Determinants of commercialization modes of science: Evidence from panel data of university technology transfer in Japan

FUKUGAWA Nobuya

25 October 2022

RIETI Innovation Seminar

INTRODUCTION

1. The systematic application of science plays a critical role in industrial innovation in knowledge-based economies.
2. Universities are the largest source of scientific knowledge.
3. Since the Bayh-Dole Technology Transfer Act (BDA), many countries have introduced university IP ownership and TLOs to promote university licensing.
4. The knowledge spillover theory of entrepreneurship (KSTE) highlights the commercialization of science through entrepreneurship as a critical route for knowledge-based economies to grow (Acs et al., 2013).

INTRODUCTION

1. Economic theory identified factors affecting commercialization modes of science: search cost for licensees, post-license development cost, IP ownership, commercialization skills of large firms and startups, and efficiency of innovation intermediaries.
2. Most of empirical findings built on the US-based AUTM data.
3. Using comprehensive panel data of university technology transfer (UTT), this study clarifies determinants of commercialization modes of science in Japan.

ECONOMIC MODEL OF COMMERCIALIZATION MODES OF SCIENCE

1. Damsgaard & Thursby (2013) model the utility maximization mechanism through which entrepreneurial outcomes (license to large firms or university spinoffs) resulting from academic inventions emerge according to IP ownership.
2. Academic IP is owned by university in the US and by inventors in Sweden.
3. TLO maximizes royalty while inventors maximize utility determined through income and basic research.

PARAMETERS IN BASELINE MODEL

1. **search cost for licensees "k" that is borne by an inventor in Sweden and by TLO in the US**
2. **its cost share borne by the TLO "v"**
3. inventor's development effort "e" that reduces basic research effort and is affected by "k" only in Sweden
4. royalty rate charged to the large firm (F) or the startup (S) "$0.02 \leq rF \leq 0.2$", "rS"
5. inventor's ownership share in the startup "$0.1 \leq \sigma \leq 1$". When the startup does not need any external financing, $\sigma = 1$.
6. **commercialization skills of the large firm or the startup "q" independent of the invention**
7. **fixed cost of post-license development "c"**
8. inventor's share of royalty "α"
9. relative weight on basic research "A"
10. productivity of effort in the probability of development success "B"
11. concavity of the development success function "λ"
12. scale parameter of the development effort "γ"
13. Probability of commercialization success "$B(e)^{\lambda}q$"

PROBABILITY OF E-SHIP BEING SELECTED AS THE COMMERCIALIZATION MODE OF SCIENCE

Table 1 Percent of cases where invention is licensed to startup

qS=0.1, qF=0.1, c=0.1 qS=0.1, qF=0.25, c=0.1 qS=0.1, qF=0.9, c=5	Baseline	Two systems US	Two systems SWE
Equal skills	93	100	93
Firm skill advantage	75	8	75
Firm general advantage	10	0	7

Table 5 Robustness checks, percent of cases where invention is licensed to startup

A=0.3 ➔ A=1 B=1 ➔ B=1.2 λ=0.5 ➔ λ=0.9	$A = 1$ US	$A = 1$ SWE	$B = 1.2$ US	$B = 1.2$ SWE	$\lambda = 0.9$ US	$\lambda = 0.9$ SWE
Equal skills	100	93	100	93	100	93
Firm skill advantage	18	75	0	75	19	75
Firm general advantage	0	2	0	10	0	6

Table 7 Percent of cases where invention is licensed to startup

	k=0➔k=0.9 Search costs		k=0➔k=0.6 Internet-based system		C-license	v=1➔v=0.5 TTO advantage	v=1➔v=1.2 TTO disadvantage
	$k = 0.9,\ v = 1$		$k = 0.6,\ v = 1$		$k = 0.9,\ v = 1$	$k = 0.9,\ v = 0.5$	$k = 0.9,\ v = 1.2$
	US	SWE	US	SWE	US	US	US
Equal skills	100	100	100	99	100	100	100
Firm skill advantage	70	88	50	84	59	40	87
Firm general advantage	10	13	10	11	9	0	10

PREDICTIONS OF THE MODEL

Simulating 100 combinations of royalty rate charged to large firms and inventor's ownership share in the startup, the authors show that the probability of academic inventors and TLOs choosing USOs as the commercialization mode exceeds 50% when

1. there is no commercialization skill advantage of large firms and fixed cost of post-license development, *c*, is very low,
2. inventors own IP and *c* is very low,
3. search cost for licensees is high and *c* is very low, and
4. TLOs are inefficient and *c* is very low.

HYPOTHESES: COMMERCIALIZATION SKILL

Innovation based on basic research tends to be radical, and startups tend to commercialize radical innovation as established firms fear cannibalization and rent dissipation.

H1a. Universities that intensively engage in basic research tend not to establish licensing agreements with large firms.

H1b. Universities that intensively engage in basic research tend to create USOs.

HYPOTHESES: DEVELOPMENT COST

The probability of development success is particularly low in drugs.

H2a. Universities that intensively engage in biomedicine research tend to establish licensing agreements with small firms.

Biomedical research and inventor IP ownership combined have a positive effect on the probability of e-ship being selected as the commercialization mode.

H2b. Universities that adopt inventor IP ownership and intensively engage in biomedicine research tend to create USOs.

HYPOTHESES: SEARCH COST

Search cost for licensees is null when UI joint patents are commercialized as industrial partners commercialize the patents.

H3a. Universities with more UI joint patents tend to establish licensing agreements with large and small firms.

Default provision of joint patents of §73 of the *Japan Patent Law* requires agreement of co-owners to license the patent to the third party. This gives industrial partners (large firms) exclusive control over university patents.

H3b. Universities associated with a risk of preemption tend not to establish USOs.

