Complementarity, Fragmentation and the Effects of Patent Thicket

Sadao Nagaoka

Hitotsubashi University / Research Institute of Economy, Trade and Industry

Yoichiro Nishimura

Kanagawa University

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Outline

1. Introduction and motivations
2. Measurement of Fragmentation and Complementarity
3. FMAs and patent value
4. Patenting motivations and patenting propensity
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Introduction and motivations

- A patent thicket is defined as a situation where a firm needs to use many complementary technologies patented by the other firms in producing its own product.
- Problems of patent thicket (Shapiro, 2001)

(1) Patent complements problem

-double marginalization problem

-mutual blocking by manufacturers

(2) Holdup problem

Cross licensing is extensively used to address these problems, but

- this solution may have its own problem

-Cross-licensing reduces the lead time advantage and the appropriability of R&D (Bessen, 2003).

- A firm may get a patent to divert the profit away from the pioneer when patentability standard is low (Hunt, 2006).

→ potential loss of FMAs in R&D

Gaps in the existing empirical studies

- Significant amount of existing studies (see Table 2.1),
- However

-They do not account for complementarity.

citation- based measure

complements vs. substitutes

- They have not studied the effects of patent thicket on first mover advantage.

- They have not clarified the mechanism of higher patenting propensity.

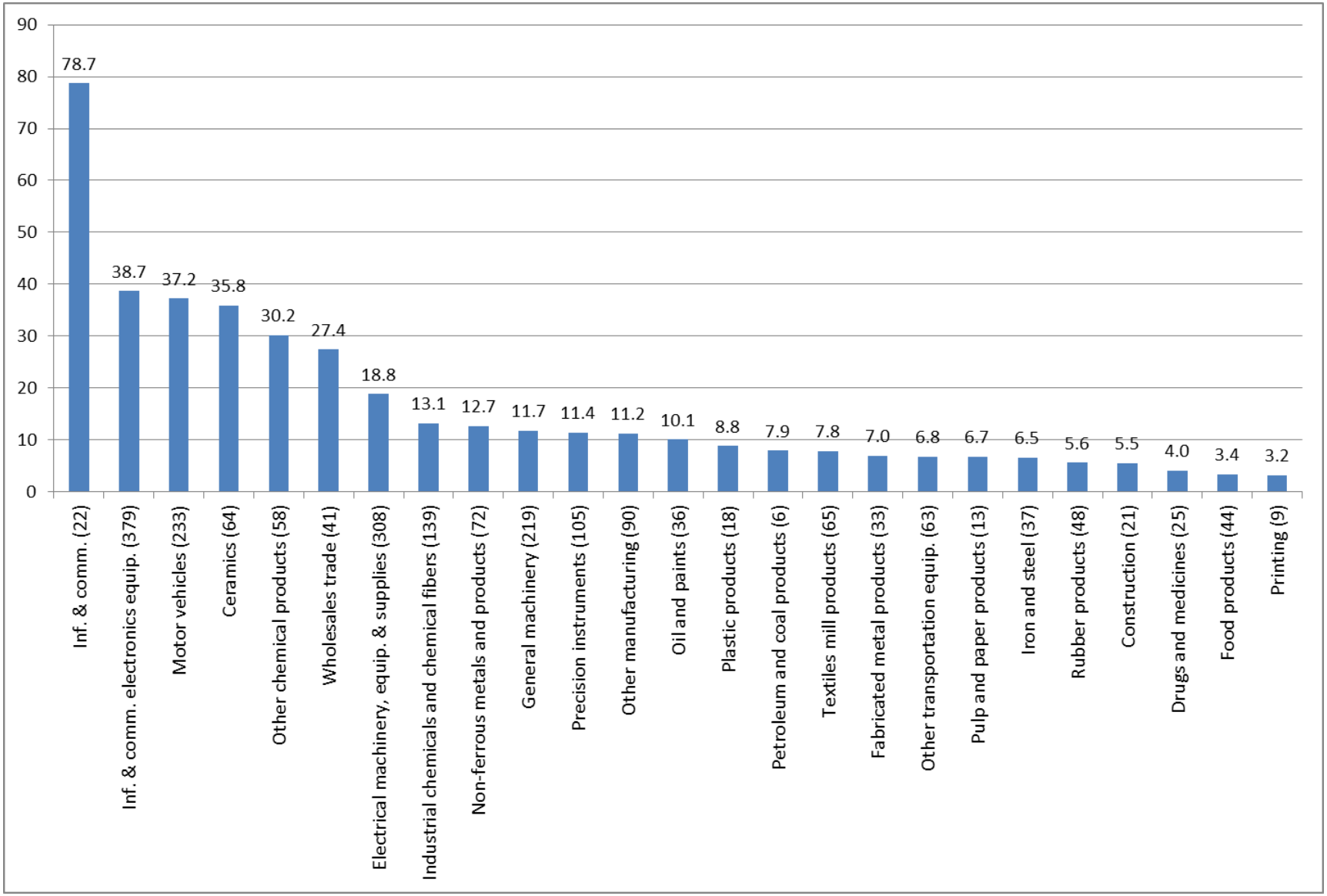
Table 2.1 Literature Review

Studies	Dependent Variable	Complementarity/ Complexity	Fragmentation	Measurement Level	Results	Note
Ziedonis (2004)	# of US pat applications	–	Frag(=1-HHI of BCs)	Firm	Frag+	67 US semiconductor firms, 1980-94
Reitzig (2004)	Patent value	the number of patents which coherentaly protect one invention	–	Project	Not significant in complex technologoies	612 European patents and related inventions from 5 industries
