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How to measure patent thickets—A novel approach[☆]

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ABSTRACT

This paper provides a direct measure of the density of patent thickets based on patent citations. We discuss the algorithm that generates the measure and present descriptive results validating it. Moreover, we identify technology areas particularly affected by patent thickets.

1. Introduction

In the United States, the establishment of the CAFC in 1982 led to a strengthening of patent rights (Jaffe, 2000). Subsequently, there was an explosion of patent applications at the USPTO (Hall, 2005; Hall and Ziedonis, 2001; Kortum and Lerner, 1999), and a similar increase has been observable at the European Patent Office (EPO) since 1995 (von Graevenitz et al., 2007). These patent explosions have had particularly strong impact on technologies characterized by modular design and high complexity of products such as electronics and semiconductors. The combination of complex technology and high volume patenting creates patent thickets, which can be defined as dense webs of overlapping patent rights (Shapiro, 2001).

Cohen et al. (2000) identify complex technologies by bisecting the standard industry classification. Kortum and Lerner (1999), Hall (2005), and von Graevenitz et al. (2007) find that patenting increased particularly in complex technologies. Hall and Ziedonis (2001) and Ziedonis (2004) conduct interviews that establish that semiconductor firms are affected by patent thickets. All these papers provide evidence that patent thickets matter but do not provide a direct measure of their existence and extent.

We propose a novel measure of the density of patent thickets and describe an algorithm to generate this measure from patent data. The measure derives directly from information on blocking of one patent by another. Blocking patents can hold up whole technologies. Prominent examples include early disputes between Texas Instruments and a number of Japanese semiconductor firms over the "Kilby" patent or the dispute between Intel and Intergraph over the Clipper patents (Shapiro, 2003).

The growth of patent thickets has given rise to several enquiries[1] and legislative initiatives in the United States and Europe. In the United States, there have been repeated, yet hitherto unsuccessful attempts to change patent law, witness the Patent Reform Acts of 2005 (HR 2795), 2007(HR 1908, S.1145) and 2009 (S. 515/S. 610/HR 1260). Both the US Patent and Trademark Office and the European Patent Office recently overhauled their fee structures and rules in order to discourage excessive patent filings. A measure that makes the evolution of patent thickets transparent provides an important contribution to the policy debate.

This paper is structured as follows: in Section 2, we motivate the measure and set out the algorithm, which generates it. Section 3 presents

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[1] National Research Council (2004), F.T.C. (2003), and Bessen and Meurer (2008) focus on the US patent system. von Graevenitz et al. (2007) analyze primarily the patent system governed by the European Patent Office (EPO).

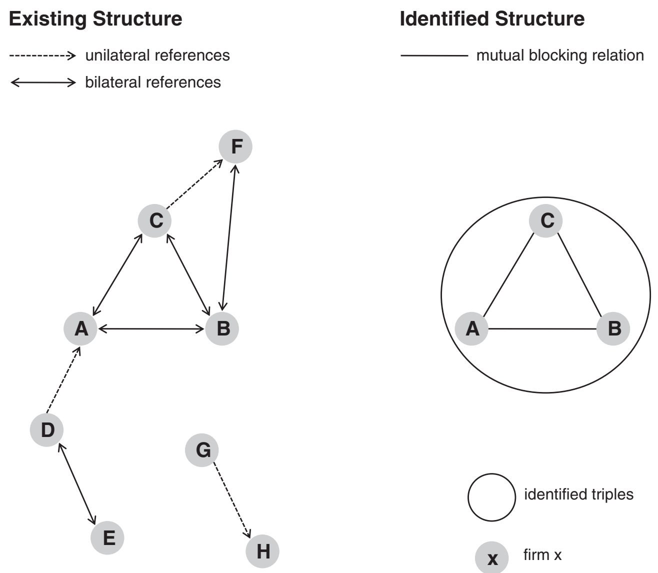

Fig. 1. Schematic presentation of the structure of unilateral and bilateral blocking relationships between patent holders.

descriptive results validating the measure. A short summary and outlook on future uses of our measure conclude the paper in Section 4.

2. The Algorithm

Our measure of patent thicket density exploits the classification of references in the search reports issued by the EPO. Search reports describe the state of prior art regarded as relevant for the patentability of an invention application and contain a list of references to prior patents and/or non-patent sources. Often, existing prior art limits the patentability of an invention and the references pointing to such critical documents are then classified as X or Y references (von Graevenitz et al., 2007).[2,3]

We propose a measure that identifies constellations in which three firms each own patents that block patent applications of the other two firms. If three firms block each other in this way, we call this a *triple*. Fig. 1 illustrates blocking, mutual blocking, and blocking in a triple. The likelihood of resolving a mutual blocking relationship between any two firms in a triple depends on the actions of the third party. Therefore, the bargaining problem facing the firms in a blocking triple cannot be resolved through independent bilateral bargaining by each firm pair in the triple, and the resolution of blocking relationships is more difficult than in a bilateral relationship. This raises bargaining costs substantially.

