The case for actively seeking startup companies for "technology-push" inventions from universities: A research agenda
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ABSTRACT

Google Inc. began as a startup when all the large players in the industry turned down the opportunity to license the technology from Stanford University; Google has since become the leader in the industry with nearly 20,000 employees and a market value of about $150 Billion as of August 2009. Startup companies, using university technologies, have the potential to become a major economic force in the economy. But, it takes additional skills and effort on the part of University Offices of Technology Transfer (UOTT) to license an invention to a startup company compared to the effort needed to license to an established company; such additional skills are often not found in most UOTTs. Data indicate that startups bring large revenues (in excess of $500K per invention) 6.4 more often to Stanford University than licenses to established companies. Inventions that bring large revenues to the universities, by implication, are successful, create more employment, and are big contributors to the economy and the society.

"Technology-pull" inventions from university labs often are the result of prior ties of the inventor with industry. Such inventions need little marketing by the UOTTs since they are often licensed by the research-sponsoring private firm. On the other hand, "technology-push" inventions from universities (often sponsored by federal funds) do not have ready markets/licensees. This paper addresses the need for new ways of actively marketing of technology-push innovations from universities to potential startups to increase the total impact of university inventions on the society, and the number of successfully commercialized inventions from university labs. Investors in startup companies based on university technologies are likely to be attracted by the projected cash flow and ROI, and not by the technology itself. Therefore, to sell technology-push inventions to investors in startup businesses, UOTTs need the skill to develop believable business plans with cash flows to attract investors. A case study illustrates how intense marketing of a university technology using a business-plan attracted a licensee interested in a startup. A research agenda is included.

Key words:
Startup companies; University Technology Transfer; Technology Transfer Office; Technology-pull inventions; Technology-push inventions; Technology marketing; Bayh-Dole Act.

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INTRODUCTION

Is the US economy experiencing all potential benefits of the Bayh-Dole Act? A study of the capacity to process inventions at University Offices of Technology Transfer (UOTT) by Swamidass and Vulasa (2009) found that there are bottlenecks in the invention commercialization process in US universities slowing the commercialization of university inventions. The finding, based on a sample of 26 US universities, indicates that a bottleneck is caused by shortages in budget outlays and invention processing personnel at UOTTs.

This paper addresses the question, given that UOTTs have budget constraints, how could they maximize the benefits of new university inventions to the economy as well as returns to the university from each dollar spent by UOTTs? The approach taken by the paper is to search university commercialization data and find which activities of the UOTTs are most valuable to the economy, and in bringing revenue to universities. The paper addresses the question, given the number of inventions and licenses that each university has, what is the most effective use of the limited resources available to UOTTs for maximizing benefits to the society and the university?

This study considers two of the primary outlets for an university invention; it could be licensed to an established business or to a new startup. This paper looks for evidence in data to see if the monetary return to the university is any different from one outlet versus the other. The goal being: if one is a better revenue generator, what needs to be done to enhance it? Further, in case the evidence shows one outlet to be superior to the other in regards to bringing income to the university from inventions/patents, what would be the optimal thing for OTTs do? And How?

The limited data presented in this paper shows that, at least in one university, startups are more effective in bringing large incomes (over $500,000 per license) than licenses to non-startups; licenses to startup business are 6.4 times more likely to bring in large incomes compared to licenses to established businesses (Table 1). Why does it matter? If universities want to maximize the impact of their inventions on the economy and the income generated by investment made in their OTTs, they may be wise to learn more about startups, learn to increase the incidence of startups, and also learn to nurture university startups so that they enhance the overall effectiveness of the scarce resources available to OTTs in most universities.

To increase the number of successfully commercialized inventions from universities, this paper advances the theme that "technology-push" inventions from universities are better suited for new startups. Some of the technology-push inventions are "disruptive" technologies that can alter an industry's landscape and rearrange leading companies in the industry the way Google did. But, they are not easy to market to established businesses that are deeply committed to one way of doing business. However, the paper notes that marketing "push" technologies to potential startups is time- and cost-intensive; UOTTs are not prepared for this task today. The paper advances an idea for funding the marketing of push-technologies because it would increase the number of commercialized university technologies.

Disproportional effect of low UOTT budgets and staff

The shortage of personnel and budgets for the UOTTs could have a disproportionately large effect on the latter stages of commercialization because, under a scenario of staff and budget shortages, UOTTs may succeed in devoting all their time to patenting but may have limited resources available for marketing inventions to potential licensees and investors. We

know that patents are not an end in themselves; university patents need licensees to complete the commercialization process that may produce income for universities and employment for the public. By devoting their limited staff to primarily patenting effort, at the end of the year, UOTTs may meet or exceed university administrators' performance goals for number of patents applied for and granted.