Cockburn & MacGarvie (2009)	Hazard rate of intial funding	–	HHI of BCs, CR4 of BCs	Firm and Market?	HHI of BCs-	Cumulative stock of pats, the # of cited assignees, US software venture
Galasso&Schankerman (2010)	Hazard rate that court dispute ends	Complementarity(=the relative level of the forward citations of the patent)	Frag1(=1-CR4 of BCs), Frag2(=1-HHI of BCs)	Firm, Firm	Complementarity-,Frag1+, Frag2+	US patent infringement cases
Cockburn et al. (2010)	Licensing Cost (Dummy, licensing Cost/Sales)	–	Frag(=1-HHI of BCs)	Tech	Frag+	German Companies
Von Graevenitz et al. (2011a)	Ln(# of pat applications)	Complexity(=# of triples)	Frag(=1-HHI of BCs)	Tech, Tech	Complexity+, Frag+/-	Firms which applying pat app to EPO, 1980-2003
Von Graevenitz et al. (2011b)	Not Available	Complexity(=# of triples)	–	Tech	Not Available	Algorism Description
Entezarkheir (2011)	TobinQ	–	Frag(=1-HHI of BCs)	Firm	Frag-	1975 US publicly traded manufacturing firms, 1979-1996
Hall et. al (2013)	Hazard rate of entry	Complexity(=# of triples)	–	Tech	Negative	UK firms
Noel & Schankerman (2013)	(1)TobinQ, (2)# of US granted pats, (3)Ln(RD)	–	CR4 of BCs	Firm	(1)+, (2)-, (3)-	121 US software firms, 1980-99

Measurement of complementarity

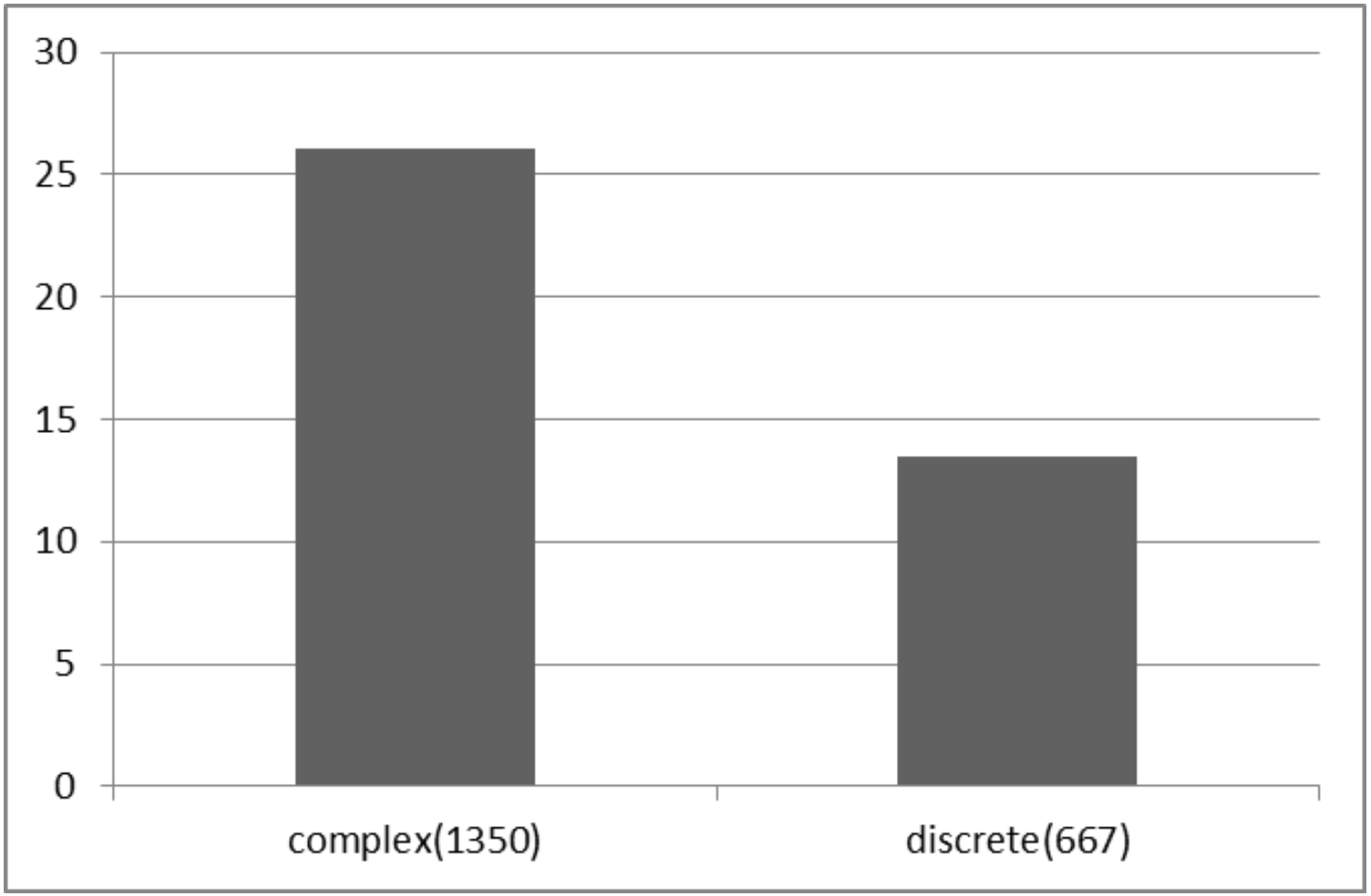
- The number of patents *jointly used in a commercial exploitation* of the focal patent
- It is based on the survey RIETI inventor survey
  - Q. “how many domestic patents (including the other firms’ patents) are jointly used in the commercial exploitation of the invention?”
  - The 8 response categories are: (1) only a single patent, (2) 2-5 patents, (3) 6-10 patents, (4) 11-50 patents, (5) 51-100 patents, (6) 101-500 patents and (7) 501-1000 patents and (8) more than 1000 patents.
- This is different from a measure based on “a number of patents coherently protecting patents”, which would include the substitute patents.

