30 Years After Bayh-Dole: Reassessing Academic Entrepreneurship

Rosa Grimaldi
Department of Management
University of Bologna
Via Capo di Lucca 34, 40126 Bologna - Italy
Tel.: +39 (051) 209-0207
Email: rosa.grimaldi@unibo.it

Martin Kenney
Dept. of Human and Community Development
University of California, Davis
Davis, CA 95616
Tel: (530) 754-5943
Email: mfkenney@ucdavis.edu
and
Berkeley Roundtable on the International Economy
University of California, Berkeley

Donald S. Siegel
School of Business
University at Albany, SUNY
Albany, NY 12222
Tel: (518) 442-4910
Email: dsiegel@uamail.albany.edu

Mike Wright
Centre for Management Buy-out Research
Nottingham University Business School
Nottingham NG8 1BB, UK
Tel: +44 (0)115 951 5257
Email: mike.wright@nottingham.ac.uk
and
University of Ghent
Belgium

Forthcoming, *Research Policy*

April 24, 2011

30 Years After Bayh-Dole: Reassessing Academic Entrepreneurship

Abstract

On the 30th anniversary of enactment of the Bayh-Dole Act in the U.S., we consider the rationale for academic entrepreneurship and describe the evolving role of universities in the commercialization of research. We also discuss and appraise the effects of legislative reform in several OECD countries relating to academic entrepreneurship. The article synthesizes papers from the special section and outlines an agenda for additional research on various aspects of academic entrepreneurship in terms of system, university and individual levels. We also consider measurement and methodological issues that must be addressed in additional research.

1. Introduction

In recent years, there has been a rapid increase in technology-based economic development initiatives, focused mainly on stimulating technological entrepreneurship in universities via patenting, licensing, start-up creation, and university-industry partnerships (for reviews of different channels of university technology commercialization see Phan and Siegel, 2006; Lockett et al., 2005; Siegel et al., 2007). We refer to this activity as "academic entrepreneurship," since the objective of such efforts is commercialization of innovations developed by academic scientists (for a comprehensive review of the literature on academic entrepreneurship, see Rothaermel et al 2007).

The thirty- year anniversary of the Bayh-Dole Act 1980 is an opportune time to assess the antecedents and consequences of academic entrepreneurship. The Bayh-Dole Act contributed to significant changes in how universities commercialize and diffuse technologies developed in their research laboratories and elsewhere on campus. While there is a consensus that these trends have profound managerial and policy implications for those involved in university research and commercialization (Siegel et al., 2007), some question whether the current institutional arrangements for research commercialization are socially optimal (Litan et al 2007; Kenney and Patton, 2009).

On the positive side, there is the potential for promoting technology commercialization and generating revenue for the university, which is typically re-invested in academic research (Siegel et al., 2004). On the other hand, there has been some concern regarding the dangers of university commercialization, many of which pre-date the enactment of Bayh-Dole (Mowery et al., 2004). This concern has increasingly been narrowed down to particular practices, such as the transfer of materials, publication delays, and material transfer agreements (Blumenthal et al., 1997; Louis et al., 2001; Mowery and Ziedonis, 2007; Walsh et al., 2007).

There is also some debate regarding the contribution that the Bayh-Dole Act has made to society more generally (Verspagen, 2006). The evidence remains mixed on the societal impact, with the strongest criticisms resulting from anecdotal observations (e.g., Press and Washburn, 2000).

Academic research has found little systematic evidence of a destruction of the open culture of science or to support the assertion that universities are performing less basic research (Thursby and Thursby, this special section; Welsh et al. 2008).

Given the debate regarding these issues in the scientific literature and the attention of different stakeholders worldwide, it is timely to reassess progress and rethink the direction of policy and practice. An assessment of institutional and public policies and managerial practices can yield new insights for reforming existing policies and creating new mechanisms to support academic entrepreneurship. This special section aims to contribute to such a reassessment.

In the following section, we provide a background to the emergence of academic entrepreneurship offering a qualitative assessment of its antecedents and consequences and focusing on changes in legislation governing the ownership of intellectual property at universities. Section 3 proposes an integrative framework for developing academic entrepreneurship competencies. This is followed by a description of the papers contained in the special section. Next, we outline an agenda for additional research on academic entrepreneurship. The final section considers policy implications.

2. The evolving role of universities in the commercialization of research

2.1 Rationale for academic entrepreneurship

There is widespread global agreement on the value of promoting the commercialization of knowledge and research generated at public and private universities. A re-conceptualization of the role of public research systems began during the late 1970s in the U.S., following growing concern about the apparent deterioration of national comparative advantage in manufacturing and, in particular, the increasing competition from Japanese firms (Coriat and Orsi, 2002; Florida and Kenney 1990). Policy-makers, influenced by the success of Silicon Valley and Route 128, came to believe that universities could undergird a response to Japanese success (Branscomb and Brooks, 1993). The United States would compete by introducing the newest science-based technologies;

many of which would be developed in research universities, while older technologies and their attendant manufacturing would be abandoned.

A set of reforms, targeted at improving the transfer of research results to industry, affected universities in different ways. First, specific expectations regarding the direct contributions of academic institutions to economic growth emerged, with particular attention paid to the local industrial environment (David, 1994). Second, reform of the ownership scheme for federally-funded research was enacted (Mowery et al. 2004). Third, these greater pressures and incentives stimulated the creation of new organizational units within universities specifically dedicated to technology licensing activities, as U.S. universities as tax-exempt institutions could not practice their inventions commercially. These changes were initiated during a period of decreasing public funding of universities, largely due to significant cuts in research budgets implemented during the Reagan Administration (NSF 2011). After 1986 and the end of the Cold War, Federal R&D funding steadily increased, as U.S. universities became part of a societal response to global economic challenges.

The Bayh-Dole Act was both an outcome of and response to the changing climate, by enhancing incentives for firms and universities to commercialize university-based technologies. Specifically, the legislation instituted a uniform patent policy across federal agencies and removed many restrictions on licensing. Furthermore, it allowed universities to own the patents arising from federal research grants. Bayh-Dole also stipulated that researchers working on a federal research grant are required to disclose their inventions to the technology licensing office (Berman 2008; Mowery et al. 2004).

Several European (Wright et al., 2008a, b) and Asian (Kodama, 2008) countries adopted similar legislation. The EU has paid increasing attention to public-private research interaction in its strategic policy for Europe's role in the knowledge economy. On the basis of developments in the U.S., starting from the early 1990s, structural changes in the external environment, aimed at encouraging a more active role for universities in technology transfer, were introduced in Europe.

It was envisaged that these developments would enhance public-private research interaction, university patenting and, more generally, increase awareness of the opportunities for commercialization of research. First, due to changes in the modes of allocation of public funds and to government budget constraints following the enforcement of the Maastricht criteria for joining the common European currency, science funding entered a period of constant or shrinking budgets (Geuna, 2001). These constraints placed pressures on universities to develop alternative and complementary strategies to raise funds. Second, this shortage of public funding has been coupled in some European nations with reform of the public sector in general, and of National Innovation Systems, in particular (Wright et al., 2008a).

In this context, the concept of the emergence of entrepreneurial universities has attracted increasing attention (Phan and Siegel, 2006). Enhanced entrepreneurship from those at academic institutions can generate benefits to universities, including greater access to industry facilities, laboratories and industrial know-how (Grimaldi and von Tunzelman, 2002), opportunities for sponsored research from the university-related entrepreneurial firm, increased flow of funds to the institution and its researchers in the form of licensing income and professorial consulting, capital gains from selling shares in academic start-ups, and finally, donations to universities from successful entrepreneurs (Quintas and Guy, 1995). Although universities' abilities to recruit faculty and students have been and are likely to continue to be based on their reputations for the quality of their research, support for academic entrepreneurship may also contribute to the recruitment of excellent students and faculty (Florida, 1999). For example, researchers contemplating creating a spin-off may prefer to work at a different university of similar research quality offering better support for academic entrepreneurship.

2.2 Reforming University IP laws

Changes in legislation governing university technology transfer, such as the enactment of Bayh-Dole in the U.S., resulted in nearly all major research universities establishing a technology transfer office, with an increasing attention to academic patents and to licensing the results.

Outside the U.S., changes in university commercialization are tied to more general reforms (Geuna and Rossi, this special section). Examples are the reform of the entire academic system introduced in the U.K. and in the Netherlands during the 1990s, the so called Loi Allègre of 1999 in France, efforts by the Swedish Government to promote university technology commercialization since the beginning of the 1980s, and the transfer of several powers from the central Government to universities in Italy (Baldini et al., 2006). Denmark, Germany, Austria, and Norway reformed their IP laws to grant IPRs to universities, in a manner similar to Bayh-Dole. Other nations are considering similar reforms (So et al, 2008).

These institutional reforms, on top of fostering the proliferation of technology transfer offices (henceforth, TTOs), have spurred universities to elaborate their own internal specific regulations and implement mechanisms supporting academic entrepreneurship. Several empirical studies (Siegel et al., 2007) appear to indicate that the key determinant of increasing enforcement of intellectual property ownership by universities has been the creation of a formal technology transfer/licensing office. Interestingly, in Europe, despite the spread of TTOs, in several countries where universities had owned the IP, patenting activity was weak (Baldini, 2009). This is probably due to inadequate internal support mechanisms, the relatively embryonic nature of TTOs, and the thinly spread commercial capabilities of those within TTOs charged with commercialization (Lockett and Wright, 2005). Reasons also include the lack of sufficient incentives for the faculty - beyond legal requirements - to disclose and exploit IP, public sector pay-scales that make it difficult to recruit qualified technology transfer personnel, and scarce diffusion of institutional level policies among researchers (Wright et al., 2008a). The final reason not recognized in much of the TTO literature is that likely the vast majority of universities have few research results of sufficient value

to justify an attempt to monetize the results. In some cases, it is possible that having a poorly performing TTO might lead to the blocking of the diffusion of such knowledge.

