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Are Patenting Activities in U.S. Universities Still Affected by Bayh-Dole Act?*

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Based on four data sources, the trends of the patent activities of US universities in the last 40 years are quantitatively assessed. It has been found that patenting activities in U.S. universities slowed down greatly after 2000 and remained flat until the period from 2010 to 2012, when activities recover to the level of strength characterizing the period before 2000 and after the enactment of the Bayh-Dole Act. The affects of the (Bayh-Dole) Act on the university patenting activities (UPAs) are specifically analyzed for the time span considered. We found that the impacts of the Act had been remaining strong until the year of 1999 and then greatly diminished. We also identify that economic recessions are the major cause to the flatness of the patenting activities during 2000s. Recently, many concerns on university patent activities have been raised; these concerns are reviewed and recommendations to resolute to these concerns are provided.

Keywords: Bayh-Dole Act, commercialization, innovation disclosure, patent, patent share, technology transfer, universities

Introduction

Since 1960, U.S. productivity growth had slowed significantly and continued to grow at a slower rate in 1970's than that of its major trading partners, especially Japan, known as Japanese challenge (Cullison, 1989). As indicated by the data reported by Kendrick (1990) and Hornstein and Krusell (1996), the growth rates of the labor and the total-factor productivity of U.S. are three to seven times less than that of Japan from 1960 to 1979. Potential explanations for this slowdown have been widely debated, with lack of technology innovation one major reason cited (Cullison, 1989; Kendrick, 1990; Hornstein & Krusell, 1996). As a result, beginning in 1980, the U.S. Congress passed a series of legislation to facilitate and to encouraging technological innovation, especially university patent activities (UPAs), with the goal to reverse the productivity slowdown in the 1960s

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and 1970s (Stevens, 2004). Among them, the Bayh-Dole Act of 1980 (Cullison, 1989; Hornstein & Krusell, 1996) should be one of the most influential pieces of legislation for providing the motivation for increasing UPAs, where the UPAs normally include the activities of innovation disclosures, patent applications, and patent grants.

The Bayh-Dole Act (the "Act") confers ownership of intellectual property rights, mainly patents, which arise from government-funded research to universities with the express purpose of encouraging the commercialization of innovative technologies through licensing or cooperative ventures between the university and industry. The patent ownership or patent right is expected to provide motivation, especially economic incentives, for a university to license its intellectual property to a company. For this, the Act is commonly credited with launching the boom in UPAs. The university innovation literature tends to divide the university programs into pre- and post-the Bayh-Dole Act (Mowery, Nelson, Sampat, & Ziedonis, 2004; Geiger, 2005).

Following the passage of the Act at the end of 1980, universities in U.S. have greatly expanded their patenting efforts. For example, based on the data reported by the Association of University Technology Managers (AUTM, 2013), the number of patents granted to U.S. universities grew from fewer than 250 in 1980 to more than 5,000 in 2012, a more than 20-fold growth. The other patenting and commercialization activities, such as innovation disclosures and license signed, are also proportional to the patenting activities to have a great amount of increase, since 1980. Recently, because of the growth of Internet commerce and the advances in digital, information, and biogenetics technology, a broad range of entrepreneurial companies have been formed and the substances in technology transfer have changed greatly as compared to those in 20 or 30 years ago (Schacht, 2012). For example, the patentability of biological materials and biomedical research tools as well as the technology transfer of digital data and computer software are becoming hot issues in technology transfer only recently (COGR, 1999; Knoppers, 1999; Resnik, 2001; Cohen & Lemley, 2001; Hoeyer, 2008).

The purpose of the present paper is thus to assess the effects of the Act on UPAs under the current technology environment. Since patent grants are the major indicator or source for UPAs and commercialization (Rogers, Ying, & Joern, 2000; Huang, Ken, Wang, Wu, & Shiu, 2011; Tseng & Raudensky, 2014; 2015), the number of university patents granted in each year is specifically analyzed to quantify the effects of the Act on UPAs. Following a review of the background and the general impact of the Act on UPAs, the university patents granted after and before of the enactment of the Act are assessed with the focus on the activities in more recent years. Finally, the major concerns raised by the implementation of the Act to the current environment are discussed and the recommendations to alleviate these concerns are provided.

University Patenting Activities (UPAs) From 1963 to 2012

The mandates of the university ownership of patents and sharing the patent royalty with the inventors required by the Act are commonly credited with launching the boom in UPAs, especially the patenting activities. In this section, the background prior to Bayh-Dole Act and the effects of the Act on the UPAs are first evaluated.

Prior to Bayh-Dole Act

Before the enactment of the Act in 1980, although federal funding for university-based research was significant, the government lacked a coherent patent policy. Prior to this legislation, the process of UPAs, was very slow and often restrained by government policy. The reason for the small amount of innovation or patent right moving from universities to industry was due mostly to the fact that the U.S. government retained the rights to all patents produced by universities using government funding and also retained the licenses to all patents granted to universities using federal money (COGR, 1999). This slowed down the process of UPAs because many government agencies were reluctant to relinquish ownership of the patents to universities or industry. Instead these agencies granted non-exclusive licenses to anyone who wished to produce or use the inventions. As a result of the non-exclusive licenses, companies were turned off to the idea of manufacturing the inventions owned by the government. Companies resisted purchasing licenses or patent rights from government owned patents because their competitors could also acquire the same patent right, and could develop and sell the same product. In fact, prior to 1980, only 5% of government owned patents had ever been used in industry (Schacht, 2012). This was an extraordinarily low number and it concerned the government beginning in the 1970's (Henderson, Jaffe, & Trajtenberg, 1998). This concern contributed to the passage of the Act.