Given the difficulty in marketing inventions, it is argued that, under shortage of budgets and staff, university invention commercialization suffers disproportionately. The time and resources needed to successfully market inventions/patents could be far greater than the effort and time needed to apply for a patent. One question addressed here: how could universities market more inventions? What is needed for improved marketing of university inventions? What are the challenges of marketing to new startups? These and related questions are addressed in this paper and a research agenda is included at the very end.

Startups

Data from Stanford University, which is a leader in technology transfer among universities, has a number of big-revenue licenses that have brought in at least $500,000 in total revenue during the life of the invention. An analysis of the big-revenue licenses provides previously-unknown information on the relative effectiveness of startups based on university inventions versus ongoing firms that acquired university inventions. Stanford University provides a much larger dataset than almost all other universities to investigate the relative effectiveness of licensing to on-going companies versus new startups using university technologies.

Based on Stanford University data in Table 1, it appears that startups using university inventions

Table 1: The Case of Stanford University Technology Commercialization

All Stanford inventions to end of 2008(approx)	= 7400	
All licenses including active licenses	= 2814 (1782 active)	
Licenses to all startups to date	= 196	
Estimate of licenses to non-startups	= (2814-196)= 2618	
2008--Number of annual disclosures each year	= 400+	
Number of patents filed each year	= ~200	
Number of patents licensed each year	= ~100	
Big revenue generating inventions ($500K or more)	= 92 (to date)	
Big revenue generators among startups	= 30 (out of 92 total)	
Percent of startups bringing big revenue	= 30/196	= 15.3%
Percent of non-startups bringing big revenue	= 62/2618	= 2.4%
Startups over non-startups in bringing big revenue	**= (15.3%) /2.4%**	**= 6.4**

are more likely to bring in big revenues than ongoing businesses.[1] While startups require new investors and new investment upfront, ongoing businesses may often acquire a new university technology to blend it with existing product lines without the need for new investors and new investments. This distinction explains why it is harder to form a startup with a university technology and make it successful; more effort is needed to market push-technologies to investors/licensees. Often the investors in new startups are angel investors, or very early-stage investors, who are eager to invest in potentially risky, yet likely successful businesses. Such angel investors may not always understand the technology but they do understand cash flow; they invest in promising cash flow rather than the technology per se.

In contrast, ongoing businesses who license university inventions often acquire a technology that is relevant to their product line, have a need for the technology, and fully understand the technology. Startups offer an avenue for technologies that are not immediately usable by ongoing businesses. But, startups need capital, investors, years of time for the

[1] While Stanford University data in Table 3 indicates that startups are more likely to bring in big royalty revenue to the university, this finding is in the process of validation with data from other universities.

technology to develop, and slow and careful development of new markets or replace existing products already in the market. Many university inventions, with large potential markets, are fit for startups. How could universities promote more startups for the commercial of development their inventions/patents that may otherwise remain unlicensed? This is the major theme of this paper.

Marketing of technology-pull and technology-push inventions

When inventions have a ready market. University inventions of the "technology pull" variety are those sought by industry even before the invention. When an industrial partner sponsors university research, it is often because the industrial partner has a specific need that the researcher at the university could fulfill. The resulting invention and patent will be readily usable by the industrial sponsor. There are other examples of ties between university researchers and industrial firms before the invention. For example, a federal agency might sponsor the research of mutual interest to an industrial firm and one or more universities. When university inventors have aforementioned ties to industry prior to their invention, the likely licensee is (are) the industrial partner with ties to the inventor; the pre-invention contract with the university always include terminology that cover the licensing agreement in the event a invention/patent arises from the contract with the university. In such circumstances, where a pre-invention tie between industry and the inventor exist, the effort and expense for marketing the technology may not be necessary, or irrelevant.

When inventions do not have a ready market. University technologies that are not ready for the market are the "technology-push" kind that are better suited for startup companies. However, UOTTs need resources for marketing of technologies to create new startups when no

ongoing businesses are interested in the technology. The resource need includes skilled staff, who can evaluate the market and find potential markets, or hidden market space for the technology; this may require experience and a skill to see beyond current markets. Further, staff must be able to prepare business plans with reasonably reliable cash flows for four to five years into the future. This requires skilled staff who can estimate investment, staffing levels, fixed and variable costs, product development costs, management, pricing, etc.

