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Technology Transfer and the Instrumentality of Bayh-Dole: a Comparative Study of Patent and Publishing Data, 1973-2007

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Technology Transfer and the Instrumentality of Bayh-Dole: a Comparative Study of Patent and Publishing Data, 1973-2007

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Abstract

Technology transfer is the process by which universities and other higher education institutions (HEIs) channel discovered knowledge and innovations into commercialization. Increasing commercialization has been a feature of HEIs in the United States, especially, for the last several decades. A turning point can be seen with the passage of what is known as the Bayh-Dole Act in 1980. This landmark piece of legislation allowed universities to keep licensing rights from federally funded projects, an institutional ownership model that spurred innovation. HEIs with medical schools are especially affected due to the lucrative nature of biotechnology.

One such measure of innovation and, crucially, commercialization is the number of patents filed per institution. As such, patent data has been obtained for a sample of HEIs in New York State, Ireland, and New Zealand. For benchmarking activity levels, data has also been compiled on the volume of journal publications from each school. Using the statistical software Minitab to analyze these data sets, this paper finds (1) evidence of a significant acceleration in patenting activity after Bayh-Dole, and (2) that increased patenting rates may be causing deceleration in publishing activities at HEIs with medical schools.

Executive Summary

This study works with patent and publishing data from the last 40 years to understand and comment on trends in the commercialization of Higher Education Institutions (HEIs). HEI is a broader catchall term for university-level education and research organizations. These last few decades have seen the advent of the entrepreneurial university: going beyond the tradition two missions (education, research) to a third mission of commercialization.

It is now commonplace for HEIs, Syracuse University included, to have a Technology Transfer Office (TTO) on campus. TTOs are responsible for helping bring to market innovations developed or researched on campus. Therefore, TTOs become the middleman between HEIs, industry, and government in how new knowledge and innovations are disseminated. Such operations include a wide range of possible activities, including patenting, licensing, facilitating entrepreneurial spinout ventures, or otherwise seeking to generate revenue.

In New York State, the average founding year for TTOs is 1985. This likely accounts for a lag after what many consider to be the catalyst for the entrepreneurial university, passage in 1980 of the Bayh-Dole Act. This legislation amended United States patent law to reflect an institutional ownership model whereby HEIs almost completely control the licensing of innovations resulting from federally funded research. With few exceptions, the HEI controls how an innovation is brought to market. Previously, the federal government could mandate that only non-exclusive licenses were granted. Thusly, before Bayh-Dole, if a company invested in licensing and making an innovation market-ready, there would not be an intellectual property protection to stop other market participants from imitating.

These changes to patent law unleashed a wave of innovation and commercialization at HEIs, but especially those with medical schools. This is because biotechnology is a field where innovations can be extremely lucrative. Academics are thus encouraged to commercialize innovation (Siegel and Wessner 2012). Pharmaceutical and medical device inventions discovered at HEIs can generate revenue in the hundreds of millions – not often, but it does happen. Within the patent and publishing data accumulated for this study, a distinction was made between schools with and without a medical school for these reasons.

This study's methodology is built on the framework of a comparative and longitudinal analysis across geographies and types of HEIs. Patenting and publishing data from HEIs in New York State, Ireland, and New Zealand were assembled for the years 1973-2007. These countries provided large data sets with a mix of public and private HEIs, with and without medical schools, in mature technology transfer environments. Arranged longitudinally, the data was then reduced per country by the number of HEIs in each category. For instance, with 18 HEIs in New York State and 12 of them operating medical schools, total New York figures were divided by 18, HEIs with medical school figures were divided by 12, and HEIs without medical school figures were divided by six.

The resulting graphs visualized what had been expected behavior in the wake of Bayh-Dole. An acceleration in patenting occurs after 1980, first in the United States and then in the other two countries as the institutional ownership model was replicated. Publishing data grew in a comparatively linear fashion over the same time period. Interestingly, the produced graphs appear to show a deceleration in publishing as patenting continues to increase in HEIs with medical schools. This trend is present in the data for all three countries surveyed.

This significance of such a phenomenon would be conflict between the second and third missions of HEIs: research and commercialization of knowledge. While patenting is only one measure of commercialization, this is an area that deserves further study.

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Acknowledgements

I would like to thank my advisor, Professor Will Geoghegan, for his constant support, especially with the literature review and assembled data set. I would also like to thank Professor Raja Velu for being generous with his time as well as his guidance in handling the data and creating relevant visual components. Finally, thanks go to Professor Don Cardarelli, my reader, and Eric Holzwarth, of the Renée Crown University Honors Program, for being integral in this process.

Advice to Future Honors Students

"Don't panic."

–Douglas Adams, *The Hitchhiker's Guide to the Galaxy*

Introduction

In recent years, universities have grown to play an outsized role in national innovation systems. As centers of knowledge creation, in the form of academic research, it makes sense that universities should become highly integrated within a national economy – particularly in a globalized world where information and innovation travel across geographies instantaneously. This study will examine the changing nature of universities within innovation systems, as well as how parties such as government and industry have affected and been affected by these changes.

Particularly of interest is the instrumentality of Bayh-Dole, a piece of legislation from 1980, in creating this environment in the United States, and then serving as a model for other countries. In general terms, patents (and the resulting potential of licensing) can be used as a proxy measurement of overall commercialization, and that is what this analysis seeks to confirm using 1980 as a global turning point.

What is an innovation system? What is the Triple Helix?

Innovation systems are the interactions between and within institutions that coordinate to include knowledge production in a national economy. Recent studies have noted the transformation of many universities, especially in the United States, to include an entrepreneurial bent, a "third mission," alongside traditional goals of teaching and research (Breznitz and Feldman, 2012; Breznitz et al., 2008). An effective visualization of the way these changes have affected larger innovation systems is by use of the triple helix: essentially a Venn diagram showing the overlap between institutions in higher education, industry, and government (Etzkowitz and Leydesdorff, 1999).

What role do HEIs and TTOs play in innovation systems?

