

PROMOTING AND MEASURING UNIVERSITY-BASED INNOVATION AND ENTREPRENEURSHIP

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ABSTRACT

There exists an imperative in many countries to find effective paths for utilization of the knowledge created within their borders. To a large extent, these activities are entrusted to universities. Thus, they receive considerable resources to not only facilitate knowledge and research activities, but also to identify, package and transfer the results to society, stimulating university-based innovation and entrepreneurship. The U.S. regulation structure of the Bayh-Dole Act of 1980¹ has become a benchmark model for commercialization. Revenue resulting from transferred intellectual property (IP) is often redistributed not only to the university, but also key actors and their associative groups, often with the intention to support and sustain both academic research and commercialization activities. Even so, university-based development and investment in the creation of entrepreneurial environments is ambiguous at best. Although some initiatives seem to have effects in both innovation and entrepreneurship, such as venture creation, they often only account for parts of the effects achieved. As innovation and entrepreneurship programs continue to permeate through regions, there is a risk their full value is not acknowledged. Long-term infrastructural results might be overshadowed by metrics for short-term success and – vice versa – imprecise infrastructural effects might be sought while missing opportunities for stating concrete examples and creating role models through more immediate success. This paper derives and organizes a framework for promoting innovation and/or entrepreneurship at universities, by comparing different university settings and linking both their experiences and expectations to innovation and entrepreneurship theory. The purpose is to provide university policy-makers with tools to account for effects and identify metrics suitable and adaptable to their unique environments. Universities must continue to strive to maintain their long-term aspirations. At the same time, individual and team-based processes are vital to sustain in the proposed platform framework to university-based innovation and entrepreneurship.

INTRODUCTION

Many countries are seeking effective paths for utilization of the knowledge created within their borders. This path of utilization often requires a bridge across the so-called innovation gap between science and business. To a large extent, the bridging of this gap has been entrusted

to universities, in part because of the failure or unwillingness, due to various constraints, of established firms to do so. Universities have always been “entrepreneurial” environments for the promotion of new ideas and building of new areas. Thus, university environments receive considerable resources to not only facilitate knowledge and research activities, through education and the building of excellence, but to also identify, package and transfer the results to society, and in general, stimulate university-based innovation and entrepreneurship.

Criticism of using the university to bridge the innovation gap provides different points of view. Among the more recognized arguments are: blurring institutional spheres that are fundamentally different (Dasgupta & David, 1994), negative effects from privatizing publicly funded research and the “scientific commons” (Nelson, 2003) and questioning if it is worthwhile from an economic standpoint to invest in the bridging of research (Thursby & Thursby, 2003). But, there are two reasons to not accept these critiques: the first is the survival, continuance and sustainability of the university increasingly dependent upon being “an actor” in the economy; the second is the opportunity, perhaps necessity, for the university to combine and balance interests and incentives towards research, education and innovation/commercialization. Thus, there is recognition for establishing a balance between the multiple missions and “societal obligations”, while also promoting innovation and entrepreneurship. The formal incentive structures at universities have not necessarily promoted innovation and entrepreneurship. Nor have universities fully designed the commercial equivalent (i.e. processes for collaboration, licensing, and venture creation) towards a more academic entrepreneurship of championing new knowledge areas. There are also “prejudices” and concerns about the mixing and combination of scientific and commercial entrepreneurship. Namely these concerns include the potential of the university becoming too opportunistic, or focused on only short-term goals (a focus on close-to-market research instead of early-stage), which could lead to conflicts of interest, if inventors or academic entrepreneurs are asked to operate in the business arena as well (Leslie & Slaughter, 1997). And there always exists the concern of maintaining the social contract of the university researcher – ensuring that this person continues to pursue science, innovations, methodologies, etc. that are to benefit and serve society, free from influencing factors.

To some extent, these concerns are unfounded. While the academic, particularly science- and technology-based, environment, and the business and industrial environment seem to be attempting to converge, they are more often, in part due to constraints, naturally diverging at the same time. Within universities, science continues to delve more deeply into the minute aspects and constructs of their fields, which ironically continues to reveal increased connectivity and complexity of the structures that exist and are necessary if to be used by society (Boettinger & Burk, 2004; Etkowitz & Viale, 2005)ⁱⁱ. The innovations, inventions, intellectual property (IP), etc. that were readily recognized by industry and society as meeting immediate needs and adaptability have been “plucked” from the university “tree of knowledge” and digested into society. What remains are the early-stage and developmental research areas, still churning and recycling, as well as cross-breeding and integrating, on the way to bearing fruit, but with other objectives as well.

At the same time, businesses are currently engaging less with university faculty in developing innovation, choosing instead to collaborate most with suppliers and customers (i.e. individuals most closely linked to them), according to the 2005 National Innovation Survey.ⁱⁱⁱ “Survey

respondents indicate that universities and state-of-the-art research centers are not integral to their company's innovation processes. Poor linkages to academic institutions rank last as a barrier to a company's ability to innovate." (COC & NES, 2005, pp. 6) While business executives identify innovation as the largest factor in productivity gains, as compared to capital improvement, employment, outsourcing, etc., their competitiveness is most heavily reliant on price and delivery, and much less on innovation and new technology. More often, innovations within these businesses are modifications or extensions to existing products, than products that are new to the industry. This divergence increasingly calls for a framework to help bridge the innovation gap, which thus entails an understanding of how innovation is promoted and evaluated.

