Harnessing success: incentives for invention and technology transfer in universities

Universities are a key source of the new scientific knowledge that drives long-run economic growth. But what are the incentives for scientists to generate commercially valuable inventions and for university managers to license such technologies to the private sector? Research by **Mark Schankerman** and colleagues investigates.

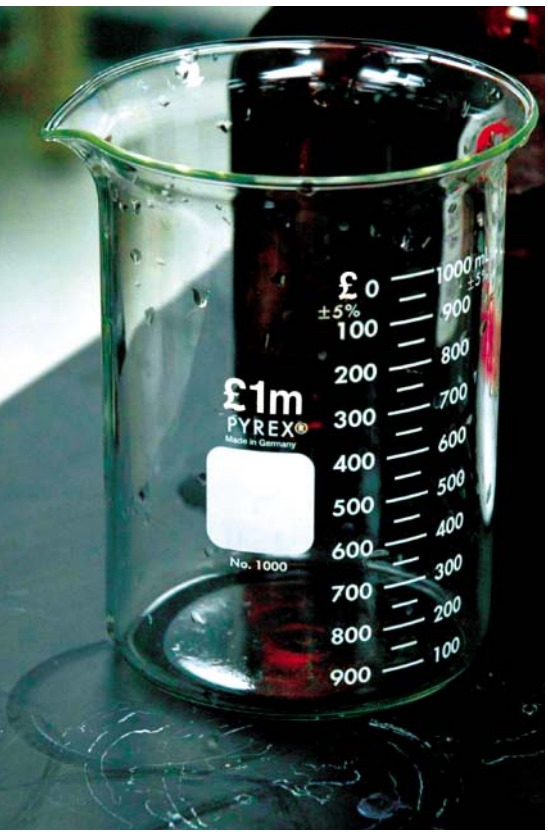


Image: Ron Achin

Perhaps the greatest long-term productivity advances come through breakthroughs in basic knowledge – and a substantial proportion of the research and development (R&D) that creates new knowledge and leads to increased productivity is done in universities.

University research not only raises the productivity of private sector R&D (through 'knowledge spillovers') and encourages more of it to be done; it also leads to inventions that can be commercialised, either through licensing to private firms or via the formation of new start-up companies.

Such 'technology transfer' by universities has grown dramatically in the past two decades, particularly in the United States. Between 1991 and 2004, the number of US university patent applications rose from 1,584 to 10,517, and licensing income increased from $218 million to $1.4 billion (which is 6% of federal R&D financing for universities). European and Asian universities are less involved in this form of technology transfer but are rapidly expanding their activities.

The rapid growth of technology transfer in the United States is in part due to the Bayh-Dole Act of 1980. This piece of legislation not only gave universities the right to patent new discoveries but also mandated them to license inventions made with federally sponsored research to the private sector. Now, nearly all US research universities have a technology licensing office and explicit intellectual property policies and royalty-sharing arrangements for their scientists.

Analysing technology transfer

In essence, technology transfer involves two distinct activities: innovation by university scientists and commercialisation by the university's technology licensing office (see Figure 1). In the first stage, scientists produce both publications and inventions. The mix of these two may be influenced by the incentive of money,

either for themselves directly or as enhanced funding for their research laboratories. Other incentives – such as promotion and tenure rules, and intrinsic motivation to do basic and applied research – are also likely to play a role.

The second stage is the commercialisation of inventions by the technology licensing office, which decides whether to patent and license inventions, identifies licensees and structures contracts. The effectiveness of the technology licensing office is likely to be influenced by the university's objectives, government constraints on licensing and incentives given to its managers.

Our research programme is studying the role of incentives and other institutional features that can make the process of technology transfer more effective. Given the importance of research for long-term growth, it is critical to understand what drives scientific endeavour and technology licensing activity.

Is research a purely intellectual pursuit driven by intrinsic motivation, or do economic incentives play a role in the way that scientists structure their work? What are the most appropriate incentives for managers in technology licensing offices? And how is technology transfer performance influenced by whether a university is private or public (and hence constrained by government objectives) and the degree to which it chooses, or is obliged, to promote local and regional development? Our research programme explores all of these questions.

