349-1367.
- Goto, A and A Nagata. 1997. "Technological Opportunities and Appropriating the Returns from Innovation: Comparison of Survey Results from Japan and the U.S." *NISTEP Report.* 48.

Appropriability Mechanisms, US and Japan



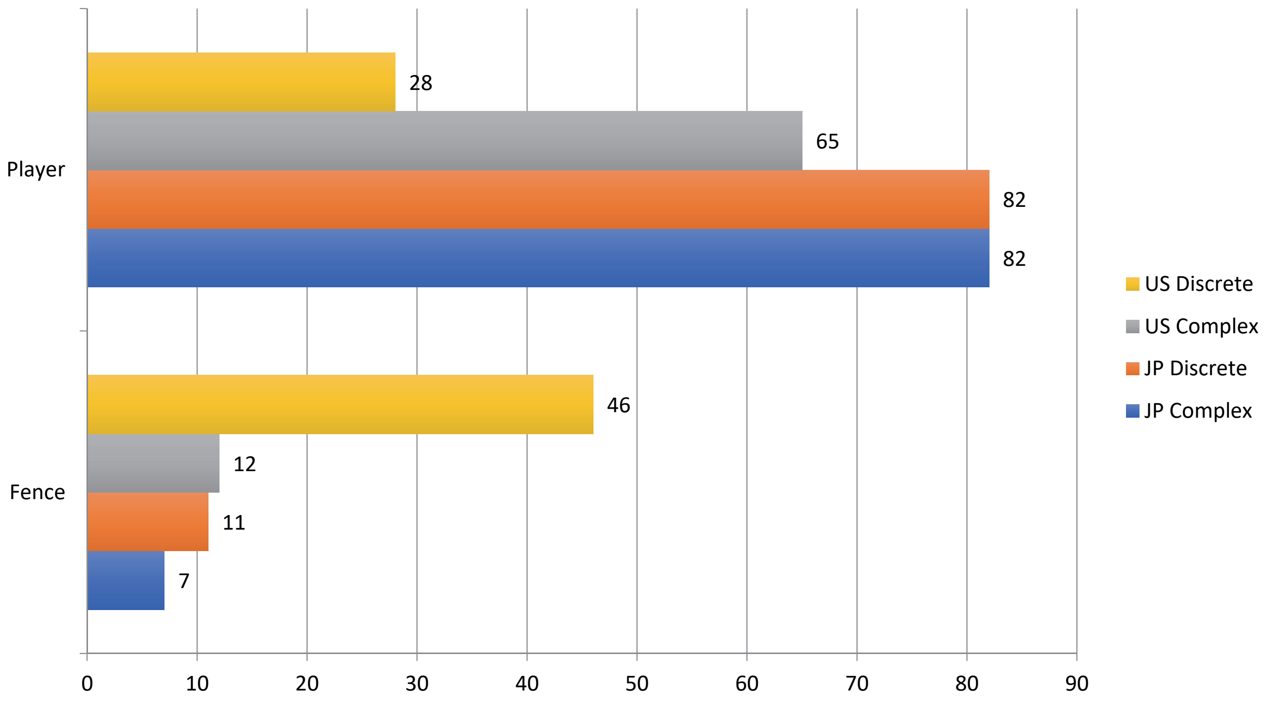
Appropriability Mechanisms (CMS/NISTEP)

- Lead time is most important for product innovations
- In US, secrecy also very important (but less so in Japan)
  - Spillovers seem to be higher in Japan—patent system?
- Patents much less important in US, but in Japan about as important as lead time
- For process patents, **secrecy**, complementary manufacturing capabilities and lead time most important

“Strategic” patenting

- Non-commercialized patents can be used to support commercialized technologies
- Fence: prevent inventing around
  - Patent many substitutes for commercialized product
  - More common in discrete products?
- Player: ensure you can participate
  - Patent enough components that any firm that accuses you of infringement would infringe you as well
  - More common in complex products?
- National differences? Japan v. US, due to differences in patent system, competition?

Strategic Patenting, US and Japan



Source: Cohen, et al., 2002

Fence: block but not license revenue or negotiation;

Player: block and negotiation, but not license revenue

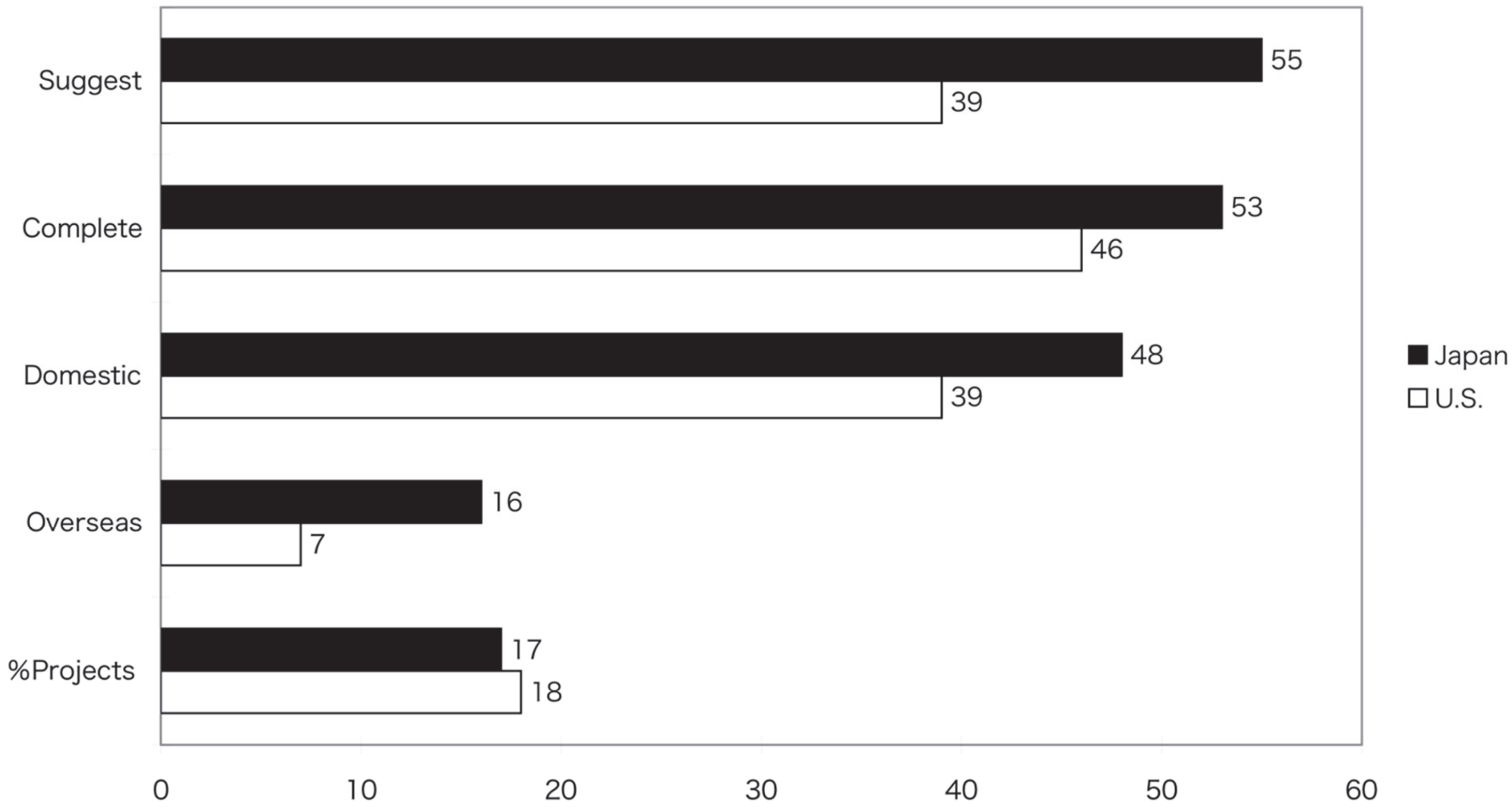
Strategic Patenting

- Fence more common in discrete
- Player more common in complex (cf. Hall and Ziedonis, 2001).
- Player more common in Japan, and little difference across industries
  - All industries are "patent complex"
- Fence less common in Japan
  - Patent system less geared toward "exclusivity"
- Changes since then (1993). May be less country difference now?