In fact, a broad range of federal initiatives had resulted in laws during 1980s and 1990s to design to remove barriers for the innovation invented in universities and to foster the innovation and associated technological advancement developed in industry, thereby permitting market forces to operate. These laws and policies, which had shaped the dynamics of technology transfer, include Stevenson-Wydler Technology Innovation Act of 1980 (Pub. L. 96-480), Bayh-Dole University and Small Business Patent Act of 1980 (Pub. L. 96-517), Small Business Innovation Development Act of 1982 (Pub. L. 97-219), Federal Technology Transfer Act of 1986 (Pub. L. 99-502), and Small Business Research and Development Enhancement Act of 1992 (Pub. L. 102-564). The key change to the field of UPAs was made by the Bayh-Dole Act (Stevens, 2004; Mowery et al., 2004; Geiger, 2005; Schacht, 2012; Tseng & Raudensky, 2014), which was enacted into law on December 12, 1980 and became effective on July 1, 1981. The Act allows universities, small businesses, and other non-profit organizations to elect to retain any "subject invention" made with federal funds. The university retaining the title must commit to the commercialization of that invention and is required to share a portion of the royalties from the invention with the inventors. Also, a portion of the royalties must be used for research purposes.

University Patents and Patent Shares From 1963 to 1999

Based on the database of the patents issued by United States Patent and Trademark Office (USPTO, 2013a), the number of the patents are counted for all domestic (US) patents that contain any of the three key words: "university", "college", and "institute", in their patent assignees and are plotted in Figure 1 for the time period from 1963 to 1999. The patent assignees with "institute" are rechecked by comparing the number of patents with "institute" and with "institute of technology" to eliminate any non-academic organizations to be counted. As shown in Figure 1, universities increased their patents from less than 100 in 1963 to more than 3,000 by 1999. A correlation analysis is performed to determine the associated growth rates, which are also shown in Figure 1. As shown, the growth rate is somewhat constant at 18.5 patent/year from 1963 to 1984, while the patent increase rate jumped to 159.7 patents per year from 1985 to 1997, which is more than eight times higher than that before 1985. The increase of the patent growth before and after the end of 1984 is significant; the acceleration of the patent growth should be attributed to the Act, since it usually takes two to three years from filing a patent to issuing a patent. A four-year time lag reflected in the patent growth shown in Figure 1 should be considered as adequate to be the effect of the Act.

Also, Figure 1 shows that the number of the patents issued to universities jumps from less than 2,500 in 1997 to near 3,200 in 1998 and keeps on growing to approximately 3,380 in 1999. This large jump in 1998 may imply the patenting activities entering a new era. However, after examining the annual numbers of the US patents issues to domestic assignees, which are reported by USPTO (2013b) and shown in Figure 2, a big jump from 1998 is also observed and, in fact, this big jump lasts four years. This should be contributed to the economic boom of the 1990s (a further discussion on the impact of the economic cycle on patenting activities can be found in section "US Domestic Patents During Economic Recessions"). To eliminate the effect of the economic contribution to the university patenting activities, the university patent shares should be considered as argued by Mowery and Sampat (2005). The patent share here is defined as the university patent numbers shown in Figure 1 divided by the respective US patents issued to the domestic assignees shown in Figure 2 (USPTO, 2013b). Note that, since USPTO does not report the percentages of the total patents granted to foreign assignees in 1975 and 1976, interpolation from the percentages of the neighboring years is used to calculate the numbers of US patents issued to the domestic assignees shown in Figure 2.

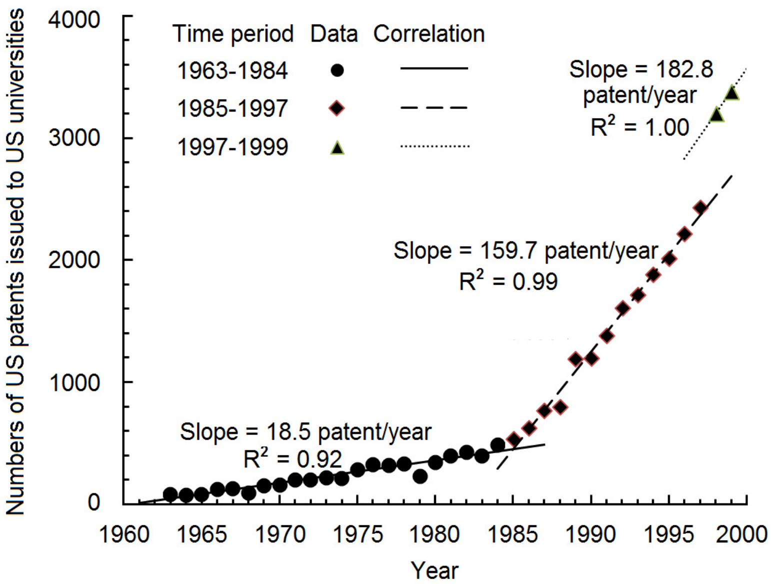

Figure 1. US patents issued to US universities from 1963 to 1999.

The results of the patent share analysis, which are shown in Figure 3, indicate that universities increased their share of patents from about 0.2% in 1963 to nearly 4% by 1999. The correlation analysis also shows that the jump of the patent growth from 1998 to 1999 shown in Figure 1 is not appeared or discovered in patent share growth, which means that the jump of patent growth in 1998 is not due to the Act, since the jump is also shown in the total US domestic patents granted as indicated in Figure 2. Also, as shown in Figure 3, the growth rate of the patent share is somewhat constant about 0.04% per year from 1963 to 1981 and the share increase rate jumped to 0.17% per year from 1982 to 1999, which is more than four times higher than that before the end of 1980. The acceleration of the share increase before and after the end of 1981 is substantial and should be, again, attributed to the Act. The results of Figure 3 also suggest that the economic boom of the 1990s should benefit to all sectors of the economics and the total number of patents can increase due to an economic boom while the normalized patent share should be less affected by the economic boom.

