

**Understanding
technology
transfer**

Contents

ACKNOWLEDGEMENTS

Page 2

PREFACE

Page 3

EXECUTIVE SUMMARY

Page 4

1

THE FOCUS ON TECHNOLOGY TRANSFER

Attention is increasingly focused on the role of the universities in the creation and commercialisation of innovation. People and passion are the main ingredients of success.

Page 6

4

THE PATH TO COMMERCIALISATION

More patents do not necessarily mean more licences and more revenue. Could universities do a better job of picking the winning technologies of tomorrow?

Page 22

2

RESEARCH: PREREQUISITES FOR SUCCESS

Understanding the elements of successful transfer requires an understanding of the funding and structure of university research.

Page 12

5

THE ROLE OF VENTURE CAPITAL

From the perspective of most venture capitalists, university inventions take too long to become viable commercial propositions. There is broad consensus on the need to expand public seed-funding initiatives further.

Page 26

3

EMPOWERING RESEARCHERS AND UNIVERSITIES

For disclosure of an invention to lead to commercialisation, both researchers and universities must be incentivised.

Page 16

6

IN CONCLUSION

Universities cannot do it all. The expertise of outside professionals should be systematically leveraged.

Page 32

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PREFACE

Survey: Participating institutions

Universities

Brunel University, UK
 California Institute of Technology, US
 Cambridge University, UK
 Carnegie Mellon University, US
 Dresden University of Technology, Germany
 Georgia Institute of Technology, US
 The Hebrew University of Jerusalem, Israel
 Imperial College, London, UK
 Massachusetts Institute of Technology (MIT), US
 Oxford University, UK
 Stanford University, US
 Technion, Haifa, Israel
 UCLA, US
 Universität Stuttgart, Germany
 University College London, UK
 University of Manchester Institute of Science and Technology (UMIST), UK

Venture capital firms


Amadeus Capital Partners
 Apax Partners
 ARCH Venture Partners – Southwest
 PolyTechnos Venture-Partners
 Pond Venture Partners Ltd
 Wellington Partners Venture Capital GmbH

The ability to innovate is widely recognised as a critical source of competitive advantage for economies. Universities are increasingly pivotal players in the process of innovation, and the past two decades have seen the emergence of structured mechanisms for transforming university inventions into commercial products and services. These mechanisms are critical elements of university technology transfer, the process by which discoveries made on the laboratory bench are transformed into commercial products, and the subject of intensive scrutiny by policymakers, academics, businesspeople and the investment community.

This report aims to inspire a deeper understanding of this critical area by examining the enablers and hallmarks of best practice in technology transfer in five countries—France, Germany, Israel, the UK and the US. As part of our research, we carried out a survey of technology transfer offices at 16 of the world's leading universities into the factors, outside the university and within it, that drive successful transfer. To compare their views against those of the investment community, we also conducted in-depth interviews with a number of early-stage venture capital firms. The institutions that participated in the survey are listed on this page and our thanks are due to all respondents for their time and insights.

The report has five main sections. The first assesses the intensifying focus on universities as wellsprings of innovation. The next three broadly follow the process of technology transfer, from initial research, through disclosure and patenting, to commercialisation. The fifth chapter analyses the financing challenges that university technology transfer poses and assesses the role of venture capital in this process. A conclusion offers some final reflections.

EXECUTIVE SUMMARY



In a knowledge-based world, innovation is king. Everywhere you look, money from public as well as private coffers is being heaped on efforts to hasten the innovation process along—in a bid to spur profits, employment, regional development and national competitiveness.

In recent years, spurred by the experience of the US in particular, policymakers, enterprises, investors and academics throughout the industrialised world have paid increasing attention to the role of universities as drivers of innovation. Ironically, the principal contribution that universities make in this regard is often overlooked—whether attracting the entrepreneurs of tomorrow to study in a particular country or supplying start-ups and established companies with smart, problem-solving graduates, universities are critical actors in importing, refining and supplying the human talent upon which economies ultimately depend.

This report focuses on structured forms of technology transfer. Many universities have established formal offices and processes for identifying promising discoveries made within their walls and turning them into revenue streams through licensing or spinouts.

The results are not to be sneezed at. By 2000, US university and college patents accounted for 2% of all US utility patents granted and 4.4% of US corporate-owned utility patents, discernibly up on figures of 0.5% and 1.1% respectively in the mid-1980s. Net licensing income flowing to US universities topped US\$1.3bn in fiscal year 2003. Other countries are catching on: licensing income to UK universities grew by more than 20% in 2002.

University technology transfer is extremely difficult, however. Universities wield a competitive advantage in basic research, experimental work that has no particular outcome in mind. The combination of technical and commercial knowledge required to identify and nurture new discoveries into commercial products

demands a set of exceptional skills rarely found within universities. The time required to take an embryonic invention to market is longer than the lifespan of most venture capital funds and there is a scarcity of private funding in this space. The experience of even the most successful and sophisticated US research universities is that technology transfer accounts for only a small proportion of overall revenue and that very few technologies deliver significant revenue.

Technology transfer has a better chance of success in some industries than others. Life sciences is one field that is better aligned with university research activities, for example, thanks to its dependence on basic science, increasing reliance on out-of-house innovation and structured development processes. But a sense of realism is necessary—technology transfer from universities is tough, expensive, constrained by environmental factors, and likely to fail more often than succeed.

This report, imbued by this sense of realism, points to the issues that need to be addressed, by policymakers and universities, to improve the odds of technology transfer success. Most underscore the importance of people.

More specialist early-stage capital. There is a structural financing gap at the heart of university technology transfer that is mainly bridged by government funding mechanisms. Larger venture capital firms will continue to steer clear of this extremely high-risk investment area but there are a number of specialist investors active in identifying and exploiting university discoveries. These investors are critical links in the financing food chain, as sources of knowledge as well as money. Business angels are another vital source of financing and expertise.

Better communication and networking. It is impractical for even the very largest and richest universities to

hire the requisite commercial and technical skills that technology transfer entails. It is similarly unrealistic to expect too many academic researchers to combine the technical and commercial skills that new ventures demand. Our survey shows that leading institutions make concerted and conspicuous efforts to set up structured networks and communication forums through which they can draw on the advice and insights of venture capitalists, industrialists, mentors and alumni as they identify and progress discoveries with genuine commercial potential.


Meaningful measurement. The success of technology transfer is too often measured solely by absolute numbers of patents, licences or spinouts. These metrics can encourage overly aggressive patenting and do not accurately reflect the long-term commercial impact of transfer activities. Internal incentives and external funding that reflect average licensing revenue or spin-

out survival rates and product sales will drive universities to focus on the discoveries with true potential and help ensure that research in other areas can continue unimpeded by legal barriers.

University technology transfer is all about transforming the fruits of university research into commercial value. But it is worth noting that the other great mission of universities, that of teaching, also has its part to play in this process. In countries where entrepreneurial values are engrained, such as the US, business and innovation topics are widely taught. In other countries, most graduates and academic researchers lack such skills. If successful innovation depends in part on cultural attributes, and if universities are important channels for disseminating cultural values, they can do much themselves to improve the wider context in which technology transfer occurs.

1

THE FOCUS ON TECHNOLOGY TRANSFER



Innovation accounts for more than half of all economic growth in developed countries.

University technology transfer takes many forms, primarily the annual migration of university graduates into the wider commercial world and the publication of research findings. There is increasing interest in structured processes for transferring technology through licensing and spinouts.

US universities are the benchmark for the structured processes of technology transfer. Income from these activities has grown markedly in recent years but the barriers to success are still formidable.

Until the late 1950s, when Robert Solow, an economist at the Massachusetts Institute of Technology (MIT), questioned the thesis, it was widely held that the output of an economy—and hence its productive potential—rested upon just two inputs: labour and capital. Solow won his Nobel prize for realising that there must be a missing ingredient in the productivity brew to explain a post-war economic expansion in America, followed by Europe and Japan, that was over and above the level suggested merely by the sum of capital and labour inputs. This missing ingredient is now better understood to be the application of new technological knowledge—innovation.

Innovation is now reckoned by a whole new school of “growth” economists to account for more than half of all economic growth in developed countries—and nowhere has this been better underlined than in the growth trajectory of the United States since the early 1990s.

There is a growing interest in the role of the university in the alchemy of innovation.

Evidence from America, Japan, South Korea and Israel shows convincingly that waves of technically trained young people—steeped in the latest theories, exposed to advanced research tools and experimental techniques, and honed by some of the smartest minds in science and technology—do more for raising a country’s industrial competitiveness than all the tax breaks, development aid and government initiatives put together. This annual migration has long been at the core of what universities are all about, and will long remain so. It is so fundamental to what universities do that it is often taken for granted.

In addition, universities transfer their discoveries and inventions to the outside world by publishing scientific papers in academic journals. They impart new knowledge to the public via extension courses and edu-

cational programmes designed to keep outside professionals abreast of the latest developments. In some countries, academics are expected to work as industrial consultants during the summer break, transferring their findings in the process while gaining useful industrial experience to enrich their academic work.

