Technology Entry in the Presence of Patent Thickets

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Bronwyn Hall[1], Christian Helmers[2], **Georg von Graevenitz**[3]

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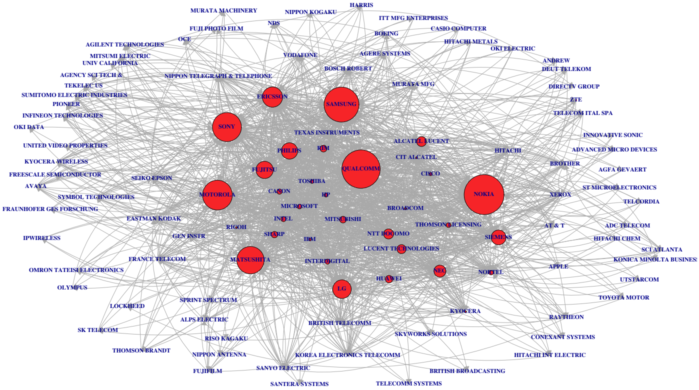
[1]University of California, Berkeley
[2]Santa Clara University
[3]Queen Mary University of London & Centre for Competition Policy

Patent Thickets

- Shapiro (2001): “... a dense web of overlapping intellectual property rights that a company must hack its way through in order to actually commercialize new technology.”



Questions

- Do patent thickets affect entry?

1. Are there patent thickets ?
   Yes: Hall and Ziedonis (2001); Ziedonis (2004); Jaffe and Lerner (2004); Bessen and Meurer (2008); Graevenitz et al. (2013)
2. Effects on patenting, R&D investments and competition?
   Patenting increases, opposition decreases, R&D unaffected (?), competition ?
3. Is there a measurable effect on entry into patenting by UK firms?
   This paper

Context:

- Patent applications growing faster than patent offices can keep up.
- Concerns about effectiveness of patent examination:
  Quillen et al. (2003); Quillen and Webster (2009), Lei and Wright (2009); van Pottelsberghe de la Potterie (2011)
- Unitary Patent Package

Contributions

- We model entry into patenting and patenting choices in discrete and complex technologies;
- We derive predictions on effects of complexity of technologies, technological opportunity and of thickets on entry;
- We test these predictions using UK data;
- We report statistically and economically significant effects on entry;
- All predictions hold in our data.

Causes of Patent Thickets

- New patentable subject matter
- Increasing complexity of some key technologies (e.g. ICT)
- Changing technological opportunity
- Changes in US legal system, resulting in frequent use of injunctions
- Strategic patenting, rise of Patent Assertion Entities (PAEs)
- Lack of resources at patent offices
- Increased trade

- Some of these forces arguably improve social welfare

Details

Theory

Discrete technology

Technological opportunity raises patenting, competition reduces it (Graevenitz et al., 2013).

$$\pi_{ik}(o_i) = o_i p_k V - o_i L - o_i C_o - o_i p_k C_a - C_c(o_i) \quad .$$

where

o_i – Number of opportunities (=patents) applied for

V – Value of an opportunity

p_k – Probability of patent grant

L – Legal costs

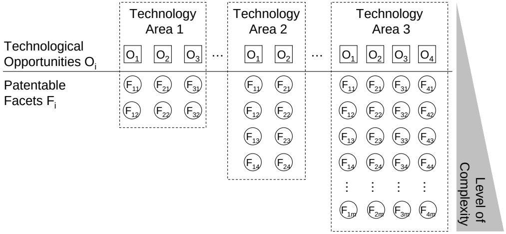
C_o – R&D costs

C_a – Costs of administering the patent

C_c – Costs of R&D coordination

Theory

Extension to complex technology



- In a technology area there are $\Omega = FO$ patents. Here O represents technological opportunities and F facets of these.
- $$N_k = \sum_{j=0}^{N} j \binom{N}{j} \left(1 - \frac{o}{O}^{(N-j)}\right) \frac{o}{O}^{j}, \; p_k = \sum_{j=0}^{N_k} \frac{1}{j+1} \binom{N_k}{j} \prod_{l=0}^{N_k - j} \left(1 - \frac{f_l}{F}\right) \prod_{m=0}^{j} \frac{f_m}{F}.$$