UOTT may try cost-free or low-cost university resources to market new technologies that are only fit for new startups. They may try and recruit teams made of professors in the colleges of business and engineering/sciences and their graduate students to study markets for new technologies without a ready market, and use the teams to prepare business plans to market the technologies. As a collateral benefit, universities that are successful with this option prepare graduate students for employment as technology commercialization professionals and managers.

One hurdle to the commercialization of technologies without a ready market is the cost of finding markets, business plan preparation, and finding licensee/investors. These costs are beyond the reach of most UOTTs today given that they are often underfunded. Some recommended avenues for funding these legitimate activities of UOTTs to enable the creation of more startups are:

1. Federal and state research sponsors to earmark a portion of their research grants for commercialization.
2. Use the earmarked funds to compensate teams of university professors and graduate students assisting UOTTs with technology commercialization.

3. If the university does not have internal capability to engage teams of professors and students, hire external consultants to do the same—this may be a more expensive option compared to Item 2 above.

"Push" Technologies. Technology-push inventions are those which do not have an immediate market. Some of them may be the result of "basic" research and may need time for market research, extended product and market development, and investment. Some "push" inventions are likely to be "game changers," or "radical, discontinuous or disruptive innovations" (Christersen, 2000; Utterback, 1994) capable of replacing a dominant, currently successful, or widely used products (incandescent electric bulbs, Google, etc.). These new inventions would not have ready, established markets unless they replace existing, established products.

Most "push" technologies are of little interest to ongoing businesses, although these technologies might compromise their long-term survival and competitiveness. These technologies may require one to as much as seven years of product/market development before successful introduction to the market. Incumbent large businesses are resistant to the idea of investing in new radical technologies that may have profound impact on the industry. Christensen (2000) mentions several reasons why incumbents do not grab new disruptive technologies immediately. The reasons he mentions are:

1. Small initial markets for new push-technologies do not solve the growth needs of large businesses; a $10 billion company needs a $1 billion dollar market to grow by 10% over 12 months. Most new technologies cannot deliver such markets in a short time.

2. An inability to analyze markets that do not exist—when Edison invented incandescent light bulbs, the market for the product was difficult to analyze for dominant gas companies that provided most of the street lighting.
3. Disruptive technologies will underperform entrenched technologies for some time and only steady investment in their development would make them overtake existing technologies on based on superior performance—Utterback (1994) records that, when the first electric bulbs were publicly displayed by Edison and associates, employees of gas lighting companies are reported to have declared, "Edison's invention was a big disappointment and that none of the 40 'burners' on display produced as much light as a single gas light." This is an example of how initial versions of new push-technology-based inventions may fall short of the properties of the products they would eventually replace.
4. The competence of personnel as well as large successful organizations' capabilities do not match with the needs of a new disruptive technology unless the existing organizations are substantially reorganized—the switch from main frame computers to personal computing changed design, manufacturing, marketing, customers, etc. Similarly, the switch from gas lamps to incandescent light bulbs for street lighting would have disrupted the gas companies if they were to make the switch to electric light bulbs, when electric light came along in 1879 via American inventor Thomas Edison—the generation of electricity, wiring for distributing electricity, lighting structures, training, maintenance, pricing, etc. could not have been absorbed by a large successful gas company "as is" without a major overhaul.

5. Most customers would not switch to the new technology, which is a disincentive for large companies to investigate and invest in new disruptive technologies in their industries. For example Christensen notes, "…companies find it difficult to invest adequate resources in disruptive technologies…until their customers want them. And by then it is too late" (Christensen, 2000; p. xxiii)

Thus "technology push" inventions need considerable marketing to find a licensee, who is not a major player in the relevant industry. This is the reason why, most often, the licensee of a push-technology may be a startup company that starts with a grand vision of dislodging established giants in the industry, who tend to disregard the technology.

Google is a case in point. A well-known case of a market-changing technology that was repeatedly turned down by large companies in the industry is the case of "Google" technology that originated at Stanford University. The inventors, upon being turned down by the leading firms of the industry, created a startup that has became the leader in the industry and still growing. The bold decision by the inventors to form a startup has created employment for thousands (19,786 employees, August, 2009; 13,600 employees to the nearest competitor) with a market capitalization exceeding $148 billion (August 2009; $21 billion for the nearest competitor and leader in the industry prior to Google's entry as a startup). The point is that very good market-changing technologies are likely to be turned down by the leading companies in the industry for the reasons explained above. If Google inventors chose not to form a startup, the nearly the US economy will be one short by one company with 20,000 employees and $148 billion market capitalization—not to mention the fate of the thousands of companies and their employees who do business with Google. Not every startup could become a "Google." By failing

to purse startups with university inventions that are not attractive to ongoing businesses, we may be leaving potential "Googles" on the shelf.