Some of the most significant innovations in recent years can be traced back to basic research in universities or other public research institutions.

- Stanford University and the University of California’s Cohen/Boyer patent for the technique of recombinant DNA cloning, or gene-splicing, is said to be the most valuable and influential academic invention ever patented. Licensed use of the technology has yielded products ranging from insulin treatments for diabetes to growth hormone for children with growth deficiencies, and the invention is regarded as the midwife of the biotechnology industry.
- University-led breakthroughs were central to the emergence of fibre optics. The development of imaging bundles by separate groups of scientists at Imperial College London and the Technical University of Delft was a key stepping-stone to today’s communications environment, in which more than 80% of the world’s long-distance voice and data traffic is carried over fibre-optic cables.
- University research has also revolutionised agriculture by developing vaccines and treatments that have eliminated or controlled plant and livestock diseases. University researchers are heavily involved in efforts to develop genetically modified foods.

Defining technology transfer

The focus of this report is on structured efforts to realise and capture the commercial value of such basic “blue-sky” research in universities. The formal process of technology transfer describes the process

whereby new ideas embodied in academic inventions and discoveries are transformed (“translated” is often the word used) as they move from laboratory bench to the commercial mainstream.

There are a number of routes to commercialisation: ■ **Licensing.** Licensing know-how to established firms seeking to incorporate the technology into the products they sell is the most common practice. Licences can be exclusive, granting the sole right to a single company in a single country, region or market sector, or non-exclusive.

Exclusive licences are usually granted when inventions require significant private investment to reach the marketplace or are so embryonic that exclusivity is necessary to induce long-term investment.

Non-exclusive licences tend to be used where the underlying technology is some form of enabling process or diagnostic method that is likely to be used widely in laboratories and workshops. For instance, if Stanford University and the University of California at San Francisco had granted an exclusive licence to the Cohen/Boyer patent to the first drug company that expressed an interest instead of offering non-exclusive rights to all-comers, the world would have been a poorer place (not to mention the two universities). A more telling point is that, had that happened, biologists reckon international progress in molecular biology, genetic engineering, drug design, gene therapy and forensic science

would have been set back as much as 15 years.

■ **Spinouts.** A spinout can be defined as a start-up company whose formation is dependent on the intellectual property (IP) rights of the university and in which the university holds an equity stake. Often, but not always, these firms are founded by the academic researcher responsible for the invention.

Spinouts are riskier than licensing technology to established companies but they have the inestimable advantage of bringing together a focused, passionate team of researchers and business-minded managers. According to Robert Langer, the Kenneth J. Germe-shausen Professor of Chemical & Biomedical Engineering at MIT and a prolific inventor: “It never works well with big companies. They focus their energy on showing why the new technology won’t work. I always prefer to start a new company: it will deliver total focus, energy, passion, and commitment.”

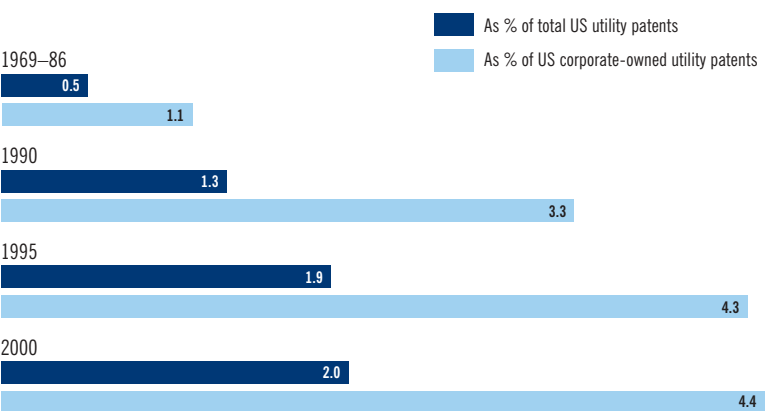
Importantly, the approaches of licensing and spin-outs are not mutually exclusive. MIT, one of the most successful transferers of technology in the world, for example, regularly licenses inventions to spinouts in return for an equity stake in the company. That both helps the new firm by not hoovering cash out of the venture and aligns the interests of the university squarely with those of the entrepreneurs.

Almost all the respondents to our survey of technology transfer professionals stressed that a formulaic, rigid approach is inappropriate. First, the involvement of the inventor is the most important element. “If he wants to stay on at university, then you are very foolish to push for a start-up,” says Peter Hiscocks, Acting Director of Cambridge Enterprise in the UK. A second factor is the nature of the innovation. If an “incremental” one, licensing to an established company makes more sense; if a “fundamental” one, the argument for setting up a company is stronger. Third, the decision should take into account the level of concentration in the market for which the technology is being considered: if you have a clever new cashpoint machine, you don’t found a new bank; you sell it to existing ones.

The growth of technology transfer

Interest in structured forms of technology transfer is on the rise, largely thanks to the example of the United States. The Bayh-Dole Act of 1980 allowed US universities not only to license their inventions and dis-

Numbers of US university patents



Source: USPTO

coveries, but also to grant exclusive licences to individual firms. That was rarely possible when the intellectual property resulting from publicly funded research was owned by the government, as had been the case before. Companies that license university know-how have to take a big gamble and commit considerable resources. One expert interviewed for this study estimated that US\$1,000 worth of academic intellectual property (IP) needed between US\$1m and US\$10m of development effort to turn it into a usable product. Even then, there is no guarantee that the company will get its money back in the marketplace. It is the ability to acquire exclusive rights to a new piece of technology that gives companies the confidence to make the kind of investment needed to bring a licensed invention or discovery to market five or ten years hence.

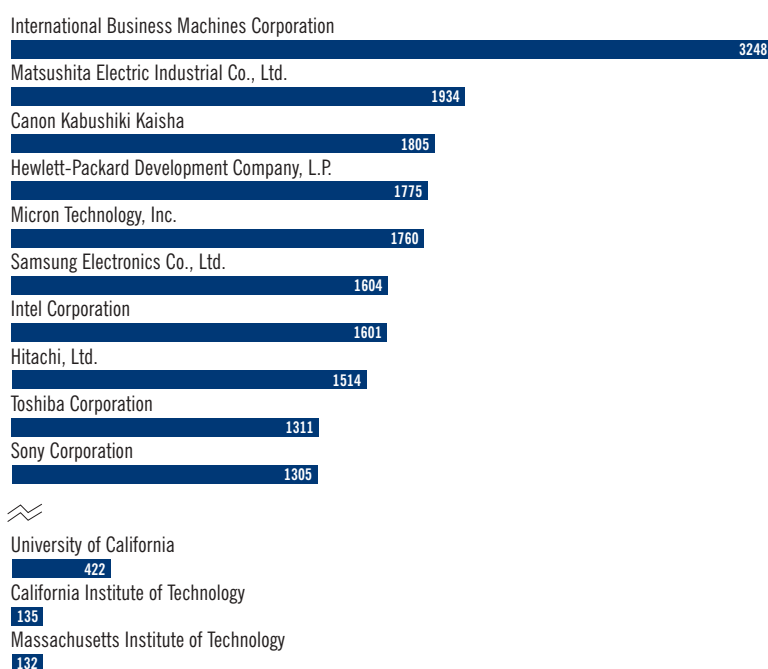
The results have been striking. There has been a surge in the number of patents issued to US universities: figures from the US Patent and Trademark Office (USPTO) show an increase from 250-350 new ones a year before 1980 to more than 3,200 in 2001. University patents still account for a small percentage of overall patents, but the proportion has grown perceptibly over the past two decades.

Income to US universities from technology transfer is substantial and growing. In its most recent annual survey, the Association of University Technology Managers (AUTM) in the US found that US universities increased the number of licences and options executed by more than 20% between the 2001 and 2003 fiscal years. The AUTM survey also showed that overall net income from licensing reached more than US\$1.3bn in the 2003 fiscal year, up from just over US\$1bn in 2001. The US numbers dwarf those of other countries, but growth in technology transfer activity is also striking elsewhere—UK universities reaped licensing income worth £22.4m (US\$40m) in 2002, an increase of 21% on the previous year, as the levels of technology transfer activity, funding and staffing grew.

Other governments elsewhere are sitting up and taking notice. In 2004 Germany unveiled its High Tech Masterplan, for example, whose elements include programmes to promote university spinouts and to encourage collaborative research between small- and medium-sized enterprises and public-sector research bodies. In France, the government's 2003 Plan for

Top patenting organisations receiving US utility patents in 2004

Number of patents



Source: USPTO

Innovation also aims to strengthen links between public research bodies and private firms, in part by proposing tax credits for private seed investors.

Around the world, universities have adopted broadly similar approaches to technology transfer. Taking their lead from the early pioneers at Wisconsin, Massachusetts and California, they have built organisations that rely on these crucial steps—disclosure, patenting and commercialisation through licensing or spinouts.