In Europe, in particular, recent research has shown that in Italy (Balconi et al. 2004), Finland (Meyer 2003), and Belgium (Saragossi and van Pottelsberghe 2003) many inventions that have input from university professors are patented by other institutions, even if the universities are legally allowed to retain IPRs on such inventions. Cesaroni and Piccaluga (2003) analyzed the patenting activity of Italian, French and Spanish universities and other PROs at the EPO and USPTO, showing that patent policies are among the determinants of inter-country and inter-organizational differences in university patenting productivity. Yet, Geuna and Rossi (this special section) show that despite the general trend towards institutional ownership, university IPR regulations in Europe remain extremely differentiated and there is no one-to-one mapping to the US system.

3. Developing academic entrepreneurship competencies: an integrative framework

3.1 Forms of Academic Entrepreneurship

While recognizing that it is difficult from an empirical point of view to make an assessment of the benefits related to Bayh-Dole Act like laws, there is consensus that this legislation represents an important trigger for a re-evaluation of the role of the university in society. Recent studies of the manner by which university-generated knowledge diffuses to society have recognized that the university has a multi-faceted role in transferring knowledge (Bishop et al., 2011; Lester, 2005; Wright et al., 2008b). For example, in some nations the university's role as social critic is a powerful knowledge transfer function.

University patents represent only one mechanism by which academic research results can be transferred to the market place. Other mechanisms include licensing, the generation of academic spin-offs, collaborative research, contract research and consulting, as well as ad-hoc advice and networking with practitioners (Bonaccorsi and Piccaluga, 1994; Meyer-Krahmer and Schmoch,

1998; D'Este and Patel, 2007; Perkmann and Walsh, 2008; Wright et al., 2008b). They also encompass teaching, joint publication with industry and personnel-related learning activities such as staff exchange and joint student supervision (Schartinger et al., 2002). External engagement is also sometimes referred to as informal technology transfer (Link et al., 2007) even though interactions are often formalized via contracts and, in nearly all of these types of entrepreneurial ventures the TTO is irrelevant.

One of the least recognized and inadvertent roles of universities in "encouraging" entrepreneurship is providing a protected environment where students can experiment with new ideas and follow their passions. For example, the University of Texas provided the dormitory room where Michael Dell could start his computer retailing business or, in another case, Stanford provided the computing and network access for Jerry Yang and David Filo to start their website cataloguing business, which became Yahoo! Finally, three Stanford students drew inspiration from the Stanford University network and were joined by William Joy who was a Ph.D. student at UC Berkeley to establish Sun Microsystems (Stanford University Network). The importance of student entrepreneurship has received far less attention than it likely deserves.

IP activities clearly represent traceable ways in which academic research contributes to the economy and society, but the importance and volume of the overall academic entrepreneurship activities tend to be underestimated, as it is not possible to rely on data drawn from national statistics or patent and publication databases. Primary data need to be collected directly from individuals as university managers often have an incomplete picture of these activities. While data on university spin-offs, patents and disclosures are often either publicly available or are collected by universities or professional associations (Murray, 2002; Siegel et al., 2003; Bercovitz and Feldman, 2008), there are concerns about the extent to which this activity is fully recorded, as some of the papers in this special section recognize (Aldridge and Audretsch, this special section). This suggests the need for further investigation on the impact that institutional changes had on other forms of academic entrepreneurship.

3.2 Factors affecting the development of academic entrepreneurship competencies

Over the last three decades, the general tendency among universities worldwide has been to advocate the commercialization of academic knowledge, frequently in response to national institutional changes including governmental actions at both the national and sub-national level; new regulations such as Bayh-Dole like legislation; and specific initiatives to promote university-industry partnerships (e.g., the National Science Foundation's establishment of engineering research centers and industry-university co-operative research centers); and the introduction of organization such as incubators/accelerators, science parks, dedicated venture capital initiatives.

The wide variety of strategies implemented by universities can be traced to the complicated and disparate roles that universities play in all political economies. Strategy selection is, in part, influenced by government policies enacted by a wide variety of actors (local, regional, national, in Europe even supra-national); the culture of individual universities and even departments; individual campus leadership[1]; the quality of the university; and the dynamism and resources of the local economy. Moreover, as in the case of all ecosystem evolutions, the initial conditions are transformed through human action. Policies and strategies, such as, for example, incubators and dedicated venture capital funds, may or may not be useful during any particular stage.

Recently, some have argued that academic entrepreneurship can be stimulated by universities developing capabilities/competencies to transfer knowledge and technology. These competencies include: opportunity refinement, leveraging competency, championing competency, and a networking competency (Rasmussen et al., 2011). This may be particularly important in

[1] University leaders can have an important effect on the entrepreneurial propensities of their faculty. For example, Karl Compton, MIT's president in the 1930s and 1940s was a strong advocate of professorial entrepreneurship and a key advocate of the formation of American Research and Development, the first non-family venture capital firm that funded a number of early MIT spin-offs (Hsu and Kenney, 2006; Etzkowitz, 2002). Another example is Frederick Terman, the Stanford University dean of engineering and then provost, who was actively involved in encouraging students and faculty to form entrepreneurial ventures (see, among many others Gilmour, 2004; Kenney and von Burg, 1999). Finally, the role of Richard Atkinson in encouraging entrepreneurship among UCSD faculty is notable for the San Diego's high-technology growth (Walcott, 2002; Walshok et al., 2002).

societies where entrepreneurship is not encouraged. If such competency building is deemed necessary, they can be considered at three levels: a) system-level specificities (governmental actions, institutional configurations, local-context characteristics, etc.); b) university-level internal support mechanisms; and c) individual scientist level factors.

3.2.1 System level

As for 'system-level' specificities, the process through which academic entrepreneurship competencies come into existence and develop over time is influenced by the legal frameworks and institutional characteristics of countries in which universities are settled. In addition, the support and incentives that academic institutions receive from their regional and local actors/institutions are also important.

However, universities likely benefit from commercialization of their knowledge only when the local context in which they are embedded is supportive, which allows them to leverage academic resources and provides infrastructure and financial inducements. Degroof and Roberts (2004) have suggested that in entrepreneurially developed contexts, a strong community has the capability of selecting the best projects and allocating resources to them. Thus universities may adopt a fairly passive strategy. In contrast, in underdeveloped entrepreneurial contexts, which have weak and more fragmented support networks that lack a strong community, some researchers have concluded research institutions need to be more proactive by being selective and providing incubation to their start-up projects (Clarysse et al., 2005; Wright et al. 2008a,b). In these contexts, universities are likely to have a greater impact by facilitating contacts and building bridges than by conducting start-up policies in a directive way and in relative isolation (Fini et al., this special section). The current research suggests that the application of rigid uniform system-level rules within complicated systems where universities have different levels of competence at technology transfer and entrepreneurial activity may be ill-advised. For example, applying the same set of rules

to Stanford University and a small teaching-oriented state university might handicap both and lead to outcomes opposite of those desired by policy-makers.

3.2.2 University-level internal mechanisms

Early academic entrepreneurship activities evolved outside formal university structures especially at some of the leading research universities. A wider range of universities have recently taken formal steps to invest in the creation of internal organizational structures and support mechanisms, with the intention of speeding up the process and encouraging commercialization that may otherwise not have occurred. These latter mechanisms are evolving in line with institutional contingencies and local context specificities (as outlined above) and according to the specific characteristics of individual universities (history, culture, internal values, organizational identity) (Jain and George, 2007; Clarysse et al., 2005).

Business plan competitions are a comparably recent introduction meant to encourage interest in entrepreneurship in the university community (Barr et al., 2009). In the last decade they have proliferated to such an extent that there are now international competitions involving numerous institutions (e.g. Rice Business Plan Competition; European Business Plan of the Year Competition; Research Councils UK Business Plan Competition). Although there is some debate about the usefulness of business plans for early-stage businesses (Honig and Karlsson, 2010), the benefits of such competitions include training in various aspects related to the launch of a new business, cash awards, consultancy services, and an opportunity to network with the industrial and financial community provided. Another group of initiatives are efforts by university technology transfer offices to seek out new commercialization opportunities (Siegel et al., 2007). This is often as simple at TTO members regularly visiting university labs searching for promising lines of research and listening to faculty ideas in their early stages, the promotion of invention disclosure communications to facilitate early evaluation of possible IPR strategies, and the organization of networking events to facilitate the meetings between researchers and the business community.

The aim of these mechanisms is to increase awareness in the university community of the possibilities of starting a new business and pursuing an entrepreneurial career. In many parts of the world, such as Europe, for example, where university education has traditionally been associated with fulfilling the employment needs of large organizations, policies fostering entrepreneurship are promoting a deeper cultural shift and directly contributing to re-framing the image and opportunities associated with university education (Phan et al., 2009; Mustar and Wright, 2010). Supportive university infrastructures may organize entrepreneurial boot camps to stimulate specific venture initiatives and provide coaching through peer sessions (Clarysse et al., 2009).