A typical, simplified university IP commercialization process may look like the flow model in Figure 1:

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Figure 1

Invent→disclose→evaluate→apply patent→license→generate revenue

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The model in Figure 1 may be inadequate to successfully market and commercialize "Technology-Push" inventions from university labs. It is hypothesized here that the process of marketing "push" inventions requires at least two more stages in Figure 1 for successful marketing:

1. First, careful study of all relevant markets and the search for a previously-unknown potential market space/gap/niche for the new technology. This could be a very time- and skill-intensive effort that average UOTTs lack today.
2. Second, there is a need to develop a business model for the invention, and an "investor-friendly" business-plan with projected cash flow for four to five years for a business based on the push invention to convince potential investors, who might invest in the invention only when they see the complex new technology in the context of a well-developed business model and complementing business plan. UOTTs are not staffed to do this. As a result, push inventions from

universities may remain in the shelf after patenting thereby denying income to universities and the opportunity to create employment for the public.

The modified model for commercializing push inventions from universities must include two additional stages as described in Figure 2 below.

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Figure 2

Invent→disclose→evaluate→apply patent→***study the market for appropriate business model→prepare business plan to attract investors***→license→generate revenue

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Policy change proposed

Sponsored research funding to universities from federal agencies without adequate dollars for supporting active commercialization in universities may be limiting the success of the Bayh-Dole Act. When the Act was passed in 1980, its premise seems to have been, once ownership of a patent is given to universities, they would devote adequate resources to hire, train and perform appropriate commercialization. The Swamidass and Vulasa (2009) study implies that the said premise has not realized. A recommendation of this study is that federal agencies must require all federally-sponsored research grants to include an earmark for a small percentage of the grant to support market-oriented commercialization of inventions resulting from all federally-sponsored research—tragetted to business plans and startups early-stage. Federal agencies may require periodic evidence that the mandated commercialization funds are utilized for adding appropriate invention processing and marketing capacity to reach predetermined

commercialization performance levels at the university. The commercialization performance of universities monitored by funding agencies may include the number and quality of faculty/student teams engaged in commercialization projects, the use of external consultants for commercializing technology-push innovations, training and hiring of OTT staff for in-depth market analysis, and business plans preparation and marketing of push-technologies to investors. Over a period of time, it would be appropriate for sponsoring agencies to monitor the number of startups resulting from sponsored-research at various universities.

A CASE STUDY

Carpet nylon recycling technology: One case from Auburn University is described here to illustrate the foregoing discussions. This case concerns a US patent granted to Auburn University in 1997 for a chemical engineering process to recover nylon from used carpets. The business opportunity for this technology was extremely favorable:

1. About 5 billion pounds of used nylon carpets were generated in the US each year in 2005 and growing.
2. Crude oil being the raw material for carpet nylon, the trend in crude oil prices favored carpet nylon recycling.
3. By 2006, only about 250 million pounds of used carpets were being recycled (about 5% of the total waste/used carpet).
4. Carpet America Recycling Effort (CARE) was established by the carpet industry at the turn of the millennium to speed the recycling of carpet nylon. The goal of this industry-led agency is 1.5 billion pounds of nylon to be recycled each year by 2012. By 2008, the

industry was recycling about 350 million pounds a year—a far cry from its target. The industry lacks the technology to speed the recovery of carpet nylon.

5. The industry is eager to invest in a “green” technology to recover nylon from carpets.
6. Around 1999, a joint venture by industry giants invested over $100 million at the Evergreen carpet nylon recycling plant (Georgia) to produce about 100 million pounds of recycled nylon each year. The plant was shut down in 2002; it proved to be inefficient—the cost of shipping carpets three times the weight of the recovered nylon to Dalton, GA, was a logistic nightmare in addition to the energy-intensive process to convert used nylon to caprolactam before reconverting to virgin nylon.
7. Cities are enacting laws that ban non-degradable, used carpets from landfills; Los Angeles and San Francisco are examples.

Against this backdrop of industry need, the Auburn University patent for recovering nylon from carpet had these characteristics:

1. The process skirted the need for making caprolactam.
2. The process was simpler than known processes in the market to produce near-virgin nylon according to lab tests at the university (the selling price for recovered nylon is proportional to its purity).