Impact of public research

- Suggested new projects
- Contributed to project completion
- Reliance on domestic institutions
- Reliance on overseas institutions
- Percent of projects

Figure 1. The impact of university research on industrial research projects in the U.S. and Japar



Impact of public research

- Generally not as strong as sources within the firm's own "chain of production" (though above suppliers in Japan)
- However, compares favorably with competitors
- Consistent with the "feedback" model, contribution to existing research at least as important as suggesting new projects
- Pervasive
  - Almost every industry has at least one academic field that the majority consider at least moderately important
- **Impact in Japan is generally greater than in the U.S.**
  - Not true that Japanese firms more active at information gathering generally

II. US-Japan Inventor Survey (Nagaoka & Walsh) (2007)

- Survey of inventors on triadic patents (Japan=3658; US=1919)

- Walsh, JP, Y-Na Lee, and S Nagaoka. 2016. "Openness and innovation in the US." Research Policy 45(8): 1660-1671.
- Nagaoka, S and JP Walsh. 2009. “Commercialization and Other Uses of Patents in Japan and the US.” RIETI DP 09-E-11.
- Walsh, JP and S Nagaoka. “Who invents?” RIETI DP 09-E-034.
- Nagaoka, S and JP Walsh. “The R&D process in the US and Japan.” RIETI DP 09-E-010.

Table 1. Basic Profile of Inventors, Japan, and US, triadic patents (Common technology structure)

		Japan	US
	Sample size	3658	1919
Academic Background	University graduate (%)	87.6	93.6
	Doctorate (%)	12.9	45.2
Demographics	Female (%)	1.7	5.2
	Age (mean years, std. dev.)	39.1 (9.1)	47.2 (9.9)
Organizational Affiliation	Large firm (500+ employees)(%)	83.6	77.1
	Medium firm (250-500)(%)	5.0	4.2
	Small firm (100-250)(%)	3.1	3.3
	Very small firm (lt 100)(%)	4.7	12.1
	University (%)	2.5	2.3
	Other	1.0	1.0

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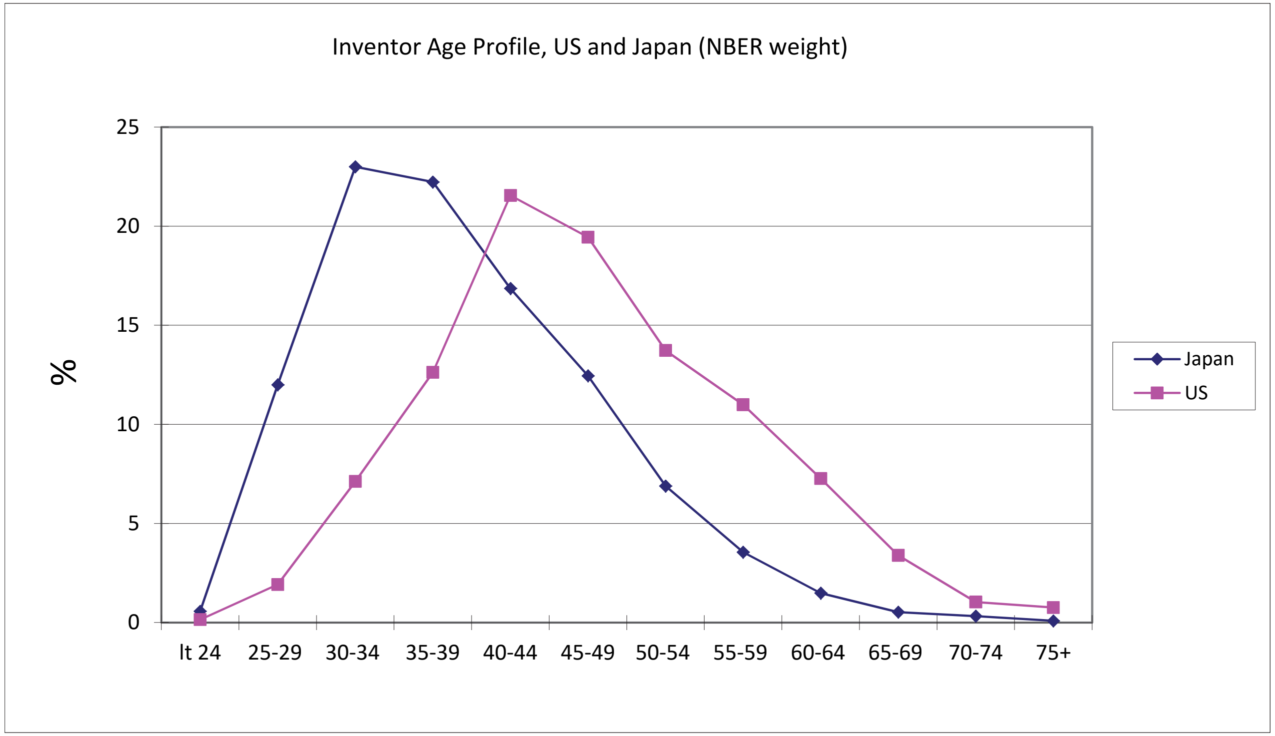
	Other	1.0	1.0

Organizational affiliation

- Most inventors were employed by organizations
- Employees of corporations with more than 500 employees made up about 80% of inventors in each country
- Inventors belonging to very small firms (lt 100 employees) more than twice as common in US than in Japan
- Inventors belonging to universities account for a small share of the triadic patents not only in Japan but also in the US