Higher education institutions in a traditional “two-mission” approach primarily contribute two things to innovation systems: educated students and research. The entrepreneurial university’s third mission is expeditiously commercializing these outputs by bringing them to market in more controlled ways. Thusly, the entrepreneurial university is an acknowledgement of “[reduced] distance among institutional spheres” in a knowledge-driven economy (Etzkowitz et al, 2000). To promote economic success, governments, industry, and HEIs are working more closely – and that means the latter group actively pushing its innovation.

The establishment of technology transfer offices (TTOs) within universities has facilitated this change. These offices are explicitly tasked full-time with bringing professors’ research to market. Common measures of productivity for the entrepreneurial university are number of patents obtained and number of licensing agreements. There are, of course, other measures of success that bring more nuance to the impact of an institution’s accomplishment; some examples are the number of licensees, start-ups formed, and their survival, or the size of revenue streams from resulting technologies.

Through this process, the ultimate goal is increasing the efficiency of an HEIs ability to bring knowledge to market. The TTO becomes the liaison, or middleman, between academics and industry agents, allowing professors to continue their research with minimal distraction and TTOs to specialize in finding the right industry partner for a patent or invention.

Outside of TTOs, another example of university activities being commercialized can be seen in a changing student experience, one more aligned with industry. Commercialization happens in the integration of students into the workforce before graduation (internships or co-ops) or collaboration between HEI and industry institutions to provide immersive professional experiences. The entrepreneurial university model affects more than just professors and university coffers – the student experience is undoubtedly affected and the type of research conducted is necessarily skewed toward IP that can lead to potentially profitable business ventures.

Above all, a successful TTO is the interface of the Triple Helix. It is the outward-facing agent of a university, but its chief quality is somewhat membranous. TTOs facilitate the chief goals (knowledge production, knowledge commercialization, economic growth) of three sectors (HEIs, industry, government, respectively) while not being directly involved in the execution of any. TTOs are not discovering the new knowledge, directly bringing it to consumers, or using it in order to stimulate regional growth.

How can we understand the internal dynamics of the Triple Helix?

Etzkowitz et al identify four key processes for understanding *change* in the "production, exchange, and use of knowledge" (2000) in the dynamic of a Triple Helix. The first process is internal change led and executed within a helix – an example being HEIs choosing to adopt the "third mission." This is a point that we perhaps take for granted today – that universities would naturally pursue commercially relevant activities related to economically viable topics. The second process is change driven by inter-helix influence, such as the impact of Bayh-Dole legislation on incentivizing the commercialization of HEI research. In that case, the overlay is influence being exercised by one helix (government) over another (HEIs) in defined relationships. Informal relationships can also exercise influence, as “the cutting edge” might necessarily reflect the nature of related research being done and the way graduates are prepared. The third process is the creation and development of institutions that overlay more than one helix: i.e. any public-private partnership arrangement overlays industry and government, while affecting change in both spheres. Finally, the fourth process driving change in the Triple Helix is referred to as being “recursive” – engendering the aggregated effects of the networks created by the first three processes over time.

The university has thusly been raised to the level of industry in the practical sense of pursuing the economic rewards resulting from knowledge creation; HEIs have always done the latter, but the former is much newer territory. There are some surface-level problems with this new arrangement that should be apparent with minimal reflection. People learn on the job just as they do in classrooms – especially in highly technical and professional roles that require new knowledge be processed. If companies can teach and universities can act like businesses, the difference between the helices is altogether blurred. When one competes with another in the same arenas, perhaps universities should legally be treated like other market participants. Amid these changes, the role of government has also changed in some instances with the rise of public-private partnerships to spur economic growth and investment. It is unclear where such an arrangement would fall into the Triple Helix model. Fully-entrepreneurial universities and public-private ventures are just two examples of why the neat, discrete boxes of the Triple Helix framework are somewhat limiting.

To understand fully how these various dynamic came to be requires a detailed look at the passage of The Patent and Trademark Law Amendments Act of 1980, better known as Bayh-

Dole, and how the spheres of the Triple Helix interacted beforehand. It is notable that the Act is what its sponsor, Senator Birch Bayh (D-IN), might be best known for considering that his other accomplishments include writing two amendments of the U.S. Constitution, Title IX of the Higher Education Act, and serving nearly two decades in the Senate.

The Bayh-Dole Act of 1980 background

As stated previously, Bayh-Dole incentivized commercialization of federally funded university research. In 1980 the U.S. economy contracted by 0.3 percent, down from GDP growth of 5.6 percent two years previous. Partly as a response to a sluggish economy, but also in reaction to the economic potential of universities going unrealized, U.S. patent law was drastically changed. Previously, the status quo held that the U.S. government could assert ownership over whatever resulted from federal funding dollars and require that licensing was done on a non-exclusive basis. Such an IP ownership model discourages first movers from investing in university-created technologies – should that first mover see any success, the lack of a non-exclusive license would provide competing firms with all the benefits and none of the risks. As such, "…a Chinese wall [was] erected between academic and corporate research. Research was literally described as being "contaminated" by federal funding because of the government's licensing policies (Loise & Stevens, 2010)."

The scale of this problem was truly stunning: before Bayh-Dole, the U.S. government owned 28,000 patents from university research but only 4 percent had found their way to the private sector in the form of licenses (Ibid). These innovations were treated as toxic because of the hyper-competitive nature of non-exclusive ownership. Bayh-Dole's simple solution was to almost entirely revoke the federal government's rights to the research it paid for: instead, the institutions conducting the research now had sole ownership. Small provisions were included in the law's text for such secondary issues as the right of inventors to a portion of resulting income, a preference for licensing to small businesses, and the necessity of manufacturing domestically consumed goods in the U.S. – but institutional ownership was still revolutionary.