Increasingly, responsibility for this process is being centralised in an office of technology transfer. The number of such offices has reached nearly 300 in the United States, while 117 UK universities had staff dedicated to commercialisation activities in 2003. Israel's six university technology transfer offices sound low by comparison, but not when one considers the country has eight universities in total.

Unravelling the process

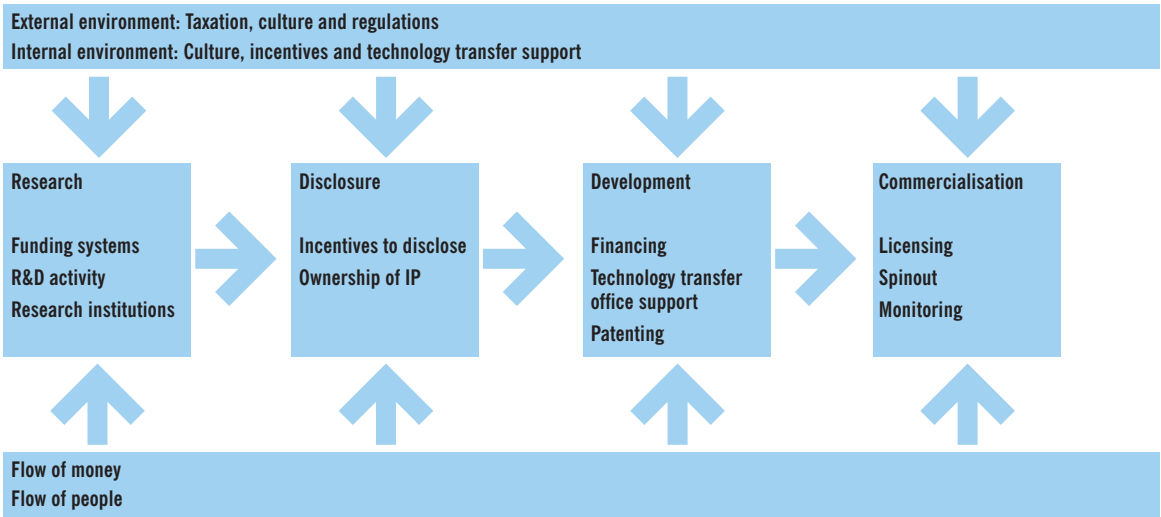
A sense of perspective on the part of government and universities alike is critical. Universities are not the engine-rooms of commercial innovation. The US university with the largest number of US patents in 2004 was the University of California. Its tally of 422 was almost eight times fewer than the 3,248 patents racked up by IBM, the most prolific patenter that year. The contribution that technology transfer makes to universities' overall income remains tiny—licensing equated to 4% of US university research spending in 2001.

Universities are vital components in innovation environments and it is right that more systematic efforts are made to unlock the commercial value that exists within academic discoveries. But even in the US, where the ecosystem that supports commercial innovation is world-class and experience of university technology transfer is far greater, the going is tough.

Organising technology transfer is neither cheap nor easy. The kind of IP generated by university professors and researchers is usually in such an embryonic form as to be practically useless to anyone apart from other scientists in similar fields. As a result, outsiders—and investors in particular—often need a good deal of convincing that a new technology, developed under the rarefied conditions of a university laboratory, can be scaled up and made to work reliably in the commercial world.

Moreover, technology transfer does not take place in isolation. The national economic, regulatory and cultural environment, the internal university environment and the availability of seed financing are all critical determinants of, and challenges to, the transfer process. In the following chapters we consider the hurdles, and solutions, that exist in technology transfer. Our natural starting-point is the structure and funding of university research in general.

The technology transfer process



2

RESEARCH: PREREQUISITES FOR SUCCESS



The amount of R&D being conducted in the country as a whole, and within academia in particular, is a determinant of the amount of technology that is likely to be transferred.

Funding systems that reward collaboration with business should not be at the expense of research excellence.

Universities wield a strong competitive advantage in multi-disciplinary, basic research, as industries such as life sciences clearly recognise.

The success of university technology transfer depends not only on processes within universities but also on the external environment. Factors such as the overall intensity of R&D activity in the economy, the wealth and funding of universities, and the structure of research systems set the framework within which technology transfer occurs.

Drivers of demand: The R&D environment

Low levels of R&D activity in the wider economy have an adverse impact on levels of demand and funding for new products and services sourced from academia. Universities are less likely to develop and transfer new technologies if companies, governments and investors are not seeking to finance and acquire them.

In R&D activity, as in so many areas, the US wields disproportionate punch. Overall R&D expenditure in the United States alone accounted for roughly 44% of all OECD member countries' combined R&D investments in 2000. More money was spent on R&D activities in the United States in 2000 than in the rest of the G7 countries (Canada, France, Germany, Italy, Japan and the UK) combined.

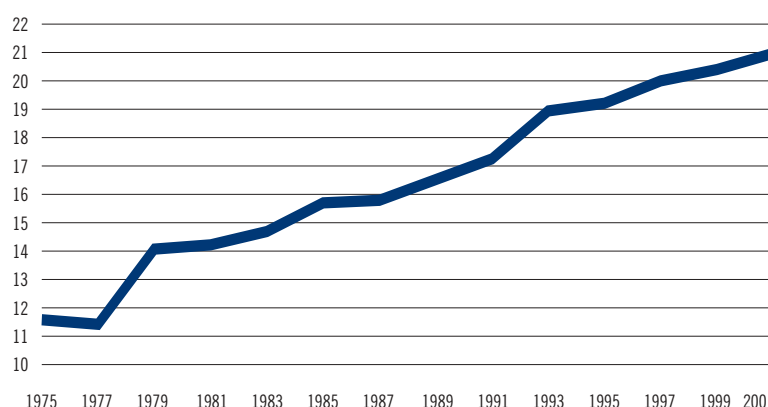
Although universities actually account for a smaller proportion of total R&D in the US than is the case in the UK, Israel, France and Germany, the absolute amounts of money flowing into the system are vastly higher. With this volume of cash flowing into the system, much of it into life sciences, scale alone is a major factor in explaining the relative success of US technology transfer.

US universities can further top up this bounty with their huge endowment funds. Of research and development undertaken in US colleges and universities in 2000, 58.2% was funded by the federal government, 7.3% by state and local government, 7.2% by industry, and 19.7% (some US\$6bn) from the institutions' own funds. Research by the Sutton Trust, a UK edu-

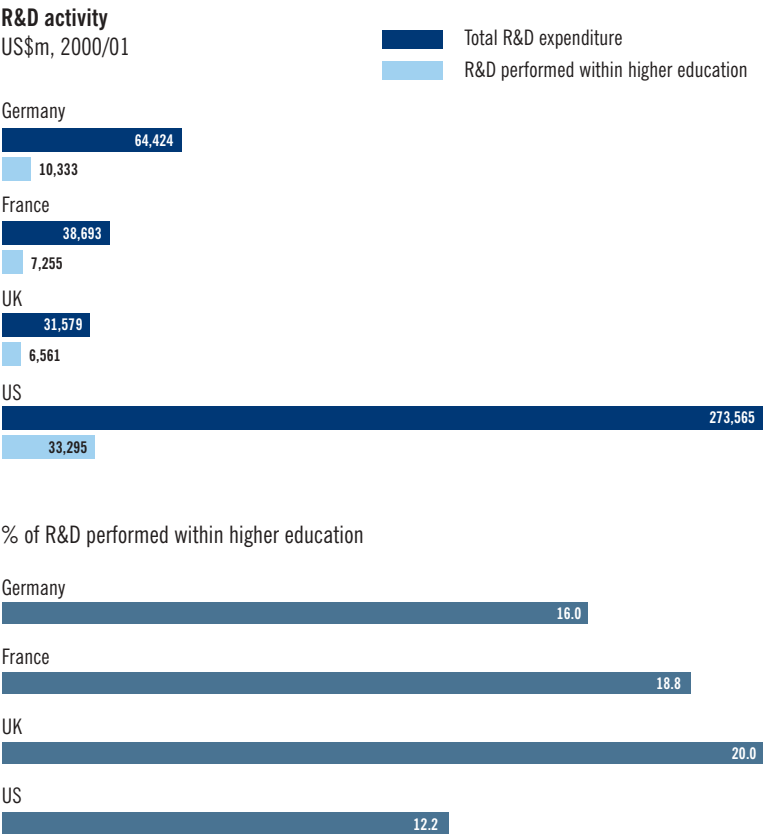
cation charity, in 2003 showed that 39 US universities have an endowment of more than US\$1bn; that only five UK universities have endowments worth at least £100m, compared with 207 US universities; and that the average top 500 US university has about 15 times the endowment of the average top 100 UK university.