The challenges faced by Auburn University in commercializing this invention were many. The technological and financial challenges were:

1. The process was developed as a batch experiment in the lab. The patent describes a batch process. The invention needed conversion to a continuous process to be of commercial value.
2. The process being pressurized, it required large pressure vessels for commercial operation. Given pressurized vessels, a relatively smaller plant of 1 million pounds of nylon output per year seemed optimal for the process. Large nylon producers and users questioned the economic viability of the plant in capacities of 1 million lbs per year.
3. The process used formic acid as a solvent and supercritical CO2 as anti-solvent. Large nylon manufacturers and users were unfamiliar with this technology and were disinterested in the technology.
4. Current nylon recyclers were unsure of the new technology and its financial viability.

There is a notable disconnect; while the market thirsting for a technologies to recover billions of pounds of nylon each year from carpets, the Auburn process had no appeal to the industry. This type of disconnect between the needs of the industry and an university's push technology is common. Such technologies remains shelved without any prospect of commercialization. A new startup with an unfamiliar process is often the only option available for commercializing inventions that break the mold familiar to the dominant players in the industry; we know Google idea was turned down by the big players in the industry. The resulting startup has dominated the industry eventually, and brought substantially large revenue to Stanford University.

Breakthrough Business Model and Business Plan

A faculty champion of the technology at the university, outside the UOTT, but with encouragement from the UOTT, prepared a business plan with a graduate student team —about 400 person-hours of time were invested. The business plan had two critical breakthrough decisions to make based on an extensive study of the nylon and nylon recovery business: first to convert the batch process in the patent into a commercially-viable continuous process (on paper), and the second was not to focus on a business to recover and sell nylon, but to sell manufactured, small nylon recovery plants to independent, small nylon recyclers with an annual capacity of 1,000,000 pounds each (in contrast, the competing Evergreen plant's capacity was around 100,000,000 pounds a year at an investment of about $100 million). The business plan projected a viable business that would build and sell many turn-key, mini-recovery plants, which a customer could locate near big cities that generate plenty of used carpet. The idea of "distributed carpet recycling" was the core business idea; it contrasted with the older failed idea of building large recycling plants in a few locations, a la failed Evergreen plant.

The business plan for making and selling several small distributed plants attracted a licensee, who saw an opportunity to raise the necessary capital using the business plan. While he knew the nylon industry, he knew investors (unfamiliar with the industry) who would invest in this "green" technology given the business plan. He was confident that he could sell the business plan to potential investors. He has since then raised $3 million from angel investors within 12 months after licensing, subcontracted the building of a pilot plant, and as on spring 2009, the startup is valued at about $10 million based on the offers to purchase shares in the budding business.

AN AGENDA FOR RESEARCH

While university inventions are being commercialized every day, this paper notes that startups based on universities' technology-push inventions could commercialize inventions shunned by large established businesses in the industry, and give commercial life to push technologies that are "game-changers" such as Google technology that employs nearly 20,000 with a market capitalization of $148 billion (August 2009). Further, evidence from Stanford University shows that licenses to startups are 6.4 times more likely to bring big royalty incomes (over $500K per invention) to the university compared to licenses to established companies.

Without a concerted effort to find investors in startup businesses based on push-technologies, many inventions remain on the shelf after they are patented by universities. The theme of this paper is that special effort and resources are needed to take push-technologies to the market through startups. Finding licensees/investors for technology-push inventions is a challenging task. The paper argues that UOTTs lack the skills, time and budget to market them. Potential-market analysis backed by a business plan showing cash flows over a period of time for such technologies would increase the chance of licensing to investors motivated to fund new startups. One objective of this paper is to open a new avenues for research on technology transfer. Based on the data and arguments presented here, the following are several research questions for future research:

1. Do universities have the processing capacity to go beyond patenting and licensing and engage in rigorous marketing of patents?
2. How to enhance UOTT's capability to prepare and market business plans for technology-push innovations that are not close to the market?

3. What university and federal policies are needed to enhance the capability of UOTTs to enable effective marketing of technology-push innovations resulting from federally sponsored research?
4. Should federal research sponsoring agencies earmark a portion of research grants for technology commercialization purposes as proposed in this paper?
5. What metrics and procedures would ensure that the earmarked funds for commercialization in Item 4 above would ensure commercial success?

The theoretical underpinnings of university IP commercialization process are less than adequately understood. *This paper addresses startups as a superior or perhaps the only option for technology-push innovations and recommends a transformational change in handling these inventions; proposes earmarking funds for commercialization in all federally sponsored research projects.*

While US universities are patenting several thousand inventions each year, thousands of patents issued to universities will remain unlicensed. It is argued that hundreds of the unlicensed university inventions are fit for startups but it would take a realistic in-depth business plan to attract investors to take technology-push innovations to the market. By addressing thousands of unlicensed university patents as proposed here, the US could create several new startups, new products and employment.

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