Practical impacts of legislation

This is best demonstrated by the explosion of innovation soon after passage of Bayh-Dole, as the private sector could then acquire exclusive patent licenses for potentially valuable technologies. The number of U.S. institutions with offices serving technology transfer purposes went from around 20 before Bayh-Dole to over 200 today – this simple law essentially began the entrepreneurial university model used worldwide today. Some of the many innovations that have since arisen from this process are the internet web browser, nicotine patches, cochlear implants, and mobile phones (AUTM). As one might imagine, these kinds of inventions are rare but quite lucrative. In 2008, U.S. universities saw licensing revenues of $3.4 billion, making the same figure in 1981, $7.3 million, look quite paltry (Loise & Stevens, 2010).

Health-related technologies and their related industries have been the biggest beneficiaries of this revolution. In 1995, just 15 years after Bayh-Dole, 54 percent of federal dollars for university research and development came from the Department of Health and Human Services. That figure, which amounted to more than $6.5 billion, came almost entirely from the National Institutes of Health (GAO, 1995). As is common with medical innovations, exceptional moneymakers are few and far between but exceptionally lucrative. Of the $3.4 billion in licensing revenues universities earned in 2008, 24 percent of that figure was royalties paid to Northwestern University by Pfizer for the license to Lyrica, a drug used to treat epileptic seizures and other neuropathic conditions (Loise & Stevens, 2010). Indeed, five licensing institutions, four of which were hospitals or medical schools, accounted for a full 53 percent of total university licensing revenue in 2008 – the remaining 47 percent went to the other 180 reporting institutions (Ibid). This suggests two things: that financially successful technology transfer operations are primarily medical, and that the majority of institutions do not see the vast riches of commercial success.

The level of inequality is stark between the top and bottom earners, and this fact shows in the proportion of technology transfer operations that are unprofitable for their hosting academic institution. According to Loise & Stevens (2010), in 2006 only 16 percent of U.S. institutions with technology transfer activities actually covered their operating costs with income from licensing and other commercial activity. Partly, this is because the benefits of these innovations are experienced in the private sector or by researchers themselves. But the overall sense remains that, despite Bayh-Dole and the potential it unlocked, most schools cannot and do not depend on income from commercialization.

Roessner et al (2013) suggest that there is a prima facie case to be made for the Bayh-Dole Act having spurred the significant economic growth seen as a result of university research after passage in 1980. The creation and growth of a multibillion industry, biotechnology, is credited to the increasing contributions of universities to innovation made possible by Bayh-Dole (BIO, 2009). The ingrained nature of academic research in this field is illuminated by the fact that 76 percent of biotechnology companies hold a university license and, further, 50 percent of such companies actually began from university licenses (Ibid). Far from being limited to boutique labs and small start ups, in 2008, these firms accounted for 1.42 million jobs in the

United States alone (Ibid). The economic impact is wide reaching, from institutions, to regions, and across industrial sectors.

Criticisms of Bayh-Dole

In 2005, *The Economist* labeled the Bayh-Dole Act as “a law of unintended consequences.” Among its criticisms, *The Economist* decries the “Third Mission” of HEIs in everything but name, saying, “…[Bayh-Dole] makes American academic institutions behave more like businesses than neutral arbiters of truth.” Further, they charge that the pace of research and technological advancement, along with the collaborative spirit of academia, is negatively impacted due to concerns of secrecy or eventual royalties. Particular cases from Columbia University and the University of Utah are cited, where a legal attempt was made to reclaim an expired patent and an essential technology was exclusively licensed to one firm, respectively. Such actions seem antithetical to academic notions of strictly pursuing knowledge.

Philosophically, practically, and certainly legally, the question of academia’s function is thusly muddled. A 2002 Federal Circuit court ruling essentially dismantled the “experimental use defense” for universities accused of infringing on a current patent (Cai, 2004). Michelle Cai, of University of California – Berkeley, noted that this “shattered a long-held myth that universities are immune.” The case’s logic is that universities should not be exempt from charges of infringement precisely because of the overtly commercial nature of processes such as technology transfer. Universities are competing, with each other and sometimes with industry groups, for research dollars and any resulting revenue streams. In regards to a professor and a company both infringing a patent for research purposes: why should a court of law distinguish between these commercial activities and give a clear advantage to one group? This extraordinary ruling can be seen as the result of an academic-entrepreneurial culture catalyzed by the Bayh-Dole Act 22 years previous.

The situation of researchers commercializing their work “may be problematic and lead to real or perceived conflict of interest unless the nature of overlap, co-mingling and ties are clearly elucidated” (Murray, 2002). That “overlap” between the academic and commercial worlds inherently bestows perceived bias, especially in the cases of particularly lucrative subjects such as discoveries in biotechnology. There is a distinction to be made here, of course, between simply the “transfer of tacit knowledge” versus “active participation” – the latter being certainly more problematic (Murray, 2002).

Data set – patents by HEI, country

In order to better understand technology transfer – domestically and in an international context – I will be examining data from three countries: the United States, Ireland, and New Zealand. While the United States can be thought of as the birthplace of technology transfer because of first-mover advantage and wide variety of participating institutions, Ireland and New Zealand both have fairly sophisticated and mature HEI commercialization operations as well. As the amount of data relating to schools in the United States, their patents and publications, is predictably large and unwieldy, it makes sense to focus simply on research institutions in New York State.

New York State’s 18 schools with technology transfer operations serve as an interesting microcosm of commercialization across different types of institutions: it is a healthy mix of public and private institutions, as well as medical and non-medical schools. The latter detail is relevant for the aforementioned reason of biotechnology’s prominent roots in university research.

Medical university research seems more likely to have lucrative innovations, and thus be a richer source of patents than non-medical studies (Chapple et al., 2005; Jensen et al., 2003; Thursby et al., 2001). Further, in academia there is sometimes the dilemma of whether to patent or publish: situations where publishing cutting-edge information could threaten eventual claim to an exclusive patent (Daizadeh et al. 2002). Of the six New York State institutions without medical schools, two are primarily focused on technology (Rochester Institute of Technology, Rensselaer Polytechnic Institute), two are private research universities (Syracuse University, Clarkson University), and two are public institutions (Binghamton University, University at Albany).