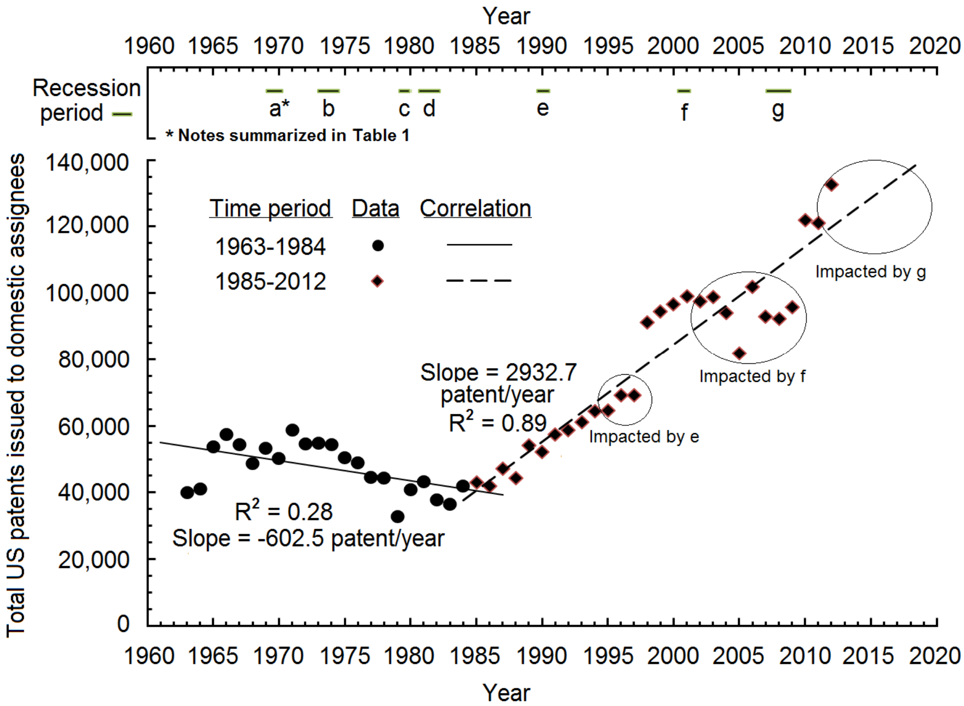

Figure 2. Annual numbers of US patents issued to US assignees from 1963 to 2012 and impacts of recessions on US patents issued.

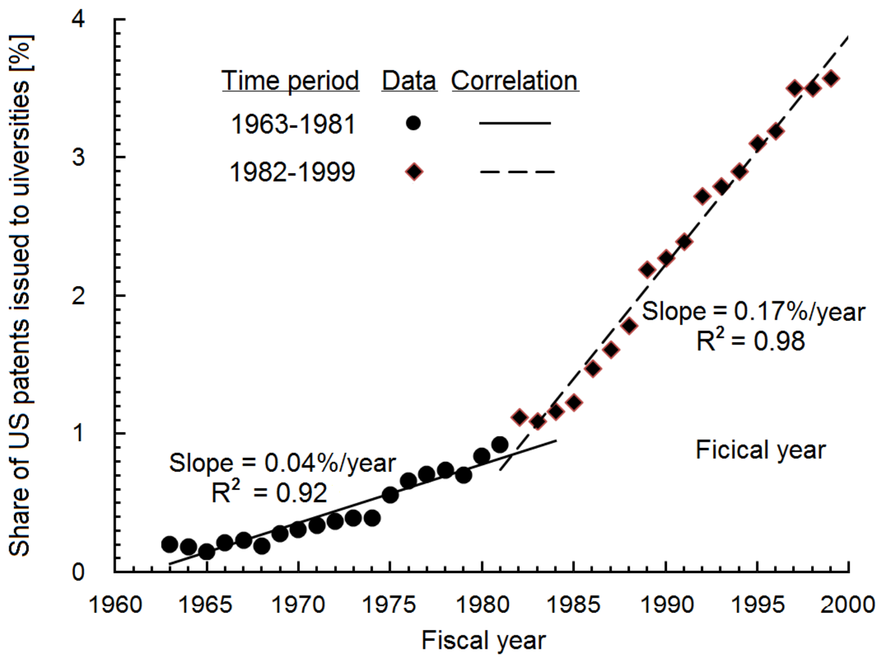

Figure 3. University shares of U.S. domestic patents from 1963 to 1999.

The coefficient of determinations (R^2) shown in Figures 1 and 3 is specifically computed to quantify data fitting accuracy for a correlation analysis. The R^2 coefficient is an overall measure of the deviation of a correlation regression to quantify how good is the correlation curve (or function) to represent the data. The coefficient always lies between 0 and 1. A value of zero occurs when the two variables are totally independent of each other, while it reaches 1 when the two variables correlate perfectly, i.e., no deviation from the correlated curve (Tseng, Raudensky, & Li, 2013). As shown in Figure 1, the corresponding R^2 for the correlations before and after the end of 1984 are 0.92 and 0.99, respectively, which imply that the patent data fit the correlation lines extremely good with the maximum deviation less than 8% from the correlated lines. Since only two data points are available in the time period between 1997 and 1999 in Figure 1, the correlation becomes the exact line connecting these two points, which means R^2 = 1.00 mathematically. Similarly, R^2 equal to 0.94 and 0.98 for the two correlations shown in Figure 3 implies that the correlation accuracies are also very good and the correlations for university patent share should be appropriate and reliable.