Figure 4.1 Complementarity across industrial sectors



Note. The numbers in the bracket indicate the sample size

Figure 4.2 Complementarity index by complex and discrete industrial sectors



Measurement of Fragmentation

- *The number of the firms* whose patents or patent applications are cited by *an examiner* in examining *the focal patent* application which is ultimately granted
- Characteristics
  - Restricted to Examiner citations ≈ XY citations in the search report of a European patent
  - Restricted to backward citations from the granted patents
  - *Identify the owners (firms) of the cited patents (or patent applications) but only for the publicly traded companies (the coverage>=80%)*

Figure 4.3 Fragmentation across industrial sectors

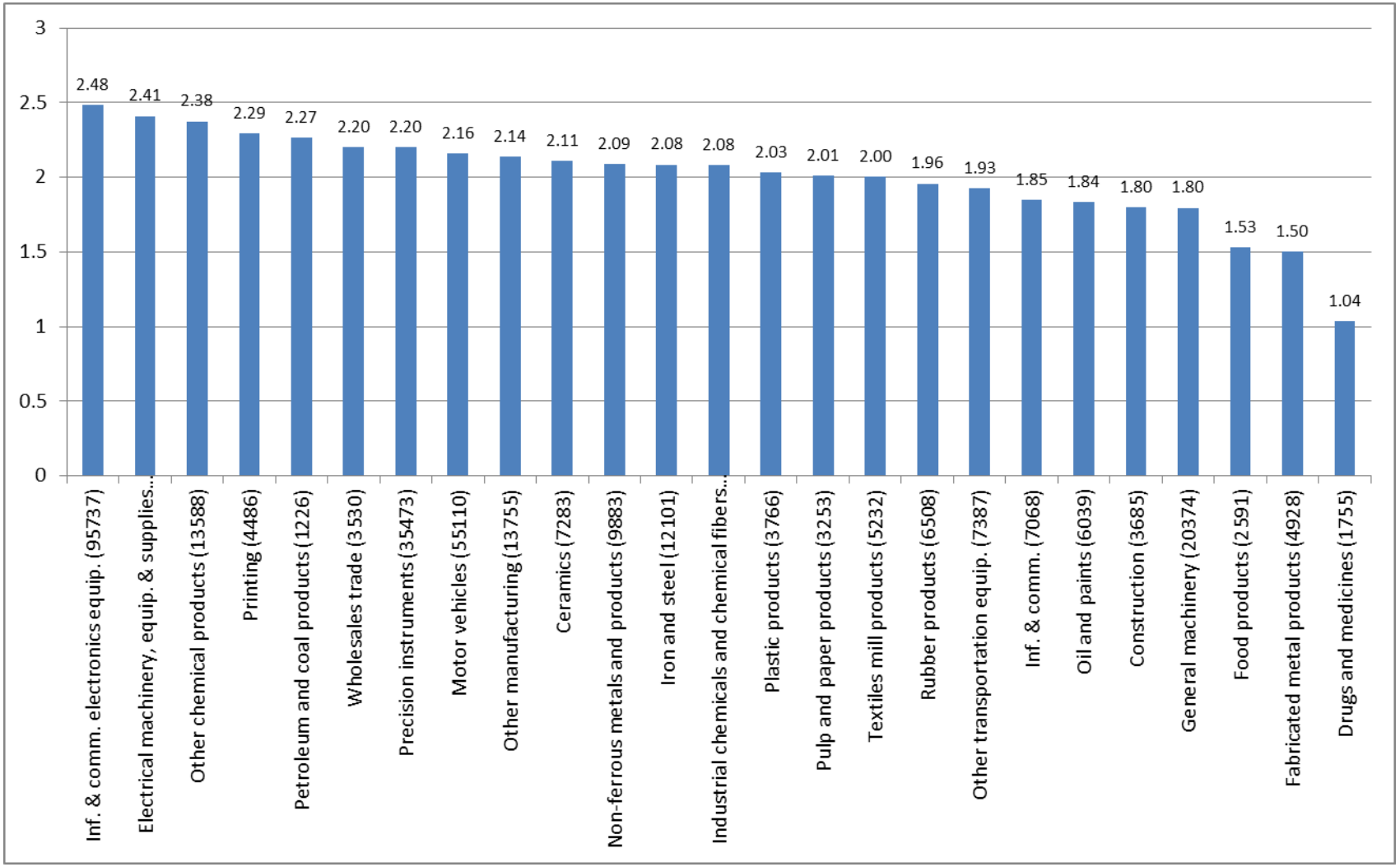
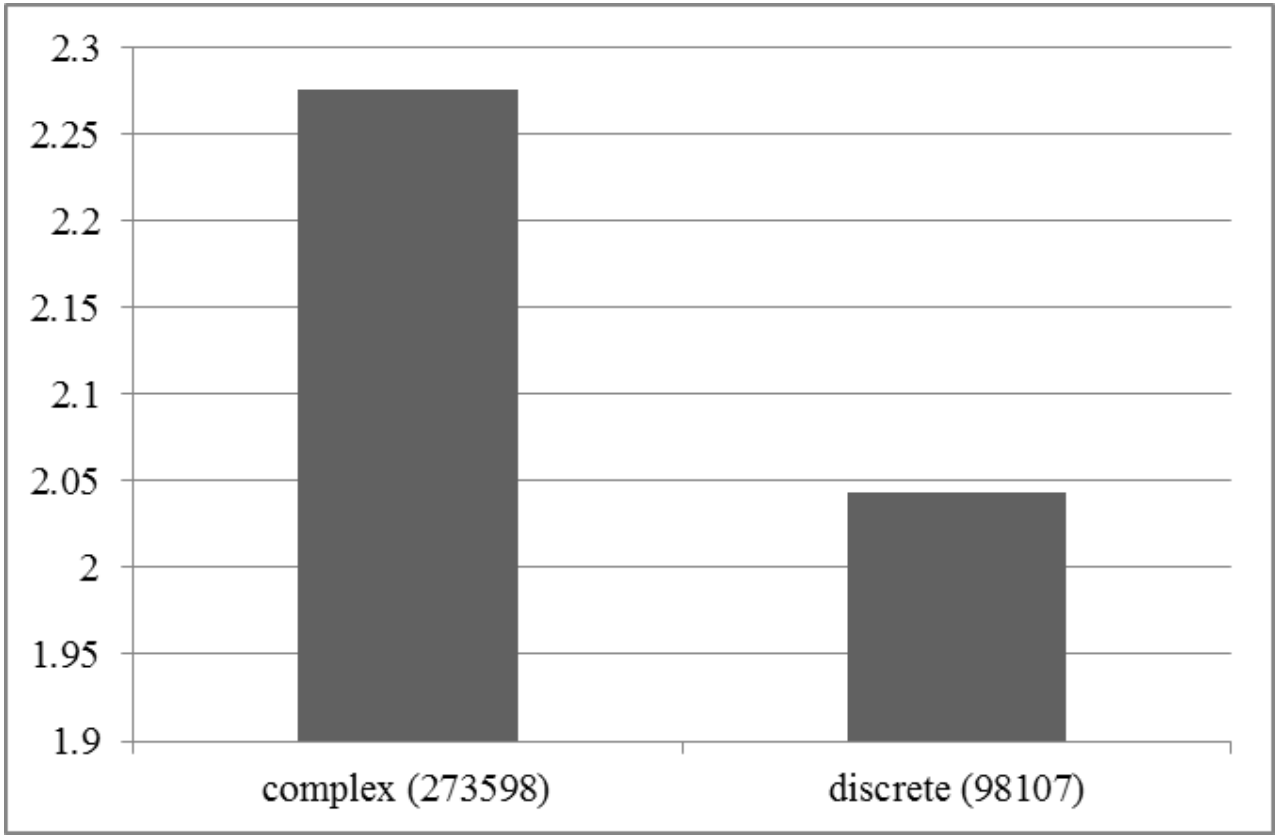


Figure 4.4 Fragmentation index by complex and discrete industrial sectors



Note. The standard deviation is .0034 for complex industrial sectors and .0057 for discrete sectors.

FMAs for appropriation and patent value

- Two type of FMAs (further innovation vs. lead time) for appropriation
  - *the FMA in complementary R&D,* measured by whether *realizing* it is "very important" for appropriation or not in Likert scale from 1 ("not at all") to 5 ("very important").
  - *the FMA in the commercialization of the focal patent*, measured by whether realizing it is "very important" for appropriation or not.
- PV (Patent Value)
  - The *subjective economic value of the focal patent* relative to the inventions in the same field and during the similar period (*top 10%, top 25%, top 50 % and bottom 50%)*