Once new business ideas have been developed sufficiently to justify the attempt to start-up a new business, the route to commercial distribution of product and services is still very uncertain. Many argue that specific support targeted at the early stages of the start-up life-cycle is important. University incubators are a good example of specific policies working in this direction (Mian, 1996; Rothaermel and Thursby, 2005). In addition to the typical incubator services, university incubators typically offer some university-related services, such as faculty consultants, student employees, enhancement of reputation, library services, related R&D activities, etc. Their physical proximity to the campus labs and research facility allows entrepreneurs to 'ripen' their technologies in close proximity to inventors whose inputs are useful for further development (Di Gregorio and Shane, 2003). Increasingly, there is recognition that incubators may be prone to adverse selection problems, and one of the most important skills incubator managers must have is an ability to terminate support to the "bad eggs" every incubator encounters. However, an important challenge that has proved difficult to meet is for universities to have internal intermediaries (available in universities' organization to support the commercialization of research results), and to identify actors to bridge academic and commercial context as a first step towards the evolution of technology transfer competencies (Wright et al., 2009).

In the search for mechanisms to ease the establishment of firms meant to commercialize university inventions, another policy that has received much attention is the creation of University

Venture Funds, fully or partly funded with university resources. These are meant to provide seed funds for new firms. There is ample anecdotal evidence that such funds are unlikely to experience much success (Lerner, 2005), due to the limited number of viable ventures generated by nearly all universities, the adverse selection problems mentioned earlier as a truly exciting firm is likely to receive professional venture capital, and the probability that the venture professionals operating small university fund may not be of the highest quality. If expectations for and investment in these university venture funds are not high, then they may have some impact (Atkinson, 1994) but there are some indications that they do overvalue their contribution to spin-off ventures (Clarysse et al., 2007). It is also possible that if these are not managed by extremely competent venture capitalists, they may harm their portfolio firms – a possibility not addressed in the literature.

The interest in encouraging entrepreneurship has motivated an increasing number of universities to experiment with changing a number of rules and procedures. For example, some universities have decided to provide preferential treatment to university-affiliated entrepreneurs wishing to license technologies they developed. In some universities, customs and procedures have been changed to allow professors to establish new businesses, granting leaves of absence to commercialize a technology, or even permitting freezing the tenure clock), and changing rules and procedures governing access to universities' R&D laboratories and scientific facilities.

An increasing number of universities are investing in educational programs supporting entrepreneurship and technology commercialization. Some, such as Wright et al. (2009), argue that business schools through faculty and experience MBA students may have an important role in academic entrepreneurship through the development of internal university processes that promote rather than hinder internal knowledge flows between business schools, TTOs and science departments. Yet care is needed in involving business school students in advisory positions for technology-based ventures since this may burden fledgling firms with well-meaning, but

inexperienced advisors that might be detrimental to long-term success. This may be a particularly serious problem in the case of lesser quality business schools.

The still muted but increasing criticism of the current institutional arrangements and policies of TTOs, the increased recognition of the desirability of encouraging entrepreneurship, and the positive economic development impacts that university-related entrepreneurial ventures can generate has led to some pioneering experiments at a few universities aimed at encouraging entrepreneurship. The boldest of these initiatives is the "Carolina Express Licensing Agreement." Developed, at the University of North Carolina at Chapel Hill, in collaboration with local members of what Kenney and Patton (2005) termed the entrepreneurial support network. This initiative involves a uniform (no negotiations) agreement available to any UNC faculty, student, or staff member wishing to establish a company to commercialize their inventions. To qualify, the entrepreneur must produce a business plan approved by the TTO and a business school faculty member. Also, the professor must forgo the inventor's share of licensing revenue. In return for assigning the license to the startup, the university "receives a 1.0 percent royalty on products requiring FDA approval based upon human clinical trials and 2.0 percent royalty on all other products, and cash payout equal to 0.75 percent of the market value of the firm upon a merger, stock sale, asset sale, or IPO." The 0.75 percent of market value is a powerful incentive because it does not absorb any firm equity, thereby making negotiations with potential investors simpler than would be the case if, for example, five percent of the equity (particularly if it is non-dilutable) was owned by the university. For the start-up firm, this is a generous arrangement that provides some immediate return to the university in the form of income.

In another case, the University of Missouri (2011) recently established a policy that "in general, students of the University of Missouri will be entitled to own any Invention or Plant Variety made during their enrollment as a student of the University and will generally not be required to assign his or her ownership to the University" in cases where the student is not a university employee and is not using more university resources than "than those generally available

to all other students within the class or than those available to the student as part of his/her enrollment with the University." How great an exception to general university TTO procedures the University of Missouri revamping of its rules is remains unclear, but it does show that there is growing awareness that not all ideas conceived on the university campus are the automatic property of the university.

In the case of North Carolina, in particular, there appears to be an explicit awareness of the regional economic development benefits of startups, which all of the extant academic research suggests is, at least, initially captured in close proximity to the university (for an early exposition of this phenomenon, see Jaffe et al 1993). There is also the possibility that successful entrepreneur(s) will appreciate the university's generosity and reciprocate with gifts. It is also possible and, even likely, that the new firm will provide research contracts to the university. Finally, the State will benefit as these new local firms will create employment and contribute to the tax base. And, often forgotten, but most important, one of the university spin-offs could become a "stem" firm from which numerous other firms spin-off, as was the case in San Diego with UCSD spin-offs, Hybritech (see, for example, (Casper 2007) and Linkabyte (Simard) or in South San Francisco with UCSF spin-off Genentech in the San Francisco Bay Area (see, for example, Kenney 1986 among many others). Whether these experiments are the harbinger of further experimentation in changing regulations to encourage entrepreneurship is uncertain, but for scholars these anomalies provide significant opportunities for longitudinal data collection.

While the academic research on university encouragement of entrepreneurship has largely been quantitative, the micro-level qualitative literature (e.g. Mosey and Wright, 2007; Rasmussen et al., 2011) and anecdotal evidence show the importance of intangible factors in the successful encouragement of entrepreneurship. For example, it is difficult to measure the importance of a commitment to encouraging entrepreneurship, even when no discernable organizational changes are made. In his study of the commercialization of scanning electron microscopy, Mody (2006) found that informal channels could be extremely effective in commercializing new inventions. Our

understanding of the invention commercialization process will be enriched by further detailed qualitative research into how technology transfer and concomitant commercialization takes place – and we should not be surprised if we find that a variety of pathways inventions can take to the market place. This also suggests that a single policy may not fit the differing disciplinary communities of practice that co-exist in the university.

Finally, although there have been important initiatives, evaluating their success is difficult, because there is little agreement as to what standard is appropriate. Moreover, there is no easy way to measure the counter-factual of what would have occurred if these initiatives had not been implemented. However, Thursby et al. (2009) do provide some insights into the benefits of these kinds of programs.

3.2.3 Individual scientists

The development of academic entrepreneurship competencies at university level is influenced by the extent to which individual scientists and research teams are willing and have incentives to become involved in the commercialization of their research results. Their involvement is in turn affected by country-level factors (institutional contingencies and local-context specificities) and by the university level. More specifically, their proactive role in undertaking academic entrepreneurship will be influenced by the extent to which they find themselves aligned with university level encouragement, and whether they accept this as a university mission and the values, norms and beliefs underlying their universities' decision to recognize a new societal role. This is particularly tricky because, as a generalization, professors chose to work in the university because they were not attracted to working in the corporate sector.

One school of thought argues universities should provide incentives for their personnel to devote time and energy to entrepreneurial activities. The perception of such incentives by academics may be affected by efforts within universities to invest in the creation of organizational mechanisms supporting the commercial exploitation of research results (TTOs, incubators, internal

regulations, etc.). Universities should be aware that the development of academic entrepreneurship abilities at the organizational level influences individual scientists and their perceptions.

Following this line of reasoning, Jain et al. (2009) argue that establishing the micro foundations of academic entrepreneurship requires closer scrutiny of the university scientist as a key actor contributing to this phenomenon. They show that higher level changes in the legislative (e.g. Bayh-Dole Act) and normative environments are clearly fostering role identity modifications of university scientists. These changes are manifested both in their growing self-awareness of technology commercialization possibilities as well as actual involvement in such activity. They also highlight the unwillingness of most scientists to significantly forgo their existing role identity when they participate in commercialization activity. Rather, these individuals are mindful of the consequences of making such changes and take proactive steps to preserve their academic role identity, notwithstanding the institutional changes and those implemented by their organization of affiliation to invest in the commercialization of research results.

Another group of scholars finds that there is a hybridization occurring in which academic scholars are coming to share the same values as their industry counterparts suggesting the role identities themselves may be changing (Colyvas and Powell 2007; Lee 2008; Owen-Smith 2003).