It is not just the innovation factor that presents a challenge. "Innovations are highly portable, whereas entrepreneurship is place-based. Whether they are building new firms or reinventing existing ones, entrepreneurs, through the application of new ideas to products and services, capture locally the economic benefits of innovation." (Advanced Research Technologies LLC, 2004, pp. 5) Effective utilization of knowledge requires individuals to adopt entrepreneurial roles to not only commodify new knowledge, but also to carry out the transfer process, not just from the university (or other location), but also continually through a formed venture, as an entrepreneurial leader. The 2002 GEM^{iv} study presents some challenges to this need. The study found that the general level of entrepreneurial activity had declined from 2001 to 2002, by approximately 25%. Two-thirds of the individuals involved in entrepreneurial activity were opportunity-motivated, with the remaining one-third necessity-motivated. Perhaps most interesting of all, particularly when related to innovation, were the findings on the types of business being created: "93% of entrepreneurially active adults consider their business to be a replication of an existing business activity. A small minority (7%) expect their new firms to create a significant new market niche or economic sector, and a very small proportion of these expect to create new market niches, provide 20 or more jobs in five years, *and* have exports outside their own country. Most of these 'high potential' new ventures reflect the pursuit of opportunity." (Bygrave, et. al., 2002) Although many innovations might be explored also in large established firms, these GEM findings, point towards a strong need for not just entrepreneurs, but entrepreneurs capable of driving innovative, market niche types of businesses, which then requires the education and development of such individuals, presumably through university academic programs.

If we are to generate metrics for utilization (often, in the short-term, commercialization) of knowledge, typically in the form of transferred research, we must first understand why universities have been and should continue to be identified as the key platform for this transference to take place. Universities are often seen as cradles for radical innovation, not only because of a focus towards so-called fundamental research, but because universities (unlike institutes, labs, firms, etc.) have a constant flow of students asking question and vitalizing the knowledge base (Etzkowitz, 2003; Boni & Emerson, 2005). The continual student-driven flow of new ideas and energy into and out of the university environment is coupled by the anchored academic, collecting the new energy while securing the continual focus on basic and fundamental research. From the business or industry perspective, universities (and other government funded research organizations) are often considered relatively distant from research that can be easily transformed and delivered to society. The uniqueness of certain types of research, such as the current emphasis on the biosciences, information and communication technologies and applied materials, vaults the

university into a prioritized position (Colyvas et. al., 2002). In addition, there is the value driven aspect that universities are “neutral and chaste” from the influence of industry (i.e. limitations on applied research), and can therefore identify and develop innovations that could have multi-purpose benefits for society, disseminated in various, differentiated forms (ex. open sources, licensing, publications, shared patents) (Boettinger & Burk, 2004). Thus, it is the conceptualized impression that the university is the most suitable environment in which the development of both the innovative ideas and the entrepreneurial individuals (not necessarily “entrepreneurs”) that will champion these ideas can be married. Evidence exists in the increasing emphasis of entrepreneurial education and the adoption, by more and more universities, of programs in entrepreneurship (Boni & Emerson, 2005).

Based on this, it is reasonable to advocate the university platform as the most effective environment for integration of these two sides of the coin – innovation and entrepreneurial activity – in order to facilitate the utilization and transfer of knowledge to society in both objectified and role identity forms (i.e. the innovation and the entrepreneur). But, we then return to our question of how this transference is being measured and if innovation and entrepreneurship are in fact being integrated to create substantial benefit, or if the two are being run in parallel, with minimal interaction. We will investigate this further through case studies of select universities, and draw upon their experiences.

As the identified realm for knowledge and research utilization, universities receive fairly substantial support from industry and government, as well as society (individual and community), in the form of financial and other types of resources. The increasing complexity of the funding structures and use of resources has had the following repercussions. Resource utilization, and the expectations linked to their use, has resulted in universities having to balance multiple objectives and prioritizations, sometimes in opposition. The increasing complexity of the university structure has made it nearly impossible for the individual, wanting to bring forth transferable knowledge, to navigate independently. In response to these challenges, universities endeavor to establish policies to help guide the transformation process, often in tandem with regional and/or national policies and regulations. The formation of the Bayh-Dole Act in the U.S. is one example (Mowery, 2005).

TWO-SIDES OF THE COIN (INNOVATION AND ENTREPRENEURSHIP)

Regarding university-based technological innovation, there is currently a strong global emphasis towards adopting a U.S. inspired approach. The innovation practice captured in the Bayh-Dole Act includes giving universities the right to take title of IP stemming from federally-funded research. Revenue resulting from transferred IP is often redistributed not only to the university and the inventor, but also to his/her research department, the technology transfer office (TTO) of the university, and collaborative partners (licensees, entrepreneurs, etc.). In 2003 alone, the revenue generated by U.S. and Canadian TTOs exceeded 1.3 Billion US\$, though only a few universities were responsible for generating the majority of the revenue (AUTM, 2004). Because of such success, the university structures adopted, based on the Act, have become a benchmark model for commercialization of university-based, federally-funded research in other parts of the world (Pressman, et. al., 2005).

Thus, it is interesting that in the 2005 Innovation Survey, conducted by the U.S. Council on Competitiveness and New Economy Strategies, LLC^v, corporate executives reported that innovation collaboration was occurring less frequently with university faculty, federal labs and research centers, and private, non-profit institutions. American business executives were slightly positive at most towards the innovation climate in the U.S., though they were much more encouraged towards global innovation activity. This seems to reflect somewhat negatively on the university's ability to transfer innovation from within their "walls", perhaps to some extent limited by the federal regulations emphasizing U.S. manufacture of university-based commercialized research. But perhaps this only emphasizes the transactionable assets produced, particularly through the technology transfer organizations within the university structures, and does not recognize the intangible human capital assets delivered by universities. The survey also showed that some of the most highly valued assets leading to a company's innovation capacity were access to science and engineering talent pools, and availability of entrepreneurial managers; certainly two "products of human capital" generated by the university.