Figure 4.11 Complementarity and FMAs/PV

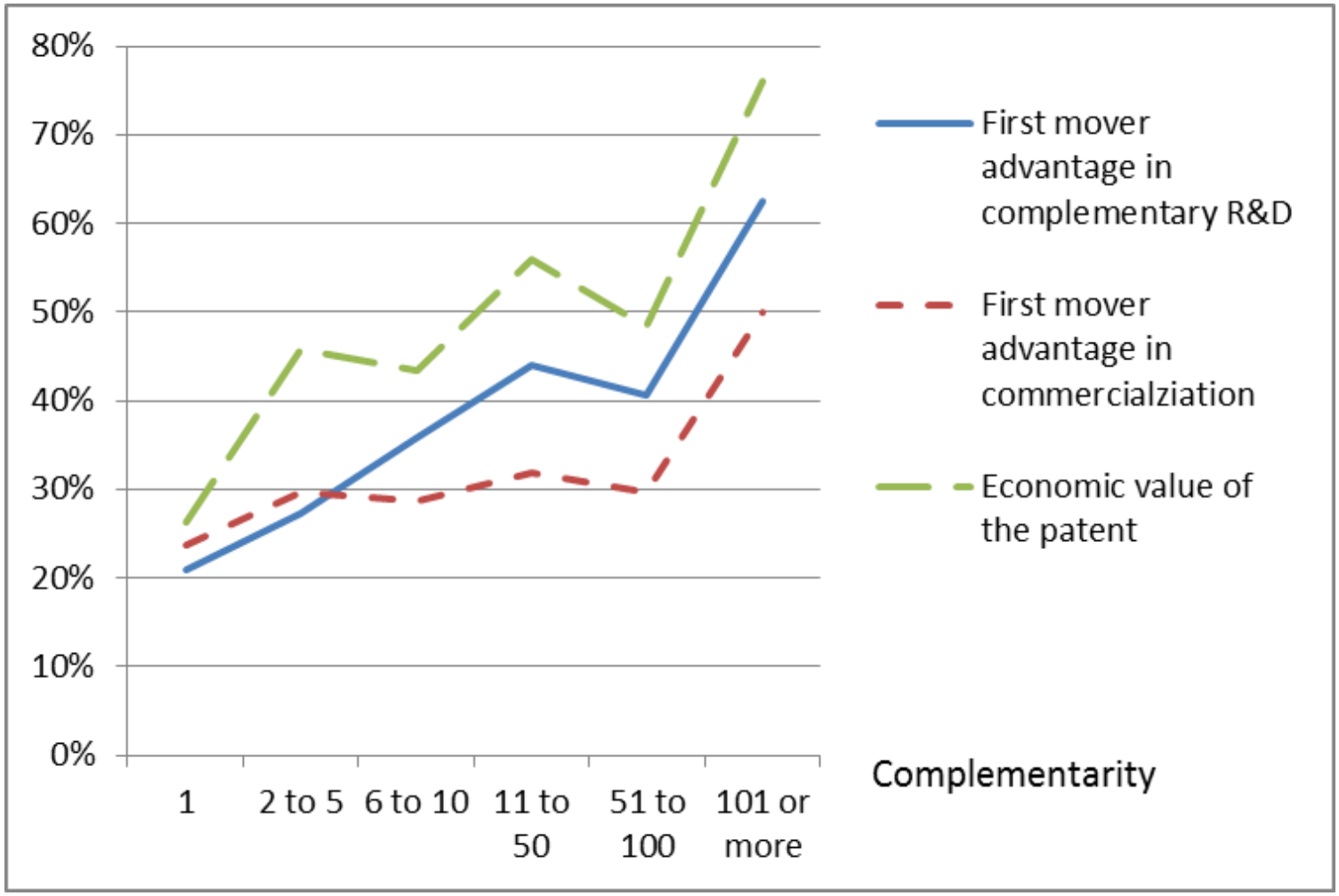
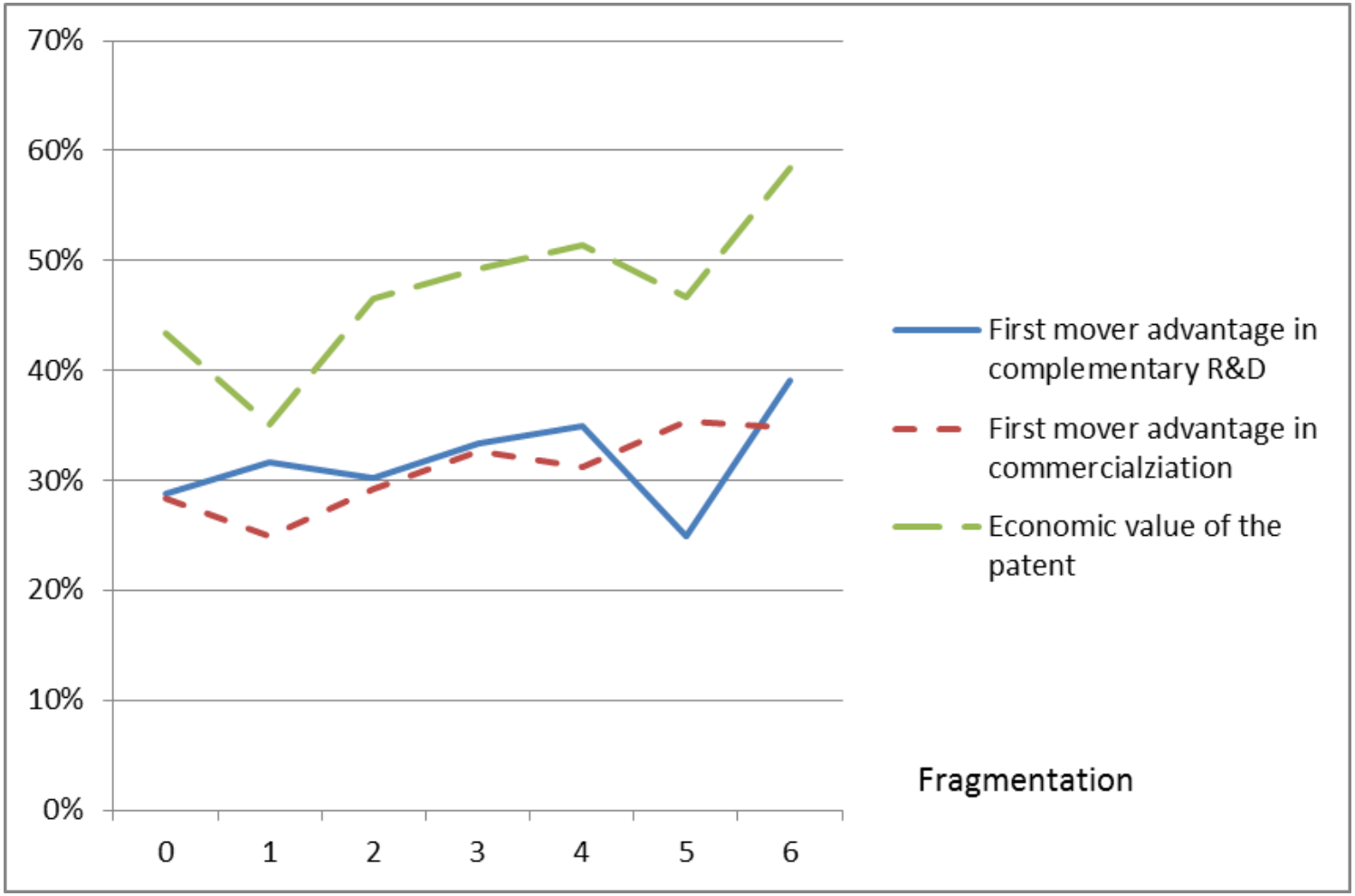