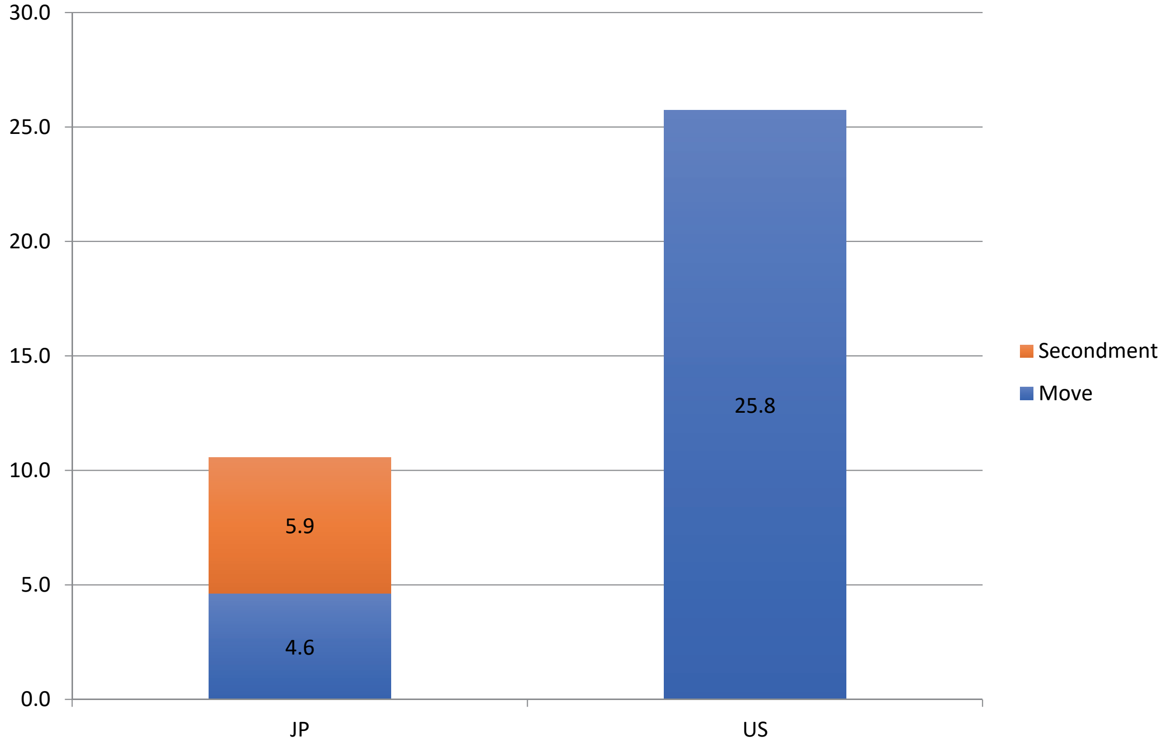
Figure 1. Age Profile, US and Japan (NBER weight)



Age profiles

- US inventors much older (47 v. 39)
- Variance in two countries similar
- Americans start later and stop later
  - Longer to graduate, more time before getting first permanent job and later retirement age?

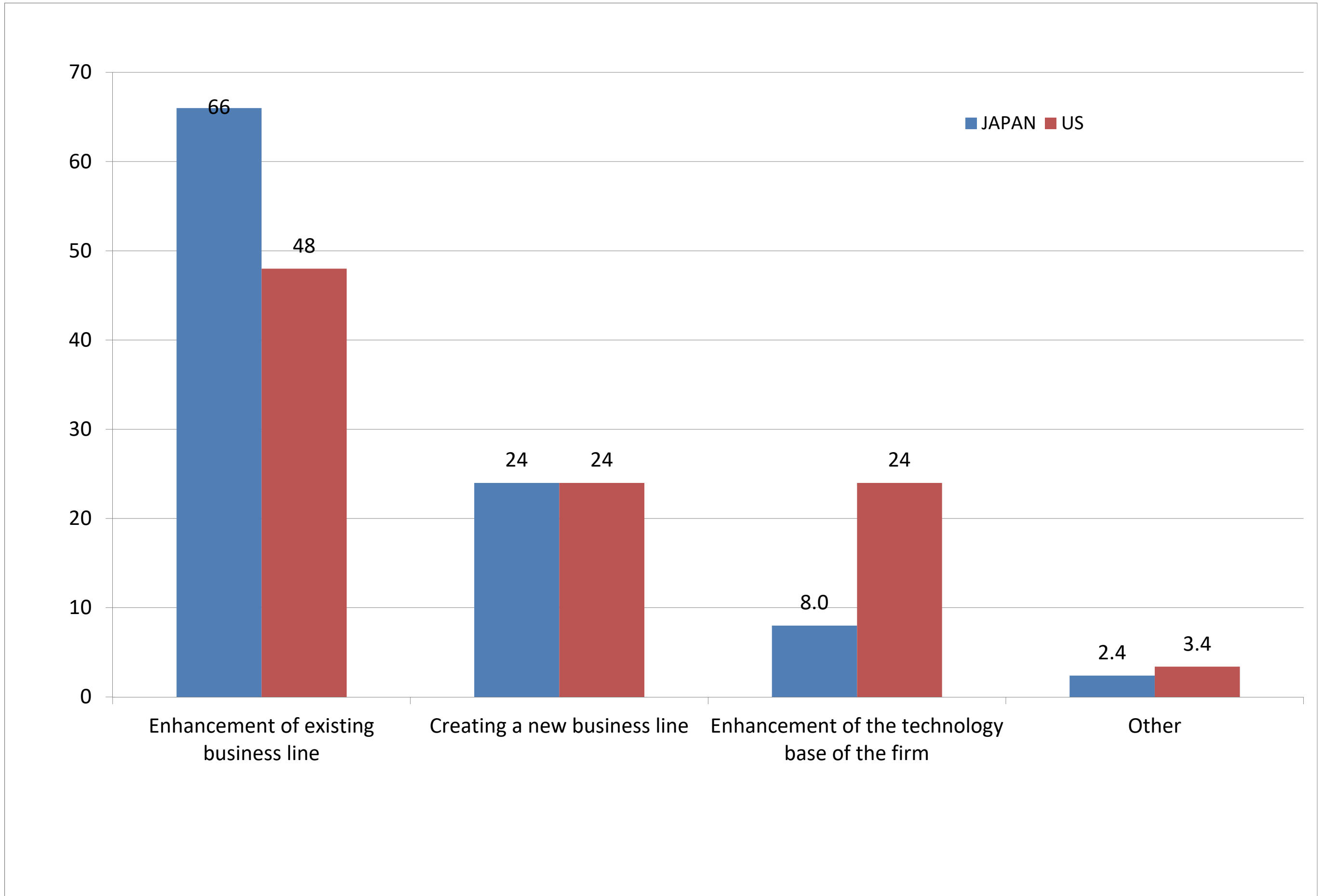
Figure 2. Inventor Mobility, US and Japan



Mobility

- Many foreign born in US
  - Immigrant inventors have higher value patents (Walsh and No, 2010)
- More mobility in US (even if include secondment for Japan).
  - But, if compare PhD v. non-PhD, Japanese PhD also relatively mobile and big gap is non-PhD
- Mobility greatest for those in small firms in both countries
  - In Japanese large firms, very little moving, though secondment is relatively common
  - Functional equivalents?
- Mobility associated with greater use of outside information

Figure 1 Business objectives of the research (%Yes)



Note. More than 95% of the samples in both countries are from the inventors affiliated with business firm. Based on the common technology class weights.

Project goals

- Fairly similar, existing lines of business most common in both Japan and US
- Japan relatively more projects on existing lines of business and US relatively more on enhancing the technology base
- Most projects are very modest
  - median is less than 12 person-months and less than 1 calendar year