University Patents and Patent Shares From 1977 to 2005

Based on the data obtained from USPTO (2013b), Wong and Singh (2010) studied the total US patents annually issued to 103 universities for the time span from 1977 to 2005. Among these 103 universities, 86 are from USA and 17 are in Canada; they are all leading research universities ranked by both the Academic Ranking of World Universities (ARWU, 2013) and the World University Ranking (WUR, 2013). The patent data originally reported by Wong and Singh (2010) are correlatively analyzed and shown in Figure 4, where the data are correlated into four time periods. From 1977 to 1985, the growth rate is almost constant at 22.1 patent/year, while, from 1986 to 1997, the patent rate jumped to 139.9 patents per year, which is more than six times higher than that before. The jump after 1985 shown in Figure 4 is consistent with the finding shown in Figure 1, i.e., the university patenting activities are booming after 1985 and indeed due to the Act. However, for the period of 1977 to 1985, the patent growth rate depicted in Figure 4 is about 20% higher than that shown in Figure 1; this difference might be due to the fact that the survey population in Figure 4 includes only top research universities whereas the universities surveyed for Figure 1 include all types of universities. From 1986 to 1997, on the other hand, the growth rate in Figure 4 is 139.9 patent/year, about 14% lower than that shown in Figure 1; this lower growth rate should be caused by the 17 Canadian universities since they are not affected by the Act and their growth rates should be still the same as that in the period between 1977 and 1982, i.e., say 22.1 patent/year. This explanation can be illustrated by the following simple calculation, i.e., 20% universities having a growth rate of 22.1 plus 80% universities having a growth rate of 159.7 can yield that the overall growth rate for the US and Canadian universities becomes 132.2 patent/year, which is very close to with the value, 139.9 patent/year, shown in Figure 1. This calculation further confirms that the growth rate of university patents should be close to 159.7 patent/year during the period of 1985 to 1997.

Also, as shown in Figure 4, the patent data for the time period from 1998 to 2002 vary irregularly and cannot be properly correlated because the R^2 coefficient can be found to be barely 0.01, which means that the two variables, the patent number and time (year), are almost independent of each other. Nevertheless the best curve for this period indicates that the average patent growth rate is less than 3% of the rate immediately before 1998, which may also suggest that the effect of the Act may disappear or be compensated by other factors, such as economic downturns or recessions. Moreover, for the time period from 2003 to 2005, the university patent data are not only not increased but also decreased with a negative growth rate at -156 patent/year. To provide some explanations for the irregular patent rates in the above mentioned two time-periods, the patent data are further studied to calculate the associated patent shares and the results are shown in Figure 5.

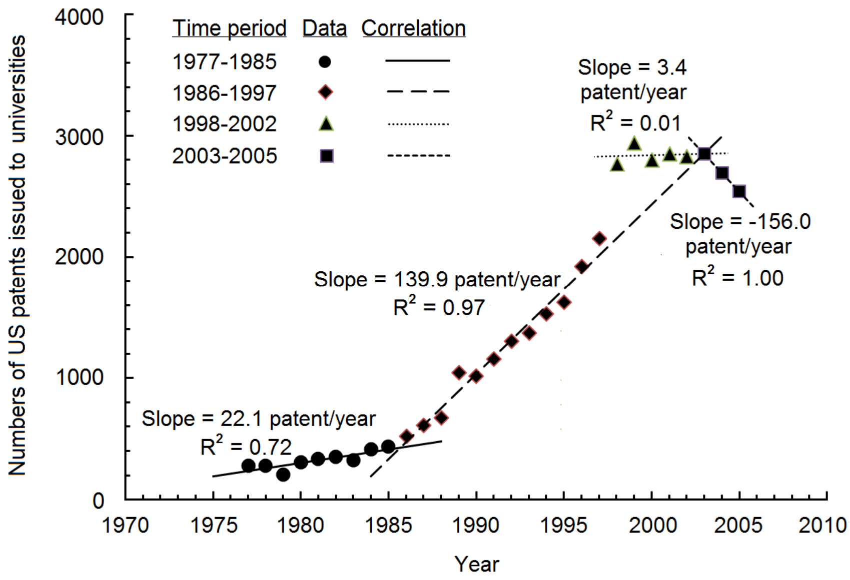

Figure 4. US patents issued to top US and Canada universities from 1977 to 2005 based on raw data from Wong and Singh (2010).

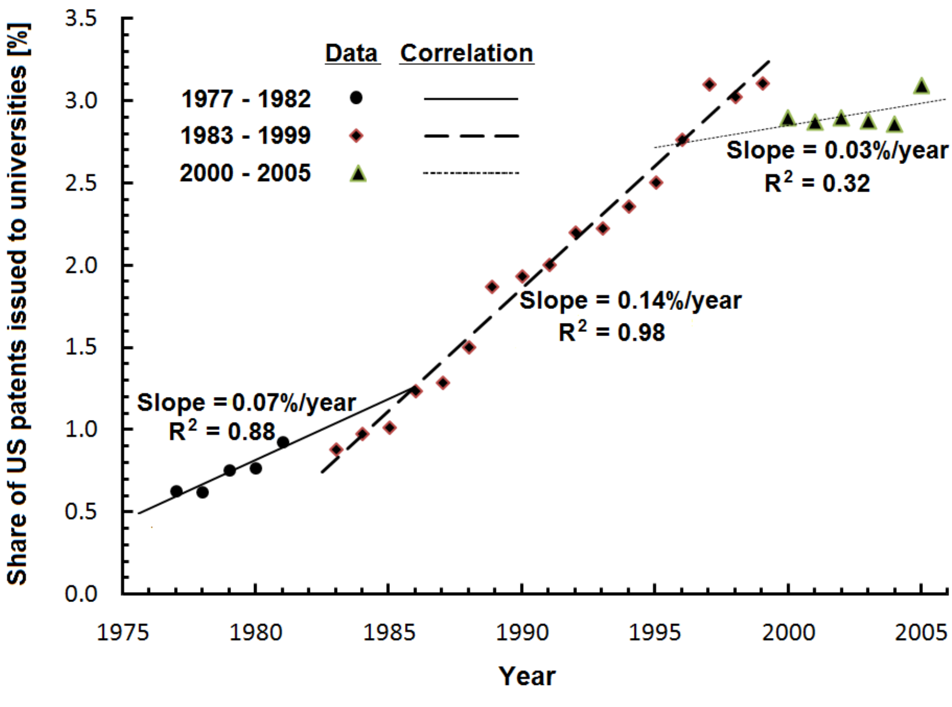

Figure 5. University shares of US domestic patents between 1977 and 2005 based on raw data from Refs (Wong & Singh, 2010; USPTO, 2013b).