Universities with high technology transfer revenue often operate in regions with strong entrepreneurial cultures and/or venture capital networks. However, university-based development and investment in the creation of such environments is ambiguous at best. While many universities are now linked to incubators and provide educational programs in entrepreneurship, the linkage to their investments in innovation is not readily obvious. University and government programs are often designed to have indirect influence towards the entrepreneurial infrastructure, in terms of attitudes and skills, rather than directly supporting entrepreneurial ventures.

Integration of these tangible and intangible resources seems to be precisely what is limiting businesses' ability to innovate. The 2005 survey also showed that business executives stated that the biggest challenges to innovation ability were competing internal priorities due to finite resources and scarce investment capital. These two challenges reinforce one another, and possibly result in the reinforcement of the third major challenge to innovation – short-term emphasis in the marketplace, and thus lack of time to encourage innovation. The market driven emphasis on immediate realization of investment goes strongly against the scientifically pure missions often found in universities of funding and supporting research regardless of whether or not there is a commercial end-product (Nelson, 2003). But it is also recognized that it is within the university setting that innovations can bloom, grow, recycle, and evolve to the point at which they are ready to be hatched into the business world.

As we reflect back on the university identified as the core arena of transference, and then recognizing the geographical constraints of a university, we start to question to what extent a broad view can be created and to what extent regionalism is inherent in the definition (particularly for the role-emphasis of entrepreneurship). It becomes clear that in the vision of the knowledge society, there needs to be a balance between the community and the objectified systems (i.e. between human resources and new structures – entrepreneurship and innovation). Instead of allowing innovation and entrepreneurial activity to continue to operate in parallel, but separately, the two need to interact and positively reinforce one another. It is through this integration of innovation and entrepreneurship that the untapped potential arguably will be recognized, creating greater efficiency and effectiveness of the utilization process, thus providing a more comprehensive end result to society, both in the short-term and long-term.

A PROPOSED FRAMEWORK FOR UNIVERSITY-BASED INNOVATION AND ENTREPRENEURSHIP

In order to capture key challenges in university-based innovation and entrepreneurship, a six-sector framework is proposed. A categorization of activities based on level of focus, utilization and time, is presented in Table 1. The level of focus ranges from an independent unit to a group to a community. Activities are categorized based on whether they are utilized in mainly a scientific context or a business context. The time dimension fits naturally into this model both in the time required for delivery/ production and the time over which the activity takes place.

Table 1: A proposed six-sector platform framework of activities for university-based innovation and entrepreneurship

INNOVATION/ ENTREPRENEURSHIP LEVEL OF FOCUS	SCIENCE ↔ BUSINESS		
Invention / Individual	Idea promotion through e.g. publishing, job placement, lecturing	Idea promotion through licensing and other contractual agreements, consulting	SHORT-TERM
Venture / Team	Building e.g. competence, laboratory and/or conferences, research project groups	Building business, ventures and/or specific innovations	↕
Culture / Community	Striving for cultural acceptance	Striving for sustainable business (established and growing firms)	LONG-TERM

In Table 2, the promotion of activities through funding/resource allocation and policy structures is represented. This framework identifies and categorizes asset requirements (fiscal, human, etc.) and creates a map for analyzing the interests and incentives (Bozeman, 2002; Markman et. al., 2004) sought by the three levels. Again, the framework differentiates between utilization within science and business arenas, and recognizes the time implications of the different investments. This calls attention to the way in which the investments are made and helps to reflect upon the potential expectations of such investments (Jensen, Thursby & Thursby, 2001; Phan & Siegal, 2004 and others), which are then measured in Table 3.

The aim of the metrics, presented in Table 3, is to understand ways in which the divergent results within the different sectors can be combined and balanced to achieve overall goals; namely how the two sides of the coin – innovation and entrepreneurship – can be aligned within the two parts of the university structure – science and business – in order to construct a positively reinforcing system of metrics. As in the other two tables, potential metrics are allocated based on level of focus, utilization and time.

Through the three different lenses of the framework – the activity-based, investment-oriented and measurement-focused – university policy-makers should be able to create a blend of activities, investments and results relative to the community, region, etc. in which the framework is applied.

Table 2: Promotion of university-based innovation and entrepreneurship in the six sectors

INNOVATION/ ENTREPRENEURSHIP LEVEL OF FOCUS	SCIENCE ↔ BUSINESS		
Invention / Individual	Salaries, tenure, publicity, other direct recognition	Direct investments in IP, salaries, consulting fees, contracts	SHORT-TERM (direct investments)
Venture / Team	Project grants, new PhD programs. Creation of center that can facilitate research and collaboration - forums, conferences, etc.	Seed and venture funding investment in R&D. Mentoring through activity in networks, on boards, etc. Student involvement in commercialization	↕
Culture / Community	Regional and national foundations and/or endowments. Academic awards, competitions, and scholarships. Public funding allocated towards education.	Indirect investments in infrastructure. Pre-incubators, science parks, clinics, etc. Establishment of industry networks, regulatory boards, capital structures, etc. Seminars and roundtables.	LONG-TERM (indirect investments)

Table 3: Measuring results in the six sectors

INNOVATION/ ENTREPRENEURSHIP LEVEL OF FOCUS	SCIENCE ↔ BUSINESS		
Invention / Individual	Number of publications, citations, patents, etc.	Licensing deals, patents, completed contracts, sales, etc.	SHORT-TERM
Venture / Team	Completed projects, inventions, graduated students, new departments	Industry collaboration, internships, spin-offs, start-ups	↕
Culture / Community	Endowments, new universities, department chairs, (educational centers). Inter-university coalitions, university associations, forums, etc. New journals, etc.	Contribution to local, regional workforce (employment), establishment of new industry sectors, scientific verification of industry activities, academia-industry collaboration.	LONG-TERM

After a display of the methodological and theoretical consideration behind the framework, some chosen case studies will help illustrate the framework, its application and relevance.

