Knowledge Exchange, Technology Transfer and the Academy

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Abstract
The relationship between the academy and the business community is currently perceived to be important to the future of both parties. Universities provide graduates to meet the needs and requirements of society and industry, and the latter supplies products and services to meet the needs of the marketplace. Whether public or private, industry increasingly seeks to use tools and techniques that increase efficiency and effectiveness, whilst at the same time maximizing quality and minimizing cost. The current trend towards companies outsourcing their R & D requirements to reduce corporate overheads and optimize staffing levels means that Universities can utilize the opportunity and bid to supply this expertise. Universities also generate their own spin-outs from intellectual property they create, as well as licensing technology to industry, rather than transferring it. However, the relationship between university and industry is not without its challenges, chief of which is the historical commitment of the academy to advance knowledge whether it is directly applicable or not. In addition, there are many fundamental and important long term research issues that many would argue are the primary duty of the academy to address, which may have no direct application in the short to medium term. This is resulting in increasing tensions in the academy, and in the priorities for national and international funding agencies. There can also be significant cultural differences and reward models between the academy and industry which give rise to difficult issues for staff at the interface. This chapter reviews the current developments and the issues at the interface between business and the academy.

Keywords: technology transfer, knowledge exchange, intellectual property, institutional frameworks, blue sky research, third stream, reward model, performance metrics

1. Introduction
As economies advance it is argued that they migrate from resource-based to knowledge-based production. Thus knowledge and innovation are two of the factors behind job creation and economic growth. This in turn affects the social context and also public and economic policy. Many national governments have therefore sought to address the challenges implicit in this observation and, in particular, provide motivation and incentives to increase the collaboration between industry and the academy in the expectation that there will be direct benefits to a nation’s economy and overall global competitiveness. In turn, the academy has sought to address the challenges and opportunities where they align with their institutional mission. Clark (1998) used the phrase “entrepreneurial universities” to characterize the aspects of promoting technology transfer within national systems of learning and innovation.
2. The Bayh-Dole Act
Before the passing of the Bayh-Dole Act in 1980, the ownership of any intellectual property generated by research funded by the US government was undefined. The Act, which passed into US legislation, resulted in all US Universities, small businesses and non-profit organisations being able to utilize the intellectual property arising from such funding. It was a recognition of two factors. Firstly, before the Bayh-Dole Act the US government had accumulated 30,000 patents of which only 5% had been licensed commercially. Clearly this was a significant waste of assets and there was much greater scope for direct commercialization if those involved with generating the patents could also exploit them. Secondly, after World War II it was clear that there was significant potential in US Universities to contribute directly to the rapidly developing fields of science, engineering, medicine, and health.

3. Technology Transfer Systems in the USA
Technology transfer systems in the USA and Germany are set out in detail in Abramson et al (1997). The following types of technology transfer are being used dependent on the particular context –

- Consultancy – where the member of the academy provides advice to industry for a fee
- Personnel exchange – where a member of the academy relocates to industry (usually for a fixed and predefined period) or a member of an industrial company relocates to an academy research laboratory (similarly for a fixed period)
- Co-operative research - where the academy and industry enter into a joint relationship. Such an arrangement could be via a University-Industry Research Center. With significant critical mass this could increase its attractive power to both government and industry funding agencies compared to applications from single research groups. Such a center can provide the framework for collaborative research and development where technology transfer is an integral part of the mission.
- Spin-off companies – where the academy translates the IP directly into a spin-off using members of the academy to develop the company (whether full or part-time) and using industry expertise for marketing and to secure venture capital to pump prime development and expansion.
- Licensing of patents – where the academy licences its patents to industry to develop and manufacture products, and the academy receives a license fee from industry. Many US Universities have Patent Offices within their research divisions that advise and support the development of patents and also market them to industry.
- Courses and workshops designed to meet the needs of industry and led by the academy.