It is clear from depositions made in the course of the FTC/DOJ Hearings on Competition and Intellectual Property Law and Policy in the Knowledge-Based Economy (2002) that firms such as Cisco or Intel patent to cross-license: "Instead, since our purpose is to create a portfolio for cross-licensing, we find it necessary to stockpile patents." (Robert Barro, Cisco). These firms must pay attention to two questions: "What do we have on them?" and "What do they have on us?"(Peter Detkin, Intel). Our measure captures the answer to these questions by uncovering which firms hold patents limiting the scope of a focal firm's patents, as well as whether that firm's own patents limit the scope of patents held by the other firms. The measure then takes this logic one step further by looking for triadic relationships of this type.

By identifying and counting the number of triples within a given technology area, we can measure the density of patent thickets. The count of the number of triples is related in spirit to the triad census undertaken in the analysis of network structures (Holland and Leinhardt, 1981). Patent data may be thought of as network data, although it is not often analyzed this way by economists. Recently, Milo et al. (2002) show that triples (triads) are a form of "network motif",[4] which arises in the World Wide Web, indicating that triad counts capture information about the nature of the web that is non-random. It remains to determine whether this finding also applies to patent data.

Our algorithm to count triples in patent data involves the following steps:

1. We partition the set of all patents into subsets corresponding to technology areas using the OST-INPI/FhG-ISI technology nomenclature (OECD, 1994).

For each technology area, we:

2. then identify all firms whose patents are referenced as X or Y references by a given firm;
3. compile a directed list of all firm pairs in which the first firm blocks one or more patents owned by the second;
4. identify all pairs in which each party can block at least one patent belonging to the other;
5. identify all groups of three firms that consist of mutually blocking firm pairs from the subset of firms that block each other mutually.

Our measure is a count of the number of triples arising in a technology area in a given time period.

In practice, we have limited the number of blocking firms considered for each blocked firm at step 2 of the algorithm to the ten most important firms blocking that firm's patents. This reduces the computational burden and helps us to focus on the most important blocking relations.

3. Descriptive Validation

To demonstrate that the triples measure of patent thicket density is capable of identifying patent thickets, we provide three descriptive results. These have been obtained by applying our algorithm to patent filings at the EPO between 1980 and 2003. Data were taken from the PATSTAT database ("EPO Worldwide Patent Statistical Database") as of September 2006.

First, we bisect the technology areas in our data according to the definition of complex and discrete technologies suggested by Cohen et al. (2000) and compute the aggregate number of triples for complex and discrete technology areas by year. Fig. 2 shows that the density of patent thickets in complex technology areas has risen steadily since the early 1980s, whereas the density of patent thickets has been constant in discrete technology areas. The decrease in the number of triples in 2004 is the consequence of grant lags at the EPO (Harhoff et al., 2006).

Second, Fig. 3 provides information on the number of triples relative to patent applications in complex and discrete technologies and shows that the difference between discrete and complex areas is not a function of the number of patent applications.

Finally, Table 1 sets out the number of triples by technology area. This table shows that very dense patent thickets exist in all technology areas related to information technology and semiconductors. This

[2] Type X references refer to prior art documents, which, taken by themselves, call novelty or inventive step of a claim into question. Type Y references do so in conjunction with other documents.

[3] In patent data that do not contain a classification of links indicating critical references (such as data from USPTO), our measure will not identify blocking and the need for cross-licensing as clearly as it does in our current data. Nonetheless, it is likely that some of the references on US patents are there because they limit the scope of the patent. Thus our measure when applied to US patent data is likely to be noisier than when applied to EPO data.

[4] A network motif is defined as a recurring, significant pattern of interconnections in a network.

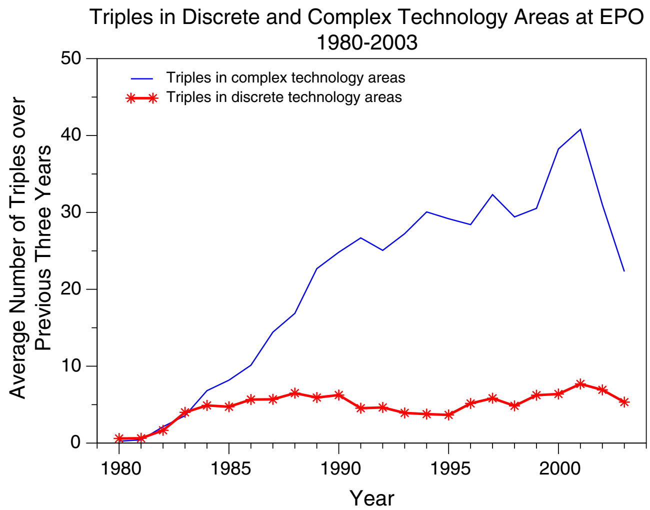

Fig. 2. Average number of triples identified in complex and discrete areas.

finding accords well with the results of Hall and Ziedonis (2001) and Hall (2005), who identify these technology areas as affected by patent thickets. It also supports the statements of the representatives of Intel and Cisco cited above.

