

PATENTING PARTNERSHIPS BY U.S. UNIVERSITIES

Mark Funk
Assistant Professor of Economics
University of Arkansas at Little Rock
2801 South University Avenue
Little Rock AR 72205
mffunk@ualr.edu
501-569-8877

Abstract

This paper examines patenting partnerships between U.S. universities and other entities. Approximately 10% of all patents assigned to U.S. universities have at least one other assignee. These assignees are typically U.S. firms, but may be government agencies, other non-profits such as hospitals, or foreign entities. Our question centers on the success of these patenting partnerships, with success defined as the number and quality of the patents the partnerships generate. Using publically available data, we find that approximately two-thirds of the U.S. university partnerships produce just one patent. Partnerships that are repeated generate almost four patents, on average, with some partnerships generating twenty or more patents. Using a range of different measures that capture different aspects of patent quality, we next examine the quality of patents produced by the partnerships. Compared to the patents from the one-time partnerships, the initial patents from repeated partnerships appear to be of higher quality. The initial patents from a repeated partnership appear to be more important innovations, more original, and more valuable than are either the follow-up patents or the patents from one-time partnerships.

PATENTING PARTNERSHIPS BY U.S. UNIVERSITIES

Introduction

Universities are under increasing public and legislative pressure to play an active role in the economic growth and development of their communities. One way universities have responded to this pressure is by devoting more effort and resources to developing and disseminating innovations. Evidence of this effort is shown by the rapid increase in patenting by universities since 1980 (e.g., Henderson, et al., 1998; Mowery and Ziedonis, 2002; Sampat, 2006). One particularly striking feature of this development is the number of university patents shared with other entities: while just 1.2% of all U.S. patents from 1976 to 2006 were assigned to more than one entity, 11% of all U.S. university patents were shared with a firm, another nonprofit (hospitals, research institutions, and other universities) or government agencies. While universities accounted for 3.5% of US patents during the 1976-2006 period, universities accounted for 22% of all shared patents with US assignees.¹

There are several reasons why universities may share patent assignments with outside entities. The university researchers may receive external funding. Innovations emerging from the externally funded research may be jointly assigned to the university and to the external funding agent as specified by the funding agreement. Alternatively, university researchers may collaborate with researchers outside of the university. If the collaboration results in a patentable innovation, with substantial contributions by both the university and the external researchers, then the university will share the patent assignment with the external parties. This collaboration and patent sharing does not imply a financial-funding relationship. Lastly, the university researchers may be principals in a firm, such as those associated with university incubators. Patents emerging from these researchers may then be assigned to both the university and the firm.

The different motivations to share patent assignments may lead to qualitatively different patents. Collaboration between researchers may result from a need for specialized expertise, knowledge, or facilities to complement existing research capabilities. The quality of innovation may improve as the contributions of the additional external researchers broadens and deepens the knowledge embedded in the patented innovation. Alternatively, the external funding agent may have a particular innovative outcome as a goal. In this case the patented innovation may be relatively incremental. In the case of university researchers as principals in a firm, the patented innovations may be relatively incremental and narrow in scope.

Relatively little research has examined the patenting partnerships between universities and outside entities. Thursby et al., (2009) examine the large number of patents that are not assigned to a US university but whose inventors are associated with US universities. They find that the university-invented patents assigned solely to firms are less basic than the patents assigned solely

¹ All data in this paper comes for the National Bureau of Economic Research Patent Data Project (<https://sites.google.com/site/patentdatapoint/Home>)

to universities. They interpret this as evidence of faculty consulting, rather than as a failure to enforce university policy on innovation and patenting. Thursby et al., (2009) document the large number of patents with assignments shared between universities and private firms, but drop these joint patents from their analysis. In a similar paper, Crespi et al., (2010) compare university-owned patents and university-invented but firm-owned patents in Europe, and find no significant differences between them. Audretsch et al., (2012) develop a model of industry and university partnerships. Using data from research funded by the US Department of Energy, they find that industry-university partnerships are more likely for large firms and firms with academic founders. Czarnitski et al., (2012) examine patent applications by German academics inventors. The German patents assigned to industry were found to be less complex but more immediately important. Czarnitski et al., (2012) also find evidence that the academic-invented but industry-assigned patents are more likely to be used to block future patent grants to other entities.