4. Technology Transfer in Germany – the Fraunhofer Model
In Germany, industrial research is conducted principally by the 60 institutes of the Fraunhofer Society. They receive 20-30% of their total income from the government based on the degree to which they generate contract work for public and commercial clients. Thus the agenda is primarily demand-driven and much of the work is of an applied nature. However, the classic research ethos is maintained by appointing directors of Fraunhofer Institutes who are also professors with research programs within their Universities. Thus the Fraunhofer establishes a direct bridge between the academy and industry. It is also particularly relevant for European multi-partner research grants where a combination of academic and industrial expertise is often required in the consortium. The Fraunhofer gives priority to work directed to the areas of health, security, communication, energy and...
the environment. As a result, the work undertaken by researchers and developers can have a significant impact on people’s lives. The advantage of the institutes being organized into one overall framework provides opportunity for the development of an overall national strategy which is coherent and ensures added-value across the network. In addition, it can provide access by all the institutes to specialist centres of expertise or high cost equipment (e.g. for nanotechnology).

http://www.fraunhofer.de/en/institutes-research-establishments/

The accumulation of fundamental research can lead to the establishment of an institute as summarised by Earnshaw (1998) in the areas of computer graphics, visualization, and virtual reality at the University of Darmstadt.

http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=656784
http://www.igd.fraunhofer.de/

5. Lambert Review

In the UK in 2003, the Lambert Review was initiated to address the following three objectives –

- To recognise the changing nature of industrial R&D such as outsourcing, and the increasingly global nature of R&D due to the Internet and international competition
- To benefit from successful role models of collaboration between the academy and industry that had already benefited the UK economy
- To make recommendations for the future

http://www.hm-treasury.gov.uk/d/lambertemergingissues_173.pdf

The review recognised that research in the academy operated on international networks, particularly that in the internationally-leading institutions. There was potential therefore for industry to benefit by linking in with these. The review noted that a key performance indicator was the total spend of the UK on R&D as a percentage of the Gross Domestic Product (GDP). When compared with leading nations such as the USA and Germany it was noted to be lower and needed to be increased. The review supported the UK government’s third-stream funding (i.e. in addition to teaching and research) established in 2001 and proposed that this be expanded. This Higher Education Innovation Fund (HEIF) provides funding direct to institutions to support business/academy collaborations.

“The Government Treasury advised that:

- the best form of knowledge transfer comes when a talented researcher moves out of the university and into business, or vice versa. [p12]
- the most exciting collaborations arise as a result of like-minded people getting together – sometimes by chance – to address a problem. [p12]
- encouraging academics and business people to spend more time together should be a high priority for knowledge transfer professionals. [p12]
- the innovation process is non-linear, so knowledge transfer is not simply a question of channeling clever ideas from researchers down a production line into commercialisation. "Great ideas emerge out of all kinds of feedback loops, development activities and sheer chance. This is another reason why it is so critical to build dynamic networks between academic researchers and their business counterparts.” [p12]
- diversity is good, both in mission and in funding. "The type of business collaboration that would make sense for one kind of university might be either impossible or irrelevant for another." [p13]
- proximity matters when it comes to business collaboration. [p13]
- "business-university collaborations need careful and consistent management by both sides, and a number of joint programmes have failed for lack of such attention". [p13]
- an emphasis on knowledge transfer requires institutions to put in place new mechanisms for establishing institutional priorities. [p13]
• universities are more complex to manage than businesses, with a variety of different stakeholders – academics, students, and funders. [p13]
• that the large number of pots of ring-fenced financing is ‘the source of endless unnecessary frustration’. [p13]”

http://en.wikipedia.org/wiki/Lambert_Review

The UK operates a dual funding system for research. Firstly, an amount is distributed to each institution determined by a periodic (usually every 5 years) national and international audit of research quality in each discipline in each institution (the Research Assessment). This amount is known as the Quality Related (QR) funding stream and remains constant for the next 5 years to provide a secure and stable baseline for funding research, and is supplied to institutions on an annual basis. In 2011-2012 the Higher Education Funding Council for England will distribute a total of £1.5 billion via this mechanism. The second aspect is the funding of grant proposals submitted to the national research councils. Thus the HEIF stream added to this and provided direct funding to support the development of academy/industry collaborations. This can also be used to support and strengthen central Technology Transfer Offices in institutions. £150 million per annum has been allocated by the Higher Education Founding Council for England for the period 2011 to 2015. This can be compared to the total of £3 billion annually available from the research councils (to cover all the areas of science, engineering, biosciences, medical, economics and social science, arts and humanities) by peer review of grant bids.