Figure 4.12 Fragmentation and FMAs/PV



Regression evidence: project level estimations

- Two sets of estimations, with the following dependent variables
  - the dummies of whether FMAs are very important or not, and the patent value (PV)
  - 5 major patenting motivations and patenting propensity (number of patents, given the size of R&D man months)
- Data: RIETI survey data
  - Around 1000 R&D projects generating the focal patents granted and commercialized at the time of the survey

Two variables characterizing patent thicket

- Three dummy variables characterizing the level of complementarity and fragmentation ("High", "Medium" and "Low") :
  - *Complementarity* : the count of patents to be jointly used in commercialization of the focal patent
    - *10 or less=low, 11-100=medium, 101 or more=high*
  - Ownership *Fragmentation* : the count of firms whose granted patents are cited by an examiner in patent examining the focal patent.
    - *2 or less=low, 3-4=medium, 5 or more=high*

Estimation Models (OLS)

- (1) The thicket effects on FMAs and PV
  - $Dummies\ of\ FMAs\ or\ Ln\ (PV) = \sum \beta_i \cdot Complementarity_i + \sum \delta_i \cdot Fragmentation_i + \boldsymbol{Invention\ Quality\ and\ Scope} + \boldsymbol{Frontier\ Opening} + Other\ Controls + \varepsilon_i$
- (2) The thicket effects on patent propensity and patenting motivations
  - $Ln\ (Number\ of\ Patents) = \sum \beta_i \cdot Patenting\ Motivations_i + \boldsymbol{Key\ Inputs\ for\ R\&D} + Other\ Controls + \varepsilon_i$
  - $Dummies\ of\ Patenting\ Motivations = \sum \beta_i \cdot Complementarity_i + \sum \delta_i \cdot Fragmentation_i + \boldsymbol{Invention\ Quality\ and\ Scope} + \boldsymbol{Frontier\ Opening} + Other\ Controls + \varepsilon_i$

Control Variables

- Invention quality and scope
  - Quality measure of the invention: forward citations and the triadic patent
  - Basic inputs to the R&D project: labor input (the number of inventors as well as the total man-months for the project) and the PhD degree of the focal inventor
- Frontier opening of the research area
  - “New product/New process development”, rather than “improvement”
  - Importance of science literature and that of public research at university or national laboratory as knowledge source for suggesting the project
  - Objective of research (whether it is “for existing business” or “for exploring new technology base”, rather than “for new business”)
  - Research stage (“basic”, “development”, “technology service ant the other”, rather than “applied”)
- Other
  - Size dummies of the applicant firm (“Large, Medium”, “Small”, “Very Small”)
  - Industry dummies and application filing year dummies