Figure 4. Inventor Functional Affiliation

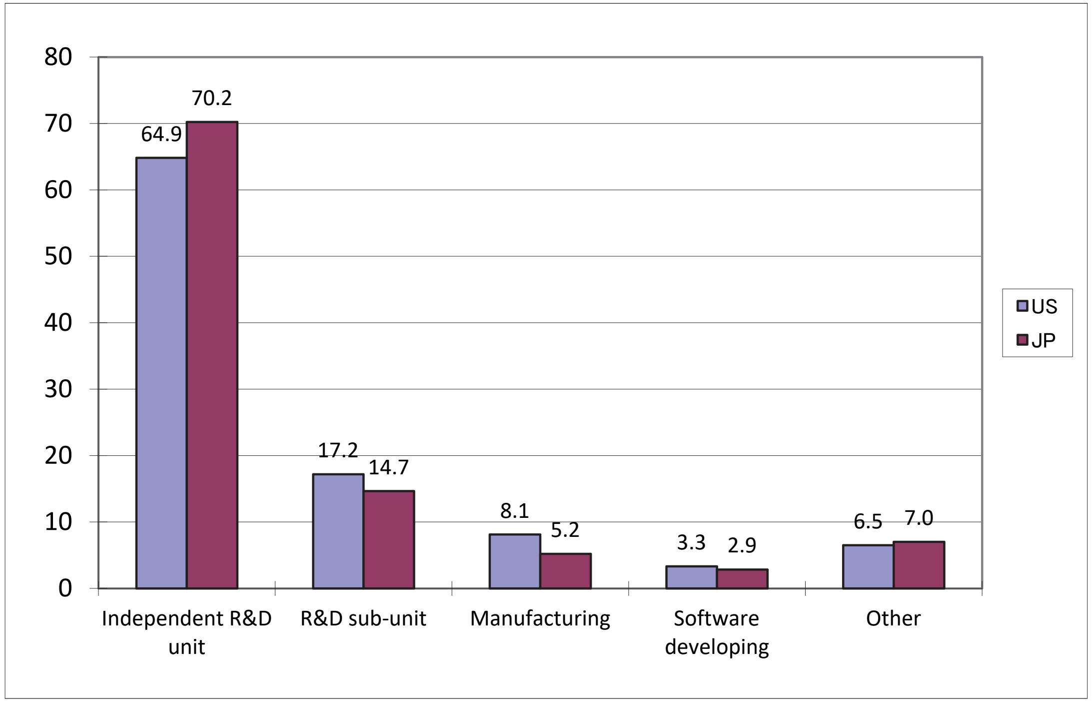
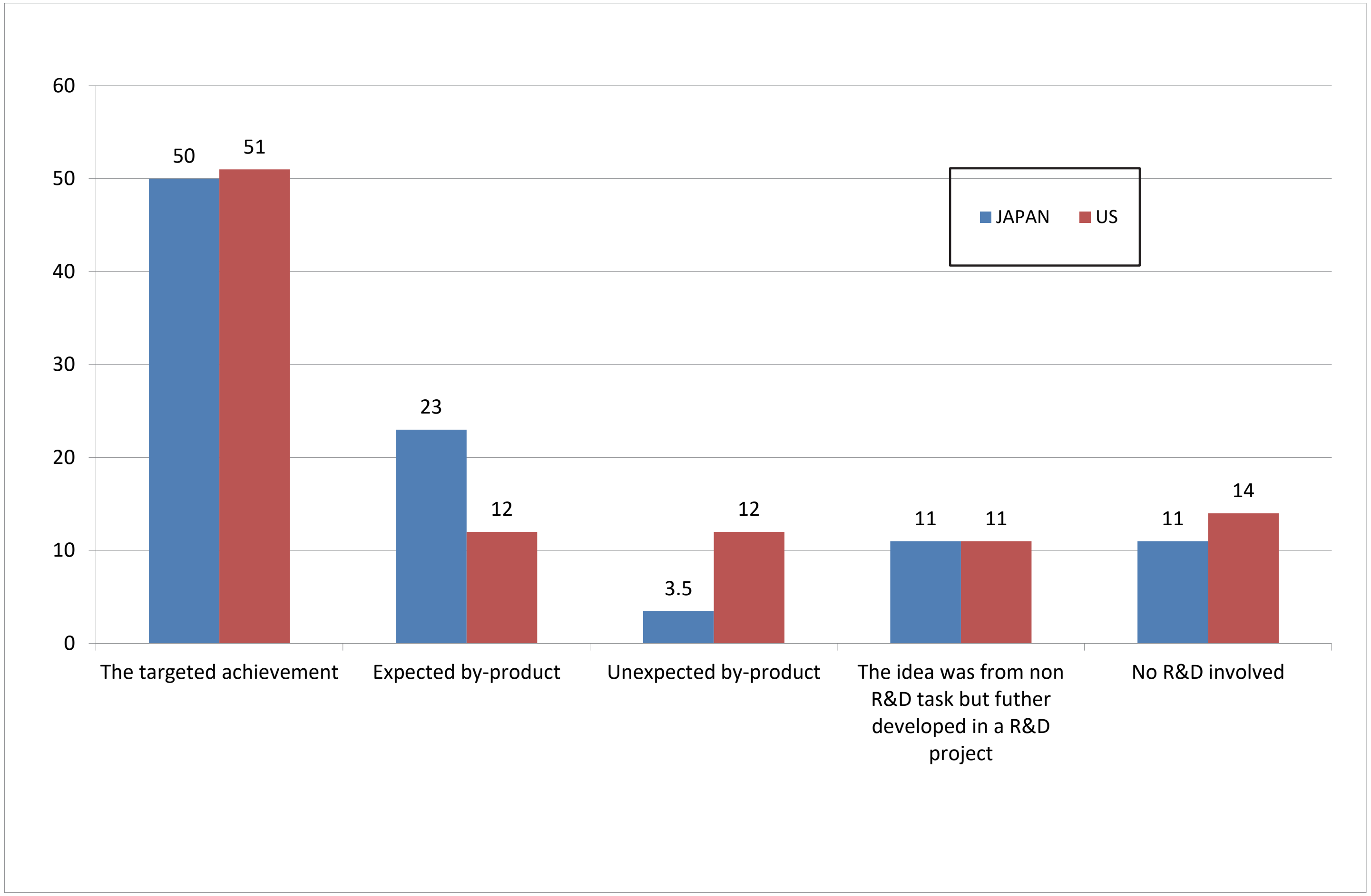


Figure 6 Invention Process (Targeted v. others)



Note. Based on the common technology class weights.

Descriptive statistics: R&D v. non-R&D invention (US)

	Invention type		
	R&D inv (N=1519)	Non-R&D inv (N=219)	t
Inventor characteristics			
Age at first patent application	34	37	-5.2 ***
Age at highest degree	28	27	2.0 *
Highest degree = PhD	48%	24%	7.6 ***
Highest degree major = Science/Engineering	98%	92%	2.8 ***
Invention process			
No. of information sources (university, customer, supplier etc., max = 11)	5.1	4.5	2.6 ***
Invention output			
Product (vs. Process) invention	79%	80%	-0.2
Value of invention			
Any commercialization (Inhouse, start-up, or licensed)	53%	64%	-2.8 ***
No. of claims	23.2	22.6	0.5
Forward citation	3.2	3.4	-0.8