Scientists are motivated by both love of research and potential monetary rewards

Royalty incentives for scientists

In a study with Saul Lach, I use US data (as similar data are not yet available in Europe) to examine how the share of licensing royalties from university inventions received by academic inventors (their 'cash flow rights') affects the number and licensing value of inventions in universities.

Our central finding is that incentives are effective: universities that give greater royalty incentives do much better in terms of licensing income from technology transfer. This works both by inducing greater effort by researchers and through 'sorting' of the most productive and entrepreneurial scientists into high-royalty universities. We also find that royalty incentives have a much larger impact in private universities than in public ones, and technology licensing activity is more commercially effective in the former.

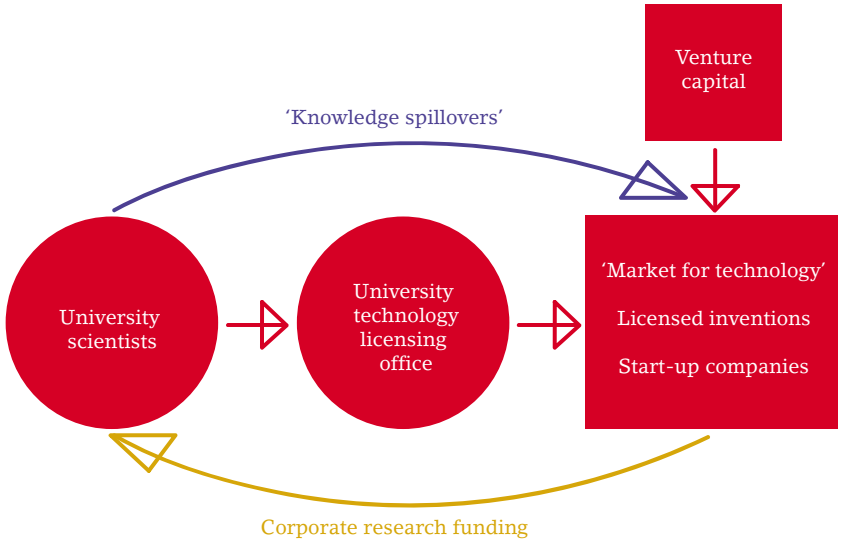
In the United States, universities usually claim exclusive ownership ('control rights') over inventions made by their scientists. But the cash flow rights from licensing inventions are typically shared between the inventor and various parts of the university according to specified royalty-sharing schedules. There is substantial variation in these arrangements across US research universities, which makes it possible to estimate their effect on inventive output.

Our study focuses on two outcomes – licensing income and the number of inventions disclosed by faculty scientists to technology licensing offices – using data from the Association of University Technology Managers, combined with information on the distribution of royalty shares for 102 US universities during the period 1991-99.

The novel aspect of the data is the information on the distribution of licensing income between the university and the inventor(s). The inventor retains a given percentage of net licensing income and the rest is allocated to the inventor's laboratory, department and college and to the university. Our criterion for identifying the inventor's share is that the inventor must gain either cash flow rights or must have direct control rights over the income (for example, lab research money).

In about half the universities, these royalty shares vary with the level of licensing income generated by an invention ('non-linear royalty schedules'). The average inventor's share is 41% among the 58 universities using linear royalty schedules, but there is substantial variation: the minimum inventor royalty share is 25% and the maximum 65%. The royalty shares in the 44 universities with non-linear schedules display even larger variability: the average royalty share is 51%, but the minimum is 20% and the maximum 97%.

Figure 1:
University-private sector science links



Another striking feature is that in every university, inventor royalty shares are either constant or decline with the level of licensing income per invention. On average, they start at 54% and decline to 30% for inventions generating over $1 million. Royalty shares are also unrelated to various characteristics of the universities, such as faculty size, academic quality and the number of technology licensing office professionals per faculty.