Table 6.1 The thicket effects on FMAs and patent value

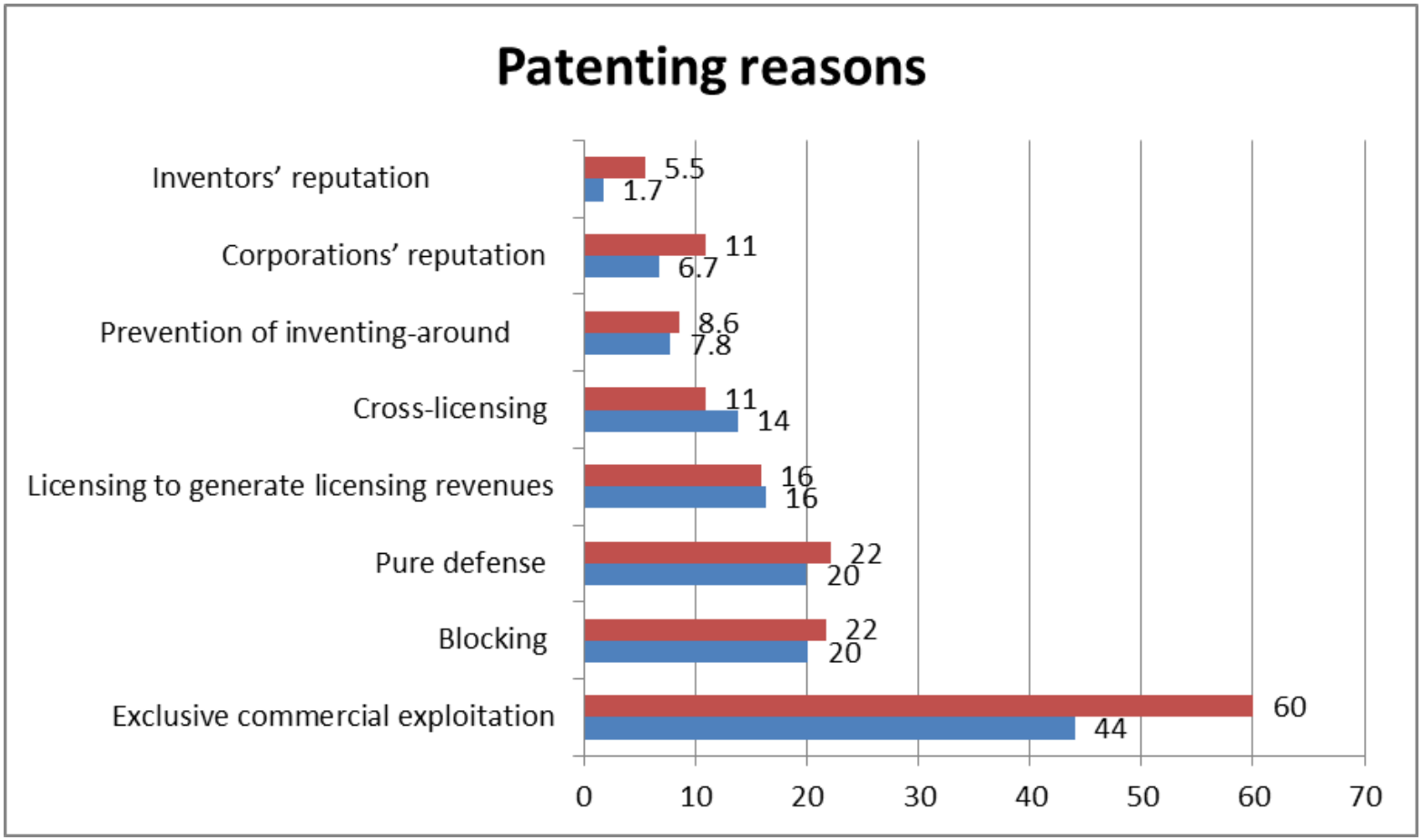
		First mover advantage in R&D	First mover advantage in commercialization	Value of the focal patent	Value of the focal patent
		(Model 1)	(Model 2)	(Model 3A)	(Model 3B)
	VARIABLES	fmvrd_d	fmvmrk_d	lnvalued	lnvalued
Complementarity (base: low)	bundl_m	0.127***	0.0261	0.0564	0.155**
	(medium)	(0.0400)	(0.0386)	(0.0764)	(0.0750)
	bundl_h	0.329***	0.189*	0.312**	0.383***
	(high)	(0.101)	(0.101)	(0.131)	(0.135)
Fragmention (base: low)	fragment_m	0.00584	0.0168	0.0748	0.0940
	(medium)	(0.0296)	(0.0297)	(0.0596)	(0.0573)
	fragment_h	-0.0153	0.0762	0.0463	0.0887
	(high)	(0.0537)	(0.0541)	(0.0937)	(0.0887)
Quality and size of the focal invention	ln1fwcit_inv	0.0111	0.0190	0.0651**	
		(0.0152)	(0.0154)	(0.0290)	
	lninventors	0.0399*	0.0614***	0.0736	
		(0.0238)	(0.0233)	(0.0454)	
Inventor inputs	lnmonth2	0.0163	0.0212*	0.0508**	
		(0.0113)	(0.0110)	(0.0226)	
Innovation type(base:improvement)	new_prodproc	0.0549*	0.0108	0.154**	
		(0.0297)	(0.0310)	(0.0609)	
	Observations	1,172	1,173	939	1,011
	R2	0.114	0.074	0.125	0.073
	Adjusted R2	0.0697	0.0273	0.0693	0.0325
	RMSE	0.443	0.446	0.773	0.788
	Log Likelihood	-678.8	-689.3	-1061	-1171

Note. *** p<0.01, ** p<0.05, * p<0.10, Robust standard errors in parentheses. The coefficients for application year dummies and industry dummies not reported.