http://www.hefce.ac.uk/econsoc/buscom/heif/
http://www.bis.gov.uk/policies/science/knowledge-transfer/heif

6. Case Studies

6.1 MIT, Cambridge and Tokyo
Hatakenaka (2003) investigated the industry academy collaborations at MIT, Cambridge and Tokyo. The purpose of the study was to identify the nature of change taking place in these partnerships, and to understand the underlying factors that influence that change, and to explore the underlying process of change. In general, each of these institutions developed an agenda to contribute to, and benefit from, collaboration with industry, whilst at the same time maintaining an internationally leading reputation in all areas of research.

6.2 Johns Hopkins University
A counter example is Johns Hopkins University which has consistently advanced knowledge through scientific discovery and scholarship and which has traditionally not supported interaction with industry in order to ensure that such enquiry was free from commercial interests (Feldman et al, 2001, Brody, 1999). Although technology transfer is provided for at Johns Hopkins, the academy has been slow to accept it because of the long tradition of the University.

6.3 University of Utah
At the University of Utah, one of the first things President Young did after arriving in 2005 was to move the technology commercialization office under the direction of the business school. He then combined three separate technology transfer areas under one organization called “Technology Ventures”. However, “the 3-part mission of the organization remains:

1. Create enterprises in Utah that are technology leaders in their markets and provide quality jobs for the citizens of Utah.
2. Support technology development for existing Utah businesses and enterprises founded on University technologies so they prosper and expand in Utah.
3. Generate returns on the University’s technologies for investment in new research, to support and retain current faculty, and to hire world-class scientists.”

It is also reported that the University of Utah spin-outs had attracted some $250 million in venture capital. More than 100 start-ups have been spun out of the university in the past five years, leading to more than 15,000 direct and indirect jobs in the state.

6.4 National Visualization and Analytics Centers
The National Visualization and Analytics Center (NVAC) is a national and international resource providing strategic leadership and coordination for visual analytics technology and tools. The unique partnerships created under NVAC between national laboratories, university research centers, scholars, and other government agencies represents an on-going commitment to collaboration in the discipline of visual analytics. NVAC provides stewardship for the Research and Development Agenda, ensuring that a continual stream of advanced analytical tools for information discovery are developed and implemented for stakeholders. This owes much to the pioneering spirit and leadership qualities of Jim Thomas.

http://nvac.pnl.gov/
http://www.vacommunity.org/Contributing+Members
http://nvac.pnl.gov/about.stm

7. Challenges, Cultural and Social Issues
The following issues characterize the interface between the academy and industry –

7.1 Time scale
The academy operates on a much longer time frame for R&D than industry which is generally concerned with this year’s balance sheet, this year’s products and this year’s share price. In particular, some institutions concentrate primarily on pure, “blue-skies” research and do not wish to be concerned with interaction with industry (except perhaps to obtain sponsorship grants). Thus there can be a very real issue between short-term technological progress and longer term research on what are regarded as the more important fundamental questions (called “Grand Challenges” in some disciplines).

7.2 Reward Models
Reward models in the academy for faculty who work at the industrial interface are generally not well defined, or even if they are defined, are deemed by some tenure and review committees to be of less academic value than research grants and publications of high scholarly value in journals of a high impact factor. Even if the modification of the traditional reward models is agreed by the institution, the culture on the ground can be slow to change. Where the peer review of the progress of a faculty member also includes external peer review, those who provide it may have a different view to those of the institution where the work has been supported. Whilst there is general agreement on academic excellence as defined by traditional metrics in the academy, there is no general agreement on how excellence is defined in knowledge transfer, or whether it should even be included in the evaluation of academic excellence.