Among the more detailed findings of our research:

- Academic research and inventive activity in universities respond to variations in inventors' royalty shares. Controlling for a variety of factors – including university size, quality and R&D funding – universities with higher royalty shares generate higher levels of licensing income. This finding is important because it implies that the design of intellectual property rights and other forms of incentives in academic institutions can have real effects.
- Inventors respond both to cash royalty share and to royalties used to support their research labs (when the scientists have direct control over their use). Thus, both high-powered monetary incentives and intrinsic motivation seem to play a role. This is relevant to the design of university royalty-sharing arrangements. For example, non-science faculty may view generous payments to support research labs as less objectionable than direct cash payments to the scientists.
- The incentive effects of royalty-sharing work both by inducing greater effort by scientists and through sorting of scientists across universities so that the most productive and entrepreneurial scientists tend to work in higher royalty universities.
- The response to incentives is much larger in private universities than in public ones. If universities do not expect a strategic reaction from their competitors, the research indicates that in most private universities, and in about half the public ones, the incentive effect is strong enough to produce a 'Laffer effect', where raising the inventor's royalty share actually increases the license revenue retained by the university (net of payments to inventors).
- But when universities expect competing universities to match changes in their royalty share, the benefits to the universities of raising inventors' royalty shares will be smaller. Thus, high-powered, invention-based incentives are important, but so too is the strategic behaviour among universities in setting these incentives.
- Technology licensing offices are more productive in private universities, suggesting that private institutions have more effective, commercially-oriented technology transfer activity.

The incentive effect of royalty-sharing for scientists is much larger in private universities

Incentives for technology licensing offices

Why might university ownership affect technology transfer performance? In a study with Sharon Belenzon, I combine evidence from surveys of US universities' technology licensing offices with panel data on licensing performance to address this question.

Whereas previous research has shown that technology transfer performance is influenced by university characteristics and other factors, including university ownership (public versus private), academic quality, local (high-tech) demand conditions and licensing contract design, our study focuses more on the `black box' of productivity within the technology licensing office. We examine three key determinants of technology licensing productivity – performance pay; local development objectives; and government constraints on licensing activity – combining new survey data with panel data from public sources on 86 US universities for the period 1995-99.

The survey data show that universities' two main objectives are generating licensing income and promoting local and regional development, the latter goal being more prominent in public universities. Institutions that view local economic development as one of their primary functions might perform differently from those that exclusively pursue income maximisation.

Public universities are also more affected by the imposition by state governments of a variety of constraints – both statutory restrictions and informal political pressure – on their licensing activity. Our study quantifies the impact of incentives and measures the implicit cost of these constraints and of concentrating on local development objectives by estimating forgone licensing income.

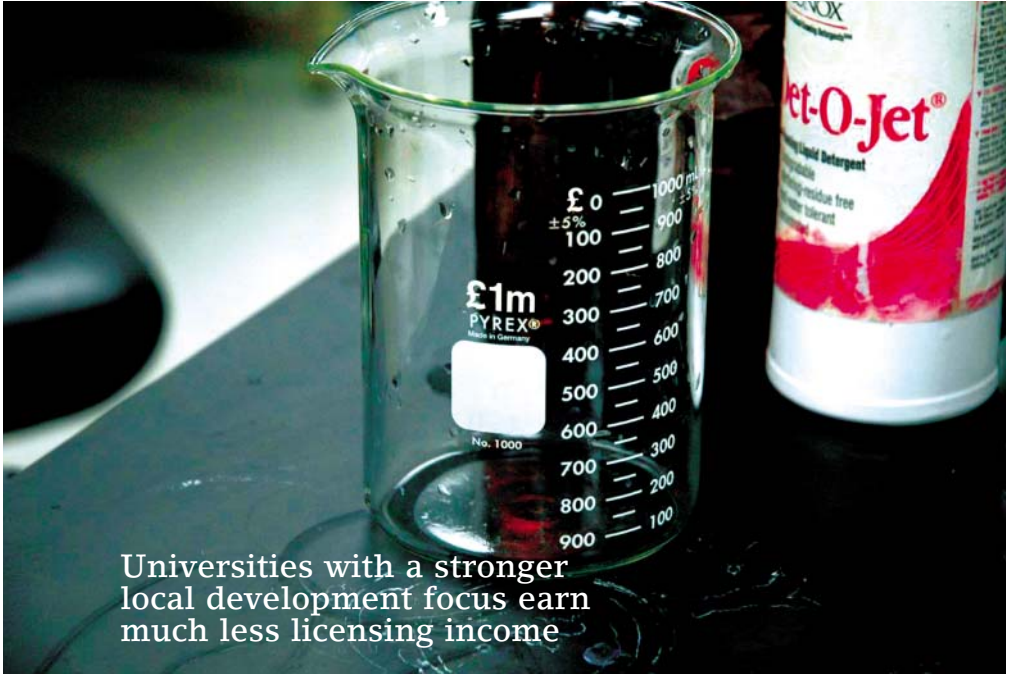
We find that technology licensing offices in private universities are much more likely to adopt incentive pay for their staff than those in public institutions. But ownership does not affect the licensing performance of the technology licensing office once the use of incentive pay is controlled for. From a policy perspective, this means that it might be possible to get 'private performance' from public institutions if the right incentives are introduced.