HYPOTHESES: INNOVATION INTERMEDIARIES

University-based inventors disclose inventions when they regard TLOs as efficient. The quality of innovation intermediaries and university IP ownership (implemented in the US) combined positively affect licensing and negatively affect e-ship.

H4a. Universities that adopt university IP ownership and are associated with efficient innovation intermediaries tend to establish licensing agreements with large firms.

H4b. Universities that adopt university IP ownership and are associated with efficient innovation intermediaries tend not to establish USOs.

DATA

1. UTT panel data (2018-2020) compiled by Ministry of Education, Science, and Technology (MEXT)
2. In the 2020 survey, a questionnaire was sent to 86 national universities, 102 public universities, 810 private universities, 57 technical colleges, and 4 Inter-University Research Institute Corporations.
3. All the national and public universities and technical colleges responded the survey while the response rate of private universities was 97%. The overall response rate was 98%.

DEPENDENT VARIABLES

1. *USO* denotes the number of USOs established in a year, t, at a university, i. *LARGE* and *SMALL* denote the number of licenses to large firms and small firms, respectively. Firm size is identified by the definition provided by the SME Basic Law. These variables involve count data, and there are many zeros in the startup data.
2. Random-effects negative binomial regression model
3. Robustness test by fixed-effects regression model

LARGE FIRMS' COMMERCIALIZATION SKILLS

1. Established firms are reluctant to introduce radical innovation due to cannibalization, encouraging entrepreneurial firms to leapfrog.
2. Innovation based on basic research tends to be radical.
3. Universities' basic research intensity is measured by # of projects that received the JSPS GIA for scientific research (*KAKENHI*). KAKENHI is the largest peer-review-based funding source for basic research.
4. IP from universities that intensively engage in basic research tends to be developed into radical innovation large firms have no skill advantage.
5. With # of researchers kept constant, *KAKENHI* is expected to positively (negatively) corelate with *USO* (*LARGE*).

TECHNOLOGICAL SPECIALIZATION IN BIOMEDICINE

1. The probability of development success is low in drugs due to difficulty in identifying promising compounds and time-consuming process of meeting regulatory requirements.
2. *BIO* denotes # of clinical tests conducted by medical schools and is assumed to capture universities' tendencies to generate USOs engaged in biomedicine and expected to capture USOs' tendencies to encounter high development cost.
3. *BIO* is expected to positively corelate with *SMALL* and *USO*.

IP OWNERSHIP

1. *IIPDUMMY* denotes a binary dummy for inventor IP ownership.
2. *UIPDUMMY* denotes a binary dummy for university IP ownership.

SEARCH COST FOR LICENSEES

1. Search cost for licensees is null when UI joint patents are commercialized as it is industrial partners that are supposed to undertake commercialization.
2. # of UI joint patents, *JOINT*, is expected to represent the absence of search cost for licensees.
3. *JOINT* is expected to positively (negatively) correlate with *LARGE* (*USO*).

RISK OF PREEMPTION

1. UI joint research partners apply joint patents not for immediate commercialization but for strategic reasons, such as blocking.
2. UI joint research agreements include a clause requiring industrial partners to pay compensation (*fu-jisshi hoshou*) for universities being unable to execute patents.
3. The risk of preemption is real when licensees are large firms as small firms file joint patents for immediate internal use.
4. *PREEMPT* denotes the number of patents that received *fu-jisshi hoshou*.

THE QUALITY OF INNOVATION INTERMEDIARY

1. A dummy variable, *TLODUMMY*, denotes the presence of internal TLO or alliance with external TLO.
2. Experience of TLO staff or age of TLOs cannot be obtained from the MEXT UIC survey.
3. Inventors disclose inventions when they consider innovation intermediaries efficient. # of disclosed inventions is used to represent the efficiency of university-based intermediaries, *QUALITY*.
4. With # of inventors kept constant, *QUALITY* is expected to positively corelate with *LARGE* and *SMALL*.

CONTROL VARIABLES

1. # of researchers controls for size of universities.
2. # of faculty inventors and student inventors represent human resources.
3. # of patents applied for and granted by foreign and domestic patent offices represent technological resources.
4. Donation represents financial resources.
5. A dummy variable for the presence of USO policy (*USOPOLICYDUMMY*) represents institutional support for academic entrepreneurship.
6. *TOKYODUMMY*
7. *NATIONALUNIVDUMMY*

FINDINGS

	H1a	H1b	H2a	H2b	H3a	H3b	H4a	H4b
Commercialization mode	License	USO	License	USO	License	USO	License	USO
Key determinant	Basic research	Basic research	Biomed.	Biomed. Inventor IP	UI joint patents	Preemption	Univ. IP Efficiency of innov. Interm.	Univ. IP Efficiency of innov. Interm.
Predicted sign	**-**	**+**	**+**	**+**	**+**	**-**	**+**	**-**
Results		**+**	**+**			**-**		**-**
Support for hypothesis	**No**	**Yes**	**Yes**	**No**	**No**	**Yes**	**No**	**Yes**
Robustness test	H1a	H1b	H2a	H2b	H3a	H3b	H4a	H4b
Results	**+**	**+**	**-**	**-**	**-**	**-**		
Support to hypothesis	**No**	**Yes**	**No**	**No**	**No**	**Yes**	**No**	**No**

IMPLICATIONS

1. The commercialization of science through e-ship is promoted by encouraging universities to intensively engage in basic research, which requires more even allocation of basic research grant.
2. The provision of co-ownership of the Patent Law and Japan’s weak entrepreneurial ecosystems combined constrain e-ship as the commercialization mode of science.
3. TLOs’ effort to bypass the default provision of article 73 of the *Patent Law.*
4. University startup ecosystems need to be strengthened.