7.3 Value of Applied Research
Applied research is regarded by some institutions as of lesser academic value compared to pure research. Peer review of research grant proposals or publications in applied research can often result in these being ranked lower than those in pure research. It is noted that early in their life cycle during the development of disciplines they have to concentrate on the pure academic aspects in order to establish themselves amongst their fellow disciplines in the academy. An example is computer science. It clearly began with hardware and programming but had to establish itself on a wider front to gain academic respect and standing. However, when disciplines are well established they can do applied research without question (e.g. medicine, surgery, pharmacology) and those within these disciplines no longer talk in disparaging terms about applied research within their discipline. It is now perceived to enhance them. However, in emerging disciplines, such as computer science, there can be
a tendency to still regard the more practical aspects as merely “applications” and of lower academic merit compared to other areas of the discipline.

7.4 Technology Transfer Culture
Institutions with a strong technology transfer culture in the faculty often result in undergraduates and graduate students being entrepreneurial and setting up their own companies (sometimes before even completing their courses and graduating). This could be regarded as an advantage to those on the course of study, but some faculty can regard this as a diversion from concentrating on the course material. It can be argued that the syllabus is designed to prepare a graduate for 2-4 career changes during their working life and to concentrate on the immediate career can be too short-sighted.

7.5 Communication and Values
Communication protocols in academia can be different in the academy to those in industry. Most academic institutions are collegiate in nature and decisions are often based on an informal consensus within the faculty. Industry on the other hand can be more formal and may require board meetings for any decisions to be approved by senior management. There can also be differences in the stated values in the missions of the respective organizations which can give rise to tension and misunderstandings.

7.6 Differences across Discipline Areas
Some disciplines, such as those in the applied sciences, lend themselves more naturally to collaboration with, and technology transfer to, industry. Discovering a new technique or process in science or engineering can lead to improvements in the design and manufacture of products and services. However, there is less natural affinity in the arts and social sciences, where there is less potential intellectual property to patent and exploit. The academic discipline of economics has an uneasy relationship with the market place and its financial complexities, and no single theory appears to win favour in all, or even any, circumstances. For example, experts differ widely on what to do in times of economic recession in order to stimulate growth. This asymmetry between disciplines can create tension in the academy when its mission includes technology transfer or improvement of society in general. The academy can give different internal priorities to its various academic disciplines with corresponding financial implications. Some institutions allow financial cross-subsidy between revenue generation areas and those areas in deficit in order to allow the institution as a whole to remain in balance. This can enable the academy with a given academic footprint to deal with fluctuations in student demand in the market place for its courses, and in the varying research priorities that may be set by governments over time. Others ring fence the revenue generation so that it can benefit the areas producing it, and provide motivation for growth and expansion of these areas. By contrast, deficit areas need to be restructured to become viable, or closed down, with consequent implications for the careers of faculty members and support staff. In addition, the academy may use different financial models at different times, which can create uncertainty in the planning processes for academic areas and can affect the tenure and job security of academic staff.

Patent generation is much less common in the academic areas of the arts, humanities and social sciences, so this raises the issue of how to promote, value, and reward knowledge transfer in these areas. However, some areas of the academy have been particularly successful in exploiting interdisciplinary research, though there can still be challenges within the academy due to the budget ring-fencing of faculties and deans wishing to protect their respective disciplines. Structures within the academy may need to be modified to take full advantage of new research opportunities which cross traditional academic boundaries.