*** at .01, ** at .05, * at .10

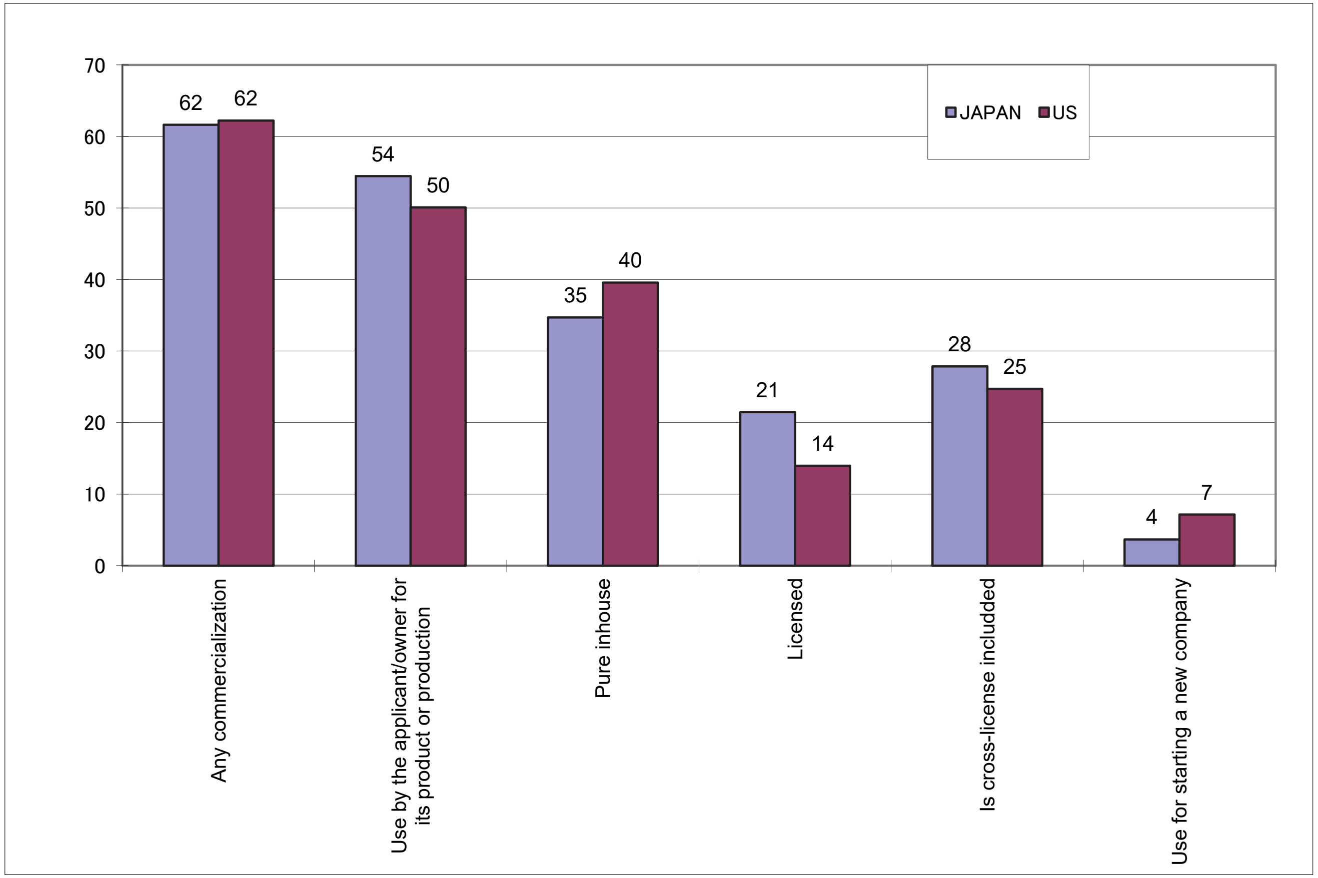
Non-R&D inventions

- In both countries about 25% not part of R&D project
  - Using US data, we find that using narrower definition (excluding those by R&D unit members), still 10%
- Non-R&D inventors (in US) tend to be older, more experienced
- Lee & Walsh (2016, RP) find that non-R&D inventions (in US) tend to be at least as valuable (e.g., citations, commercialization rate).
- Non-R&D innovation greater when knowledge is more visible and when less generalizable

Table 2. Mean share (%) of funding by source, by organization type, US and Japan (weighted by man-months)

	Own (including debt)		Government		User		Supplier		Other firms		Venture Capital and Angels	
	JP	US	JP	US	JP	US	JP	US	JP	US	JP	US
Large firm	95.5	93.9	1.3	2.9	1.2	1.8	0.8	0.5	0.6	0.5	0.1	0.3
Medium firm	96.2	90.8	0.8	4.7	2.1	4.5	0.6	0.0	0.0	0.0	0.0	0.0
Small firm	87.6	88.5	2.5	5.9	8.9	3.6	0.4	0.0	0.1	0.8	0.1	1.1
Smallest firm	87.2	64.9	4.0	4.8	2.2	6.1	0.4	0.9	3.9	4.7	0.9	18.2
University or college	47.8	30.1	23.6	54.5	0.3	0.6	3.3	0.0	6.2	8.8	0.0	6.0
All	92.8	86.2	2.5	5.5	1.5	2.9	0.8	0.5	1.1	1.4	0.2	3.3

Figure 1. Commercialization of the inventions



How were inventions commercialized?

- About 60% of triadic patents commercialized
- About 50% used in house
- 14% licensed out in US; 21% in Japan
    - About one quarter are part of cross-license
- Many inventions used in-house also licensed out (about 10% in US, about 20% in Japan)

Reasons for Non-use

- Blocking and the prevention of inventing-around reasons are important for both countries
  - In each country, about 16% of triadic patents are used for blocking (40% of the 40% that are not commercialized)
- Business reasons (such as the relevant business was downsized) also important

External co-inventors, by partner type

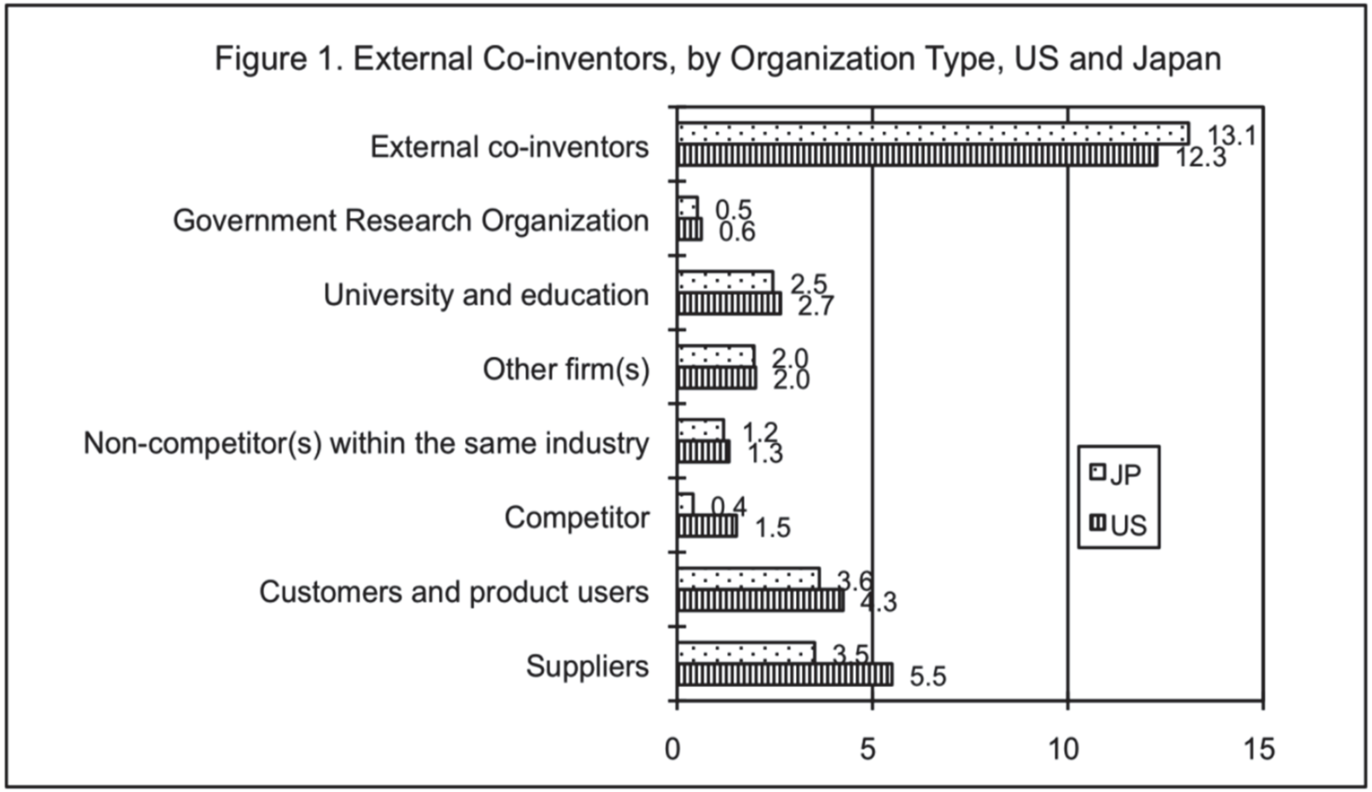


Table 2. Co-application, co-invention, and collaboration for Japan, US and EU triadic patents