THEORETICAL AND METHODOLOGICAL CONSIDERATIONS

A major concern of this paper is that there is a lack a holistic understanding of innovation and entrepreneurship in the university setting and in general. Methodologically, this implies that such an understanding needs to be generated through broad and common sense understandings of the phenomena, rather than through demarcating the phenomena from any single theoretical or practical perspective. However, in this broad discourse, several theoretical understandings need to be introduced in order to end up with a relevant framework. A first theoretical stand is in the perspective taken on innovation and entrepreneurship as two sides of a coin: innovation primarily focusing on the object (new knowledge, new offerings, new business) while entrepreneurship focusing on the role of establishing these objects. To understand such a relationship between innovation and entrepreneurship one needs to alternate (Lundqvist & Petrusson, 2002) between a structural perspective (the innovation in relation to other structures) and a communicative perspective (i.e. roles and communications that lay behind an experience of the object). This alternation is analogue to shifting between the play mode and the commentary mode of a DVD movie in order to appreciate both the movie itself (the “innovation”) and what lay behind its creation (the “entrepreneurship”).

The second theoretical stand is the relatively recent understanding within “research on research” that much knowledge has so called polyvalent characteristics (Mingers, 2005; Viale and Etzkowitz, 2005). The phenomena, labeled polyvalency, include observations that a lot of scientific knowledge can be claimed in scientific and commercial arenas simultaneously. Polyvalency implies that research platforms can be reinforced by the interaction and integration of scientific and commercial aspirations. Polyvalency champions a strong perception of innovation as being linear and only gradually translated into increasingly commercial forms. Polyvalency, in areas such as bio, materials- and nano-science, implies opportunities for direct mutual reinforcement between science and commercialization, and constitutes a ground for presenting a platform framework for university-based innovation and entrepreneurship encompassing both a research and business part, as depicted in Tables 1-3.

Finally, the proposed framework is derived from an understanding of universities as being special by having both long-term societal responsibilities – to reflect upon, criticize and contribute to societal development – and also stimulating the promotion of new ideas through self-assertive behavior (i.e. publishing, patenting, etc.). Universities in these two respects, normally differ from that of business-life, which in turn has a focus on team-work and building collective economic structures, such as firms and markets. These three apparently conflicting ambitions – self-assertiveness, team-building and societal concern – are argued to be necessary to appreciate in a university platform striving for innovation and entrepreneurship. This understanding is not obviously deduced from theory and therefore benefits from empirical illustration in order to fully qualify the proposed framework. However, arguably, universities not promoting all of the three behaviors could be criticized for lacking long-term sustainability. Universities not promoting self-assertive behavior such as publishing would have difficulty claiming excellence. Universities

not concerned with the societal effects of innovation and economic development would easily be criticized for disregarding a strong societal contract, in which universities, in order to educate future generations, are trusted to provide tools for reflection and critique. Finally, universities not promoting team-building and the building of strong academic environments will have difficulty building sustainable platforms and critical mass, and risk ending up as only “hotels” for excellent individuals.

The chosen empirical illustrations should help qualify the proposed framework for different types of national and cultural environments. Two leading cases, one from the U.S. and one from the U.K., represent generally renowned actors having proven track records both in innovation and entrepreneurship. However, they also show differences compared to recognized entrepreneurial ecosystems, such as Silicon Valley or San Diego. At this point, it is interesting to bring forward a brief reflection on the University of California (UCAL) system, as juxtaposition between both traditional and entrepreneurial regions, and between individual universities and university systems. UCAL is a conglomerate of 10 university campuses with substantial statistics,^{vi} and has been a particularly important source of innovation for the biotechnology industry in California.^{vii} UCAL operates under the U.S. university ownership systems, but has an internal, system focused policy that brings forward traditions from the German model.^{viii} Like the Anglo-Saxon cases, UCAL redistributes earned revenue,^{ix} and in addition, has established an internal system of metrics for commercialization and transfer.^x The Scandinavian structures reflect this type of state-owned holistic view and centralized operation, while at the same time having independent actors. The Swedish and Norwegian cases help create reference to university environment not having a Bayh-Dole type of system (i.e. Sweden) and recently having implemented such a system (i.e. Norway). There is, of course, a concern regarding the conceptual relevance, operationalization and stability of the proposed model. The Scandinavian cases are built upon participatory involvement in policy-processes as well as practice. The Columbia and Imperial cases are based upon ten on-site interviews during 2004-2005.

Columbia University

Columbia University is one of the oldest and most prestigious universities in the United States, and comprises of a medical, engineering, law, business and liberal arts/sciences schools, as well as specialized graduate programs. The university consists of more than 23,000 students, 3,000 faculty members and 4,000 researchers/clinicians, and has produced 70 Nobel Laureates, over 500 patents, and an accumulated ½ Billion US\$ in research support.