Theory

Complex technology

- We analyze a two stage model of entry and patenting.
- Stage two is a generalized version of Graevenitz et al. (2013):

$$\pi_{ik}(o_i, f_i) = o_i \left(V(\tilde{F})\mathbf{\Delta}(s_{ik}) - L(f_i p_k, s_{ik}, h_k) - C_o(\sum_j^{N_O} o_j) - f_i p_k C_a \right) - C_c(o_i) \quad .$$

where f_i, o_i – Number of facets/opportunities applied for

$\tilde{F}$ – Total facets granted per opportunity

s_{ik} – Share of facets granted to the firm

- If the game is supermodular, doing comparative statics is simple.

⇒ The conditions for supermodularity are *fragmentation* of patent applications and *elasticity* of V > *elasticity* of Δ.

- Extension to incumbents and entrants.

Theory

Main Results

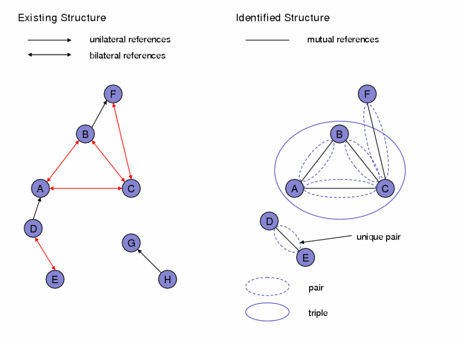
- Greater opportunity increases entry.
- Greater complexity increases entry.
- Greater likelihood of hold-up reduces entry.
- Greater experience with R&D increases entry in new areas.

Data Sources and Sample

- ▷ PATSTAT 2010 & 2011 yielding data on UK and EPO patents until 2009.
- ▷ FAME 2005, 2009 & 2011 - covering the population of registered UK firms until 2009.
- ▷ PATSTAT and FAME are matched at firm level.
- ▷ Sample includes all UK firms with at least one patent application between 2001 and 2009.
- ▷ Additionally, we include 1% of all non-patenting UK firms.
- ▷ 29,435 firms that might enter 34 areas, yielding 998,219 obervations at risk with 12,991 actual entries.

Triples: Measuring the Density of Patent Thickets

▷ We exploit citation from european patents to measure thicket density using a count of **triples**:



Triad census: Holland and Leinhardt (1976); Milo et al. (2002, 2004)

Three is a crowd: Grujić et al. (2012)

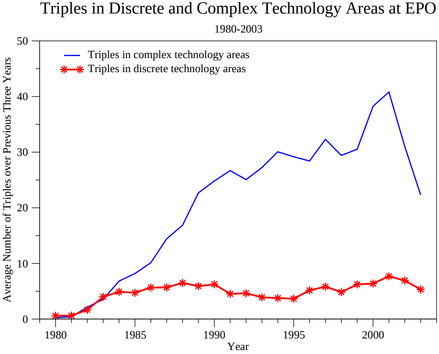
Advantages & Disadvantages of the Triples Measure

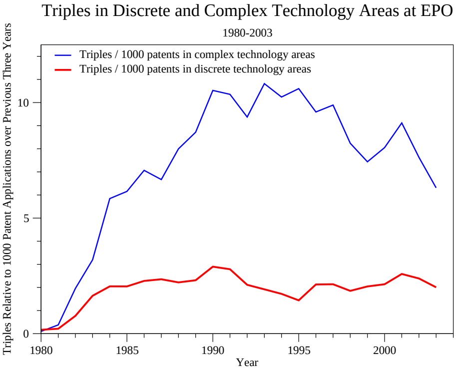
- It is based on the "objective" research of patent examiners.
- It captures the network aspect of patent thickets using an established measure of local network structure.
- It captures firm and time specific variation in intensity of thickets.
- The measure is a proxy measure of hold-up potential.