Ireland and New Zealand provide geographical diversity, as well as the different context of exclusively public universities. Of the eight major New Zealand research institutions with technology transfer operations, only two have medical schools and both were relative latecomers to commercialization with founding of TTO offices in 1998 and 2002 for the University of Auckland and University of Otago, respectively. The opposite is true in Ireland: five of the seven major research institutions have medical schools and two do not. One of the Irish institutions with a medical school, National University of Ireland, Galway, stands out for having formed a technology transfer office in 1973, nearly a decade before the explosion in the U.S. prompted by Bayh-Dole. For New Zealand, Ireland, and New York State, the average founding year for their technology transfer office was 1996, 1991, and 1985, respectively. The New York State figure is likely indicative of several years' lag time after passage of Bayh-Dole.

Information on patents granted per university is available publically online from the appropriate governmental office of each country. For the three countries in this study, those offices are the U.S. Patent and Trademark Office, the Irish Patents Office, and the Intellectual Property Office of New Zealand. It should be noted that the mere amount of patenting at an HEI is not the ultimate measure of “commercialization” in the most general sense, but reliable data for a better indicator is not easily available. The degree to which an institution is truly commercialized must necessarily rely upon diverse data sets such as a breakdown of funding sources, revenue earned, all patent and licensing measures, the number of spinoff companies and their success in terms of revenue and employees, and other activities typical of the entrepreneurial university’s designation as such.

But even within patents, not all are created equally. Northwestern University’s patent for the drug Lyrica, generating annual revenue in the hundreds of millions of dollars, should not count as equal to a never licensed, never cited patent in some obscure niche of engineering. Though the former is more rare, both such examples are equally sized data points in terms of this data set. This is because patents are likely still the best proxy available, and we use caution in interpreting this data as not to misrepresent that fact.

Data set – publications by HEI, country

If the first area of study in this paper is a longitudinal analysis of patenting, its second focus is the relationship between patents and publishing of academic journal articles. As discussed briefly above, certain fields of academic sometimes struggle with the question of whether to patent or publish a new idea. A hypothesis, therefore, is that the data should bear out this relationship that the amount of patenting negatively affects publishing rates.

Publishing data was acquired from Web of Science, Thomson Reuters’ subscription-based proprietary index for academic journal publications. Similarly to the patent data, it is worth noting that not all papers are created equal. Some articles become highly influential in their fields, garnering hundreds of citations and becoming the cornerstone of subsequent influential works. Other papers go largely unnoticed, unread, and un-cited. In both of these cases, this data set weighs such papers as equal. The qualitative determination of relative value and merit in academic publications is not the question at hand and it is sufficient, for the purposes of this study, that a team of editors vetted each article.

Methodology

Reliable patenting and publishing data from 1973 to 2007 and, importantly, this range includes the passage of Bayh-Dole in 1980. Pre-1973 publication data from Web of Science appeared to be incomplete, and was thusly excluded. Post-2007 patenting data from the relevant governmental bodies was also unreliable, as the proper tracking and recording of patents is an arduous process requiring years. That is how the range of years, 1973-2007, was arrived at – the seemingly most reliable data for both patenting and publishing that included 1980.

The data, separated into categories by HEI and country, were assembled in Minitab statistical software for ease of analysis. Within each country's categorization, a distinction was also made between schools that do and do not have medical schools. With totals by year for publishing and patenting, the data was then divided by the number of schools in a category to arrive at a "per capita" average for universities with medical schools ("Med"), universities without ("Non-Med"), and total country figures.

For instance, New York State's schools had 38,053 publications and 238 patents filed in 2007. Of these, 34,438 publications and 216 patents came from Med schools. The data therefore seems quite lopsided against Non-Med institutions, but less so when you consider that there are twice as many Med schools (12 of 18 in NYS). In this case, for New York in 2007, the "per capita" average when divided by the number of schools was 2869.83 Med publications vs. 602.5 Non-Med publications, and 18.0 Med patents vs. 3.667 Non-Med patents.