	Japan	US	EU
Co-application	10.3%	1.8%	6.1%
External co-invention	13.2%	12.4%	15%
Other research collaborations	28.5%	22.7%	20.5%

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External co-invention	13.2%	12.4%	15%
Other research collaborations	28.5%	22.7%	20.5%

Conclusions

- Japan and US roughly equally open in their innovation processes
  - Vertical ties (customers, suppliers) most common
- **Broad** collaboration networks associated with higher quality patents (US data)
- **Targeted** (vertical) collaboration associated with higher rates of commercialization (net of value), in both US and Japan

Lessons for Bibliometrics

- US co-assignment significantly under-represents cross-organization collaboration
  - Misses about 85% of cross-organization **co-invention**
  - Misses almost 95% of cross-organization collaboration
  - although reasonably good estimate in Japan (making cross-national comparisons vulnerable)
- Also university assigned patents under-estimate university contribution, especially in Japan
  - Misses 36% of university-based patents in US
  - Misses 83% of university-based patents in Japan
  - Again, making cross-national comparisons vulnerable
    - This may be less of a problem since University Incorporation

III. University-Industry Linkages in Japan (Baba, Goto, Yasaki and Walsh) 2003-2005

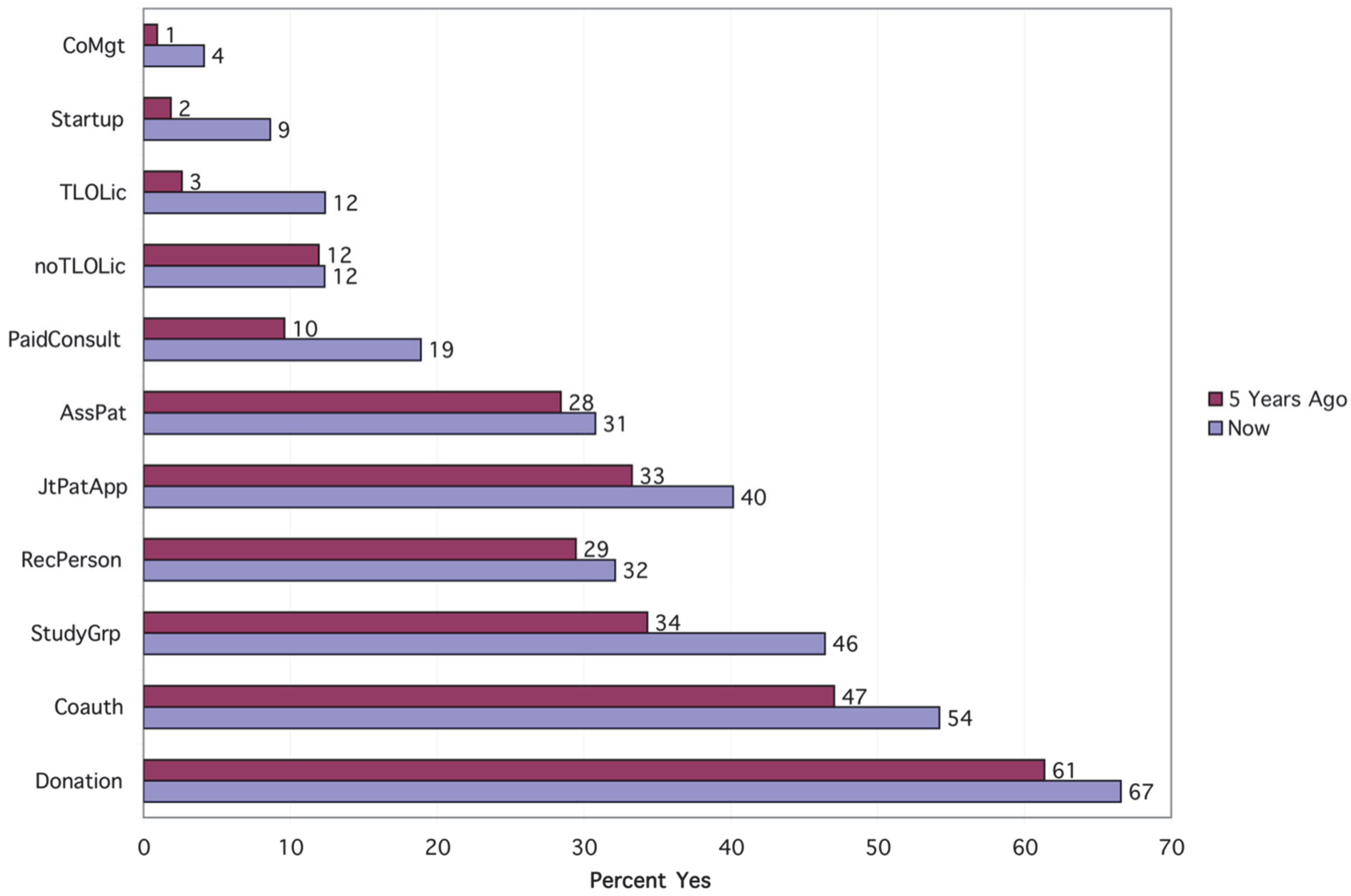
- Survey engineering and biomedical faculty in 15 Japanese universities (top 10 national and top 5 private, in terms of research funding) (Japan=1446)
- Also compare biomed sample with sample from US (Walsh & Cohen) (US=309)
- Focus on effects of university-industry linkage policies (1998-2003 era)

- 2008. Walsh, JP, Y Baba, A Goto, Y Yasaki. 2008. "Promoting university-industry linkages in Japan" Prometheus 26: 39-54.