Even while a few TTOs are loosening regulations, many TTOs have become increasingly aggressive in claiming their rights to any inventions by researchers affiliated with their university or unilaterally changing the formulae for dividing any patent income. This has led not only to researcher discontent and internal administrative investigations, but also litigation initiated by universities against their employees, including prestigious faculty members. For example, Yale University sued John Fenn, winner of the 2002 Nobel Prize in Chemistry for compensation because he secretly patented a process that he had developed while being a researcher at Yale University. The judge in the case agreed with Yale University and awarded $1 million to the university. This case and others like it is not about whether the technology is transferred, but rather who owns and should benefit the invention (Borman, 2005). The number of cases that enter litigation is small, but

there are likely many other such disputes that result in administrative investigations. Such investigations, often undertaken in secret, can be time-consuming and stressful for the university professor, and remain hidden from academic researchers studying the operation of what Colyvas and Powell (2007) term the patent-ownership university. They may also have negative implications for the universities concerned since they may serve to demotivate faculty to pursue academic entrepreneurship and increase mobility to universities that are more receptive, particularly where investigations find there is no case to answer. This could prove to be a fruitful area of future research considering the overall implications of an increased institutional emphasis on the income generated from university patents.

The dynamics that we have illustrated above at three different levels (system – university – individual) should be taken into account when making sense of the process through which academic entrepreneurship abilities at university level come into existence and evolve. To understand how such competencies emerge and evolve, it is necessary to consider the complex interaction of different factors and their interdependencies. We suggest that system-level factors (government intervention and local-context opportunities/characteristics), university-level investments and individual scientists' willingness to participate in the commercialization process all play a role in the process through which academic entrepreneurship competencies come into place and evolve.

4. Papers in the Special Section

The 30th anniversary of the enactment of Bayh-Dole is an opportune time to re-evaluate the managerial and policy implications of academic entrepreneurship. An assessment of institutional and public policies and managerial practices can yield new insights for reforming existing policies and creating new mechanisms to support academic entrepreneurship. The special section contains articles that address these issues. They include multiple levels of analysis and examine various aspects of research commercialization. The research questions, data and methods and findings of the papers are summarized in Table 1.

INSERT TABLE 1 HERE

Link, Siegel, and Van Fleet isolate the direct impact of legislative changes, such as Bayh-Dole, the Stevenson-Wydler Act, and the Federal Technology Transfer Act on patenting at federal laboratories. This contribution is significant because roughly contemporaneously with the passage of Bayh-Dole for Federal contractors, Congress passed analogous legislation for the U.S. national laboratories. They show that these, quite different, research institutions that established financial incentive systems, embodied in passage of the Federal Technology Transfer Act, and allocated internal resources to support technology transfer successfully stimulated an initial increase in patenting.

Thursby and Thursby address a central question of the impact of Bayh-Dole on the basic research activities of scientists. Using a novel dataset of individual scientists' disclosures they find no support for the hypothesis that scientists have been diverted from basic research. Rather, there appears to have been a substantial increase in both basic and applied research.

Several of the papers focus on entrepreneurial aspects relating to business start-ups and incorporate both individual and institutional level measures. First, addressing concerns about the apparent extent of scientist start-up activity in official figures published by bodies such as AUTM, Aldridge and Audretsch undertake a novel survey of scientists to ask them directly whether they have started a business based on formal IP from their research. With the caveat that they are researching only one specific group, they find a much higher level of such start-up activity than many studies have suggested (for a similar finding, see also Fini et al. 2009).

The paper by Kenney and Patton provides the first empirical test of the ability of differing ownership regimes to encourage technology commercialization through entrepreneurship. The results suggest that broader thinking about, and experiments with, the types of invention-ownership

regimes is long overdue. Universities operating under a system of inventor ownership can successfully commercialize campus inventions and encourage entrepreneurship even in environments where the dominant ideological position is that TLOs are necessary for success. A key message of the paper is that policy makers desiring to foster entrepreneurship and local economic development should consider adopting an inventor ownership regime.

In a third study examining individual level entrepreneurship, Clarysse, Tartari and Salter consider the relative importance of an individual scientist's entrepreneurial orientation, prior entrepreneurial experience, their social capital and the role of TTOs in explaining whether they start a business. Using a large panel study of UK scientists, they find that entrepreneurial orientation is most important single factor explaining entrepreneurship followed by prior entrepreneurial experience. TTOs were found to have only a marginal influence on whether scientists started a business.

A crucial issue in discussing the impact of academic entrepreneurship is addressed in the fourth paper to adopt an individual (and team) level analysis. Wennberg, Wiklund and Wright compare the performance of university and corporate spin-offs. Using a large panel study of Swedish spin-offs, they find that Corporate Spin-Offs (CSOs) perform better than USOs in terms of survival as well as growth; human capital endowments mattered more for University Spin-Offs (USOs) than for CSOs; the nature of the parent organization mattered more for CSOs than for USOs (especially organizational size and number of engineers but not PhDs). The importance of this paper in the context of this special section is that it suggests that the focus upon Bayh-Dole may by misplaced in the sense that there are far more CSOs than USOs and that the CSOs perform better. Hence government policy might be better focused on encouraging more CSOs. For example, there is ample evidence now available showing that the inability to enforce employee non-competition contracts encourages greater entrepreneurship (Samila and Sorenson, 2009). Of course, changing legal regimes to encourage entrepreneurs to leave existing organizations is likely to provoke substantial business opposition.

The paper by Fini, Grimaldi, Santoni and Sobrero, building upon the desirability to have a more systematic assessment of the impact of universities' intervention to support academic entrepreneurship in EU countries, looks at the nature and role of University-Level Support Mechanisms (ULSMs) for the creation of academic spin-offs and the way they interact with other forms of support mechanisms, which they call Local-Context Support Mechanisms (LCSMs), available at large in the context in which these companies operate. By focusing on one single country, Italy, they try to control for the national level institutional setting and for the regulatory environment to which all universities must adhere. The paper shows that, while the regulatory legislative framework can contribute to increasing universities' willingness to undertake technology transfer activities, the extent to which universities are successful in the commercialization of public research through academic spin-offs depends on their internal policies and the specificities of their local context.

The paper by Geuna and Rossi offers a general framework to describe the changes in university IPR regulations in Europe and their effects on the patenting activities of universities and on knowledge transfer processes. The analysis of patterns of ownership of academic patents shows that there has been a general increase in university patenting since 1990, with a significant slowdown (and even reduction in some countries) after the early 2000s accompanied by a switch in academic patents ownership in favor of university ownership though preserving the European tradition of high levels corporate ownership of patents that include academic inventors.

5. Future Research Agenda

In this section, we outline a future research agenda on academic entrepreneurship, in terms of the three levels of analysis identified above: system, university and individual. For each level we consider further research in terms of general issues as well as in respect of the different dimensions of knowledge and technology transfer from universities. We also highlight a number of

measurement and method issues that arise in conducting further research. The main research questions we identify are summarized in Table 2.

INSERT TABLE 2 HERE

5.1 System level

In general terms at the system level, there is a need to move beyond expectations that all universities need to address all aspects of knowledge and technology transfer equally. There are major differences in the scope and quality of knowledge and technology generated within leading and mid-range universities (Wright et al., 2008b). This suggests that it is important to consider what are the 'optimal' portfolios of academic entrepreneurship activities in different types of university, academics and regional clusters. Relatedly, evaluation approaches would need to be developed that took account of this different mix of activities.

Different universities also operate in different local and regional contexts and there is a need to explore how to adopt different strategies for academic entrepreneurship consistent with these environments (Fini et al., this special section). There may also be conflicts between national and sub-national system levels that need to be reconciled in assessing the impact of academic entrepreneurship activities. For example, world class intellectual property generated by a university in a particular region may lead to employment creation elsewhere than in the locality and as Nelson (2009) shows measurements of the diffusion of the newly created knowledge will differ depending upon what indicators are used, i.e., patents, publication citations or licenses granted. This suggests that understanding the spillover effects related to academic entrepreneurship might require the analysis of multiple variables.

5.2 University level

Universities face challenges when encouraging academic entrepreneurship. Some have argued that such activities can conflict with their traditional roles of research and teaching (Ambos et al., 2008), though yet other researchers are more sanguine (see, Thursby and Thursby in this special section and also Zucker et al., 1998). If difficulties do occur, it may be necessary for universities to design new structures to ameliorate any tensions arising between traditional research and teaching, and entrepreneurial endeavours by university researchers. What seems clear is that there is no simple separation between the skills necessary to be a successful scientific researcher and the skills to be a successful entrepreneur. Clearly, many academic researchers will not be successful entrepreneurs. Even within universities' entrepreneurial activities there is some heterogeneity in the skills required to pursue different modes of research commercialization such as patenting, licensing, spin-offs and contract research. Universities may also need to adopt different structures and processes to promote potentially world-leading high growth high tech spin-offs and those with only local markets (Clarysse et al., 2005), though it should be recognized that a wide diversity of universities have been the source of important spin-offs suggesting that even in their current configuration universities as diverse as North Carolina State University (SAS) and the University of Waterloo (Research in Motion), in addition to better known universities such as Cambridge, MIT, Stanford, and the various campuses of the University of California, have gestated firms that would later become world-leading firms.

Different universities have evolved along different trajectories. As noted above, some universities have developed academic entrepreneurship informally alongside other activities, while others are more recently adopting formal approaches. Many universities, if they are to realize the expected gains from enhancing academic entrepreneurship activities may need to shift from their traditional trajectories to create new development paths (Ahuja and Katila, 2004; Rasmussen et al., 2011). A major issue is how universities are able to affect such shifts in their path dependencies. The processes by which these shifts may occur are not trivial yet remain little understood and warrant further research.