This paper takes a closer look at the patenting partnerships between U.S. universities and other entities. Our question centers on the success of these partnerships, with success defined as the number and quality of patents they generate. Are these partnerships one-time temporary alliances that produce a single patent, as might arise from a funding relationship? If so, then the university may be seen as playing the role of a technology consultant, working toward a well-defined goal. This interpretation would be particularly likely if the patents emerging from the university partnerships are of relatively low quality. Or are the partnerships long lasting and repeated, generating several patents, as might arise from a collaborative relationship? If so, then universities may be seen as innovation generators and incubators from economic growth. This interpretation would be strengthened if the shared patents are of relatively high quality.

The answers to these questions will help clarify the role of universities in sparking economic development and growth. The paper proceeds as follows. Section 2 explores the data on patents with assignment shared by US universities. We are interested in learning what types of universities pursue co-assigned patents, the characteristics of their patenting partners, and whether these patenting partnerships are repeated. Section 3 examines the quality of patents co-assigned to universities. We are interested in learning whether the quality of patents in repeated patenting partnerships is measurably different than the quality of patents in one-time partnerships. Section 4 concludes with some suggestions for further research.

2. University Joint Patents: Data

In this section we examine the data on university patents. Our data comes from the Patent Data Project at the National Bureau of Economic Research (NBER).² This data, consisting of several datasets compiled by NBER researchers, includes the patent application and grant year, technology classifications, citations, names of the initial assignees, and classification of the initial assignees (US firm, foreign firm, US government, foreign government, US hospital or research institute, foreign hospital or research institute, US university, foreign university, US individual, and foreign individual). The data covers patents applied or granted during the years 1976-2006.

² <https://sites.google.com/site/patentdataproyect/Home>

Joint patents are defined as patents with more than one assignee. Joint patents account for 1.7% of all US patents applied for and granted during the years 1976-2006. The majority (68%) of US patents with more than one assignee are assigned to foreign entities. Of the 23,892 joint patents with at least one US assignee, 5,258 (or 22%) have a US university as an assignee. As shown in Table 1, 10.8% of all university patents are co-assigned. This compares to the 1.2% of US corporate patents with more than one patent assignee.

Table 1:

Joint Patents, 1976-2006

Type of Co-assignee	Total Joint Patents (percent of all patents to assignee type)
US Corporation	16,135 (1.2%)
US Government	868 (3.2%)
US University	5,258 (10.8%)
US Hospital/Institute	1,631 (10.9%)
Foreign Assignees	50,953 (4.2%)
Note: A patent assigned to two different types of assignees counts toward the totals of both assignee types. For example, a patent assigned to both a US corporation and a US university counts in both the US corporation totals and in the US university totals.	

To identify patenting partnerships we create an identifier for each unique partnership pair. For this analysis we limit our focus to the patent partnerships between a university and a non-university partner. Removing patents whose assignment is shared only by universities leaves 4,804 co-assigned patents representing 2,506 unique partnerships. Note that since a patent may have more than two assignees (the maximum number of assignees in our sample is seven), there may be more than one partnership represented on any one patent. For example, for a patent with a university and two non-university assignees, there are two university/non-university partnerships.

Table 2 provides sample data characteristics on the partnerships between US universities and non-universities. Of the 2,506 unique US university partnerships with non-universities, 1,698 (68%) were one-time patenting partnerships that were not repeated beyond the first patent. The 808 partnerships that were repeated generated 3,106 patents, or 3.8 patents each on average. Thus while only 32% of US university patenting partnerships are repeated, they generate 65% of all joint patents with US universities co-assignees. Approximately 15% of all patenting partnerships were repeated just twice and 17% of all partnerships were repeated three or more times. The maximum number of patents from a US university/non-university patenting partnership during this time period is 30. This data suggests that while most patent partnerships last for just one patent, the repeated partnerships produce a significant number of patents.

Table 2:

University Joint Patent Partnerships, 1976-2006

Total Partnerships		2,506
One-time Partnerships		1,698
Repeated Partnerships		808
	Repeated twice	375
	Repeated three or more times	433

Several studies of university patenting have questioned whether the increase in the number of universities pursuing patents has affected the average quality of university patents. Mowery and Ziedonis (2002), among others, tackle this question by comparing patents assigned to universities with experience in patenting prior to the passage of the 1980 Bayh-Dole Act, which said universities could patent innovations emerging from federally funded research, to universities that began patenting after the Bayh-Dole Act. With that in mind, we divide universities based upon whether they applied for their first patent before or after 1980. The universities with patent application in 1980 or prior are labeled “Incumbent”. Universities whose first patent application occurred after 1980 are labeled “Entrant”. We also explore whether the patent partnerships varies according to whether the university is public or private.