Findings

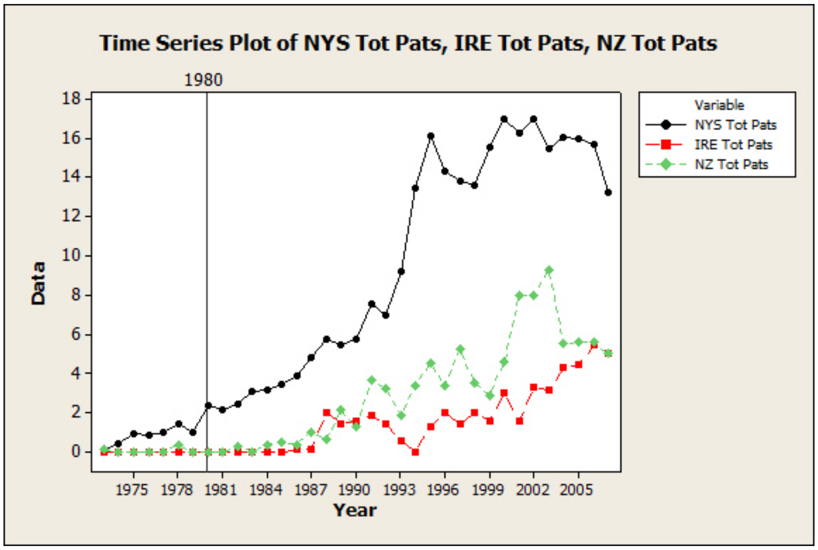

Fig. 1: Comparison of patents per HEI in NYS, Ireland, NZ

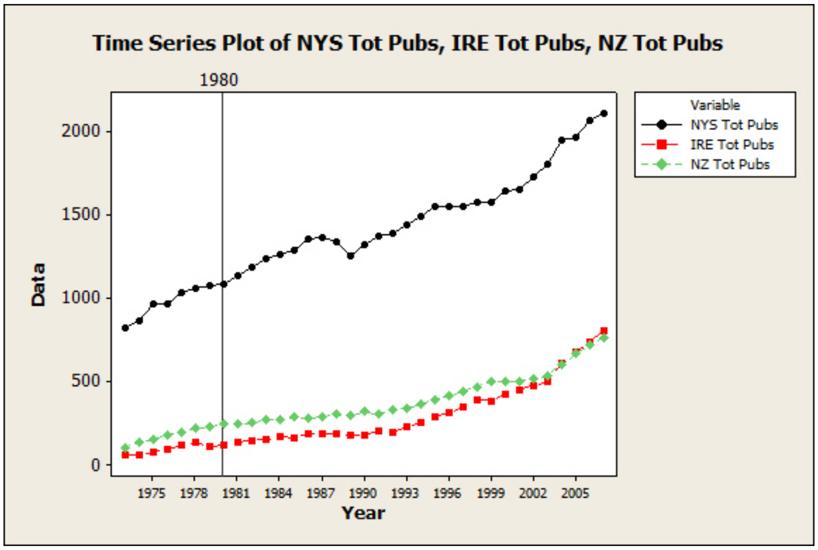

Fig. 2: Comparison of publications per HEI in NYS, Ireland, NZ in the years 1973-2007

In the case of both patents and publications, the volume of activity per university has increased tremendously since the 1970's. An acceleration of activity is more obvious in the case of patents in Fig. 1, where the New York HEIs are near even with those in Ireland and New Zealand before 1980. Starting around that time, the per-university figure for patents increases tremendously before exploding in the 1990's. This may be due to a lag in assembling technology transfer processes at individual institutions – hiring and training staff as well as establishing relationships with the professors doing research. In Fig. 2, for publishing, growth is steadier and appears to be approximately linear in all three countries. This can likely be accounted for by the increasing size of universities globally, a much likelier conclusion than a constant number of professors becoming 3-5X more productive.