These shifts therefore raise important issues about where the resources and capabilities come from to enable academic entrepreneurship. There have been critiques of the role and skills of TTOs (Lowe, 2006; Siegel et al., 2007) and papers in this special section also add evidence that TTOs play a limited effective role in creating and developing start-ups especially (Clarysse et al., this special section). Unanswered questions remain concerning how universities can recruit the appropriate caliber and mix of TTO staff. Further, it is questionable whether universities draw sufficiently upon capabilities elsewhere in the university, for example entrepreneurship faculty in business schools (Wright et al., 2009). While not receiving much research attention, there is suggestive evidence that a valuable source of expertise and advice are peer academics that already have experienced the entrepreneurial process. These individuals can act as mentors and role models (Mosey and Wright, 2007). Some of these individuals may be able to fulfill much needed boundary spanning roles between the university and industry. Further research needs to explore both institutional mechanisms and the informal networks that allow potential entrepreneurs to access this expertise for academic entrepreneurship.

Although some research has focused on the role of the university level and of the academic discipline in influencing academic entrepreneurship (Mustar et al., 2006; Kenney and Goe, 2004), the influence of the department from which potential academic entrepreneurship emerges has attracted less attention (Murray, 2004; Bercovitz and Feldman, 2008). The extent of entrepreneurial activity may vary significantly between departments within the same university and between departments in the same discipline across different universities. Limited available research does suggest that the local work environment at the department level can influence faculty engagement in academic entrepreneurship activities (Bercovitz and Feldman, 2008; Stuart and Ding, 2006). Certain departments may have a culture of supporting academic entrepreneurship, while others may be quite hostile. Some departments may have extensive and deep linkages with industry while others do not. Further research is needed to explore the influence of these contexts on whether scientists create ventures and how they then develop them.

Finally, studies of academic entrepreneurship have largely focused on the biomedical sciences, and, to a lesser degree, engineering, mathematics and statistics, and the physical sciences. While there has been less technology-based entrepreneurship from the social sciences, new firms are emerging from the humanities including music and the visual and creative arts that are being transformed by digital technologies. There is a need for further research analysis of these aspects of academic entrepreneurship.

5.3 Individual level

An emerging research stream is now examining the behavior of academic entrepreneurs at the individual level, to which some of the papers in this special section make insightful contributions (Aldridge and Audretsch, this special section; Clarysse et al., this special section). A central question of the impact of Bayh-Dole and related legislation is whether and how it changed the behavior of scientists. On one hand, a change in the behavior of specific individuals may have occurred over time. On the other hand, behavior patterns of entrenched academics may have remained the same, but the shift in culture and incentives that resulted from legislative changes may have led to a marked difference in the behavior of more recently recruited cohorts of academics who come into the profession with different expectations.

Immigration status of potential academic entrepreneurs may also play a role (see Krabel et al., 2011). This is part of a wider issue of entrepreneurial mobility that has further implications for academic entrepreneurship (Wright, 2011). While universities may be fixed to their locations, individual academics are highly mobile, both between regions within a country and across countries, especially star researchers who may also be the most promising academic entrepreneurs. These flows have implications not just for individual universities but also for local and national economies. For example, there has been a movement of academics to those European countries whose university systems have shown greater openness to accept other EU nationals, although at

the same time barriers may have increased against non-EU nationals. At present, we have little systematic evidence relating to any of these aspects.

More specifically regarding individual behaviors concerning how academic entrepreneurs develop their ventures there is also limited evidence. Industry networks and partners may be important for academic entrepreneurs to establish and grow their ventures because they bring capabilities and resources that academic entrepreneurs lack. However, academic entrepreneurs face major challenges in accessing the specific partners they need. At present, we have very limited knowledge about how academic entrepreneurs successfully identify and establish such contacts (though, see, for example, Wright et al. 2004)

Like entrepreneurs in general, academic entrepreneurs often create a venture as part of a team. While we have some evidence on the initial creation of these teams (Vanaelst et al., 2006), as yet we have little insight into the challenges involved in how these teams evolve into boards that will take the venture to IPO or strategic sale or otherwise enable it to become an established private business. Addressing this gap is important since developing a board with the right blend of networks and skills that can both help the business grow and monitor managers can provide a competitive advantage for the spin-off (Bercovitz and Feldman, 2011; Zahra et al., 2009).

A generally neglected aspect of academic entrepreneurship activities concerns the knowledge and technology transfer involved in contract research, outreach activities and the mobility of academics between the university and industry. While universities may seek to encourage these activities as part of their overall profile there are a number of little understood issues concerning their feasibility. For example, how are incentives for individual academics to undertake secondments to industry aligned with those of the university, for example in terms of fit with promotion criteria?

5.4 Measures and methods

Analyzing the impact of a governmental change is challenging, since it is always difficult in the social sciences to tease out cause and effect. Even though there have been several rigorous empirical studies of the impact of Bayh-Dole (e.g., Henderson et al., 1998; Mowery et al., 2005), it is especially useful to examine both quantitative and qualitative evidence. Specifically, we conjecture that an assessment of Bayh-Dole like legislation requires an integrated, multi level approach, addressing the effects/consequences at different levels of analysis, including country level specificities, internal organization of public research institutions and universities and finally individual scientists.

One methodological problem highlighted by papers in this special section concerns access to suitable data that does not just relate to the right hand end of the distribution, for example, in terms of the most successful universities or the most successful forms of technology and knowledge transfer. This is an important issue if the conclusions of studies are meant to be generalizable both academically and for policy.

With respect to start-ups of ventures by academic scientists, a major measurement issue concerns the ability to evaluate start-ups based on both formal IP (e.g., start-ups resulting from university patents and licenses) and other not legally protectable knowledge. While considerable attention has been devoted to the former, the latter is almost certainly more important, in terms of contributing to employment and regional economic development (Clarysse et al., 2009). The Bayh-Dole Act, in many ways, attracted attention away from the far greater and more diffuse role that the university has had in generating and diffusing knowledge, some of this being technology, but as much or more being other forms of knowledge to the entire society, of which some becomes embodied in products. A recent report from the U.S. National Research Council (2009: 34-35) illustrates the complicated interactions between university and industry knowledge creation and the development of new information technology products. In most of the knowledge transfers to industry illustrated in these figures, there was little or no involvement by the TTOs. They were, quite simply, irrelevant. This illustrates how the emphasis on Bayh-Dole and the concomitant

nearly single-minded attention to technology licensing may be limiting our understanding of the university as a contributor to the general technological progress of society.

Another measurement issue concerns the need to move beyond count measures of key outcome measures of academic entrepreneurship, in order to estimate the value and quality of that activity. For example, it is possible to estimate the number of IPOs and strategic sales involving university spin-offs, but, as recent research increasingly indicates university records particularly those generated by the U.S. Association of University Technology Managers, are recent and incomplete. This is a very important point, because limiting study of university entrepreneurship to those firms identified by AUTM surveys leads not only to an undercount, but a de-legitimation of other entrepreneurial activity and validation of a particular organizational form reinforcing a hierarchical corporatist view of the university interacting with society through closed channels, thereby devaluing open-access, open-source models. This has occurred without a debate about in which ways the university can make the greatest contribution to society and the encouragement of entrepreneurship.

6. Conclusions and policy implications

The evidence reviewed in this article and the special section of the journal indicates that the rise of commercialization associated with the Bayh-Dole Act has <u>not</u> resulted in less basic research (Thursby and Thursby, this special section). Bayh-Dole may have also stimulated an increase in start-up activity at universities, which is accelerating due to a growing emphasis on that dimension on university technology commercialization. The social networks that spawn such activity are critical, but the Fini et al. and the Wennberg et al. studies in the special section both demonstrate that strong support mechanisms are needed for university spin-out companies to improve their performance, relative to non-university startups.

However, it is important to note that there is an alternative view on the merits of intellectual property regime that emerged in the aftermath of Bayh-Dole. Kenney and Patton

(2009) argue that the system in which universities maintain the legal ownership of inventions, is not optimal, either in terms of economic efficiency or in advancing the social interests of rapidly commercializing technology and encouraging entrepreneurship. These structural uncertainties can lead to delays in licensing, misaligned incentives among parties, and delays in the flow of scientific information and the materials necessary for scientific progress. They propose two alternatives that would address the current dysfunctional arrangements in licensing university technology. The first would be to vest ownership with the inventor, who would be free to contract with the university technology transfer office or any other entity that might assist in commercialization. The second is to make all inventions immediately publicly available through an open source strategy or, through a requirement that all inventions be licensed non-exclusively.

A related policy question concerns whether other countries might usefully adopt Bayh-Dole type legislation. Comparisons with US experience could be misleading and should not be used to predict the evolving features of institutional IPR ownership systems in Europe (Verspagen, 2006; Mowery and Sampat, 2005). Prescriptions, models, and regulations generated in the developing nations might be even more dubious for developing nations (So et al. 2008). Following Geuna and Rossi (this special section), there is still significant differentiation in the academic IPR ownership patterns across individual European countries and in the general regulation of universities. Further case-by-case analysis is necessary in order to understand how these systems are evolving.

Most European countries have been interested by legislative changes that, even when not in line with the Bayh-Dole Act, e.g. not granting universities the legal ownership of inventions, share with it the objective to spur the commercialization of public research results. These government regulations in several countries worldwide have defined the general boundaries of national research systems, accounting for various actors and factors at different level of analysis, including system level specificities (governmental actions, institutional lows, local context characteristics, etc.), university level internal support mechanisms and individual scientist level factors. All of these

factors play a role in the process through which universities develop capabilities/competencies to transfer knowledge and technology.