Critical References in Applications and Granted Patents

	Share with		
	any X cite	any Y cite	X or Y cite
Granted	30.7%	15.9%	37.3%
Not granted	43.0%	20.0%	49.7%

A simple test of the *triples* measure





Variables

- Dependent variable:
  - Entry into a technology area new to the firm
- Independent variables:
  - Technological opportunity (+): log of area applications in a year, 5 year growth rate in non-patent literature references
  - Technological complexity (+): network density of citations in US patents in 10 years before potential entry
  - Thicket density (−): triples measure

Results: Empirical Models

- We estimate duration models:

  How long before a firm **first** patents in sector j?

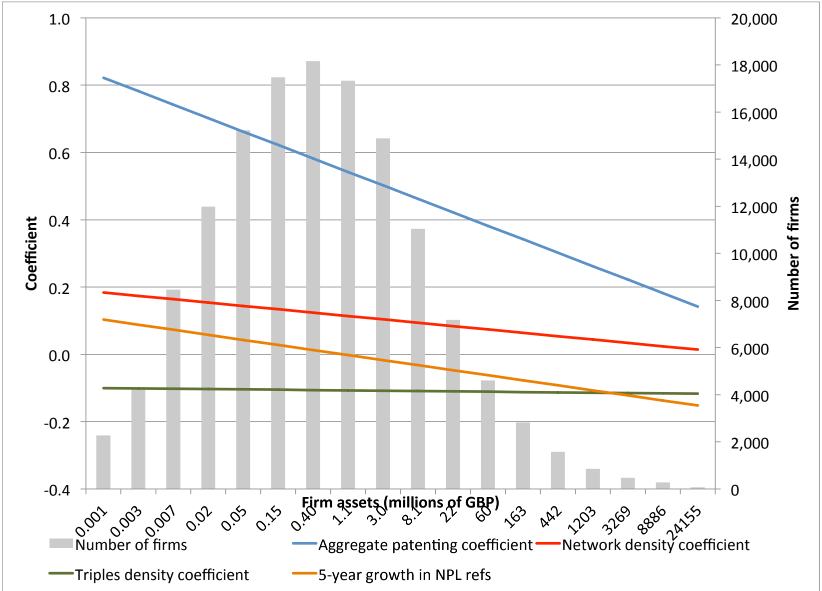
- Duration models explain how variables of interest (normalized triples) affect probability of patenting.
- Covariates are firm characteristics (assets, age), sector characteristics (applications).
- We stratify by industrial sector.
- Different models are estimated; AFT models allow the hazard of patenting to vary with firm characteristics.
- We do not have an experiment/shock to allow identification of a causal effect.

Table 4: *Cox Proportional Hazard Model*

Coefficients for the hazard of entry into patenting in a TF34 Class 538,452 firm-TF34 observations with 10,665 entries (29,435 firms)				
Compl. : Log (network density)	0.115***		0.127***	0.107***
	(0.024)		(0.023)	(0.021)
Opp. : Log (patents in class)	0.317***	0.506***	0.545***	0.514***
	(0.025)	(0.031)	(0.030)	(0.027)
Opp. : 5-year growth of non-patent refs in class	0.060***	0.084***	0.072***	-0.009
	(0.022)	(0.022)	(0.022)	(0.021)
Hold-up : Log (triples density in class)		-0.138***	-0.139***	-0.101***
		(0.011)	(0.011)	(0.010)
Age : Log firm age in years	1.135***	1.135***	1.136***	0.773***
	(0.104)	(0.104)	(0.104)	(0.130)
Age : Log (pats applied for by firm previously)				0.836***
				(0.021)
Size : Log assets	0.270***	0.270***	0.270***	0.142***
	(0.011)	(0.011)	(0.011)	(0.013)
Industry dummies	stratified	stratified	stratified	stratified
Year dummies	yes	yes	yes	yes
Log likelihood	-65.96	-65.86	-65.84	-58.69
Degrees of freedom	12	12	13	14
Chi-squared	1270.6	1429.1	1517.2	3465.1

Std. errors are clustered on firm. *** (**) denote sig. at the 1% (5%) level.