In accordance with Bayh-Dole and other federal legislation, the large majority of inventions and innovative ideas generated by university staff, students, faculty, etc. are assigned to Columbia. In return, Columbia is obligated to commit resources to the investigation and potential commercialization of disclosed innovations. If successfully transferred, proceeds are redistributed to various actors within the university system, after a percentage is claimed to cover operating costs (marketing and IP securitization expenses). Distribution of revenue is dependent on the total income received. If lower than a certain level, one half of the revenue (after operating costs) is returned to the inventor(s), with the remaining half equally distributed between the university (as a whole) and the inventors' research. If equal to or greater than a certain level of income, the inventor's department and school also receive a percentage of income. In this case, the largest

percentage is given to the university, with the inventor and the inventor's research each receiving $\frac{1}{4}$ of the distributed revenue, and the remainder equally shared between the department and school to which the inventor is connected.

Educational integration has been mainly focused towards the business school. S&TV, Columbia's technology transfer office (TTO) utilizes MBA students for Business Plan preparation, research etc, and takes-on interns. Industry integration occurs on several levels. The Audubon Center, Columbia's incubator, has existed for nearly 10 years, having housed several start-ups based on Columbia research, though not exclusive to Columbia-based companies. NYC's Mayor recently announced a major science park initiative on the east side of NYC, designed to lure and retain Biotech/Pharmaceutical companies. Columbia will be involved with this initiative at a policy level through the economic development corporation.

Columbia has substantial external collaborations. One example is a government/industry sponsored research foundry (Industrial Technology Research Institute) in Taiwan, geared towards licensing partnerships. Columbia has contributed to development by guiding their research activities, providing faculty education, and contributing to an outreach program to Taiwanese manufacturers. With Imperial College and Singapore Exploit Technologies, Columbia explores joint research projects in the biosciences. Columbia also has a long-standing relationship with Stanford in bio- and nano-technologies.

Applying the proposed framework, particularly through the promotional lens (Table 2), shows Columbia's activity in both the science and business sides. As seen above, the policies implemented by Columbia support commercialization of IP, but with due diligence clauses^{xi} to allow for the joint utilization of knowledge (ex. publishing). Policies also support non-exclusive licensing and, while there is an emphasis on regional/national manufacture, it is possible for Columbia to explore opportunities globally, thus allowing for more sustainable development. These practices are reinforced by allocation of resources for S&TV management towards collaboration and partnership activities, both academic and industrial. Entrepreneurial learning is linked with innovation transfer through the cooperation between S&TV and MBA students, as well as through mentorship programs (internships) or through industry training, such as in the Taiwan program. Promotion of innovation and entrepreneurship thus occurs in the proposed framework on all three levels.

However, there are limitations placed on both the discretionary use of funds towards venture creation and equity ownership, and even when ventures are effectively transferred to the incubator, they quickly migrate from the region (Manhattan) once mature, in order to reduce costs. Bundling patents in cooperation with other institutions has also been explored, but is challenging because of lack of policy encouraging such collaborations. And, while proactive in their top-down communication with policy makers by, for example, key individuals in S&TV, there is limited recognition in the potential bottom-up effects that could be implemented through training and integration of students (not just business, but law and others) into the knowledge transfer process. It is the longer-term investment in educating these future institutional entrepreneurs, who if trained properly could be critical in establishing future infrastructures that is a core weakness in the current platform.

Imperial College of London

Imperial College of Science, Technology and Medicine, has historical foundations linking back to 1834 and the basis of the St. Mary's medical school, currently the largest medical school in Europe. The college supports a strong scientifically-based education platform including 10,000 students, 3,000 research staff and 14 Nobel Laureates. To stay attuned to academic policy development and funding protocols, the college communicates with the UK Government's Office of Science and Technology (OST). The main business commercialization activities are channeled through the TTO, Imperial Innovations – a wholly-owned subsidiary company of Imperial College London. To date, the organization has successfully generated over 60 start-up companies (creating more than 1000 jobs), and 74 active licenses which together have already generated in excess of 30 Million UK£. The college receives approximately 160M UK£ externally per annum from research contracts, 20 Million of which comes from industry sponsored research. Recognizing the importance of engaging in commercial policy development, Imperial Innovations maintains substantial contact with the London Development Agency (LDA) in regards to funding new initiatives (particularly funding in infrastructure) that will benefit not just Imperial, but all of the universities in London region. Imperial Innovations also is a member a larger association of regional TTO agencies, contributing to best practice and training development.

The guidelines for use of intellectual property (including inventions) at the colleges is based on U.K. legislation, most importantly the Patents Act of 1977 and the Copyrights, Designs and Patents Act 1988, which gives ownership of IP generated by an employee to the employer, if generated through the course of normal work activities. This includes student developed IP, if generated together with an academic staff member, or through sponsored research or studentship programs. Imperial Innovations has additional commercialization policies utilized to motivated collaboration (minimized royalties, due diligence), limit constrictions or items that would prevent partnerships, with an emphasis in establishing incentives for both sides in order to establish mutually attractive opportunities (win-wins). If exploited commercially, the revenue from university-owned IP is redistributed in the following manner, after remuneration for direct costs, including legal and patent expenses, shares payable to third parties and income due to Imperial Innovations (all figures are in £):

- First 50k: 100% to inventors
- 50-175k: 70% to inventors, 30 % to faculty
- 175-500k: 35% to inventors, 65% to faculty
- Over 500k: 35% to inventors, 52.5% to faculty, and 12.5% to the college.

Imperial's recognition of the importance of integrating innovation with entrepreneurial development is exemplified in the working arrangement between Imperial Innovations and the Tanaka Business School, through the so-called Technology Venture Program. Teams of 5-6 MBA students have 3-4 months to research and complete projects culminating in a business and market analysis report and presentation to MBA faculty and Imperial Innovations (as their 'clients'), which is used to help make decisions between spinning-out or licensing a technology. In particular cases, student teams continue to engage with Imperial Innovations after the course is completed, carrying out competitive analysis reports, or even contributing in taking the business idea to the market-place.