Results (1)

- Complementarity is significantly associated with the importance of FMA in R&D and (less significantly) with that in commercialization, while more fragmentation is not significantly negatively associated with neither of them.
- Complementarity is associated with the patent value, while more fragmentation at patent level is not negatively associated with it.

What are the important patenting reasons (“very important”,%)



Source RIETI inventor survey, Japan & US

Table 6.2 Patenting Propensity and patenting motivations

		(Model 4)	(Model 5)	(Model 6)
	VARIABLES	lnsize_pat_num	lnsize_pat_num	lnsize_pat_num
		Total	Complex	Discrete
Patenting motivations (Likert Scale)	score_crlice	0.0926***	0.0894**	0.0938*
		(0.0294)	(0.0375)	(0.0538)
	score_defense	0.0146	0.0270	-0.0114
		(0.0291)	(0.0393)	(0.0506)
	score_licen	0.0462	0.0811**	0.0215
		(0.0286)	(0.0365)	(0.0519)
	score_excl	-0.00121	-0.0247	0.0364
		(0.0292)	(0.0368)	(0.0606)
	score_block	-0.0296	-0.0462	-0.00438
		(0.0304)	(0.0410)	(0.0524)
Quality and size of the focal invention	ln1fwcit_inv	0.116***	0.115***	0.115***
		(0.0264)	(0.0358)	(0.0427)
	lninventors	-0.102**	-0.0815	-0.141
		(0.0428)	(0.0521)	(0.0878)
Inventor inputs	lnmonth2	0.217***	0.239***	0.173***
		(0.0206)	(0.0264)	(0.0365)
	Observations	1,709	1,086	496
	R2	0.225	0.243	0.231
	Adjusted R2	0.198	0.216	0.156
	RMSE	0.952	0.980	0.893
	Log Likelihood	-2312	-1500	-623.9

Note. *** p<0.01, ** p<0.05, * p<0.10, Robust standard errors in parentheses. The coefficients for application year dummies and industry dummies not reported.

Results (2)

- Cross licensing motivation among five major patenting motivations is highly and positively significant in accounting for the level of patenting propensity in either sample limited to complex industrial sectors or discrete industrial sectors.
- Licensing for revenue motivation is highly and positively significant in accounting for the level of patenting propensity in the only sample limited to complex industrial sectors.

Table 6.3 Patenting motivations

		(Model 7)	(Model 8)	(Model 9)	(Model 10)	(Model 11)	(Model 12)
		score_defense_d	score_crlice_d	score_crlice_d	score_licen_d	score_block_d	score_excl_d
	VARIABLES			(no actual cross license)			
Complementarity (base: low)	bundl_m	0.0500	0.110***	0.102**	0.0465	0.0106	0.0162
	(medium)	(0.0377)	(0.0341)	(0.0405)	(0.0318)	(0.0376)	(0.0425)
	bundl_h	0.203*	0.293***	0.113	0.235**	-0.0583	0.0550
	(high)	(0.106)	(0.107)	(0.133)	(0.105)	(0.0840)	(0.120)
Fragmention (base: low)	fragment_m	-0.0386	0.00558	0.0423	0.0229	0.00536	0.0117
	(medium)	(0.0296)	(0.0242)	(0.0284)	(0.0244)	(0.0301)	(0.0344)
	fragment_h	-0.0583	0.0497	0.0602	0.0241	-0.00482	-0.0514
	(high)	(0.0500)	(0.0459)	(0.0533)	(0.0421)	(0.0516)	(0.0570)
Quality and size of the focal invention	ln1fwcit_inv	0.0257*	0.00638	0.0104	0.0210	0.0148	0.0288*
		(0.0147)	(0.0126)	(0.0144)	(0.0136)	(0.0149)	(0.0167)
	lninventors	-0.0318	-0.0179	-0.0150	0.00466	-0.0343	-0.0135
		(0.0236)	(0.0204)	(0.0234)	(0.0201)	(0.0240)	(0.0267)
Inventor inputs	lnmonth2	-0.0156	0.00575	0.00227	0.00793	0.0129	0.0394***
		(0.0112)	(0.00910)	(0.0107)	(0.00958)	(0.0115)	(0.0126)
	Observations	1,053	1,048	732	1,048	1,052	1,053
	R2	0.061	0.097	0.107	0.084	0.063	0.116
	Adjusted R2	0.00893	0.0470	0.0360	0.0333	0.0109	0.0674
	RMSE	0.418	0.338	0.316	0.338	0.426	0.483
	Log Likelihood	-547.9	-322.1	-167.7	-320.5	-565.8	-699.2

Note. *** p<0.01, ** p<0.05, * p<0.10, Robust standard errors in parentheses. The coefficients for application year dummies and industry dummies not reported.

Results (3)

- Complementarity is weakly significantly associated with pure defensive patenting.
- Complementarity is significantly associated with cross licensing and licensing motivations, but not with blocking and exclusive exploitation.
- Fragmentation is not associated with all the five major patenting motivations.

Conclusions

- We do not see negative patent thicket effects on R&D incentive by incumbents.

  - No negative effect on FMAs

  - Stronger cross licensing motivations but not stronger blocking motivations

  - Cross licensing motivations and licensing for revenue motivations mainly account for high patenting propensity

- Implication for policy

  Policy focus would be paid to improving patent quality and to facilitating the mechanism of ex-ante contracting.

Appropriation methods ("very important", %)