The patent shares shown in Figure 5 are the patent data shown in Figure 4 divided respectively by the annual number of the total domestically assigned US patents (USPTO, 2013b). As shown, the annual patent shares can be linearly correlated with reasonable accuracy into two time frames, from 1977 to 1982 (R^2 = 0.88) and from 1983 to 1999 (R^2 = 0.98), and are non-correlative in the time period from 2000 to 2005 (R^2 = 0.32). The corresponding annual growth rate is 0.07%/year for the time span from 1977 to 1982 and leaps up to

0.14%/year for the period of 1983 to 1999, which are consistent with the findings shown in Figure 3, i.e., the university patenting activities are booming after 1983/1984 and indeed due to the Act.

For the period of 1977 to 1982, the share growth rate depicted in Figure 5 is about 70% higher than that shown in Figure 3; this difference could be again due to the facts that the survey population in Figure 5 is based on the top research universities and that the 20% of the top universities surveyed are from Canada. On the other hand, from 1983 to 1999, the growth rate in Figure 5 is about 18% lower than that shown in Figure 3; this lower growth rate should be caused by the 17 Canadian universities since they are not affected by the Act and their growth rates should be still the same as that in the period between 1977 and 1982, i.e., say 0.07%/year. Again, this argument can be proved by the calculation, i.e., 20% universities having a growth rate of 0.04%/year plus 80% universities having a growth rate of 0.17% can yield that the growth rate for the total universities combined becomes 0.14%/year, which is the value shown in Figure 5. This calculation re-confirms that the growth rate of university patenting share should be approximately 0.17%/year during the period of 1983 to 1999.

During the time period from 2000 to 2005, although the share growth rate is not negative as indicated in Figure 4, it is very small at 0.03%/year, about 80% lower than that of the previous periods. Again, this may imply that the effect of the Act is diminished or compensated by other factors discussed earlier. A further discussion of this irregular patent share changes is provided in section "US Domestic Patents During Economic Recessions". Nevertheless, since R^2 = 0.32 for the time period, the correlation obtained may not be reliable enough and more recently data should be included. As a result, the study presented in the subsequent section includes the data up to 2012, the most recent year, in which data are available.

University Patent and Patent Share From 1993 to 2012

By compiling the US patent issued data reported by AUTM (2013), the annual numbers of the US patents issued to the US universities and non-profit research organizations are plotted in Figure 6 for FY (fiscal year) 1993 to FY 2012. As shown in the Figure, the increase of the patent numbers can be linearly correlated well in two time periods: from 1993 to 1999 (R^2 = 0.91) and 2010 to 2012 (R^2 = 0.97), but cannot be properly correlated from 2000 to 2009 (R^2 = 0.19), where the corresponding patent increase rate is 331 and 338 patents per year. In the period from 2000 to 2009, the annual patent data are fluctuated and the average increase patent rate is even negative at -31 patent/year. It was suspected that the fluctuation could be due to the variation of the number of the institutions (universities + non-profit organizations) surveyed. However, after carefully examining the total numbers of the institutions surveyed by AUTM (2012, 2013) in each year, any correlation between the change of the number of the institutions surveyed and the fluctuation of the annual patent issued in the period from 2000 to 2009 cannot be found. The number of the institutions reported by AUTM has been adjusted by eliminating the contributions of the organizations for profit making. Other causes, such as the dot.com bubbling occurring 2001 (Lowenstein, 2004) and the housing bubbling occurring 2007-2009 (Holt, 2009) are expected for the fluctuation. More discussions on the dot.com and housing bubbles are presented in the next section.

The corresponding correlations for patent shares are performed and the results are also presented in Figure 6. As shown, the patent shares can be correlated into three time periods, which are consistent to the three periods based on the patent numbers shown in Figure 6 too. As shown, from 1983 to 1999, the share growth rate is 0.203%/year (R^2 = 0.80), which is 19% higher than the result shown in Figure 3 and 45% larger than the correlation shown in Figure 5. The reason for the higher share growth rates based on AUTM data during the period from 1993 to 1999 can be due to the fact that only 7 AUTM data are used for the correlation while 18 data and 17 data are used for the correlations shown in Figure 3 and Figure 5, respectively. Also the correlation accuracy (R^2 = 0.80) shown in Figure 6 is much lower than that shown in Figure 3 (R^2 = 0.98) or Figure 5 (R^2 = 0.98), which implies that the share correlation shown in Figure 6 is less reliable. The same reason can also be extended to explain the patent growth rates shown in Figure 6, which are also higher than those shown in Figure 1 or Figure 4 during 1990s.

During the period from 2010 to 2012, the patent share data shown in Figure 6 are similar to the patent data and cannot be correlated appropriately, where R^2 is only 0.02, an extremely low number. Further study of the patent and patent share fluctuation in 2000s and beyond should be encouraged.