Besides Imperial Innovations, additional business focused activities at Imperial include a business development department, a consulting network, and an incubator. The business development office communicates with industry and develops opportunities for collaborations and funded research. The main objective is to build large, long-term projects, with the potential of commercial activity. The incubator focused on start-up venture formation, with start-ups also often used as an avenue for licensing. The incubator is not exclusive to Imperial. There is also a newly developed Biopharma Business Development group, focused on industry liaisons and alliances, with already established trans-Atlantic connections with Columbia University, Singapore University, University of Maryland-Anderson, Oakridge and Georgia Tech.

Similar to Columbia, Imperial supports, promotes and recognizes the importance of commercialization activities towards the business arena while continually investing in the catalysts of knowledge creation within the university. On the business side of the framework (Table 1), the college has taken steps to streamline the individual and team-based activities by creating a structurally separate, but wholly-owned organization. This allows for the independent support of scientific activities, supported through university policy, while also allowing for the integration of innovation and entrepreneurial activities within the university platform, thus mitigating the risk of divergent objectives, through different policy or management structures, as viewed through the third lens.

Looking through the promotional lens (Table 2), the business side of the proposed framework is actively supported and prioritized through the TTO activities and reallocation of commercially generated income, as well as through policy initiatives to develop and support business and incubation in the region and through TTO agencies. The commercialization revenue is also redistributed to the scientific side of the platform, and investments in time and other resources are dedicated to the entrepreneurial education of students. Policy emphasis is placed on the development and identification of serial entrepreneurs. Attention and prioritization towards business student development and regional activity reinforces longer-term sustainability while delivering short-term results. The incubator attempts to “encourage serendipity” as much as possible; an activity, very much driven by communication and investing a great amount of time in business development as well as seeking attention from key actors of the universities. However, like Columbia, there is still recognition of the potential importance of educating and aligning with the education and development of students from different disciplines, who will become the future drivers of public policy and infrastructure.

The Swedish university system

Sweden basically has a state university system. There are no clear metrics of success as regards university-based innovation and entrepreneurship. This is partly due to the so-called teachers' exemption, regulated in Swedish law since 1949, in which intellectual property rights (IPRs) are given to the professor, if not otherwise contractually agreed upon. Swedish universities have thus had little incentive to engage actively in innovation, and therefore promotion of innovation and entrepreneurship is done on a national policy level. University administration also has to relate to a long tradition of professors being viewed as civil servants charged with “serving society from a distance”. However, this tradition should not hide the fact that, for decades many university professors have built strong personal and informal ties with industry. Working in an “unmanaged”

university environment most Swedish professors today work with lots of expectations on their shoulders, but with no coordinated function to evaluate these expectations.

In the recent decade, there has been a major shift towards an innovation policy in Sweden (Jacob et al., 2003), in which research, industry and regional policy increasingly converge. Most notably, for universities, these policies have produced incubator and seed financing programs for new ventures, as well as PhD-programs and centers of excellence in which industry collaboration is a key ingredient. At the same time university researchers have adapted to diminishing fixed funding, forcing universities to currently – on average – finance 70% of their costs through externally competitive grants, compared with 20% some 20 years ago. Many types of current external grants require the researcher to show how the research is useful for society. However, few require the researcher to outline or implement a strategy for commercialization around research results. Thus, so far, most researchers pay only lip service to these aspects. Many universities also account for entrepreneurial experience in their tenure policies. However, it is only recently that these mechanisms for innovation are actually starting to effect behavior. Instead, an increased focus on short-term publishing and search for short-term financing is the dominant trend, only to some extent “counterbalanced” by a more long-term recognition of innovative and entrepreneurial achievements in, for instance, processes of receiving tenure or full professorships as well as a recent focus on so-called “strong academic environments” from some of the research councils. The latter activity aims at recognizing team-building and academic performance, beyond individual publishing. However, it is too early to judge how selection and promotion of such academic environments will work in practice.

The proposed framework helps appreciate different historical paths in the Swedish university system that co-exist but do not necessarily align. Firstly, a historically-focused long-term “civil servant” perspective among researchers is still part of the university culture, especially among the more senior professors. In such a culture, professors take pride in teaching, and building a “good academic environment”. This tradition is in alignment with the culture/community activities in the proposed framework. Secondly, a younger generation of researchers has, mainly due to external pressures, adopted more short-term publishing and grant seeking strategies, corresponding to the short-term activities in the proposed framework. Thirdly, recently policies and incentives have been created that correspond to the proposed framework’s mid-term focus on building teams. Fourthly, in lieu of a Bayh-Dole type of system regarding IP management, the mechanism for research commercialization has been indirect, either focusing on the generative side of innovation through collaborative centers of expertise, etc., or on the care-taking of spin-out companies started voluntarily by university professors, increasingly with the help of incubators adjacent to the university. Thus, as regards the business side of the proposed framework, the Swedish example can be said to focus on the venture/team level, with little or no emphasis on object/individual or culture/community levels. Current policy initiatives place increasing emphasis on how to work more systematically with early stage IP management.^{xiii}

The Norwegian university system

One can draw many similarities between the Swedish and Norwegian university systems. However, one major difference is that from 2003, Norway has implemented a Bayh-Dole type regulation, through which universities now own the IP produced, thereby abandoning the teachers’

exemption policy still utilized in Sweden. It is also fair to say that the strong, oil-driven Norwegian economy has not forced upon its university researchers dramatic economic changes and challenges at the same level as in Sweden, although the Norwegian policy-initiatives in other respects have been greatly aligned with the Swedish development towards an innovation policy.