Much recent policy attention has been at the systemic and university levels. USOs have been a particular focus, yet the evidence on their performance is decidedly mixed, especially in relation to CSOs by individuals with a university education (Wennberg et al., this special section). There has generally been less focus upon the individual academic entrepreneur, yet they likely have an important role in spin-off performance through being able to identify and exploit suitable opportunities as indicated by Clarysse et al. (this special section). There is a need to develop policy at the individual level to support both USOs and CSOs.

Research commercialization is considerably broader than spin-offs and licensing, involving reach-out, contract research etc. In order to assess the effects of Bayh-Dole like legislation on academic entrepreneurship, we need more systematic data on all dimensions of technology commercialization efforts at universities and national laboratories. At minimum, it would be especially useful to design an AUTM-like survey for the national laboratories. Given that universities are increasingly stressing the entrepreneurial dimension of technology transfer, it would also be useful for statistical agencies, such as the Department of Commerce/U.S. Census Bureau (rather than AUTM) to systematically collect more information on academic entrepreneurial activity that includes all startups not just those identified by the AUTM surveys of their members. (An example of superior data collections is the one Statistics Canada collects through the Survey of Intellectual Property Commercialization in the Higher Education Sector. In many Nordic nations, there is data such as that used by Wennberg et al. (this special section); such data can be exploited to better understand academic entrepreneurship.

In the larger picture, the role of universities in creating and exploiting knowledge seems only likely to grow. In an environment within which the commitment of enterprises to their current locations is increasingly dubious, universities are particularly interesting institutions because thus far they appear to be spatially fixed and unlikely to abandon their current location for lower-cost

destinations. In the U.S., many have remarked upon the retreat by the largest transnational enterprises from basic research and, in a number of sectors, including R&D-intensive ones such as pharmaceuticals, even from early development work. This trend suggests that university research will become only more important in maintaining the innovatory leadership necessary to maintain high incomes. In this larger context, we predict that the debate about the best ways to ensure the diffusion of university knowledge to the larger society will intensify and that academic entrepreneurship is certain to be a part of this debate. We hope that the papers in this special section contribute to an ongoing discussion that will continue.

References

Ahuja, G., Katila, R. 2004. Where do resources come from? The role of idiosyncratic situations. Strategic Management Journal 25 (8-9), 887-907.

Ambos, T., Makela, K., Birkinshaw, J., D'Este, P. 2008. When does university research get commercialized? Creating ambidexterity in research institutions. Journal of Management Studies 45, 1424-1447.

Atkinson, S. H. 1994. University affiliated venture capital funds. Health Affairs 13 (3), 158-175.

Balconi, M., Breschi, S., Lissoni, F. 2004. Networks of inventors and the role of academia: an exploration of Italian patent data. Research Policy 33 (1), 127–145.

Baldini, N., Grimaldi, R., Sobrero, M. 2006. Institutional changes and the commercialization of academic knowledge: A study of Italian universities' patenting activities between 1965 and 2002. Research Policy 35, 518–532.

Baldini, N. 2009. Implementing Bayh–Dole-like laws: Faculty problems and their impact on university patenting activity. Research Policy 38, 1217–1224.

Barr, S., Baker, T., Markham, S., Kingon, A. 2009. Bridging the valley of death: lessons learned from 14 years of commercialization of technology education. Academy of Management Learning and Education 8 (3), 370-388.

Bercovitz J., Feldman M. 2011. The mechanisms of collaboration in inventive teams: Composition, social networks, and geography Research Policy 40 (1), 81-93.

Bercovitz J., Feldman M. 2008. Academic entrepreneurs: Organizational change at the individual level. Organization Science 19 (1), 69-89.

Berman, E. P. 2008. Why did universities start patenting?: Institution-building and the road to the Bayh-Dole Act. Social Studies of Science 38 (6), 835-871.

Bishop, K., D'Este, P., Neely, A. 2011. Gaining from interactions with universities: Multiple methods for nurturing absorptive capacity. Research Policy 40 (1), 30-40.

Blumenthal, D., Campbell, E.G., Anderson, M.S., Causion, N., Louis, K.S. 1997. Withholding research results in academic life science: Evidence from a national survey of faculty. Journal of the American Medical Association 277 (15), 1224-1228.

Bonaccorsi, A., Piccaluga, A. 1994. A theoretical framework for the evaluation of university–industry relationships. R&D Management 24, 229–247.

Borman, S. 2005. "Yale recovers lucrative patent decision resolves dispute with Nobel Laureate over mass spec technique." Chemical & Engineering News 83 (8), 11 http://pubs.acs.org/cen/news/83/i08/8308notw4.html

Branscomb, L. M., Brooks. H. (Ed) 1993. Empowering technology: Implementing a U.S. strategy. MIT Press. Boston, 202-234.

Casper, S. 2007. How do technology clusters emerge and become sustainable?: Social network formation and inter-firm mobility within the San Diego biotechnology cluster. Research Policy 36 (4), 438-455.

Cesaroni, F., Piccaluga A. 2003. Technology transfer from Italian universities: Is an entrepreneurial model starting up? Proceedings of the International Workshop: "Empirical Studies on Innovation in Europe. Urbino, December 1st-2nd.

Clarysse, B., Wright, M., Lockett, A., van de Elde, E., Vohora, A. 2005. Spinning out new ventures: A typology of incubation strategies from European research institutions. Journal of Business Venturing 20 (2), 183-216.

Clarysse. B, Wright. M, Lockett, A, Mustar, P, Knockaert, M. 2007. Academic spin-offs, formal technology transfer and capital raising, Industrial and Corporate Change 16, 609-640.

Clarysse, B., Mosey, S., Lambecht, I. 2009. New trends in technology management education: A view from Europe. Academy of Management Learning and Education 8 (3), 427-443.

Colyvas, J., Powell, W. 2007. From vulnerable to venerated: The institutionalization of academic entrepreneurship in the life sciences. Research in the Sociology of Organization 25, 219-259.

Coriat B., Orsi, F. 2002. Establishing a new regime of intellectual property rights in the United States. Origins, Content and Problems Research Policy 31, 1491-1507.

David, P.A. 1994. Reputation and agency in the historical emergence of the institutions of open science, CEPR discussion paper # 261, Stanford University.

Degroof J. J., Roberts E. B. 2004. Overcoming weak entrepreneurial infrastructure for academic spin-off ventures. Journal of Technology Transfer 29 (3-4), 327-357.

D'Este, P., Patel, P. 2007. University-industry linkages in the UK: what are the factors determining the variety of interactions with industry? Research Policy 36 (9), 1295–1313.

Di Gregorio, D., Shane S. 2003. Why do some universities generate more start-ups than others? Research Policy 32 (2), 209-227.

Etzkowitz, H. 2002. MIT and the rise of entrepreneurial science: Routledge Press, London, UK.

Fini, R., Grimaldi, R., Sobrero, M. 2009. Factors fostering academics to start up new ventures: an assessment of Italian founders' incentives. Journal of Technology Transfer 34, 380–402.

Florida, R., 1999. The role of the university: leveraging talent, not technology. Issues in Science and Technology. Online http://www.nap.edu/s/15.4/florida.htm.

Florida, R., Kenney, M. 1990. The Breakthrough Illusion: Corporate America's Failure to Link Production and Innovation. (New York: Basic Books).

Geuna, A., 2001. The changing rationale for university research funding: are there negative unintended consequences? Journal of Economic Issues 35, 607–632.

Grimaldi, R., von Tunzelmann, N. 2002. Assessing collaborative, precompetitive R&D projects: The case of the UK LINK scheme. R&D Management 32, 165–173.

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

Honig B., Karlsson, T. 2010. Institutional Forces and the Written Business Plan. Chicago: University of Illinois at Urbana-Champaign's Academy for Entrepreneurial Leadership Historical Research Reference in Entrepreneurship. Available at SSRN: http://ssrn.com/abstract=1501585.

Hsu, D.H., Kenney, M. 2005. Organizing venture capital: The rise and demise of American Research & Development Corporation, 1946-1973. Industrial and Corporate Change 14 (4), 579-616.

Jaffe, A. B., Trajtenberg, M., Henderson, R. 1993. Geographic localization of knowledge spillovers as evidenced by patent citations. Quarterly Journal of Economics 108, 577-598.

Jain, S., George, G. 2007. Technology transfer offices as institutional entrepreneurs: the case of Wisconsin Alumni Research Foundation and human embryonic stem cells, Industrial and Corporate Change 16, 535-567

Jain, S., George, G., Maltarich, M. 2009. Academics or entrepreneurs? Investigating role identity modification of university scientists involved in commercialization activity. Research Policy 38 (6), 922-935.

Kenney, M. 1986. Biotechnology: The University-Industrial Complex. (New Haven: Yale University Press).

Kenney, M., von Burg, U. 1999. Technology, entrepreneurship and path dependence: industrial clustering in Silicon Valley and Route 128. Industrial and Corporate Change 8 (1), 67-103.

Kenney, M., Goe, W.R. 2004. The role of social embeddedness in professorial entrepreneurship: A comparison of electrical engineering and computer sciences at UC Berkeley and Stanford. Research Policy 33 (5), 691–707.