In related work, von Graevenitz et al. (2008) show that triples capture the complexity of technology in a technology area. Complexity in turn is shown to increase firms' patenting incentives conditional on technological opportunity and the number of patenting firms. Also, Fischer and Henkel (2009) employing the triples measure find that patent trolls are more active in areas characterized by a large number of triples.

Table 1 identifies additional technology areas – previously not identified as being affected by patent thickets – characterized by patent thickets of lower intensity. These include Optics; Handling and Printing or Machines, Pumps and Turbines.

4. Summary

We provide a measure of the density of patent thickets based on triples of firms that can mutually block some of each others' patents. The number of triples measures the density of patent thickets in a technology area.

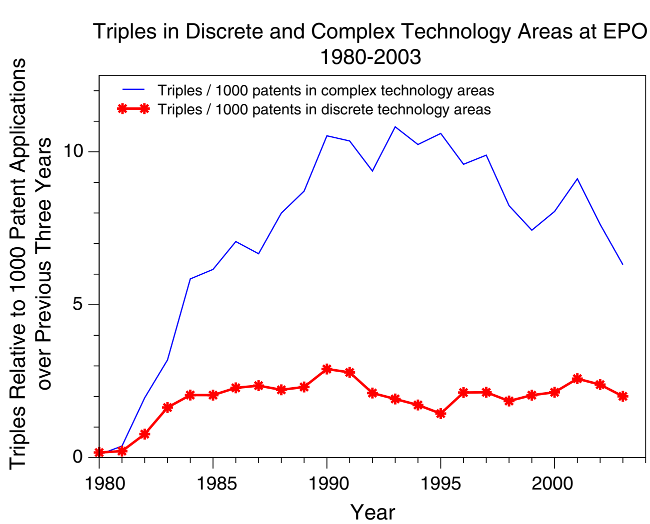

Fig. 3. Average number of triples identified relative to 1000 patent applications in complex and discrete areas.

Table 1
Patent applications and the distribution of triples between 1980 and 2003.

Technology area	Patent	Triples				
	Applications	Mean	Median	Min.	Max.	Classification
Electrical machinery, electrical energy	3790	18.79	19	0	42	Complex
Audiovisual technology	2377	93.68	116	0	148	Complex
Telecommunications	4979	78.01	88	0	166	Complex
Information technology	3047	47.53	55	0	73	Complex
Semiconductors	1740	52.72	57	1	91	Complex
Optics	2684	46.57	47	0	77	Complex
Analysis, measurement, control	3662	5.45	3	0	21	Complex
Medical technology	1666	3.15	3	0	8	Complex
Nuclear engineering	281	0.8	1	0	4	Complex
Organic fine chemistry	4816	5.51	3	0	19	Discrete
Macromolecular chemistry, polymers	3167	16.92	15	1	38	Discrete
Pharmaceuticals, cosmetics	2979	2.78	3	0	8	Discrete
Biotechnology	1902	0	0	0	0	Discrete
Agriculture, food chemistry	451	0.06	0	0	1	Discrete
Chemical and petrol industry	2245	10.89	10	0	22	Discrete
Chemical engineering	1317	1.06	1	0	3	Discrete
Surface technology, coating	1529	2.67	2	0	9	Discrete
Materials, metallurgy	1869	1.95	1	0	6	Discrete
Materials processing, textiles, paper	2150	3.28	3	0	9	Discrete
Handling, printing	2088	15.9	9	0	50	Discrete
Agricultural and food processing	303	0.33	0	0	2	Discrete
Environmental technology	477	3	0	0	15	Complex
Machine tools	942	1.55	1	0	5	Complex
Engines, pumps and turbines	1559	18.53	13	0	69	Complex
Thermal processes and apparatus	587	0.29	0	0	2	Complex
Mechanical elements	1583	1.77	1	0	7	Complex
Transport	2114	12.89	12	0	50	Complex
Space technology, weapons	199	0	0	0	0	Complex
Consumer goods	1171	0.58	0	0	4	Complex
Civil engineering, building, mining	688	0	0	0	0	Complex

The number of triples is high for technology areas classified in previous studies as complex, whereas it is much lower in areas classified as discrete. We also find that patent thickets are particularly dense in technology areas previously identified in qualitative assessments as harboring patent thickets.

The advantage of the triples measure proposed here is that it provides a simple way of computing the density of patent thickets across technologies and at any given point in time. In this way, the measure enables researchers to analyze the effect of the threat of hold up in different technology areas on firms' patenting strategies. The measure is closely related to measures recently used to characterize network structure in a diverse set of networks including the World Wide Web and social interactions (Milo et al., 2002, 2004).

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