Wealth brings multiple advantages, from quality of research infrastructure to the quantity of projects being undertaken and, critically, to the remuneration of individual researchers. Gaping disparities in pay scales (a 2002 study showed that average academic pay at purchasing power parity stood at £21,800 in the UK, £24,800 in Germany, £34,500 in France and £56,100 in the US) help explain why more than 20% of science and engineering doctorate holders employed at US universities and colleges are foreign-born. It stands to reason that any university system that is able to attract the best researchers will produce better research.

Academic employment of US science and engineering doctorate holders
% of foreign-born doctorate holders



Source: National Science Foundation, 2004



Source: US National Science Foundation, 2004

The funding of university research

Sheer quantities of cash are important to the volume of research that gets done, but the methods by which funds are allocated are also critical in determining whether that research can be commercialised.

Funding mechanisms that pay particular attention to multi-disciplinary research are likely to be more successful in this regard. Modern healthcare research, for instance, demands not only intense knowledge of genetics, chemical engineering and medicine, but also the development of information technology tools that enable rapid sifting and interpretation of vast amounts of data. Similarly, creating neural computer systems requires the combined efforts of computer scientists, psychologists, engineers and linguists.

Funding mechanisms should take multi-disciplinarity into account. The seven UK Research Councils that hand out project grants to universities, for example, stand accused of focusing on their own areas of specialisation and neglecting the multi-disciplinary research that increasingly matters to business.

The importance of multi-disciplinary research is something for curriculum designers to think about as well as grant bodies—a National Research Council panel in the United States issued a 2003 report¹ calling for undergraduate biology education to incorporate

mathematics, physics, chemistry, computer science and engineering until “interdisciplinary thinking and work become second nature”.

The extent to which funding is concentrated on a relatively small number of world-class research universities also has ramifications for technology transfer. A concentrated approach is sensible in promoting and sustaining centres of excellence, and enables the lucky few to compete for the best talent more effectively.

But there are trade-offs, given research into the importance of the physical proximity of research institutions to small and medium-sized enterprises (SMEs). Technology transfer to the SME sector is likelier to happen via local higher education institutions, where relationships are easier, and cheaper, to form and maintain. Research in the UK shows that firms whose markets are primarily local choose to work with local universities almost all of the time. With this in mind, the 2003 Lambert Review of University-Business Collaboration in the UK recommended the establishment of a modest new stream of university funding specifically aimed at business-relevant research, designed to reward less glamorous institutions with a strong track record in co-operating with the private sector.

Even so, simple economics suggest that not every university should have its own transfer infrastructure. In the UK, a 1998 National Health Service report estimated that R&D expenditure of £20m per year is necessary to cover the costs of a technology transfer professional office. Fewer than 25% of UK universities would meet this threshold, yet 80% are now trying to run their own operations. Developing shared services between universities in certain areas of technology transfer, such as market research and licensing negotiation, is an obvious way for smaller institutions to overcome problems of scale.

Back to basics

Tying funding aggressively to commercialisation activity would carry another, more fundamental risk: that of distracting universities’ resources and energy away from the field of basic research. With teaching duties at a minimum and unfettered by the commercial imperatives of the business world or the strategic missions of national laboratories, researchers at leading universities are generally free—as they are nowhere else—to pursue pure, as opposed to applied, research. Universities

1 “Bio2010: Transforming Undergraduate Education for Future Research Biologists”, Committee on Undergraduate Biology Education to Prepare Research Scientists for the 21st Century, National Research Council, 2003

The life sciences advantage

The challenges posed by university technology transfer are immense, but they do vary in scale between industries. The field of life sciences, for example, has some inherent characteristics that increase the odds of successful university technology transfer:

■ **Basic research.** The industries that invest the most in basic research are those whose new products and services are most directly linked to advances in science and engineering, such as the pharmaceutical industry and the scientific R&D services industry. The majority of expenditure for academic R&D in 2001 went to the life sciences, which accounted for 59% of all academic R&D expenditure. Growth in US academic patents has occurred primarily in life sciences and biotechnology; the technology area that has experienced the fastest growth—chemistry, molecular biology and microbiology—increased its share from 8% to 21% between the early 1980s and 2001.

■ **R&D activity.** Although big pharmaceutical companies wield enormous R&D bud-

gets, their success rate in developing approved products has dipped—the number of new medicines approved by the US Food and Drug Administration (FDA) in 2003 was about half that approved in 1996. As a result, big pharma's pipeline of new products is drying up. Its emerging response is to turn to outside sources to supply new drugs and drug-discovery techniques. The structure of innovation in life sciences is increasingly geared towards the licensing or acquisition of out-of-house inventions.

■ **Structured processes.** Drug development is not a quick process—the average time between initial discovery and marketing approval is estimated at almost 15 years—but it is a well-trodden one. The steps that need to be taken to bring a new drug to market are transparent and well understood, which means that technology transfer offices have a better idea of the context in which to present discoveries to investors. In other fields, such as IT, there is no agreed roadmap from discovery to market, which

makes it harder for offices to structure financing and commercialisation processes.

It's worth noting that the US has some specific advantages in the field of life sciences R&D, and pharmaceuticals in particular. According to research from the Boston Consulting Group, the US accounted for 60% of the industry's global profits of US\$121bn in 2002. Since the large majority of drug development costs—such as clinical trials—are incurred once the initial stage development is complete and need to be conducted in the drug's key prospective markets, drug companies are understandably keen to concentrate much of their R&D activity in the US.

Just as important are the clusters of scientific, investment and commercial expertise that exist in specific places such as Boston and the San Francisco Bay Area. The decision by Novartis to move its R&D HQ from Switzerland to Massachusetts, for instance, was in large part driven by the quality and quantity of scientific talent in the Boston area.

would doubtless strive to make more money from technology transfer if their funding was more closely linked to commercialisation, but at what cost to the nature of universities as a whole?

Universities in some countries do not necessarily play a leading role in research at all. Some 80% of France's public research budget is devoted to organisations such as the basic research agency CNRS, the medical agency INSERM and the CEA atomic energy commission; a mere 5% or so goes to university research. In Germany, too, public research institutes are substantial recipients of public funding, with the Max-Planck-Gesellschaft (MPG), a non-profit society conducting basic research via its own network of 81 institutes, and the Fraunhofer-Gesellschaft (FhG), a society focusing on applied research and working closely with industry, being two of the biggest research networks. Current annual research income for Fraunhofer Institutes is in excess of €1bn, with two-thirds coming from research contracts and one-third from the federal and Länder (state) governments.

From a technology transfer perspective, does it really matter whether universities or other public research institutes conduct research? After all, the French and German systems confer benefits of spe-

cialisation, and Germany's in particular endows research initiatives with regional strength in depth. But there are indeed drawbacks.

■ Compared with Israel's extremely centralised system, for example, Germany's layers of research networks encourage a confusing proliferation of funding mechanisms.

■ Any system that creates a structural divide between basic and applied research is likely to minimise the amount of contact between basic researchers and industry: it is noticeable that the majority of our survey respondents tend to draw on the informal contacts of researchers to find potential investors.

■ The energy and creativity inherent in an environment that mixes teaching and research and students and academics is also lost, as are potentially useful longer-term relationships. As one respondent to our survey observed: "Most faculty have trained students and post-docs who are now in industry and those contacts are invaluable to the process of transferring technology."

The importance of networking to technology transfer is a topic to which we return later in this report, but first we examine the incentives for researchers and universities to participate in this field.

3

EMPOWERING RESEARCHERS AND UNIVERSITIES



Handing ownership of the IP in inventions to the university and giving universities freedom to negotiate exclusive licences has been the cornerstone of successful technology transfer in the US and elsewhere.

Ensuring the active involvement of the researcher in the technology transfer process is critical. Universities should enable and encourage researchers to participate in commercialisation by permitting sabbaticals and offering generous royalty and equity terms.

Entrepreneurialism is in large part a cultural attribute. Universities can do their bit to encourage its development by routinely teaching business skills to science students and faculty members.

Broadly speaking, commercialisation of new technologies is not the primary objective of academics or of universities. In order for institutions and researchers to invest time and resources into technology transfer, they need to be appropriately incentivised. It helps, of course, if entrepreneurial values run through the institution and the wider economy too.

Incentivising universities: The lessons of Bayh-Dole

The puzzle of how to motivate universities to engage in technology transfer has largely been solved, thanks to a piece of US legislation known as the Bayh-Dole Act.

Before the passage of the Bayh-Dole Act in 1980, few governments bothered to spell out whether the government owned the commercial rights to patentable inventions generated under publicly supported research, or whether the rights were to be left with the contracting university or even the actual researcher. The inevitable result was that there was a hodgepodge of patent policies everywhere.

In the US, for instance, each of the 26 federal agencies that funded academic research had its own set of IP rules. Making ownership of any potential intellectual property even more complicated, funding from different grant-giving agencies was often commingled. The result was such a nightmare for firms trying to negotiate rights to a piece of government-sponsored research that few bothered.