Summary of Results



Conclusion

- ▷ Patent thickets in technologies such as ICT exist.
- ▷ These thickets affect entry into patenting and in some cases product market entry.
- ▷ If causes of thickets are not addressed, market structure may be affected.
- ▷ UK patenting firms are not concentrated in ICT technologies.

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Background Factors: Complexity, Opportunity, Trade

- Complexity: scientific discoveries and patents are increasingly the result of teamwork, the teams involved are getting larger, their members more specialized (Jones, 2009, 2010a,b).
- Complexity: standards in ITC involve more eligible firms, more participants and more patents.
- Technological opportunity: less opportunity intensifies patenting in complex technologies (Harhoff et al., 2012b).
- Trade: between 1990 and 2007 subsequent filings grow faster than first filings (WIPO, 2011).

Institutional changes - mainly US

- Patentable subject matter extended, e.g. software.
- Establishment of the centralized Court of Appeals for the Federal Circuit (CAFC) in 1982.
- In eBay v MercExchange (2006) the US Supreme Court creates a tougher test for injunctions.
  - Now PAE's go to the International Trade Commission (Chien and Lemley, 2012).
- Both USPTO and EPO have attempted to address some of their quality problems.

Strategic responses

- Patent portfolio races among semiconductor firms. (Hall and Ziedonis, 2001; Ziedonis, 2004)
- Rising litigation by PAEs, reduces market value of defendants. (Bessen et al., 2011; Tucker, 2012)
- Large firms increase patenting, medium and smaller sized firms reduce patenting (Graevenitz et al., 2013).
- Reduction in post grant opposition (Harhoff et al., 2012a).

Effects of Patent Thickets - R&D, Entry, product Markets

- Heterogeneous effects of thickets on R&D investments and new product introduction: firms in better bargaining positions tend to benefit at the expense of others.
  Schankerman and Noel (2006); Cockburn et al. (2010)
- Cockburn and MacGarvie (2011) show that a 1% increase in software patents *cause* product market entry to drop by 0.8%.
- Balasubramanian and Sivadasan (2011) show that patenting for first time patenters is especially associated with growth through increased scope.

Patent quality at EPO

- Philipp (2006) notes quality of examination decreasing.
- EPO regularly cited as having higher quality of examination than USPTO or JPO.
- In 2007 EPO institutes “Raising the Bar”.
- But in 2008 EPO examiners go on strike because of concerns about patent quality.
- In 2010 the IP Federation issue a paper highlighting quality of examination concerns, critical of “Raising the Bar”.
- Last year EPO abolish an external audit committee set up in 2009.

Log-logistic "survival" model

- Accelerated failure time model, with industry (j) - specific speed up or slow down of firm (i) - specific distribution.
  Survival probability:

$$S(t) = \left[1 + (\lambda_i t_i)^{1/\gamma_j}\right]^{-1} \qquad \text{with } \lambda_i = \exp(-X_i'\beta) \qquad (1)$$

- Hazard of entry:

$$h(t) = -\frac{dlogS(t)}{dt} = \frac{\lambda_i^{1/\gamma_j} t^{-1+1/\gamma_j}}{\gamma_j(1 + \lambda_i^{1/\gamma_j} t^{1/\gamma_j})} \qquad (2)$$

$\gamma \geq 1$: the hazard monotonically decreases from t=0

$\gamma < 1$: the hazard first increases and then decreases

Elasticity of hazard w.r.t. regressors

$$\frac{\partial \log(h(t))}{\partial x} = \frac{-\frac{\beta}{\gamma_j}}{1 + (\lambda_i t)^{1/\gamma_j}} \tag{3}$$

- At the centre of the distribution in our data,

$$\gamma \approx 1 \text{ and } \lambda \text{ is very small}$$

- Implication: the elasticity of hazard w.r.t. x is approximately $-\beta$ for a typical firm.
- However it varies considerably across sectors.