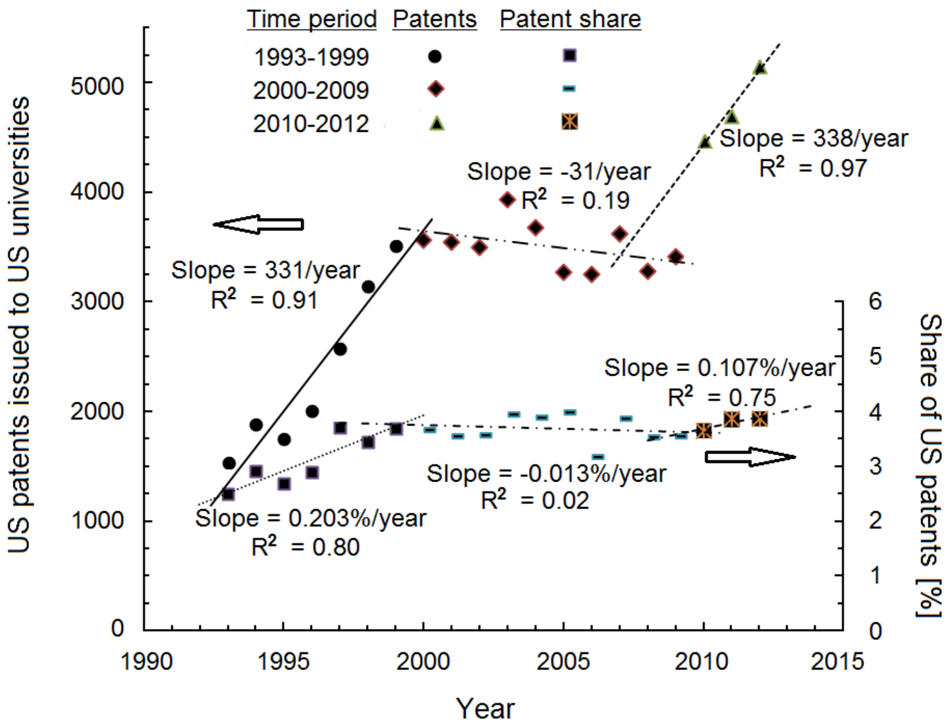

Figure 6. Correlations of university patents issues and university share of U.S. patents, 1993-2012.

US Domestic Patents During Economic Recessions

Based on the database from US patent office (USPTO, 2013a), Breitzman (2013) identified 1,279 US firms to study their patent behaviors during the Great Recession, where 42% of the 1,279 firms were small firms (500 or fewer employees). The small firms represent about 8% of the total patent filing prior to the recession and their share fell to 5.6% during recession. According to the National Bureau of Economic Research (NBER, 2013), the Great Recession started in December 2007, and bottomed out in June 2009. The study found that there was an immediate decline in patent applications from small businesses coinciding with the start of the recession, while large US firms who file the most patents did not slow down their patent filing until a year after the recession (Breitzman, 2013). It is unclear whether small firm patent activity changed earlier than large firm patent activity or the downturns cause small firms to cut R&D expenses immediately, whereas large firms try to maintain R&D throughout a downturn. Breitzman also suggested that large innovative US firms either continued to do well during the recession, or were able to rely on their prior wealth advantage, or considered R&D important enough to budget or finance in advance. Further research is needed to determine exactly which of these factors drove this result.

Since small firms and universities consist of 8% and less than 4% (Figures 3, 5, and 6) of the total patents filing, respectively, the large firms' behavior should be appropriate to be adopted as the representation of the general US panting behavior, i.e., not slow down the patent filing until a year after the recession. It is also expected that the typical delay time between the patent applications and the patents granted should be around 18 to 19 months. As a result, the impact of a recession on the patents issued would not appear until two or three years after the recession. Also, it is reasonably assumed that the longer the recession, the larger and the longer of the impact on the patent applications and the patents issued. As a result, the impacts of the three recent recessions on the US patents issued to the domestic assignees are illustrated in Figure 2, in which the impacts of the patents issued are circled. The sluggishness or irregularity of the university patent activities during 2000s shown in Figures 4, 5, and 6 is believed to be induced by the early 2000s recession as indicated in Figure 2. However, the impact of the Great Recession should be beyond 2012 as shown in Figure 2 and hinted by Kolster (2009). As soon as the data for the year after 2012 are available, the impact of the Great Recession should be evaluated.

The correlation results depicted in Figures 4, 5, and 6 also endorse the above finding for the sluggishness of the patents issued during 2000s, since the results indicated that the growths of the patents shown in Figure 4 and of the patent shares shown in Figure 5 during 2000s are either flat or even decreased, whereas the growths of the patents and the patent shares depicted in Figure 6 are all negative. Furthermore, the NBER (2012) defined economic cycles may not coincide with the business cycles of the universities. For example, since, during economic recessions, the unemployment rate is higher and the universities' enrollments become higher, because the high-school and college graduates have more difficulties to find jobs and are enrolling universities to avoid the difficulty or unemployment. As a result, this incoincidence or mismatch between the national economic cycle and the university enrollment cycle yields the fluctuations of the university patent shares during 2000s as indicated in Figures 3, 5, and 6.

Note that, since the horizontal (abscissa) coordinate is the time (year) of the patents issued for the whole year, which should be counted at the end of the year, while the recession periods reported by NBER (2013), which are also plotted in the horizontal coordinate, count from the beginning of the year and should be adjusted for this one-year difference. For example, the Great Recession (g) starts December, 2007, the corresponding value in the horizontal coordinate should be 2006.917 (or 2006+11/12) in Figure 2, since 2007 at the coordinate represents the end of 2007. For the sake of clarity of presentation, the recessions in the United States after 1963 are also summarized in Table 1.