In simply transferring the ownership of the intellectual property embodied in research done at taxpayers' expense from the government agency funding the work to the institution and researchers doing it, the Bayh-Dole legislation gave universities, national laboratories and individual scientists working for them a powerful incentive to see their work commercialised. It also enabled universities to assign exclusive licences to new technology, smoothing negotiations

with industry and investors.

The results have been striking. University patents have surged since the passage of Bayh-Dole. Roughly 250-350 patents were granted to US universities annually in the 1970s; that number had risen to over 3,000 per year at the start of this decade.

The Bayh-Dole Act is not wholly responsible for this rise in US patenting activity. Other factors, including the rise of research-intensive industries such as biotechnology and the strengthening patent regimes, have also played their part. But the fact that the universities automatically had title to any inventions made with government funds clearly unleashed a new wave of commercialisation.

The act also gave universities the impetus to hire professional licensing staff and establish technology transfer offices for marketing their intellectual property. Channelling the commercialisation of IP at a university through a single office helps speed and clarify the process. As Lita Nelsen, head of the technology transfer office at MIT, arguably America's most successful research institution, says: "I think a specific office with clear authority of IP is critical. Only then can the organisation learn and improve. Too much dispersion of responsibility leads to confusion on the part of industry, and makes it impossible for the organisation to learn and grow from its experience."

In the years since the legislation went into effect, the Association of University Technology Managers (AUTM) has swollen from 50 to more than 3,000 members. "The Bayh-Dole Act was the most critical legislation to enable universities to establish technology transfer offices," says Sally Hines, an administrator at Stanford University.

Bayh-Dole is not immune from criticisms, some more telling than others. Social critics ask why consumers should pay twice (first, as taxes used for academic research and, second, as purchase prices) for

new drugs, devices or other products that originated in government-supported laboratories. But the benefits of the Bayh-Dole reforms in America have made it clear that there is an even greater cost to the public if inventions and discoveries, made at the taxpayer's expense, remain on the shelf. When research ideas are turned into economically useful and often life-saving goods that would not have existed otherwise, the taxpaying public is still a net beneficiary, even after paying a commercial price for the product.

More of a concern is some evidence to suggest that the desire to patent and license new technologies may risk delays in the publication of research results. A 1997 survey of over 2000 US life sciences faculty members showed that 20% of them delayed publication of results for at least six months, and half of this number did so with an eye on protecting patentability². Given that other research has shown that R&D managers regard publications, conferences and other informal channels of communication as more important outlets for knowledge transfer than patents and licences, the potentially adverse impact of increased patenting warrants further study³.

Replicating the provisions of the Bayh-Dole Act outside the US may not be appropriate for more country-specific reasons. To take one example, the legislation did away with the distinction between research grants (for a researcher's investigations in general) and research contracts (for a piece of targeted research). As a result, US universities automatically own the IP in any joint research with industry that receives federal funds. In the UK, where IP can end up resting with either party depending on negotiations, introducing such a provision would arguably risk disrupting existing collaboration with industry more than it would foster new innovation.

But the Bayh-Dole Act's success in encouraging technology transfer by creating clarity of ownership in IP holds fundamental lessons for all countries and has helped trigger upheavals in industrial policy internationally. IP rights are being reassigned not just from governments to institutions, but from researchers to institutions as well—for example, Germany abolished the “professor's privilege”, the right of university professors to own intellectual property generated by university-funded research, in 2002. In the UK, only Cambridge University, which is re-evaluating its position, still hands IP

rights to its faculty under certain circumstances. In Israel, inventions belong to employers by law; in France, institutions normally, though not always, retain title.

Not all countries are heading in this direction: Italy awarded IP ownership to researchers in 2001, for instance, and Sweden continues to grant researchers sole title to their inventions. But the presumption that institutions are likely to be more efficient interlocutors with business and investors, will have lower transaction costs, and offer greater legal security to investors than individual academics is a sensible one.

Incentivising the individual

Universities should drive the process but the chances of licensing success or spinout survival are greatly diminished without the vigorous participation of the inventor. The mantra of venture capitalists the world over is that they invest in people, not technology. Miranda Weston-Smith of Cambridge Enterprise in the UK says that the best technology transfer happens “when the chemistry between company and academic works well”.

At universities, in particular, the new technology is usually “raw”: that is to say, it needs a lot more work before it is commercially applicable, and, along the way, the use to which the technology is put may change significantly. Several early applications might be tried but be ruled out until the best one is found. This search process is badly hobbled in the absence of the original inventor who understands best the possible applications of his or her technology. “Many innovations”, says Jonathan Page of Imperial College Innovations, “are of a ‘platform’ nature. That is to say, they are not developed, linear fashion, into a specific product. Rather, they are innovations with a number of applications. It often takes a long dialogue with industry and with market researchers to reach the right application.”

Academics, of course, go into academia to conduct research rather than get rich. Involvement in a spinout, in particular, is not an obviously appealing prospect for many career academics. According to the American Association of University Professors, the average age for receiving a PhD is 33 and the average age for gaining tenure in the US is 40. The years in between require academics to knuckle down hard in order to attain tenure. As one technology transfer executive puts it, why

² “Withholding Research Results in Academic Life Science: Evidence from a National Survey of Faculty”, *Journal of the American Medical Association*, Blumenthal et al, 1997

³ “Links and Impacts: The Influence of Public Research on Industrial R&D”, *Management Science*, Cohen et al, 2002

give up the prospect of promotion or tenure in favour of a spinout, with all its attendant risks? After tenure is given, the allure of the spinout looks shakier still. But universities can motivate researchers at all levels to participate actively in commercialisation activities.

■ *Provide support, not red tape.* “At the level of working relations with our staff,” says Ami Lowenstein at the Technion in Haifa, “we aim to give innovators a real service, and not just be a burden to them when they want to apply for a patent. The worker is bound by his contract to disclose a potential patent to the administration. But if the technology transfer office is just another burden in the way of the inventor going and selling his idea, then he will do everything in his power to evade it.” Most of the university administrators we surveyed agree that it is sensible to have practical guidelines and forms available, and to conduct regular training seminars to show academic staff how to make a formal disclosure.

■ *Tie commercialisation to career development.* Progressive universities make sure that researchers get the message that disclosure is not only part of their job, but can also advance their career considerably. In some institutions, the number of potential patents that an academic has disclosed to the university authorities can be more important than the number of research papers he or she may have had published when it comes to being awarded a chair, made head of department, or granted tenure.

■ *Allocate revenue and equity fairly.* Another critical imperative is to ensure that the inventor gets a meaningful cut of possible future revenue from licensing, or a fair equity stake in any spinout. Some universities go as far as sharing licensing revenues and royalties equally with the inventor, although in most cases the university gets the bulk. At Carnegie Mellon University in the US, for example, half of the university's net income from technology transfer is shared with the researchers (unless they choose to take executive positions with a spinout company).

■ *Enable researchers to carve out sufficient time for their inventions.* In more forward-thinking universities, faculty members are allowed to take leaves of

absence to form new companies without fear of losing their university positions.

■ *Consider establishing incubators.* Increasingly, incubators take the physical form of space on campus given to fledgling companies, inventions or even, in the words of Amnon Shashua, head of the School of Engineering and Computer Science at the Hebrew University of Jerusalem, a person “with a piece of paper and a bright idea”. Usually, seed money (public and private, more of which later) is needed to bring inventions to the prototype stage. Sometimes, space is also given to local venture capitalists or business angels alongside university start-ups. “There is nothing better”, says one technology transfer office head, “than for inventors and investors to pass each other's door each day, or chat over a cup of coffee.”

The entrepreneurial society

The incentives that motivate researchers to participate in commercial activity are not all in the gift of universities, of course. The most perfectly designed university technology transfer processes will come to nothing if the wider environment is not supportive of entrepreneurs (for a broader discussion of these themes, please see our previous report, *The Double Helix*).

Taxation regimes act as one powerful incentive to entrepreneurial activity, for example. Technology transfer professionals in the UK reported an abrupt fall-off in spinout activity in the wake of tax rules introduced in 2003—since hastily repealed—whereby academics risked being charged income tax on any shares they own in spinout companies, even if those companies were not yet producing cash. Previously they were only charged capital gains tax on any profits they made when they sold their shares.

Issues of culture are also critical. According to Scott Carter at California Institute of Technology's Office of Technology Transfer: “A cultural willingness to take risks and accept the inevitable failures supports technology transfer efforts in the US. Foreign-born entrepreneurs in the US often remark at the relative lack of stigma for entrepreneurial failure.” To reinforce his view, a recent Eurobarometer opinion poll showed that 44% of timid-minded Europeans agreed that “one should not start a business when there was a risk of failure” against just 29% in the US.

The power of people

The importance of people to successful technology transfer is not disputed. But many argue that the biggest contribution that universities can make to economic development is not the transfer of lab technology into the commercial mainstream, but the transfer of people.