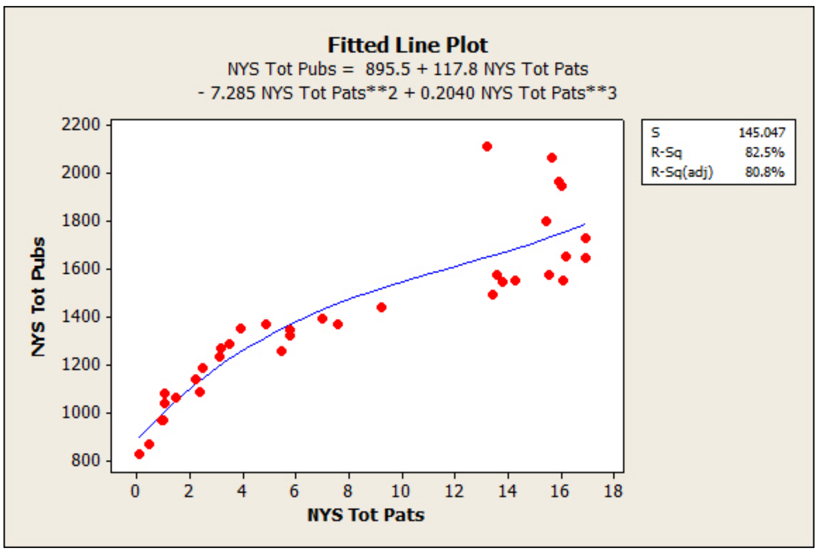

Fig. 3: Fitted line plot of New York State schools' patents vs. publications

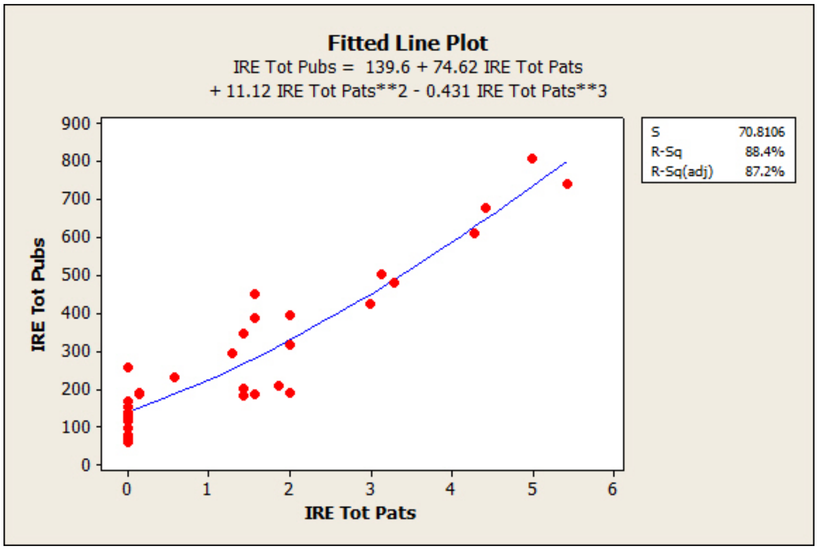

Fig. 4: Fitted line plot of Irish schools' patents vs. publications

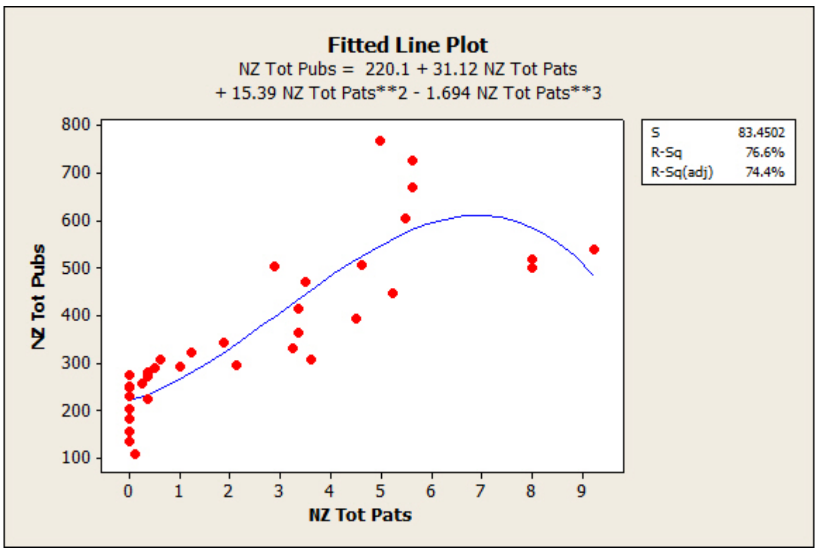

Fig. 5: Fitted line plot of New Zealand schools' patents vs. publications

Figs. 3-5 all display a positive, linear relationship between the volume of publications and patenting happening per HEI in all three countries. For Ireland (Fig. 4) and New Zealand (Fig. 5) there is a noticeable lag in the left tail, where the volume of publications is increasing and patenting is not. These data points represent the earliest years in this data set where publishing increased steadily but virtually no patenting was occurring. For New York and Ireland, the strong correlation between the data is reinforced by R^2 values above 80%, at 82.5% and 88.4% respectively. The correlation is slightly weaker for the New Zealand data, as is visualized by the right tail in Fig. 5 dipping slightly. The most likely explanation is that this is a hazard of small sample sizes – with data from only eight schools in that country, a single “down” year in patenting can quickly look like a grievous outlier.

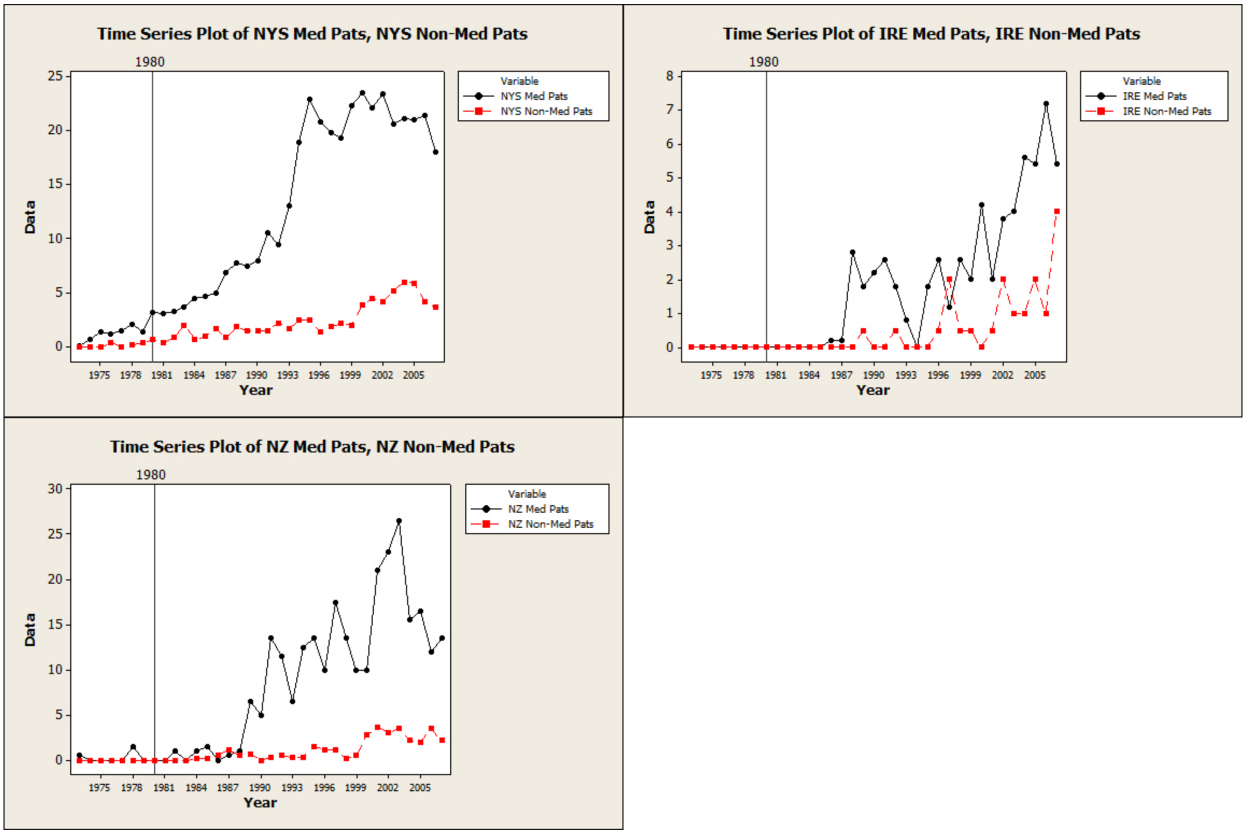

Fig. 6: Time series comparison 1973-2007 of patenting figures for Med vs. Non-Med HEIs in New York State, Ireland, and New Zealand, respectively (clockwise from top left)

Having separated the data within each country’s totals by whether or not each HEI had a medical school, we are able to see the jump in productivity appreciated by those with medical schools. The data is noisier in Ireland and New Zealand, but the overall trend matches that of the larger New York sample size where growth of Med patenting outstrips that of Non-Med patenting. In all three countries, patenting growth increases exponentially in the late 1980’s.