Formal and Informal Commercial Ties

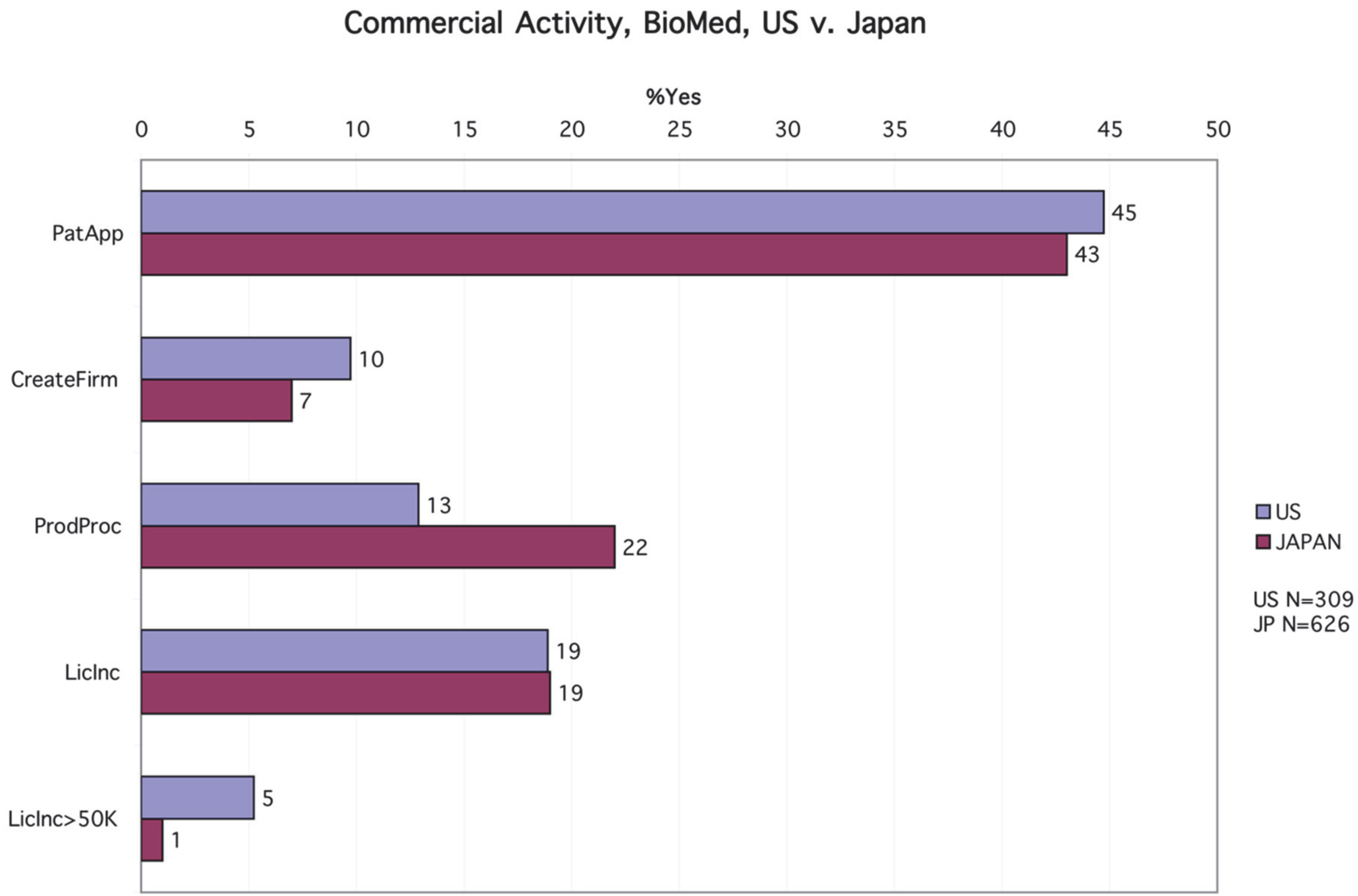
- Reforms focus on formal ties
  - Licensing, start-ups, paid consulting, management
- Pre-reform "gift exchange"
  - Donations, co-author, receive researchers, study groups, patents assigned or co-applicant

Formal and Informal Ties to Industry, Now and 5 Years Ago



Formal and Informal Ties

- Formal ties increasing
  - Goal of reforms
- But, informal, gift exchange still dominates and is also growing
  - Similar to Agrawal and Henderson, 2002, for US



Commercial Activity, BioMed, US v. Japan
%Yes
0
5
10
15
20
25
30
35
40
45
50
PatApp
45
43
CreateFirm
10
7
ProdProc
13
22
LicInc
19
19
LicInc>50K
5
1
US
JAPAN
US N=309
JP N=626

Commercial Activity, US v. Japan

- Very similar across the two countries.
- While the number with any licensing income is about the same, a somewhat greater percent of Americans report substantial income
- Greater number of Japanese respondents report products or processes in the market

Conclusions

- Reforms seem to have had the intended effect of broadening the definition of faculty role to include formal technology transfer.
- However, we should be careful not to undermine informal technology transfer and public science/training function of university
- Some evidence that scientific norms being undermined

IV. AAAS US-Japan Effects of Intellectual Property Protection Survey (Hasegawa & Walsh) (2006-07)

- Survey of scientists in Japan and US (Japan=984; US=834)

- 2014. Walsh, John P. and Hsin-I Huang. “Local context, academic entrepreneurship and open science: publication secrecy and commercial activity among Japanese and US scientists.” Research Policy 43: 245-260.

Commercial activity by public researchers, Japan and US

Measure		JP	US
Patents			
Submitted patent application	%Yes	38	24
Issued patent	%Yes	21	15
Industry funding	%Yes	18	37
Last patent was exclusively license	%Yes	40	36
Last patent was licensed non-exclusively	%Yes	21	13
Respondents	*N*	805	730

Publication secrecy by public researchers, Japan and US

Measure		JP	US
In order to protect your work, have you ever?			
Not published	%Yes	7	9
Published incompletely	%Yes	43	7
Delay publication	%Yes	25	17
Respondents	*N*	760	780

Commercial activity

- Again, commercial activity at least as high in Japan compared to US
  - Some evidence that Japanese researchers patent to show productivity (for example, when applying for funding)
- Japanese researchers also more likely to engage in some forms of academic secrecy (publishing incompletely or delaying publication)

V. US-Japan Scientists Survey (Nagaoka, Igami and Walsh) (2009-11)

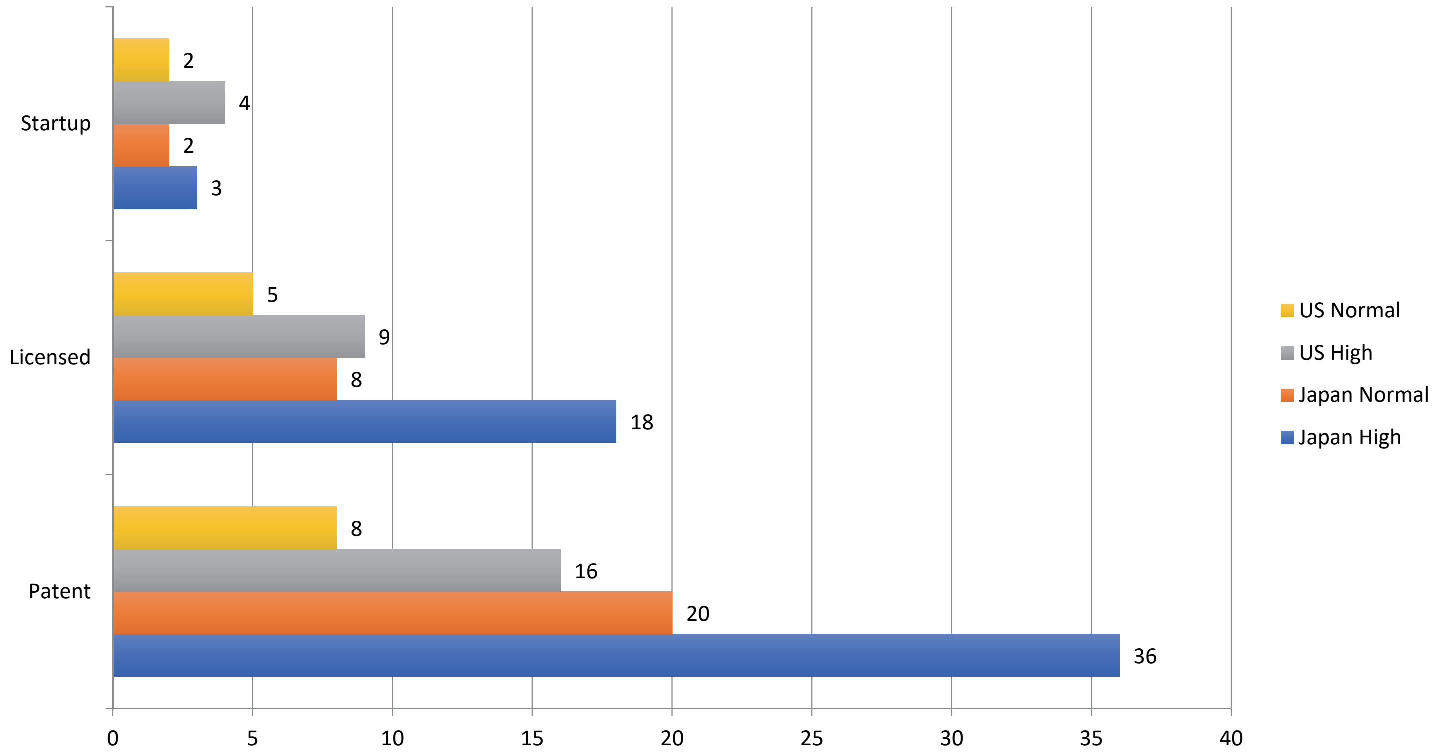
- Authors on scientific publications (Japan=2081; US=2327), stratified by highly cited (top 1%) and normal (other)