7.7 Performance Metrics
Metrics for evaluating knowledge transfer can be diverse and give different results for different disciplines and different contexts. Examples of possible metrics are number of patents, patent value, spin-off companies, commercialization, public value, private value, impact value, etc. Currently there is no general agreement on what might constitute a core set of performance metrics. Some feel that quantitative metrics favour engineering and the sciences, whilst qualitative metrics favour the arts and
social sciences. The UK is currently moving towards a research evaluation based on impact factors derived from a relatively small number of case studies for each discipline in each institution. However, it is clear that there will be significant subjective elements involved in this evaluation. The Russell Group's opinion on the Warry report's proposal can be noted, "that an individual competent in the economic impact of research should be accommodated on each Research Audit Panel": "There is no evidence to date of any rigorous way of measuring economic impact other than in the very broadest of terms and outputs. It is therefore extremely difficult to see how such Panel members could be identified or the basis upon which they would be expected to make their observations. Without such a rigorous and accepted methodology, this proposal could do more harm than good."

http://www.csc.liv.ac.uk/~leslie/impact/impact.html

The incorporation of impact factors into research grant proposals and the periodic audit of research quality has been strongly opposed by key academics in the UK. More than 18,000 academics, including six Nobel Prize Winners, have written to the UK government to condemn the current plans to include economic impact in the evaluation of research. “The scholars are concerned that making university research more accountable to the wider economy will stifle the sort of curiosity-driven research that has led to groundbreaking discoveries and Nobel prizes.”

"History shows us that in many cases it is basic research, undertaken purely out of curiosity to understand more about our world, that has delivered revolutionary breakthroughs," Dr Kirby-Harris said. "X-rays, lasers and semiconductors – technologies widely used in every aspect of our lives – all stem from discoveries made through fundamental research, undertaken without any immediate application in mind."

Sir Tim Hunt, one of six Nobel Prize winners to sign the petition, said: "The impact guidelines will discourage academics from making discoveries and will encourage people to come up with unoriginal research proposals. The whole idea of research is to find out things you didn't know before. The fruits of basic research are unpredictable and to seek to control them in this way is not in the interests of the country."


7.8 Diversification of Academic Mission

Governments have sought to diversify the missions of their academic institutions by getting them to concentrate on their strengths and select from the principal areas of teaching, research, widening access, and knowledge transfer. However, it is generally the case that institutions that do the best research also by definition have the best IP and are more highly regarded by industry. Lesser institutions can end up by being squeezed out of both research and knowledge transfer, which clearly was not the government’s original intention.

8. Conclusions

This chapter has provided an outline of the development of collaborations between the academy and industry and reviewed how governments have sought to influence the mission and agenda of the academy in order to address what are perceived to be more near-term economic and social requirements. Many eminent scientists, particularly a number of those involved in significant research leading to the award of a Nobel Prize, have criticized key aspects of these developments. In particular, they are concerned that this could result in the suppression and devaluing of long term research on the more fundamental research questions which in the history of the academy have led to significant advances.

The chapter has also reviewed issues at the interface between the academy and industry and noted that some of these are significant and have not been resolved, or in some cases, not even been fully recognized or addressed.
However, there are clearly significant mutually beneficial aspects to developing such collaborations for the R & D income they provide, the critical mass of researchers that they generate, the ability to attract future R & D grants, and the contributions to society and the economy that can follow.

There is a current trend in funding agencies to allocate larger grants to larger research groups in order to address major research challenges and also to increase international competitiveness. In addition, the aggregation of research groups across institutions in the academy creates research hubs in particular discipline areas. These can also be attractive to industry because of their larger critical mass and potential international reach, and can bring in additional sponsorship and support. However, this does have the effect of marginalising those institutions not represented in the research hubs and the academy could become increasingly stratified and divided.

9. References


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Biography

Rae Earnshaw has been Professor of electronic imaging at the University of Bradford since 1995. He was Dean of the School of Informatics (1999-2007) and Pro Vice-Chancellor (Strategic Systems Development) (2004-09). He has been a Visiting Professor at Illinois Institute of Technology, George Washington University, USA, and Northwestern Polytechnical University, China. He is a member of ACM, IEEE, CGS, Eurographics, and a Fellow of the British Computer Society. He has authored and edited 35 books on computer graphics, visualization, multimedia, design, and virtual reality, and published over 150 papers in these areas. He is on a number of Editorial Boards of international
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