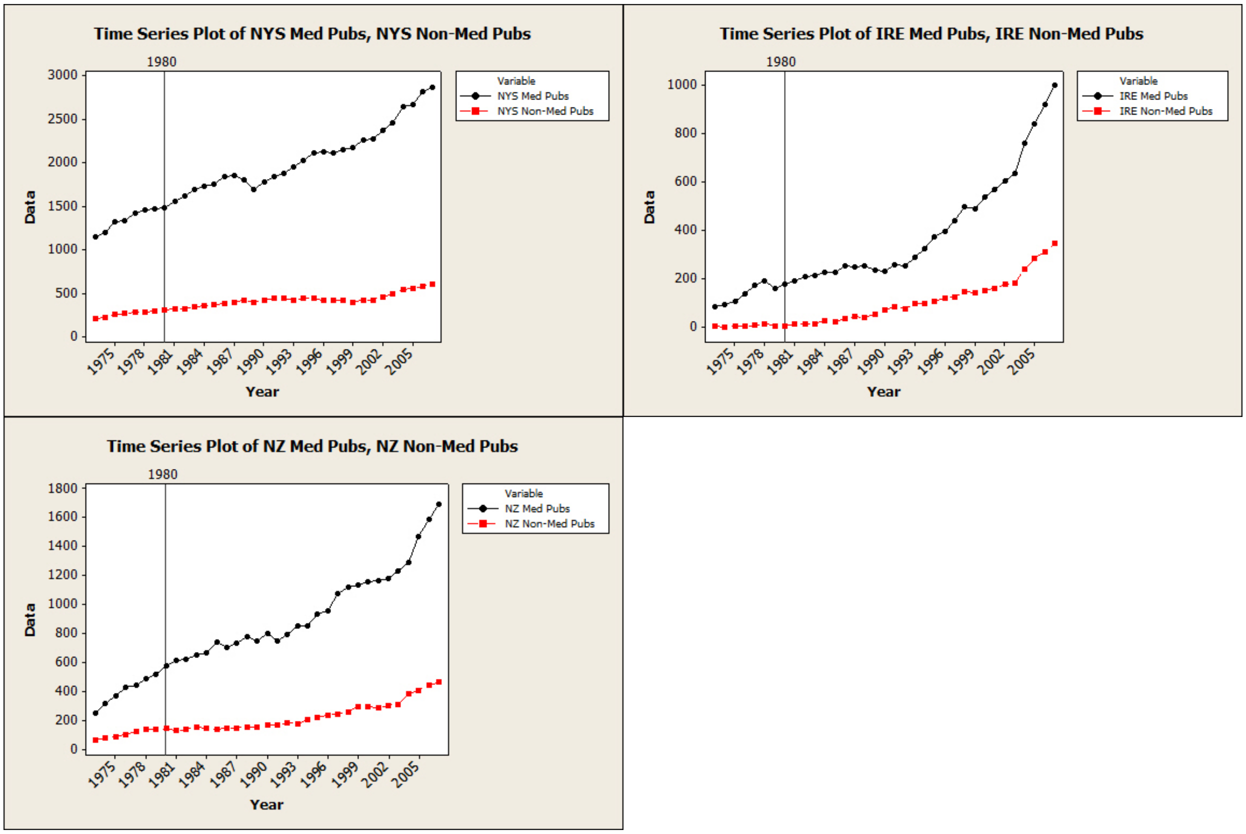

Fig. 7: Time series comparison 1973-2007 of publishing figures for Med vs. Non-Med HEIs in New York State, Ireland, and New Zealand, respectively (clockwise from top left)

The charts in Fig. 7 demonstrate that publishing volume per Med institution outpaced Non-Med institutions, similar to the patenting figures, but the discrepancy is significantly less severe. The gap in per HEI figures between Med and Non-Med might be attributable to school size (if HEIs with Med tend to be larger), but that data was not readily available to confirm this.

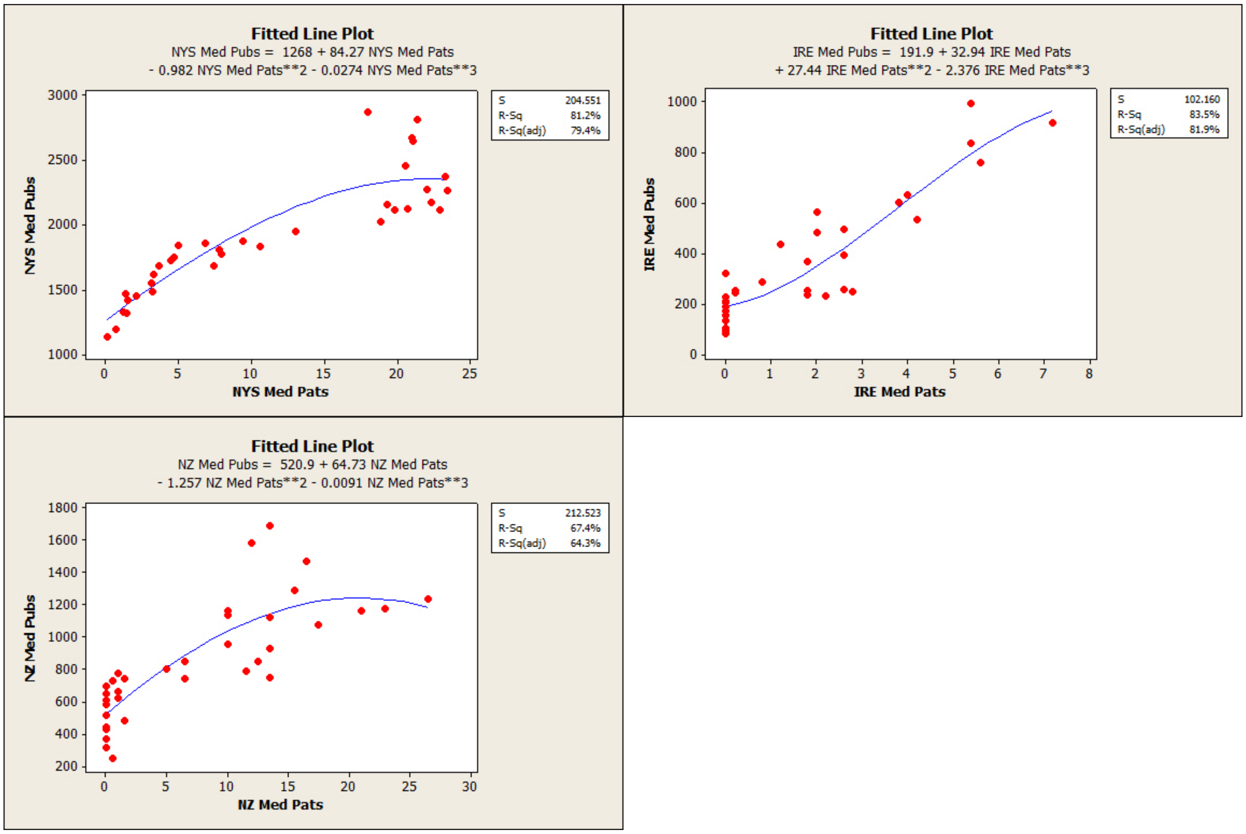

Fig. 8: Fitted line plot of Med publications vs. Med patents in New York State, Ireland, and New Zealand, respectively (clockwise from top left)