Table 1

List of Recessions in the United States After 1963 (NBER, 2013)

Figure 2 notes	Recession name	Time period	Duration [month]	GDP decline	Remarks
a	Recession of 1969-1970	12/1969-11/1970	11	-0.6%	increased inflation & deficits (Vietnam War)
b	1973-1975 recession	11/1973-3/1975	16	-3.2%	1973 oil crisis & stock market crash
c	1980 recession	1/1980-7/1980	6	-2.2%	double-dip recession
d	Early 1980s recession	7/1981-11/1982	16	-2.7%	1970s oil & energy crises
e	Early 1990s recession	7/1990-3/1991	8	-1.4%	1990 oil price shock & debt accumulation of 1980
f	Early 2000s recession	3/2001-11/2001	8	-0.3%	dot-com bubble
g	Great recession	12/2007-6/2009	18	-4.3%	Housing bubble

Concerns Related to Bayh-Dole Act in Recent Environment

While the Act has worked well in the past, several major concerns or issues have been raised due to the passing of this Act (Schacht, 2012). These concerns are reviewed and elaborated in this section.

Is Bayh-Dole Act Still Relevant?

In the past several years, US Congress has intensified its scrutiny of the Act by holding hearings to consider the possibilities for improving the UPAs and other technology transfer processes. In the hearing by U.S. House of Representatives on June 10, 2010, Rep. Daniel Lipinski (Dem.-IL), chair of the Technology and Innovation Subcommittee, announced that the intention of the subcommittee "is to carry out a comprehensive review of the Bayh-Dole and Stevenson-Wydler Technology Innovation Acts later this year". Anticipating that Congress may eventually muster the political will to amend the Act, the National Research Council commissioned a consensus report on university management of intellectual property and made a range of recommendations (Merrill & Mazza, 2010). These recommendations should be further studied and some of them should be considered for future implementation.

One of the major concerns in the report is "Is the Bayh-Dole Act still relevant?" Since the Act was enacted more than 30 years ago, it may not have specifically anticipated new technologies in the new knowledge economy (e.g., research tools and materials, software, internet, biotechnologies...). For example, the Act did not cover the management of copyrighted material, including software, data, biomaterials developed with federal funding. This issue should be addressed soon or later, since the use of copyright and biomaterials in UPAs is increasing and since the act is relevant to the government commitment to continued funding of fundamental university research, strong protection of resulting intellectual property, and market forces to drive innovation and commercialization to remains the cornerstone of UPAs. Furthermore, the concern can become more critic, because a largest portion of federal funding for academic research falls within the realm of medical and biological sciences. For example, the support for biomedical research from federal agencies to universities has increased from $12.86 billion in FY2002 to 23.68 billion in FY2011 (Britt, 2011, 2012).

Conflicts of Interest

After the passing of the Act, "Does the Bayh-Dole Act create conflicts of interest" has been frequently raised. To cope with this concern, universities have been strongly committed to preserving the integrity of their research and the public's confidence. However, new innovations of interest to companies can and do occur as indicated by Kumar (2010). Therefore, universities are increasingly involved in the transfer of technology into the private sector, and there is a small but real risk that academic research may be compromised through a conflict of interest. As reported by Cho, Shohara, Schissel, and Rennie (2000), the Act has created opportunities for conflict of interest for university faculty members because academic-industry partnerships can offer direct financial rewards to individual faculty members in the form of consulting fees, royalties, and equity in companies while simultaneously funding these faculty members' research. Many researchers have consulted for and worked for the private sector which creates ties to certain companies. This may lead researchers to favor certain companies when licensing out the patents, which would not promote fair competition. It may also lead to skewed research, which is another possibility that concerns critics of the Act.

In fact, conflicts of interests due to university researchers negotiating license with more than one company have been reported as well as leakage of confidential information from one company to another (Kumar, 2010). Although true conflicts and bias are rare, the academic community, nonetheless, recognizes the importance of addressing them in a responsible manner. As a result, most universities and government agencies (NIH, NSF, DOE etc.) have adopted policies that are designed to ensure objectivity in research projects in which the investigator has a financial interest. Such policies usually start with disclosure by the investigator of relationships in which the investigator has a significant financial interest that would pose a potential conflict of interest. While conflicts of interest and a skewing in choice of research may be reasonable concerns associated with the Act, there has been insufficient proof of these issues creating actual negative effects (Cho, Shohara, Schissel, & Rennie, 2000). However, there could potentially be problems in the future if the economy takes a dive or universities lose funding for some reason.

A final remark on the concern of conflicts of interests, the universities should try to adapt to the commercialization without giving up their identity altogether. For a university, it should be possible to achieve such a balance through appropriate modification of existing policies or guidelines to make the "ivory tower" becoming a "watch tower" (Kumar, 2010). A university should be able to adapt itself to its new roles of being a good knowledge developer as well as a technology transfer promoter and there are no simplistic solutions for this. There must be more research done into this, especially to determine how to balance these two roles and to minimize the possibility for the conflict of interest.

March-in Rights and Safeguard

According to the Act, under certain circumstances, the government can require the university to grant a license to a third party or may take title and grant license itself, which is known as "march-in rights". This might occur if the invention was not brought to practical use within a reasonable time, if health or safety issues arise, if public use of the invention was in jeopardy, or if other legal requirements were not satisfied. This provision is somewhat contentious and gives the government a final control of the intellectual proprieties, because it allows the funding agency, on its own initiative or at the request of a third party, to effectively ignore the exclusivity of a patent awarded under the Act and grant additional licenses to other "reasonable applicants". This right is strictly limited and can only be exercised if the agency determines, following an investigation, that one of four criteria is met (US Code, 2013). The most important of these criteria is a failure by the contractor to take "effective steps to achieve practical application of the subject invention" or a failure to satisfy "health and safety needs" of consumers. Though this right is, in theory, quite powerful, it has not proven so in terms of its practical application. As of 2012, the most recent year, in which government data are available for a general study, no federal agency has exercised its march-in rights. Four march-in-right petitions have been made to the National Institutes of Health (Wikipedia, 2013).