Stephen Allott, founder of the Cambridge Computer Lab Ring, the association of Cambridge computing graduates, and former president of Micromuse, has coined the term “people flow” to describe three ways in which universities shape, supply and mingle the human capital that creates wealth:

■ **Importing and retaining entrepreneurs.** Universities are often the means of attracting people from overseas—usually postgraduates—who will go on to become tomorrow’s successful entrepreneurs. Whether these people end up founding companies based on university IP or not is less important than the fact that universities lure exceptional people who will create significant wealth later in their careers. Awarding scholarships on the basis of entrepreneurial aptitude, awarding bursaries to entrepreneurially-

minded postgraduates, and marketing on the basis of entrepreneurial values are all approaches that universities can take to compete in this market.

■ **Supplying start-ups with talent.** Entrepreneurs who found start-ups often locate their companies close to their alma mater and employ technical graduates from the university.

■ **Supplying industry with research skills.** The application of existing research to known business problems is a surer route to successful R&D activity than the development of new technologies. The overall flow of graduates from universities into the employment market is most important not because of the new technologies they have discovered or will discover, but because such people are capable of looking up scientific research in their field—whether conducted locally or worldwide, contemporaneously or in the past—to solve valuable customer problems. “PhD graduates provide a science-on-demand service when employed in industry,” says Mr Allott.

Changing culture is a notoriously elusive goal. But as well as the substantive actions described above, universities have a vital role to play in achieving this objective through the teaching of business and entrepreneurial skills. As so often, US universities are ahead of the game in this regard. Kenneth Morse, Managing Director of the MIT Entrepreneurship Center, outlines a “mosaic of activities” designed to instill and encourage entrepreneurialism, among them placements of graduate students in high-tech start-ups; mentoring services for entrepreneurs; and most celebrated of all, the MIT \$50K Entrepreneurship Competition, whose 16 years have spawned over 60

companies with a combined value of US\$10.5bn.

Europe, by contrast, has far further to go. A 1999 survey of PhD students by the UK’s Engineering and Physical Sciences Research Council (EPSRC) showed that, whereas more than 60% of respondents thought that training in innovation and entrepreneurship would be valuable, fewer than 20% expected to receive such training from their universities. One venture capitalist in Germany points out that science and engineering students there graduate without any business or finance skills, and urges universities to educate students on commercial basics, such as writing business plans and analysing market potential.

4

THE PATH TO COMMERCIALISATION



Technology transfer success should not be measured solely in quantities of patents filed, or even licences negotiated or spinouts launched. Actual commercial success is a truer test of technology transfer.

The range of skills required to pick the technologies with the greatest commercial potential is daunting. The best universities draw on networks of investors, alumni and industry professionals to leverage external expertise.

Many technology transfer offices stand accused of having unrealistic commercial expectations. A strategy of seeking to maximise revenue impedes the development of repeat business and (often more lucrative) sponsored research.

In the previous chapter, we saw how the passage of the Bayh-Dole Act triggered a surge in patenting activities at US universities. As universities in other countries also seek to beef up their technology transfer processes, similar spikes in patent applications can be expected.

The reason is not hard to fathom. Every dean or provost now lives in hope that the next disclosure to come through the door will be another “recombinant DNA”. Over its lifetime, the recombinant DNA patent (which expired in December 1997 and ceased generating income the following year) returned no less than US\$225m to the co-inventors and their respective institutions, Stanford University and the University of California at San Francisco.

Patents cost money and do not necessarily deliver revenue, however. A truer test of successful technology transfer is the amount of money generated through licensing and spinouts. And the evidence suggests that only a very small proportion of technologies accounts for the bulk of US universities’ transfer revenue.

■ The 2003 AUTM survey found that just 1.4% of all licences generating revenue for US universities and other research institutions yielded more than US\$1m in income in fiscal year 2003. The average university invention that makes it successfully through the licensing process to become a commercial product or process earns the university and its inventor the princely sum of US\$120,000 over the course of its lifetime.

■ Yale University reviewed its 850 invention disclosures from 1982 through 1996. One percent (10 of 850) of total disclosures led to 70% of US\$20.4m received, and 4% (33 of 850) of disclosures accounted for 90% of the total licensing income. Almost nine out of ten disclosures (748 out of 850) generated less than US\$10,000 each, the approximate cost for processing one invention disclosure.

■ Despite its blockbuster success with the recombinant DNA patent, even Stanford is an illuminating example of the hit-and-miss nature of technology transfer. Only eight of the 2,000 or so patents that Stanford has managed to license over the years have generated more than US\$5m. Fortunately, there were more than 30 others that earned in excess of US\$1m apiece

Some universities have higher hit-rates. Columbia University, for example, was granted a comparatively modest average of only 34 patents per year from 1994 to 1998 but scored highly in terms of overall licensing revenue. If universities focused more time and resources on fewer, higher-potential technologies, could they create more value?

A more selective approach does pose practical problems. Technology transfer offices are wary of applying criteria that discourage researchers from bringing their inventions forward in the first place. Maybe so, but if researchers thought a successful disclosure genuinely signified a good chance of commercial reward, they might be more incentivised to disclose.

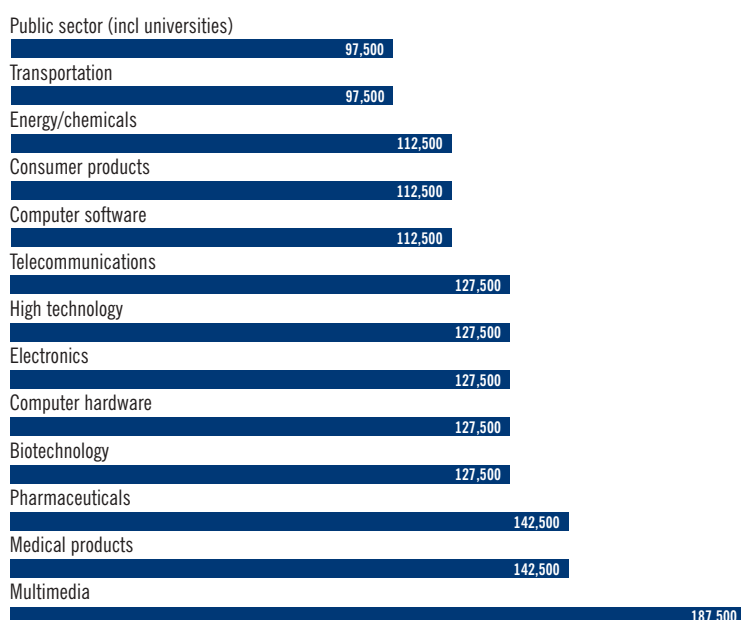
Others point out that the time and expense of assessing and identifying inventions with real commercial potential may outweigh the costs of filing patent applications on the marginal ones as well. Picking winners isn’t easy, certainly, but the process can at least be smoothed if universities can tap internal and external expertise.

Leveraging internal and external expertise

A rare blend of skills is needed to identify and nurture academic inventions into commercial products. Almost all of the technology transfer officers we surveyed pointed to the lack of managerial and commercial skills within universities as a fundamental challenge. The “rawness” of university technology

Licensing executives compensation, 2003

Median base salary by industry sector, US and Canada, US\$



Source: Licensing Executives Society, 2003

argues for the ability to spot potential discoveries: nothing worse than to have what later proves to be a winner slip through your fingers—it has happened far too often. Protecting IP needs special legal skills. Licensing requires a keen sense of market awareness, deep technological understanding and good negotiating skills. Creating spinouts requires knowledge of, and links with, investors (business angels and venture capitalists) and experience in business formation.

The trouble is, anyone with all or any of these skills can earn several multiples of a university salary in business or venture capital. A 2003 survey of licensing executives in the US and Canada showed a median base salary across all industries of US\$127,500, some US\$30,000 more than the median salary for public-sector licensing professionals. Licensing executives in pharmaceutical and medical products—key areas of academic research, remember—earn even more.

Many top technology transfer executives are recruited at a later stage in their career, at a point

when they can afford to take a salary cut in return for rewarding work. “I gave up a lot of salary,” says one, “but my kids are grown up, and I could afford to. However, now I’m getting a lot of calls from headhunters. So I know my staff are too.” The lesson is that universities are going to need to invest a lot more in their transfer operation, including paying more to hire the right skills. What that means in practice is that government funding aimed at the facilitation of technology transfer will need to be focused on attracting better talent.

There is another view. Some venture capitalists argue that universities miss the point when they “package” new, raw technology in an attempt to make it more marketable. Technology at universities is usually so “raw”, so untried, that to dress nascent companies up with business plans is, in the words of Charles Irving, co-founder of Pond Ventures, a specialist early-stage technology investor, “to dress babies up in Savile Row suits, when all we want is to see them in swaddling clothes”.

What the venture capitalists who hold this view want of universities is simply the chance to be able to take a good look at the new technology and then to deal directly with its inventors. For such investors, a hyperactive office of technology transfer is usually not a help, but a hindrance; and business plans for young university companies with no revenue are not worth the paper they are written on.