The past decade has included programs specifically funding “commercialization projects” in which researchers together with so called commercialization units (i.e. incubators, science parks, etc.) strive for proof of principle or proof of concept, start ventures, and occasionally draft licenses. With the regulatory change in 2003, universities have started TTOs, and these entities are currently exploring their role in an innovation system built upon voluntary cooperation between researcher and commercializing units. So far, many efforts are spent towards collective learning between the different entities, in order to find new constructive interplays and avoid unnecessary bureaucratization or competition, as the university-level, primarily through its TTOs, becomes more involved in commercialization. By building strong linkages between TTOs and entrepreneurship educations, there is also a strong competence development approach built into the way the Norwegian university-system relates to innovation and entrepreneurship..

In recent years, innovation policy – as in Sweden – also includes a stronger focus on building so-called centers of expertise with strong industrial and regional anchoring. Today, the Norwegian researcher increasingly finds him/her-self in an environment of collaboration, both with internal commercialization experts and with regional industry and government. However, the external pressure to engage in such collaboration is not as tough as in the more necessity-driven Swedish environment. Incentives act more as “carrots than sticks”.

Many developments around university innovation and entrepreneurship in Norway, as in Sweden, are very recent. Nevertheless, the Norwegian case, at least to some extent, illustrates a relevance of the proposed framework in an environment that regulation-wise has taken the step to empower university administrators to engage in innovation and entrepreneurship (i.e. the implementation of a Bayh-Dole type of regulation). Almost three years in practice, the new law has thus far allowed collaborative processes to emerge between established actors and the new university TTOs. There are still large differences regarding the tasks in which university TTOs focus, in different regions and at different universities. However, some of the more obvious benefits achieved include having very early-stage commercialization dialogues with researchers, stimulating research in innovative directions, strongly emphasizing commercially motivated patenting and other IPR protection, and stronger involvement and awareness in the overall university management system, regarding promotion and engagement into innovation. Thus, the short-term and long-term dimensions can be said to have been strengthened and thereby match an already high focus on venture level activities stimulated through incubator and seed investment programs. Among the challenges being faced are “islands of resistance” towards any kind of engagement into commercialization among researchers, though a majority of researchers think that commercialization and research excellence can go hand in hand. Another challenge is the dynamic between regional mobilizations around centers of expertise, in which university research only is a part, and, at the same time, the university being established as a new commercial actor. The dynamics often include initial frustration over the increased complexity of having “yet another actor” when previously researchers could interact voluntarily. However, in many cases

TTOs can “prove themselves” by adding value through helping out with more thorough and long-term contractual agreements between researchers, companies, governments, etc.

CONCLUDING REMARKS

The purpose of this paper is to provide university policy-makers with tools to account for effects regarding innovation and entrepreneurship and to identify metrics suitable and adaptable to their unique environments. The proposed six-sector framework comprises of a holistic understanding of university-based innovation and entrepreneurship on three levels – the object/individual level, the venture/team level and the culture/community level, while bridging between science and business in an interactive (polyvalent) rather than traditional linear and sequential way. The framework allows for focusing on relevant activities (Table 1), and how to promote (Table 2) and measure (Table 3) these.

A first remark to make is how important as well as apparent the integration of innovation and entrepreneurship becomes when applied on the university setting. Seeing innovation and entrepreneurship as two sides of the same coin – having an object-side as well as a role-side – is noticeable in early-stage university innovation, being heavily dependent upon the championing by (academic) entrepreneurs and on the way in which these academic entrepreneurs often must rely upon professional IP and venture management competencies (provided by a university TTO or from other sources) to further package the innovation as well as add further entrepreneurial drive. The need for balanced integration of innovation and entrepreneurship on different levels (of focus) with activities on both the science and business side of a university platform is the key claim made in this article.

How critical the proposed framework is to a particular university, in the short run, of course, depends upon what already exists at that particular institution. The provided U.S. and U.K. cases represent some of the most renowned universities in the world, in both the science and business context. Yet, as indicated in the cases, even within these university environments reside potential improvements when it comes to, for instance, combining innovation and entrepreneurship, contributing to development of sustainable (government) policies, and having discretion in the way in which returns on investments are reinvested.

The Swedish and Norwegian cases help give some alternative perspective and reference to the proposed framework. Universities in these countries have not developed the same type of autonomy and have not become strong commercial actors, as is the case in the U.S. and U.K. universities presented. The opportunity and burden of driving innovation and entrepreneurship has rested on the shoulders of individual researchers. In Norway this is changing through both cultural and regulatory shifts. In contrast, Sweden has not experienced the regulatory changes, but nevertheless, strong cultural shifts and exogenous change pressures have appeared recently. These changes do not necessarily culminate in a balance of the short-, medium- and long-term activities in the proposed framework. One may fear that by promoting a more application and publishing pressured environment, medium- and long-term activities might be sacrificed. Both in Norway and Sweden, entrepreneurship education is used as a strategy to improve innovativeness within and around universities; a development also increasingly recognized in the U.K. and U.S. examples.

Universities, through established redistribution incentives for innovation, recognize the three levels in the proposed framework – the inventive individual, the department (i.e. the team) and the university (i.e. the long-term guarantor for sustainable development). Different university environments might have specialized cultures concerning the various levels that should be recognized and rewarded through the return on investment in innovation. The proposed framework is not primarily suggesting any particular distribution, only pointing out the need that in the long run, all levels are necessary for the university as well as the knowledge-economy to prosper in a sustainable way.