The provision of march-in rights is not only to protect the public safety (or national security) but also to safeguard the public interest. Because the primary objective of UPAs is to benefit the public, in order to achieve the noble and quite reasonable goal of making technologies available to everyone, the period of exclusivity provided by the patent system should be required for companies to be willing to invest the significant resources necessary to develop early stage university innovations into marketable products. The patenting of university innovations and subsequent development into products and services that would otherwise not exist is entirely consistent with an institution's mission of public service.

Recently, Dechenaux, M. Thursby, and J. Thursby (2009) pointed out that university license contracts can include the provisions to accommodate to the march-in rights by requesting the milestone payments and annual payments. The potential for a licensee to shelve inventions is an adverse selection problem which can be addressed by annual fees or an upfront. The licensing contract can also prevent shelving by taking the license back from a shelving firm. This supports the rationale for Bayh-Dole march-in rights but also shows the need for the exercise of these rights can be obviated by contracts.

Ramifications of Leahy-Smith America Invents Act

Recently, the Leahy-Smith America Invents Act (AIA) was signed into law by Obama on September 16, 2011 (H.R. 1249, 2013). The law represents the most significant change to the U.S. patent system since 1952. The law switches U.S. rights to a patent from the present “first-to-invent” system to a “first inventor-to-file” system for patent applications filed on or after March 16, 2013. The law also expands the definition of prior art (such as including foreign offers for sale and public uses) used in determining patentability. Making a disclosure before a patent filing is extremely risky. It can no longer antedate or swear behind another’s work, so make sure that any patent application should be filed as early and as completely as possible. The AIA Act may bar a patent if any of the following occur before the effective filing date (EFD): (1) invention described in a printed publication; (2) invention placed in public use; (3) invention placed on sale; (4) invention otherwise made available to the public; or (5) invention described in issued US patent or published US patent application naming another inventor and having an EFD before the EFD of the relevant patent or application (H.R. 1249, 2013).

As indicated by Fox (2011), the AIA would simplify the application process and bring U.S. patent law into better harmony with the patent law of other countries, especially in European Union, most of which operate on the “first-to-file” system. Proponents also claimed that it would eliminate costly interference proceedings at the US Patent and Trademark Office and reduce U.S. applicants’ disadvantages in seeking patent rights outside of the United States. On the contrary, opponents, including Nesheim (2000), argued that the AIA act would prevent startup companies, a potent source of inventions, from raising capital and being able to commercialize their inventions. Typically, an inventor would have a sufficient conception of the invention and funding to file a patent application only after receiving investment capital. Before receiving investor funding, the inventor must have already conceived the invention, proven its functionality, and done sufficient market research to propose a detailed business plan. Investors will then scrutinize the business plan and evaluate competitive risk, which is inherently high for startup companies as new entrants into the market. Critics expressed concern that, venture funding now will be diverted to less risky investments.

In general, the AIA has more impacts on universities than other sectors, because the faculty has to be convinced to file the patent before to publish the research results that could be patentable. In the current tenure and/or promotion systems, the faculty is not reward for the efforts for applying patents. Although revenue sharing is significant, the reward towards tenure and promotion is paramount critical for faculty (Perlmutter, 2010). At most research universities, the academic reward system is structured to encourage quality scholarship primarily in the form of journal publications—formal contributions to the knowledge base in specific fields; scholarly publications count significantly toward both tenure and promotion as well as salary (Boyer, 1990). Consequently, the current university reward system or the guidelines for tenure and promotion should be changed to count the patent publication, at least, as good as the journal publication.

Concluding Remarks and Future Prospective

The Bayh-Dole Act has created a favorable environment to encourage the US universities to have a higher level of direct involvement in technology transfer, especially the patenting activities, in contrast to the reluctance of many US universities to become directly involved in patenting prior to the 1970s. As indicated in the present study, the benefits created by the Act greatly outweigh any possible negative consequences. The Act was built quite soundly to allow incentives for all involved parties (government, academia, industry), but also has safety measures to ensure that the inventions are handled correctly. In general, it has been found that the impacts of Bayh-Dole Act on patenting had been remaining strong until the year of 1999 and were greatly diminished after 2000. Currently, the influence of the Act on UPAs has indeed become immeasurable.

The university patenting activities, including the annual patent numbers and patent shares, are specifically studied. Correlation analyses of these patent activities are performed to quantify the effects of the Act on UPAs. Data based on four different sources are analyzed for the time periods from 1963 to 2012 and the results indicate that the patenting activities in US universities have a big jump during the period between 1981 and 1985 and the cause is identified to be the effects of the Act. It is also found that the university patenting activities, in both the patent numbers and patent shares, are slow down greatly after 2000 and remain actually flat until 2010, while the associate activities from 2010 to 2012 are active and strong again to the level in the period before 2000. This slow-down during 2000s has been illustrated to be due to the economic recessions. Some additional explanations on the differences found in the different data sources and time periods are also provided.

Furthermore, the correlation analyses and data collected presented in this article can help the university's plans to develop better patenting strategies, to retain talent, and to identify new opportunities for university/industry cooperation. All of these can be critical to advancing university research strategies, finding opportunities in emerging and new research areas. It is also found that, through appropriate legislation, such as the Act, the policymakers can provide strong and sustained basic research funding to furnish pipelines of great ideas and can encourage universities to make policies to inspirit researchers' ingenuity and innovation and to attract industrial support. As a result, patenting has become increasingly important, given concerns regarding the university's desire to maximize the returns to its patents it owns.

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