Table 3 provides the data on patenting partnerships by the type of university. Incumbent universities engage in far more patenting than entrant universities. Approximately 86% of all university patents, whether co-assigned or not, are held by Incumbent universities. However, a higher percentage of Entrant patents are shared with other entities (15.3% of all Entrants patents versus 10.8% for all Incumbents patents). Incumbent partnerships are more likely to be repeated, as 34% are repeated versus 28% of Entrant partnerships, but the average number of patents from a repeated partnership is the same (3.85) for incumbent and entrant universities. We find very little difference in patent partnerships between public and private universities. Approximately one-third of public and private university partnerships are repeated, with approximately two-thirds of the patents coming from repeated partnerships.

Table 3:

Patent Partnerships, by Type of University

	Percent of partnerships repeated	Percent of patents from repeated partnerships
Incumbent	34%	67%
Entrant	28%	60%
Public	32%	65%

Private	35%	67%
---------	-----	-----

We also explore whether the type of partner matters. We define four types of partners: US firm, US hospital or research institute, a US government agency, and foreign partners. Table 4 provides the data on the type of partners. The majority of university partnerships are with US firms: 1,481 of the 2,506 total partnerships (59%) are with US firms. A slightly larger percentage (62%) of repeated partnerships are with US firms, with the average repeated partnership lasting for 3.7 patents. While just one-third of university-firm partnerships are repeated, two-thirds of all joint university-firm patents are from repeated partnerships.

Partnerships between universities and hospitals and research universities are, by longevity measures, the most successful collaborations. Slightly more than 35% of all such partnerships are repeated, yielding 4.6 patents on average. The least successful collaborations are with foreign entities: just 25% of the patenting partnerships between universities and foreign entities are repeated, lasting an average of just 3.4 patents

Table 4:

Patent Partnerships, by Type of Partner

Type of Co-assignee	Total Partnerships	Percent of partnerships repeating	Average number of patents in repeated partnerships
US Corp	1,481	34%	3.7
US Institute or Hospital	357	35%	4.6
US Government	169	34%	4.3
Foreign	499	25%	3.4

The relative success of partnerships between universities and hospitals are research centers may result from the nature of the research involved. Patents in broadly-defined biomedical fields account for approximately 50% of all university patents (for public, private, incumbent and entrant universities), but represent 67% of all university joint patents. While 59% of non-biomedical joint patents are from repeated partnerships, 68% of biomedical joint patents are from repeated partnerships.

Section 3: Patent Quality

In this section we examine the quality of the patents emerging from university partnerships with non-universities. Many measures of patent quality appear in the university patenting literature (e.g., Hall et al., 2001; Henderson et al., 1998; Mowery and Ziedonis, 2002). We adopt several different measures, each providing a different perspective on patent quality. We do not prefer any one of these patent quality measures to any other. Rather, we present statistics on each measure and look for common conclusions.

The simplest and most common quality measures are based on the number of patent citations. Forward citations measure the number of citations made to a specific patent. A relatively large number of forward citations is a signal that the patent is relatively important to later innovations in either a technological or a market sense. Henderson et al. (1998) and Mowery and Ziedonis (2002) refer to forward citations as a measure of the “importance” of the patent. Forward citations in our data generally peak five years after the patent’s application. Because our data ends in 2006, the forward citation measure is subject to “right-truncation”, meaning more recent patents may suffer from an undercount of forward citations. To partially address this problem, we limit our sample period to include only patents applied for by 1999 or earlier.³

Backward citations measure the number of citations made by a specific patent. A relatively large number of backward citations means the innovation draws upon and synthesizes a relatively large amount of knowledge. Citing behavior in our data appears to have changed during the 1980’s, with the number of backward citations increasing across the board; Hall et al., (2001) document the same phenomenon. This change in citing behavior means that patents prior to the mid-1980’s will have relatively fewer backward citations. Therefore we limit our sample to patents applied for in 1985 or later.