These graphs of Fig. 8, just for the Med HEIs in these countries, demonstrate the positive linear relationship between patenting and publishing observed earlier for the total country figures. The same lag is still apparent in Ireland and New Zealand – the left tail of those graphs illustrating increased publishing without acceleration of patent rates in the earliest years of this data set. Interestingly, though, the right tail of each graph shows slight deceleration in the publishing rate at Med HEIs in all three countries.

This indicates that the patenting process, and the secrecy required to maintain the patentability of an idea, may be affecting publishing. This would be a clear case of the "third mission" – the entrepreneurial university – interfering with research, the knowledge creation of the "second mission." To compare these graphs with the same patenting vs. publishing figures for Non-Med schools in these countries, only New Zealand shows deceleration of publishing rates. In New York State and Ireland, the right tail of the patent vs. publishing graphs for Non-Med schools points upward, as one would expect with positively related, highly correlated data.

Discussion

The above data suggests that the two premises of this study are likely correct: (1) that patenting at HEIs increased and accelerated dramatically per institution after the Bayh-Dole Act of 1980, accounting for lag time, and (2) that the pressure to patent biotechnology innovations may be causing faculty at HEIs with medical schools to pull back on publishing efforts in favor of patenting.

Further study of this subject should account for the changing sizes of these institutions in terms of faculty and students, and a rigorous assessment of outcomes. That is, the economic impact on individuals and institutions associated with particular patents. The outlier-type nature of commercial successes in biotechnology means every patent should not be weighted equally, and that could be accounted for with a more comprehensive data set for measuring levels of commercialization.

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Appendix

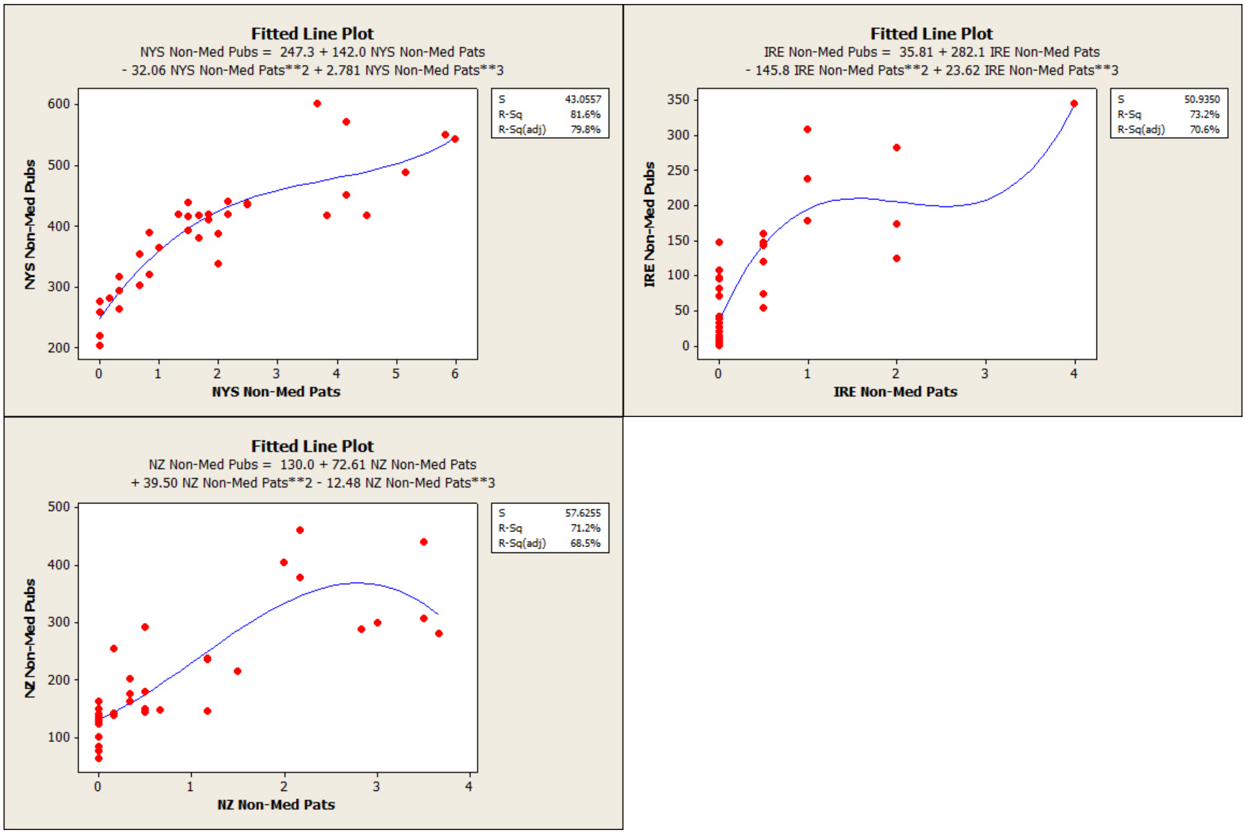

Fig. 9: Fitted line plot of Non-Med publications vs. Non-Med patents in New York State, Ireland, and New Zealand, respectively (clockwise from top left)