- 2015. Igami, M, S Nagaoka and JP Walsh. “Contribution of postdoctoral fellows to fast-moving and competitive scientific research.” Journal of Technology Transfer 40(4): 723-741.
- 2018. J Wang, YN Lee, JP Walsh. Funding model and creativity in science. Research Policy 47(6): 1070-1083.

Role of post-doctoral fellows in fast moving fields

- Participation of postdoctoral fellows is significantly higher in research with shorter mean time lag and higher competitive threat
  - Both US and Japan
  - Not true for students
- Suggests post-docs play a key role in cutting edge science

Commercial Activity, Japan and US, field weighted



Commercial Activity

- Japan generally higher than US (patent, license), though no difference for startup
  - Startups fairly rare (on project basis)
- Highly cited papers more often commercialized
- 51% of Japanese patents include foreign application (60% for highly cited papers) v. 21% in US
- Majority (65% in US, 76% in Japan) of licenses including providing know how (Thursby and Thursby 1999).

Competitive versus block funding and creativity in Japan: status contingency effects

- How best to structure science funding in the era of the New Public Management?
- Block vs. competitive funding: Which one is associated with more novel research?
- Japan: where both funding mechanisms play an important role.
- Survey + bibliometric data

Summary

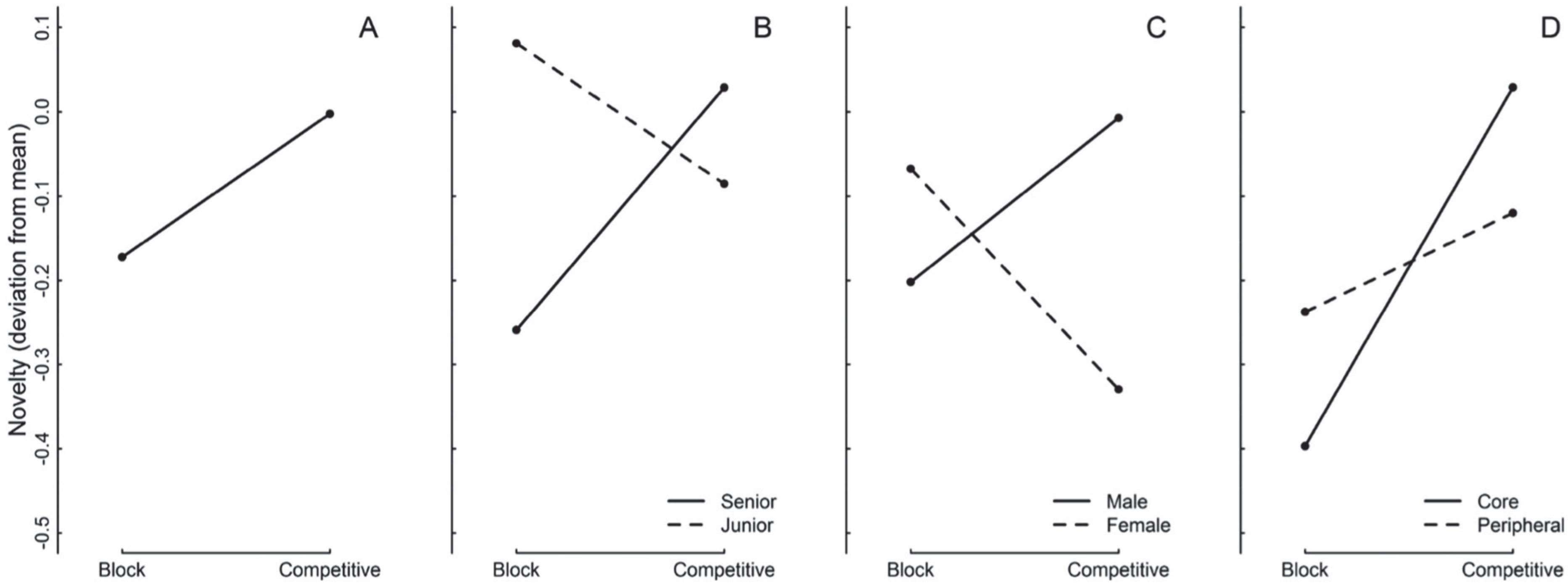


Fig. 1. Novelty, funding model, and status.

- Competitive project funds in Japan associated with more novel publications (main effect)
- But not for junior or female researchers

Implications

- Bias against low status researchers in competitive project selection procedures
  - (Self-)Selection
  - Some evidence of treatment as well

- Uncertain net benefit from transition from block funding model to competitive funding model
  - May be overall positive effect
  - But disadvantage/discourage young and female scientists in pursuit of novel projects
  - And, do not forget the significant costs of administering competitive grants system (particularly cost of writing and reviewing proposals)

- Limitations
  - Not sure of process (selection by applicants or by funders)
  - Would prefer comparison of funded and unfunded applications
  - Generalize to other countries (that perhaps have less emphasis on seniority and/or gender)?

Summary: Lessons from 25 years of comparing US and Japan

- US and Japan surprisingly similar across multiple measures of organization of science and technology
  - Represents fundamental characteristics of advanced innovation systems?
  - Some widely noted differences are the result of differences in institutional settings (functional equivalents or measurement issues)
- In some ways, more similar than most people expect
  - Especially role of universities in innovation system is much more similar than conventional wisdom suggests
  - In fact, by most micro-level indicators, find Japan $\geq$ US (across multiple studies, using various measures)
- A few surprising findings?
  - Relatively minor role of patents (in US)
  - Share of non-R&D inventions
  - How short-term (and anchored in existing businesses) most R&D is
  - Similarities in collaboration across the two countries

Summary: Lessons from 25 years of comparing US and Japan

- However, there are some significant differences
- R&D/Appropriability survey
  - Secrecy less effective in Japan
  - Also less differences in strategic patenting between discrete and complex product industries
  - Related to characteristics of patent systems (maybe convergence since then?)
- Inventor survey
  - American inventors older
  - More very small firm inventors in US
  - More VC funding in US
  - More mobility in US

Future work

- How have changes in patent systems in each country affected these practices?
  - Further convergence?
- Explaining differences in inventor demographics
  - Labor market and management practices?
- Adverse effects from increasing commercialization of university research?
- Effects of latest rounds of university reforms (increasing competition)

Thank you for your attention.

Questions, Comments, Suggestions?

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