Policy initiatives, whether on the national or the university level, are not appreciating the full complexity and dynamics of building university-platforms for innovation and entrepreneurship. The proposed framework is intended to be useful both for the determination of relevant activities to focus upon in the university platform (Table 1), how to promote and invest in these activities (Table 2) and finally to measure the progress (Table 3). Altogether, the three lenses allow university policy-makers and others to appreciate what we can call the more “progressional” side of innovation and entrepreneurship, in which objectified results (i.e. innovations) and the champions of these results (i.e. entrepreneurs of different type) are recognized, in combination, and not just the objectified and transactionable dimensions of an innovation.

Future research needs to explore relevance of the proposed framework in new settings. Other issues to explore are the following:

- How should university management styles evolve as innovation and entrepreneurship help to create university autonomy and capital? How can the needs to combine professional commercial ability (in e.g. TTOs) be balanced with focusing-on and prioritizing-between strong academic environments and teams, as well as an increased involvement in policy-work and the sustainability of society as well as specific businesses? What active role can, for instance, departments of law, sociology, economics, etc. play in such an integrated approach?
- How much is the proposed framework relevant for knowledge areas being seen as generally more applied than basic, such as some engineering subjects? How will these areas evolve, as universities increasingly may focus on platforms that both have high level of scientific as well as business output, not just one of the two? In other words, will there be parts of the universities operating more with a traditional linear model of innovation, and other parts building polyvalent knowledge resulting in mutual reinforcement of science and business? What will that imply?
- This article has focused on the university. However, as indicated, for instance, in the Norwegian case, there are strong developments in which universities are collaborating as one of many actors in regional mobilizations, sometimes called centers of expertise or centers of excellence. How will such developments affect the university as a platform for innovation and entrepreneurship? Will such arenas even replace some of the duties currently performed by universities and their TTOs, and if so, for what purpose?

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ENDNOTES

- i P.L. 96-517, The Patent and Trademark Law Amendments Act, and amendments included in P.L. 98-620, enacted into law in 1984. Referred to as “Bayh-Dole” or “the Act”.
- ii One example, illustrated in the Boettinger article to show the challenges of open source patenting, is the “HapMap Project” – a database of and haplotype map of human genomic data. Use of such data not only requires extensive bioscientific study and research into genetic variations, but information technology to arrange data in for it to be utilized effectively, and then complex ownership and utilization structures.
- iii The 2005 National Innovation Survey. (United States) Council on Competitiveness and New Economy Strategies, LLC. 2005.
- iv GEM stands for Global Entrepreneurship Monitor, a global survey and subsequential report delivering findings on entrepreneurial activity in all regions of the globe. The report is driven by the following scholars: Reynolds, Bygrave, Autio, Cox & Hay, and their associate institutions: Babson College, Ewing Marion Kauffman Foundation, and London Business School.
- v http://innovateamerica.org/download/2005_National_Innovation_Survey.pdf
- vi The UCAL system houses 190,000 students and 7600 faculty, including 44 Nobel Laureates. As of 2003, the UCAL system had issued 464 patents and operated with a total budget of 12 Billion US\$, 3 Billion of which was allocated to research funding.
- vii In 1998, a study showed that one in four biotech companies founded in California were founded by UCAL faculty. (1998 UC BioStar – Critical Linkages Project)
- viii UCAL’s general IP policy is structured to encourage faculty to pursue professional activities, including engagement with the outside community, contributing to their profession in a broad sense while contributing to the university’s public service mission. Education of students, with the purpose of preparing them for private employment/careers is emphasized, as well as academic consulting, regulated by state and university statutes – general appropriateness of activity and avoiding conflict of interest. The policy also endeavors to make research developed at the university as openly available as possible, particularly through publication and open distribution of research products.
- ix The inventor receives 35% of net income, 15% goes to the campus research fund, leaving the remaining 50% to be re-invested in the general pool at the campus/lab of the inventor(s).
- x UCAL measures industry collaborations through the number of industry-research relationships, as well as developing campus research and regional incubators to support new ventures. Technology transfer is measured through invention disclosures, proportion of issued patents subject to commercial agreement within 3 years and complete MTAs and licenses per year. Business and regional development measurement is based on the creation of new technology-based companies in the region and recognition capital through earned media coverage for economic impact. UCAL’s objectives include open dissemination of information (including research results), commitment to students, accessibility to IP for research purposes, public benefit, informed participation, legal integrity, fair consideration of results and objective decision-making regarding IP.

- xi Federal policy requires that university TTOs carry-out due diligence, meaning that all IP that is disclosed to the office is investigated, within a timely manner. The time factor is critical in two ways: 1) analysis of potential of technology is determined quickly allowing for either moving forward with claiming process or returning IP to be further utilized by the research, and 2) when applicable, IP ownership and protection is established as quickly as possible, thus minimizing the time necessary to delay publishing or other open distribution.
- xii In 2002, the Swedish government asked the Swedish agency for innovation systems – VINNOVA – to investigate and propose ways to improve commercialization and return on research investments at Swedish universities. The investigation involved large parts of the Swedish university system and gives reference to most of the developments accounted for here (see Ericsson & Sojde, 2003)
- xiii The FORNY program within the Norwegian Research Council since 1994 specifically has focused on such funding (see www.forskningsradet.no).
- xiv For instance NTNU in Trondheim and Oslo University have co-located entrepreneurship programs and TTOs, as well as started internship programs.
- xv One of the authors have partaken in several workshops in which the different TTOs present and discuss their different approaches.
- xvi Policy report found at www.vinnova.se.