Kenney M., Patton D. 2009. Reconsidering the Bayh-Dole Act and the current university invention ownership model. Research Policy 38, 1407-1422.

Kenney, M., Patton, D. 2005. Entrepreneurial geographies: Support networks in three high-tech industries. Economic Geography 81 (2), 201-228.

Kodama, T. 2008. The role of intermediation and absorptive capacity in facilitating university-industry linkages – An empirical study of TAMA in Japan. Research Policy 37 (8), 1224-1240.

Krabel, S., Siegel, D.S., Slavtchev, V. 2011. Internationalization of science and its influence on academic entrepreneurship. Journal of Technology Transfer. Forthcoming.

Lee, Y. 1996. Technology transfer and the research university: A search for boundaries of university-industry collaboration. Research Policy 25, 843-863.

Lerner, J. 2005. The university and the start-up: Lessons from the past two decades. Journal of Technology Transfer 30 (2), 49-56.

Lester, R. K. 2005. Universities, innovation, and the competitiveness of local economies. Industrial Performance Center Working Paper 05-010, Massachusetts Institute of Technology (December).

Link, A.N., Siegel, D.S., Bozeman, B. 2007. An empirical analysis of the propensity of academics to engage in informal university technology transfer. Industrial and Corporate Change 16 (4), 641-655.

Litan, R.E., Mitchell, L., Reedy, E.J. 2007. The university as innovator: Bumps in the road. Issues in Science and Technology (Summer), 57-66.

Lockett A., Siegel D., Wright M., Ensley M. 2005. The creation of spin-off firms at public research institutions: managerial and policy implications. Research Policy 34 (7), 981-993.

Lockett, A., Wright, M. 2005. Resources, capabilities, risk capital and the creation of university spin-off companies. Research Policy 34 (7), 1043-1057.

Louis, K.S, Jones, L.M., Anderson, M.S., Blumenthal, D., Campbell. E.G. 2001. Entrepreneurship, secrecy, and productivity: A comparison of clinical and non-clinical life sciences faculty Journal of Technology Transfer 26 (3), 233-245.

Lowe, R. A. 2006. Who develops a university invention? The impact of tacit knowledge and licensing policies. Journal of Technology Transfer 31 (4), 415-429.

Meyer, M. 2003. Academic patents as an indicator of useful research? A new approach to measure academic inventiveness. Research Evaluation 12 (1), 17–27.

Meyer-Krahmer, F., Schmoch, U. 1998. Science-based technologies: university–industry interactions in four fields. Research Policy 27, 835–851.

Mian, S., 1996. Assessing value-added contributions of university technology business incubators to tenant firms. Research Policy 25, 325–335.

Mody, C. 2006. Corporations, universities, and instrumental communities commercializing probe microscopy, 1981–1996. Technology and Culture 47 (1), 56-80.

Mosey, S., Wright. M. 2007. From human capital to social capital: A longitudinal study of technology-based academic entrepreneurs. Entrepreneurship Theory and Practice 31 (6), 909–935.

Mowery, D.C., Nelson, R. R., Sampat, B.N., Ziedonis, A.A. 2004. Ivory tower and industrial innovation: University-industry technology before and after the Bayh-Dole Act in the United States. Stanford University Press, Stanford.

Mowery, D.C., Sampat, B.N. 2005. The Bayh-Dole Act of 1980 and university industry technology transfer: A model for other OECD governments? Journal of Technology Transfer 30, 115-127.

Mowery, D.C., Ziedonis, A.A. 2007. Academic patents and materials transfer agreements: substitutes or complements? Journal of Technology Transfer 32 (3), 157-172.

Mustar, P., Wright, M. 2010. Convergence or path dependency in policies to foster the creation of university spin-off firms? A comparison of France and the United Kingdom, Journal of Technology Transfer 35 (1), 42-65.

Mustar, P., Renault, M., Colombo, M.G., Piva, E., Fontes, M., Lockett, A., Wright, M., Clarysse, B., Moray, N. 2006. Conceptualising the heterogeneity of research-based spin-offs: a multi-dimensional taxonomy. Research Policy 35 (2), 289–308.

Murray, F. 2004. The role of academic inventors in entrepreneurial firms: sharing the laboratory life. Research Policy 33, 643–659.

National Science Foundation. 2011. Federally funded R&D for national defense and civilian functions: FYs1955-95. Accessible at: http://www.nsf.gov/statistics/s1295/#Federaly%20funded%20R&D%20for%20national%20defense%20and%20civilian%20functions:%20FYs1955-95 (accessed January 19, 2011).

Nelson, A. J. 2009. Measuring knowledge spillovers: What patents, licenses and publications reveal about innovation diffusion. Research Policy 38 (6), 994-1005.

Owen-Smith, J. 2003. From separate systems to a hybrid order: Accumulative advantage across public and private science at Research One universities. Research Policy 32, (6) 1081-1104.

Perkmann, M., Walsh, K. 2008. Engaging the scholar: Three forms of academic consulting and their impact on universities and industry. Research Policy 37 (10), 1884–1891.

Phan, P., Siegel, D.S. 2006. The effectiveness of university technology transfer: Lessons learned, managerial and policy implications, and the road forward. Foundations and Trends in Entrepreneurship 2 (2), 77-144.

Phan, P., Siegel, D.S., M. Wright 2009. New developments in technology management education: Background issues, program initiatives, and a research agenda. Academy of Management Learning and Education 8 (3), 324-336.

Press, E., Washburn, J. 2000. The kept university. Atlantic Monthly 285 (3), 39–54.

Quintas, P. R, Guy, K. 1995. Collaborative, pre-competitive R&D and the firm. Research Policy 24 (3), 325-348.

Rasmussen, E., Mosey, S., Wright, M. 2011. The evolution of entrepreneurial competencies: A longitudinal study of university spin-off venture emergence. Journal of Management Studies, forthcoming.

Rothaermel, F. T., Agung, S., Jiang, L. 2007. University entrepreneurship: a taxonomy of the literature. Industrial and Corporate Change 16 (4), 691-791.

Rothaermel, F.T., Thursby, M. 2005. University-incubator firm knowledge flows: assessing their impact on incubator firm performance. Research Policy 34, 305-320.

Samila, S., Sorenson, O. 2009. Non-compete covenants: Incentives to innovate or impediments to growth. Paper presented at Druid Conference, Copenhagen, Denmark

Saragossi, S., van Pottelsberghe de la Potterie, B. 2003. What patent data reveal about universities: the case of Belgium. Journal of Technology Transfer 28 (1), 47–51.

Schartinger, D., Rammera, C., Fischer, M.M., Fröhlich, J. 2002. Knowledge interactions between universities and industry in Austria: Sectoral patterns and determinants. Research Policy 31, 303–328.

Siegel, D.S., Waldman, D.A., Link, A.N. 2003. Assessing the impact of organizational practices on the productivity of university technology transfer offices: An exploratory study. Research Policy 32 (1), 27-48.

Siegel, D.S., Waldman, D.A., Atwater, L., Link, A.N. 2004. Toward a model of the effective transfer of scientific knowledge from academicians to practitioners: Qualitative evidence from the commercialization of university technologies. Journal of Engineering and Technology Management 21 (1-2), 115-142.

Siegel D., Veugelers R., Wright M. 2007. University commercialization of intellectual property: Policy implications. Oxford Review of Economic Policy 23 (4), 640-660.

Simard, C. 2004. From weapons to cell-phones: Knowledge networks in the creation of San Diego's Wireless Valley. Unpublished dissertation. Stanford University, Department of Communication.

So, A. D., Sampat, B. N., Rai, A. K., Cook-Deegan, R., Reichman, J. H., Weissman, R., Kapczynski, A. 2008. Is Bayh-Dole good for developing countries? Lessons from the US Experience. PLoS Biology 6 (10). http://www.plosbiology.org/article/info:doi/10.1371/journal.pbio.0060262 (accessed January 29, 2011).

Stuart, T. E., Ding, W. W. 2006. When do scientists become entrepreneurs? The social structural antecedents of commercial activity in the academic life sciences. American Journal of Sociology 92, 92-144.

Thursby, M., Fuller, A., Thursby, J. 2009. An integrated approach to educating professionals for careers in innovation. Academy of Management Learning and Education 8 (3), 389-406.

University of Missouri. 2011. Collected Rules and Regulations; Business Management Chapter 100: Patent and Copyright Law; 100.020.D.6. http://www.umsystem.edu/ums/departments/gc/rules/business/100/020.shtml (Accessed February).

University of North Carolina at Chapel Hill, Office of Technology Development. 2009. The Carolina Express License. http://otd.unc.edu/documents/2009CAROLINAEXPRESSLICENSEAGREEMENT.pdf (accessed January 29, 2011).

U.S. National Research Council. 2009. Assessing the Impacts of Changes in the Information Technology R&D Ecosystem: Retaining Leadership in an Increasingly Global Environment Washington, DC: National Academies Press.

Walcott S.M. 2002. Analyzing an innovative environment: San Diego as a bioscience beachhead. Economic Development Quarterly 16 (2), 99-114.

Walsh, J. P., Cohen, W. M., Cho, C. 2007. Where excludability matters: material versus intellectual property in academic biomedical research. Research Policy 36, 1184–1203.

Walshok, M.L., Furtek, E., Lee, C., Windham, P. 2002. Building regional innovation capacity: The San Diego experience. Industry & Higher Education 16 (1), 27-42.