The kind of environment that suits the venture capitalist like Mr Irving is found in very few, lucky places, however. He would perhaps recognise it at MIT, where the technology transfer office chiefly invests in patents (it gets more than one disclosure a day from academics) and puts innovators in touch with business.

But such a hands-off approach lends itself most to an environment where an outstanding and highly entrepreneurial research body sits close to a geographical hinterland rich in entrepreneurs and tech-savvy companies (such as Stanford University and Silicon Valley, or MIT and Boston). “We are blessed that Kendall Square and Route 128 are a giant incubator,” says Kenneth Morse of the MIT Entrepreneurship Center. Not all universities have this hinterland of risk-taking venture capitalists to spot and invest in early-stage technologies.

Relationships, not money

Greater interaction with investors would help address one vocal criticism voiced in our survey—denied with equal vehemence by many universities, it should be noted—that universities hold out for unrealistic rewards for their new and usually untested technology. Again and again, financiers say that universities overrate the commercial value of their discoveries.

There are risks when universities sell too low, of course. Researchers may be less incentivised to commercialise innovation. So, too, the office of technology transfer itself. And it is only with the external validation of funding on competitive terms that a project can be taken seriously by all involved.

But one of the worst, rather than best, practices in running a technology transfer operation is to seek to maximise licensing revenue. It is noticeable that the most experienced universities settle for a (sometimes much) lower cut than the less experienced ones: 2-3% of revenue from licensing, for instance, compared with demands of up to 10% of revenue from others.

The important thing for universities to focus on is not to make pots of money, but to get their technology out into the world. And that means not haggling, according to MIT's Ms Nelsen. "We realise that our licensing terms have to be quite 'gentle', in recognition that our technologies are very early." The development of an agreed technology licensing framework that embraces "standard" contract terms is one way of simplifying negotiations.

Says the head of the office of technology transfer at another American university: "We recognise that in most cases a start-up company will have few cash reserves, and so we try to make deals that provide a

fair return to the university while leaving flexibility for attracting future investors; these deals usually have both an equity and a royalty component to them, but require little or nothing in the way of up-front payments from the new company."

Fostering relationships is more important than maximising revenue. Monitoring and feedback—the key to managing the licensee relationship—are crucial parts of the whole technology transfer process. Unfortunately, few universities pay anything like as much attention as they should to monitoring how a piece of their licensed technology is progressing in the customer's plant.

It is in the university's own interest to ensure that a licensed invention is successfully commercialised, and that the company involved makes money out of the venture. If a piece of licensed technology runs into unforeseen difficulties as it is being scaled up for production, the university needs to be ready to renegotiate the licensing fee—and even offer to undertake additional laboratory work for free to get the project back on track.

Doing so is the surest way of nurturing friendly relationships that can lead not only to repeat licensing fees, but also to direct contributions to the university's research budget and facilities. Encouraging industry to invest money—in the form of grants that support a scientist's research in general, rather than for specified pieces of development work—is one of the best, although often ignored, reasons for engaging in technology transfer. Says one technology transfer executive of a large US research university: "We take in US\$3m in licensing a year and US\$330m in research grants and contracts. We'd be foolish to lose research for licensing."

5

THE ROLE OF VENTURE CAPITAL



The lack of seed funding of embryonic inventions is a key barrier in technology transfer.

There is an equity gap that only a few specialist investors and business angels can bridge, although innovative models are gradually emerging to unlock venture capital.

Leading universities nevertheless recognise the worth of developing relationships with venture capitalists as a source of advice and expertise.

On the face of it, technology transfer ought to be fertile ground for venture capitalists. Universities have an asset (innovation) that can be translated into desirable and sometimes ground-breaking products, while venture capitalists have the money and, just as importantly, the business, managerial and marketing expertise to define the need for such products and to bring them to market. But the gaps between universities and investors in high-tech spinouts are not easily bridged.

Professor Shashua at the Hebrew University of Jerusalem says of universities and venture capitalists: “Our goals are contradictory. Venture capitalists are only interested in the short-term gain on an investment. It fundamentally contradicts the aim of a university.”

The equity gap

Universities face severe structural problems in accessing venture capital funding to help technology spinouts past their very earliest phases. “Good ideas,” says Jonathan Page of Imperial College Innovations in London, “are going to the wall because of a well-documented lack of money; or if they don’t fail, they take forever to get going.”

The reasons are both cyclical and structural. The cyclical reasons relate to the lingering effects of the technology bust of 2000, which has seen private equity firms move even more of their activity to later-stage investment activity, such as management buy-outs. Data for the UK show that only 3% of total private equity investment was invested at the start-up stage in 2001, and only a further 5% in other early-stage investments.

Far more important in explaining the relative lack of venture capital funding of university technology transfer activities, however, is the structural disconnect between universities and venture capitalists—namely, the fact that university technologies require financing at

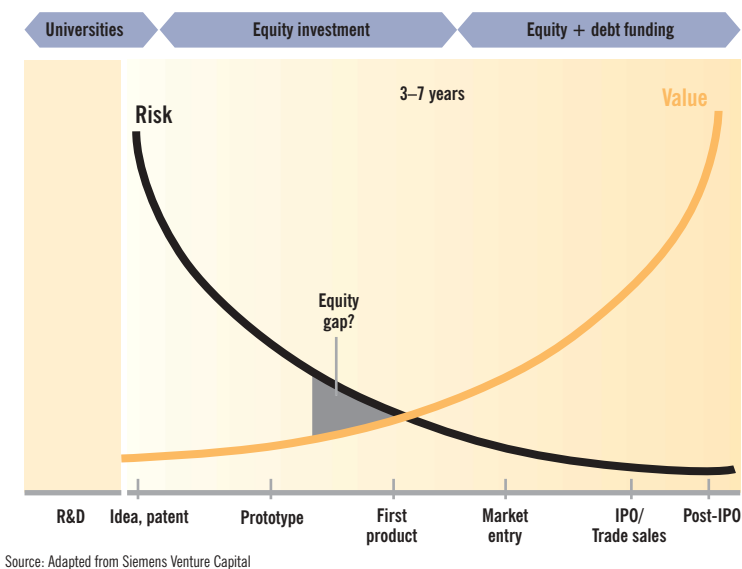
their embryonic stages which venture capitalists are not willing or able to give. Almost all respondents to our survey pointed to the lack of seed funding of embryonic inventions as a key barrier in technology transfer. The reasons for this funding shortfall, which is known as the equity gap, are twofold:

■ *The time gap.* Universities’ technologies are new and raw and a clear exit strategy is a long way off. According to the AUTM, much university technology in the US gets licensed at a point when it is seven or more years from being embodied in a marketable product. A typical venture-capital fund is open for ten years, but the pressure is on to be fully invested in the first three or four years. That leaves insufficient time for the tech company to prove itself in the market to the point where it can be sold or floated in a way that returns can be redistributed to fundholders.

■ *The finance gap.* There is a point beneath which it is not worthwhile for venture capital firms to invest money. High transaction costs, related to due diligence of the investee company, as well as ongoing running costs related to management of the company, reduce the viability of smaller venture capital investments. Whereas many venture capital companies draw the line at investments of US\$1m or below, university technologies typically require smaller amounts of money to reach proof-of-concept and prototype stages of development.

What is more, even when funds do take the risk of early-stage investments, in return for the prospect of higher returns, they all too often get heavily diluted by second-stage investors, if they are not prepared to put up pro-rata amounts of fresh capital. Because many business angels and smaller venture-capital funds making early-stage investments have got “washed out” in this way in recent years, they have

Stages of investment



proven unwilling to return. Investing in the early stage, says one UK technology transfer official, “is a very horrid place to be.”

Correcting market failure

There are some specialist seed investors focusing on very early-stage technologies, such as Pond Ventures in the UK and Arch Venture Partners in the US, but they are thin on the ground. “I have sympathy for technology transfer offices,” says Mr Irving of Pond Ventures. “There aren’t many qualified investors like us.”

Stage of development of licensed inventions by US universities

Survey of 62 research universities, 1998 (%)

Stage of development	Invention disclosures
Proof of concept but no prototype	45.1
Prototype available but only lab scale	37.2
Some animal data available	26.7
Some clinical data available	9.5
Manufacturing feasibility known	15.3
Ready for practical commercial use	12.3

Source: J Thursby, R Jensen, and M Thursby, “Objectives, characteristics and outcomes of university licensing: A survey of major U.S. universities”, *Journal of Technology Transfer* 26:59–72, 2001

Since venture capitalists can’t supply it in sufficient quantities, universities have a grave need for other sources of early-stage funding. Occasionally, universities themselves have sufficient endowments to finance this stage themselves. Stanford University, for instance, has a funding pool of US\$25,000 per invention for prototype development. Caltech runs a programme that provides funding of up to US\$50,000 to bring concepts closer to the prototype stage. At MIT, the Deshpande Center for Technological Innovation, among other activities, makes small awards that enable very early-stage, promising research to reach the proof-of-concept stage. But most universities, particularly outside the US, lack the funds.