Two proposed measures of the breadth of knowledge embedded in a patent are the generality index and the originality index (Hall et al., 2001; Henderson et al., 1998). Generality is defined as:

$$Generality_i = 1 - \sum_{k=1}^N \left(\frac{Nciting_{ik}}{Nciting_i} \right)^2$$

where k is the index of technology classes, N is the number of different classes the citing patents belong to, and $Nciting$ is the number of citing patents. Patents valuable to and cited by a large number of technology fields will have a high generality score. Patents with high generality scores are commonly described as being more “basic” in nature (e.g., Henderson et. al, 1998). The originality measure is defined in similar fashion as the generality measure, but with $Nciting$ referencing citations made rather than citations received. Patents with relatively high originality scores cite patents from a relatively broad range of technology classes. The value of these patents comes from their synthesis of knowledge from many fields.

Self-citations create an interesting dilemma. Self-citations represent an attempt to internalize knowledge and are often used to build a fence around a patent with high market value. Including self-citations may conflate the patent’s broader impact on the available knowledge pool with the private value of the patent to the assignees. For that reason self-citations are commonly removed

³ In addition to limiting their sample period to address right truncation, Mowery and Ziedonis (2002) include only citations that occurred within 6 years of the patent grant year. This may cause a relative undercount of citations for non-incremental patents, i.e., those patents whose technological and market value is not fully revealed for several years after the patent’s issue. This study uses all available citations.

from the calculation of forward and backwards citations. However, in this paper self-citations may reflect relevant knowledge transfer between the university and non-university co-assignees. For example, the university's track record as evidenced by previous patenting output may have attracted the external researchers into research collaborations. If a new joint patent emerges from the collaboration, then a backwards self-citation by the new patent to the university's prior patents may accurately represent a transfer of the university's prior knowledge to the external entity. Likewise, a forward self-citation by any co-assignee, whether the university or the non-university, to a jointly-assigned patent may reflect a valuable knowledge transfer between the assignees had occurred during the initial research collaboration.

Following these arguments we include self-citations in the four quality measures defined above. However, to measure the impact of self-citations, we take two separate approaches. First, we calculate and report forward and backward citations with and without self-citations. Second, we use two additional measures based on the patent's proportion of self-citations (Hall, et al., 2001). The first self-citation measure, which we label "moat", is the percentage of forward citations to a patent that come from all assignees on that patent. A relatively high "moat" implies the joint patent generated relatively low amounts of knowledge transfer to non-assignees. A knowledge transfer may have occurred between the assignees, but the knowledge embedded in the patent is of relatively low value to external entities. The second self-citation variable, labeled "inbred", is the percentage of backward citations to other patents held by the co-assignees. A relatively high "inbred" percentage implies the patent drew upon relatively little knowledge external to the assignees. It is worth noting, again, that we do not prefer any one quality measures to any other. We emphasize instead the common conclusions.

As a first step in our analysis, we examine the quality measures for three kinds of patents that emerge from university patenting partnerships. The first kind of patent is from one-time partnerships, that is, patents from partnerships that developed no other patented innovations. We call these "one-time patents." The second type of patent is the first patent from a partnership that generated several patents. We call these patents "initial patents." The third type of patent consists of all patents that follow the initial patent in a patenting partnership. We call these patents "follow-up patents." Since we limit the sample to the 1985-1999 period, there are 1,074 one-time patents, 684 initial patents, and 1,539 follow-up patents.

Table 5 reports the average for each quality measure for each type of patent. Initial patents have the highest average value for seven of the eight quality measures. This suggests initial patents are of relatively high quality. Follow-up patents have the lowest values for both forward cites measures, generality and originality, but the highest value for inbred. This suggests the follow-up patents are relatively low quality on average.

Table 5:

Average Patent Quality, by Type of Patent, 1985-1999

University Joint Patents, 1985-1999	One-time Patents Obs = 1,074	Initial Patents Obs = 684	Follow-up Patents Obs = 1,539
Average forward cites	9.86	13.31	7.64

Average forward cites, no self-cites	9.42	12.11	7.03
Average backward cites	7.36	8.04	8.01
Average backward cites, no self-cites	6.93	7.56	7.06
Average generality	0.55	0.56	0.53
Average originality	0.57	0.58	0.55
Average moat	6.3%	15.0%	12.8%
Average inbred	8.4%	9.3%	15.6%

As a second method to examine patent quality, we use a simple matched-pairs comparison of means. We match each initial patent with a randomly selected one-time patent. To maintain maximum consistency, the matched patents are from the same patent application year and the same technology classification. Table 6 displays the difference in the means of the repeated-partnership patents versus the control sample of one-time partnership patents for each of the quality measures.