Verspagen, B. 2006. University research, intellectual property rights and European innovation systems. Journal of Economic Surveys 20(4), 607-632.

Welsh, R., Glenna, L., Lacy, W., Biscotti, D. 2008. Close enough but not too far: Assessing the effects of university–industry research relationships and the rise of academic capitalism. Research Policy 37 (10), 1854-1864.

Wright, M. 2011. Entrepreneurial mobility. In Bergh, D. and Ketchen, D. (eds). Research Methodology in Strategy and Management 6, forthcoming.

Wright, M., Clarysse, B., Mustar, P., Lockett A. 2008a. Academic Entrepreneurship in Europe. Cheltenham, UK Edward Elgar.

Wright, M., Clarysse, B., Lockett, A., Knockert, M. 2008b. Mid-range universities' in Europe linkages with industry: Knowledge types and the role of intermediaries. Research Policy 37 (8), 1205-1223.

Wright, M., Piva, E, Mosey, S., Lockett, A. 2009. Business schools and academic entrepreneurship. Journal of Technology Transfer 34 (6), 560-587.

Wright, M., Vohora, A., Lockett, A. 2004. The formation of high-tech university spinouts: The role of joint ventures and venture capital investors. The Journal of Technology Transfer 29 (3-4), 287-310.

Zahra S., Filatotchev I., Wright M. 2009. How do threshold firms sustain corporate entrepreneurship? The role of boards and absorptive capacity. Journal of Business Venturing 24, 248-260.

Zucker, L., Darby, M., Brewer, M. 1998. Intellectual human capital and the birth of US biotechnology enterprises. American Economic Review 88 (1), 290–306.

Table 1: Summary of Papers in the Special Section

Authors	Research Questions	Data and Methods	Key Findings
Aldridge and Audretsch	How extensive is scientist entrepreneurship? What factors encourage or inhibit scientist entrepreneurship?	146 scientist recipients of an NCI grant award who had patented in biotech; Probit regressions	Scientist entrepreneurship more robust than generally indicated hitherto; social capital most important influence on decision to become an entrepreneur; scientists where the NCI grant facilitated patenting more likely to start a firm
Geuna and Rossi	Develops a general framework to describe the changes in university IPR regulations in Europe and their effects on the patenting activities of universities and on knowledge transfer processes.	Review of national university IPR ownership systems on the basis of their development since 2000. Analysis of patterns of ownership of academic patents based on university patenting in Europe between the late 1990s and the mid-2000s for a selected sample of European countries, and the US (as a benchmark).	The analysis of patterns of ownership of academic patents shows that there has been a general increase in university patenting since 1990, with a significant slowdown (and even reduction in some countries) after early 2000s accompanied by a switch in academic patents ownership in favor of university ownership though preserving the European tradition of high levels corporate ownership of patents that include academic inventors.
Thursby and Thursby	Has the Bayh-Dole Act diverted faculty from basic research?	Research and invention disclosure of faculty at 8 US universities over 1983-1999; Citation based measure of basic research publications to relate basic research effort to invention disclosures.	No support for diversion from basic research (the negative hypothesis); substantially greater support that has been an increase in basic and applied research (the positive hypothesis) than for the status quo hypothesis.
Clarysse, Tartari and Salter	To what extent do entrepreneurial orientation of academics, social appreciation of entrepreneurial activity of the environment in which they are employed and the entrepreneurial self efficacy of the individual academic explain	Panel of 2194 academics at 90 UK universities over 2001-2009; Cox semi-parametric survival model	Entrepreneurial orientation of individual academics most important in explaining engagement in entrepreneurial ventures; entrepreneurial efficacy (serial entrepreneurship) also important; social environment less important; TTO only plays a marginal, indirect role.

	engagement of academics in entrepreneurial activities? To what extent do TTOs play a direct or indirect role in explaining entrepreneurial activity?		
Link, Siegel and van Fleet	Do legislative events (The Bayh-Dole and Stevenson-Wydler Acts in 1980 and the Federal Technology Transfer Act in 1986) affect the propensity of federal laboratories to patent?	Econometric Analysis of Patent Data From Sandia National Laboratory and NIST during the period: 1970-2009; patent applications per year	SWA Legislation had an in significant impact on then propensity to patent; However FTTA appears to have stimulated commercialization, since it provided internal financial incentives to employee inventors, along with additional resources to support technology transfer
Kenney and Patton	Contrasts the effectiveness of inventor-ownership vs. university-ownership system in affecting start-up creation rates.	Descriptive analysis based on a unique database of all technology-based spin-offs created by university-affiliated personnel at five U.S. universities and one Canadian university. Data relates to 515 university spin-offs over the years 1957 through 2010.	Inventor ownership has a positive effect on entrepreneurship. The examination of the entire population of technology-based spin-offs from six universities shows that the inventor-ownership regime strikingly dominates the better funded, more highly rated, and much larger university ownership universities.
Fini, Grimaldi, Santoni and Sobrero	In which type of local context is the contribution of specific University-Level-Support-Mechanisms (ULSMs) most relevant in fostering the creation of academic spin-offs? Do ULSMs and Local-Context-Support-Mechanisms (LCSMs) complement or substitute each other in such process?	Sample of 404 companies spun-off from the 64 Italian universities over the 2000-2007 period. Poisson multi-level model	The marginal effect of University-Level-Support Mechanisms (USLM) on universities' spin-off productivity is positive or negative depending on the contribution offered by different Local-Context-Support-Mechanisms (LCSMs). Results show that regional settings' idiosyncrasies should be taken into account in order to develop effective spin-off support policies by universities.
Wennberg, Wiklund and Wright	Do firms started by academic entrepreneurs as CSOs perform better than firms started as USOs?	Population of 528 USOs and 8,663 CSOs among the Swedish knowledge-intensive	CSOs perform better than USOs, in terms of survival as well as growth; human-capital endowments mattered more for USOs than for

	Do USOs benefit more than CSOs from education, industrial and entrepreneurial experience? Do CSOs benefit more from technological knowledge environment of parent?	sectors between 1994 and 2002; random effects GLS and Cox Survival regressions	CSOs; the nature of the parent organization mattered more for CSOs than for USOs (especially organizational size and number of engineers but not PhDs)

Table 2: Themes for a research agenda

	System	University	Individual	Measurement and methods
General	What is the "optimal" portfolio of academic entrepreneurship activities in different types of university, academics and regional clusters? How can regions and countries adopt different strategies for academic entrepreneurship consistent with local environments? Beyond frequency of activity, what are appropriate indicators of success? How to reconcile systemic vs. local perspectives? (e.g. growth in employment creation but not in the local area (spillovers))	How do universities design ambidextrous organization of TTO and academic entrepreneurship? How do universities shift path dependencies from traditional activities? Do universities draw enough on resources elsewhere in universities [e.g. Business Schools]? How can they do this? How do universities develop appropriate mix of TTO skills How do universities develop and access boundary spanners between TTOs and industry & within universities? How are performance indicators combined within an institution to obtain complete view of research commercialization? Is there a disconnect between university and school levels? [dependent upon school culture/leadership?]	How has behavior of specific individuals changed versus how has behavior of different cohorts of individuals changed? Is there any complementarity at scientist level relating to different forms of engagement in academic entrepreneurship? Does scientists' engagement in academic entrepreneurship follow a specific life cycle? To what extent is scientists' engagement in academic entrepreneurship influenced by system peculiarities and university level policies?	To what extent do studies analyze the right hand end of the distribution and how generalizable is this? What are appropriate measures of human and social capital of individual academic entrepreneurs? How can multi-level studies be designed?

Spin-offs	What is the appropriate balance between evaluation based on growth, dissemination of knowledge, wealth creation (capital gain), retention of indigenous fast growers, etc.?	Do university level mechanisms supporting academic spin-offs take into account the specificities of the local contexts and regions in which they are settled? How do country peculiarities interact with university policies to support the creation of academic spin-offs?	How do individual academic entrepreneurs learn from prior entrepreneurial experience? What different legitimacy building approaches are needed by USOs? What team competencies & networks are needed under different growth strategies? When\how weak and strong ties important & how are they accessed? What use is made of Partnerships to access platform technology, downstream products and competencies? How are boards developed and what is their composition? How do USOs develop different exit strategies?	How can a complete assessment of spin-off/start-up activity be measured? How can the returns from spin-off/start-up activity be measured?
Licensing	How can the impact of licensing on the local community and its broader effects be measured?	How do universities trade-off choice between licensing and spin-offs?		

Patenting	What are the impacts of other legislative changes, capital market developments, technology push, etc.?	Do universities do enough to ensure scientists aware of IPR and patenting? What kind of organizational capacity building takes places to facilitate patenting?		
Contract research/ consulting		How do universities design strategies for international companies, technology gazelles, SMEs? How do university systems incentivize individual academics? Precursor to other forms e.g. licensing? Complement or substitute to other activities? Do school views/cultures complement or frustrate university & individual approaches?	How important are personal (not university) contacts?	How can spillovers from these into research output and informal IP generation be measured?
Reach-out/ Teaching/ Mobility		How can universities and corporations interact to innovate in the modes of academic entrepreneurship training (e.g., boot camps)?	How feasible or desirable is two-way movement? Do promotion systems incentivize the individual?	How can the quantity versus quality be distinguished?