Others have sought strength in numbers: Brunel University in the UK heads WestFocus, a seven-university consortium forming a co-ordinated innovation framework with business and industry, and incorporating a £1m early-stage fund and a £5m follow-on fund. The union between the University of Manchester Institute of Science and Technology (UMIST) and the Victoria University of Manchester is raising high hopes that greater scale will attract more interest from outside financiers at all stages of the investment continuum, especially at the equity gap stage, according to Clive Rowland, CEO of UMIP Ltd, the super-university’s new IP commercialisation company.

Often, early funding is provided by the innovator and his family. Business angels, high-net-worth individuals willing to invest their own capital in new ventures, are another important source of seed funding for very early-stage ventures.

But the most effective way to right what constitutes a market failure is government funding. In the UK, for instance, the University Challenge Fund competition was set up in 1999 specifically in response to the “equity gap”: by 2002-03, 101 projects were approved for funding, at an average investment of £126,000. In the US, the Small Business Innovation Research (SBIR) programme offers a large number of grants and contracts to new businesses. In Israel, the Office of the Chief Scientist (OCS) has created a network of 24 technology incubators to promote technology transfer from academic institutions to industry. Respondents to the survey undertaken for this report were agreed on the need to continue to expand public seed-funding initiatives.

The value of VCs

Even if most venture capitalists are not throwing cash at embryonic university technologies, they may do so later. And in the meantime, they can substantively improve the process of commercialisation by contributing their expertise.

Many technology transfer offices do not use the same set of criteria for selecting inventions to patent as outside investors would. Most of the universities we surveyed for this report are fairly clear-headed in their approach, focusing first on the inventor's track record and second, on the potential size of the market. Often, however, too high a priority is given to non-commercial considerations such as the inventor's reputation in the field of discovery and the likelihood of further inventions or discoveries in the field being made by the researcher.

To address this problem, Mr Irving of Pond Ventures argues for government funding to be channelled through a proof-of-concept fund, nationally or regionally administered, with VC representation on its board. Wherever public money is available, matching funds could also be required, so that young ventures do not quickly become "fat and lazy".

Some universities have tried their own approach, drawing on venture capital and sometimes government money. For instance, Israel's Technion, in effect, sold its incubator in 2003, privatising it to four venture funds that sit with the university every few weeks to decide which technologies to support. For the funds, this kind of scheme is still a higher risk than later-stage investments, but the risk is mitigated by the office of technology transfer undertaking the huge investment in managerial effort that early-stage academic ventures require.

Also in Israel, the trade and industry ministry's science office can choose to put up to the equivalent of US\$400,000 as seed money in new university ventures, in return for an equity stake. But since there is an option for other shareholders to buy out the government's equity within five years, there is a strong incentive for venture capitalists to put in their own money.

In the UK, one VC company, IP2IPO, has invested in Oxford's chemistry department, King's College London and the University of Southampton. Offering management expertise with the money, the company gets a stake in the universities' technology-transfer business. Imperial College has taken another tack,

selling 29% of its technology transfer arm in a private share placement and announcing plans for a public flotation within the next three years.

Heads up = head start

Our survey clearly underlines that, even if venture capitalists do not provide financing during the heart of the technology transfer process, developing relations with VCs is still taken very seriously at the best universities.

Georgia Tech takes interesting technologies on an annual roadshow to San Francisco and Boston, for example. Carnegie Mellon University holds roundtables of five to seven people from the university, industry and the investment community. Participants are invited to help review technologies and to advise on the commercial potential of those technologies—even though most VCs do not usually invest in the university's spinout companies until years later. Carl Mahler of the university's technology transfer office is enthusiastic: "[The roundtable] seems to meet everyone's needs effectively. It gives VCs early notice of our technologies, provides opportunities for our faculty to network with VCs and gives the tech transfer office the benefit of the VCs' knowledge of relevant markets."

More proactive universities have developed particular relations with certain firms. At Cambridge University, there is no exclusivity, but there is a list of venture capital firms that the university will call if there is a promising investment candidate. A condition of being on the list is that a firm must agree to a meeting with the candidate if the university asks for it. Of the last 30 companies that have been presented to investors in this way, all have got funding.

With the possible exception of a small country like Israel, it isn't practical for every university to forge significant relationships with venture capitalists, particularly in countries where the latter is a rare breed. One venture capitalist suggests running nationwide university spinout competitions in which the leading ten companies present to VCs in an annual event.

Venture capitalists in continental Europe say universities there are missing a big trick. "What I find curious", says one, "is that I'm never asked by any university representative for advice. They seem to have these closed circles for advice. Neither I nor my equivalents at other firms have been asked to join an advi-

sory board, or even to be a guest once in a while at a TT office's strategy session. Yet we are very willing to do this. We are all enthusiasts of technology, all ex-scientists or engineers. We are a resource that universities could tap into that has never been utilised."

The interests of universities and venture capitalists are closely aligned. Venture capitalists rely on offices of technology transfer at least to publicise, and in many cases to help nurture new ideas until they do

reach commercial maturity; universities benefit from the advice, expertise and (eventually) money that venture capitalists can bring to the table. Successful relationships between universities and venture capital firms need not be measured directly by financial rewards—keeping open channels of communication, networking and sharing risks is a more realistic way for these two critical innovation communities to co-operate and thrive.

6

IN CONCLUSION



The arguments for promoting university technology transfer are compelling. From the perspective of the economy at large, valuable IP will lie unutilised without specific mechanisms to push it into the commercial mainstream. From the perspective of companies, major universities are a natural source of breakthroughs in research, particularly in basic research. And from the perspective of universities, technology transfer offers the potential for additional revenue.

But the difficulties involved should not be underestimated. Despite a surge in documented patenting activity, revenue from technology transfer is small, compared with overall university income. Even in the US, where there is greater experience with academic licensing than anywhere in the world and the wider external environment is arguably more propitious than anywhere else, the average university technology transfer office is widely believed to lose money.

The inherent difficulties of commercialising new technologies aside, our research suggests a number of structural difficulties that will always make this activity particularly testing:

■ **Lack of skills.** Academic researchers too often lack the commercial skills to go with their technical expertise—successful transfer depends on creating a team of people that combines research and business acumen. Within the technology transfer office itself, the commercial, technical and managerial qualities required to choose high-potential inventions and shepherd them through to commercialisation are both rare and highly regarded. To overcome these problems, universities need to create and access fluid networks of committed people whose talents, knowledge, money and ideas can be pooled and leveraged.

■ **Lack of financing.** Seed capital is always going to

be hard to unlock when inventions have not even reached the proof-of-concept stage. Government financing schemes such as the University Challenge Funds in the UK and the Small Business Innovation-Research (SBIR) programme in the US are an obvious way to nurture technologies to the point where venture capital firms and other investors can conduct substantive due diligence on commercial prospects. But outside commercial expertise is still needed to determine where the money is allocated.

■ **Lack of incentives.** There is consensus that the active involvement of the inventor is critical to the success of the licensing and (especially) spinout process. Faculty researchers need to be actively incentivised to participate in technology transfer; postgraduates need to be encouraged to stay on at universities and placed in an environment in which their entrepreneurial instincts can flourish.

■ **Lack of scale.** The cost of technology transfer is high: the AUTM's 2003 survey reports that 193 member institutions in the US spent US\$205m between them on legal fees alone. The world's leading universities may have the staff, the infrastructure and the funds to make the economics of technology transfer work, but many smaller universities do not.

Experience garnered mainly in the US, but elsewhere too, highlights some of the ways in which these challenges can be overcome—through university policies and cultures that reward academics for their involvement in commercialisation, through a legislative and regulatory framework that assigns IP in university inventions to the university itself, and through the banding together of universities' transfer activities to create scale. But two more fundamental messages also emerge from our research:

■ *Less is more.* Too many patents don't turn into licences; too few licences turn into significant earners. Technology transfer offices ought not to be profit centres—that is only likely to encourage unrealistic negotiating terms—but they should still be measured on market-driven criteria, such as spinout profitability and product sales. Such measurement, perhaps reinforced by top-up funding awards for the best performers, is likely to encourage universities to focus their energies on the inventions with the greatest potential.

■ *Look outside the institution.* Technology transfer offices cannot do it all, even if some try to. University technology transfer should not be the purview of uni-

versities alone—the expertise of venture capitalists, business angels, alumni, industrialists and other professionals should be systematically leveraged to identify and nurture the technologies with the highest commercial potential.

Although the challenges of university technology transfer are arguably greater than commercialisation in the private sector, the principles of success are no different. A handful of the world's leading research centres may be able to rely on the overall quality of their disclosures to justify a scattergun approach to patenting and licensing. But for most universities, the sniper is needed.

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