Table 6:
Differences in Means of Quality Measures, 1985-1999

Mean difference, “Initial” patents vs. “One-time” control sample, 1985-1999 * P > 0.10 and ** P > 0.05 for tests for significance of differences in means. Unequal variances assumed.							
Forward Citations (Importance)	Backward Citations	Generality (Basicness)	Originality	Moat	Inbred	Fixed forward cites	Fixed backwards cites
3.12**	1.44**	0.00	0.03*	8.8%**	-1.4%	2.35 **	1.37 **

The data reveal that initial patents have a statistically significant higher number of forward cites and backwards cites, with or without self-citations, higher originality and a higher moat. The data suggests that initial patents attract about 30% more forward cites than do one-time patents, even when self-citations are removed. This suggests the initial patents are more important than patents from one-time partnerships. The initial patents are also slightly more original. Initial patents also have a higher moat, attracting about twice as many self-citations as one-time patents. This may suggest that the partners found the initial patents to be more valuable, in either a technology or a market-value sense, than they find patents from one-time partnerships.

4. Conclusion

This paper examines the data on patents co-assigned to universities and non-university partners. These patenting partnerships are often referenced as evidence of the impact universities have on economic growth and development. The patenting partnerships are widespread across different types of universities and external partners, and they generate a significant number of patents. However, not all patent partnerships are equally successful. Approximately two-thirds of the

partnerships last for just one patent. Partnerships that are repeated generate almost four patents, on average, with some partnerships generate many multiples of that. Compared to the initial patents from repeated partnerships, the patents from these one-time partnerships appear to be of lower quality across a range of different quality measures. The initial patents from a repeated partnership appear to be more important innovations, more original, and more valuable than are either the follow-up patents or the patents from one-time partnerships.

There is much more to learn about university patenting partnerships. Two questions seem particularly worthy of further study. First, the source of research funds may affect the number and quality of patents from a patenting partnership. If the external partner is supplying the research funding, the funding may be provided to solve one particularly technological problem. This would limit the number of possible follow-up patents. Further, external funding may mean the scope of the innovation is relatively narrowly defined. This would limit the patent's usefulness to broader applications. Research into the interaction of funding with the patent quality may reveal why some partnerships are less successful than others.

A second area that may yield useful insights concerns the university policies on technological innovation and patenting. It may be that university policies influence the university's ability to develop successful partnerships. For example, some universities require any potential patentable innovations to be reviewed by an internal review board. Typically these boards determine that the patent rights are not worth the patent costs for many innovations they review. These innovations may then be patented, by either the individual researcher or by external entities, but the university would not be an assignee. Thus it is possible that some successful research partnerships between universities and external entities are not documented in the patent applications. Uncovering these partnerships may help us learn more about the role of universities in generating economic growth and development.

References

- Crespi, G., Aldo Geuna, Önder Nomaler & Bart Verspagen, 2010. "University IPRs and knowledge transfer: is university ownership more efficient?" *Economics of Innovation and New Technology* 19: 627-648.
- Czarnitzki, Dirk, Katrin Hussinger, Cedric Schneider, 2012. "The Nexus Between Science and Industry: Evidence from Faculty Inventions." *Journal of Technology Transfer* 37:755-776
- Hall, B. H., Jaffe, B.B., Trajtenberg, M., 2001. "The NBER patent citations data file: Lessons, insights and methodological tools." *National Bureau of Economic Research Working Paper* 8498.

Hall, B. (2004). "University-Industry Research Partnerships in the United States," in *Rethinking Science Systems and Innovation Policies*. Contzen, J.P., Gibson, D. Heitor, M.V (Eds), , West Lafayette IN: Purdue University Press, ch 17.

Henderson, R. Jaffe, A.B., Trajtenberg, M. 1998. "Universities as a source of commercial technology: A detailed analysis of university patenting, 1965-1988." *The Review of Economics and Statistics* 80: 119-127.

Sampat, B.N. 2006. "Patenting and US academic research in the 20th century: The world before and after Bayh-Dole." *Research Policy* 35: 772-789.

Mowery, D.C., Ziedonis, A.A., 2002. "Academic patent quality and quantity before and after the Bayh-Dole act in the United States." *Research Policy* 31: 399-418.

Thursby, J.G., Thursby, M.C., 2011. "Has the Bayh-Dole act compromised basic research?" *Research Policy* 40: 1077-1083

Thursby, J. Fuller, A.W., Thursby, M. 2009 "US faculty patenting: Inside and outside the university." *Research Policy* 38: 14-25