These incentives certainly matter: we find that technology transfer performance is strongly influenced by whether a technology licensing office uses performance-based pay for their staff.

We also find that technology transfer performance is affected by the extent to which there is a preference for developing licensing activity locally rather than more widely, and by formal and informal constraints imposed by government. Universities with a stronger local development focus earn far less licensing income from a given pool of inventions. This raises important policy questions about the right balance between income maximisation and local development focus in technology licensing activity.

Among the more detailed findings of our research:

- Compared with technology licensing offices in public universities, those in private universities are significantly more likely to use performance-based pay. Among the private universities surveyed, 79% use some form of incentive pay as compared with only half of the public universities.
- Performance pay has strong incentive



Universities with a stronger local development focus earn much less licensing income

effects. Universities that use bonus pay generate, on average, about 30-40% more income per license, after controlling for other factors.

- While private ownership has a large, positive effect on the adoption of incentive pay, ownership has no independent effect on licensing performance, once we have controlled for whether the university has adopted incentive pay.
- Private universities are much less constrained in their freedom of operation by state laws and regulations, and are more likely to be focused on generating licensing income compared with more 'social' objectives such as promoting local and regional development.
- Local and regional development objectives are 'costly' in terms of forgone license income. Universities with strong objectives of this kind generate, on average, about 30% less income per license, after controlling for other factors. State government constraints also reduce license income.

The finding that local development objectives are costly in terms of the forgone license income raises an important policy question. There are two economic arguments for having a preference for local licensing. First, pure knowledge spillovers have a tendency to be geographically localised. Second, the new economic geography literature emphasises that growth can be stimulated by agglomeration effects working through various supply and demand linkages.

But by showing that there is an opportunity cost of promoting local development in this way, our research highlights the importance of comparing this approach with an alternative policy of maximising income from university inventions (with no preference for local development) and using the additional license income generated to finance local economic development in other ways – for example, through lower business taxes or direct subsidy programmes.

Royalty incentives for scientists need to be combined with performance incentives within technology licensing offices

Conclusions

Many countries, in Europe and beyond, are increasingly concerned about how to promote more effective technology transfer and other forms of research collaboration between universities (and other public research organisations) and the private sector. Clear ownership rights, incentives and a clear definition of the objectives of technology transfer are key elements of that process.

Our research makes a contribution to that public debate by showing that the benefits to universities are strongly affected by how incentives are set and by identifying characteristics of technology licensing offices that influence the effectiveness of royalty incentives.

One caveat applies to all this work. Our findings contribute to the policy debate about the effectiveness of university licensing activity, but they are not a cost-benefit analysis of the 'commercialisation' of universities. Many scholars have expressed concerns about the potential costs of these developments, including the threat to established norms of 'open science' and the potential redirection of research away from fundamental science. While there is only limited evidence of such costs thus far, continuing vigilance is needed to ensure that they do not get out of hand.

Important challenges for research and policy remain:

- How should the 'market for technology licensing' best be structured, and what role, if any, should government have in that process?
- Should universities have monopoly control over the inventions of their scientists, as they currently do, or should the scientists be free to market their inventions through other channels?
- Should the use of market-based patent and licensing intermediaries be allowed (while preserving the sharing of cash flow rights between the scientist and the university)?
- How much geographic specialisation should there be (for example, should universities join into regional technology transfer offices, as in some countries like Germany?) and should such offices specialise in particular scientific disciplines?
- In short, how should the market in technology transfer be structured to exploit most effectively the economies of scale and informational advantages in these activities?

This article draws on research reported in 'Incentives and Invention in Universities' by Saul Lach and Mark Schankerman, CEP Discussion Paper No. 729 (http://cep.lse.ac.uk/pubs/download/dp0729.pdf) and 'The Impact of Private Ownership, Incentives and Local Development Objectives on University Technology Transfer Performance' by Sharon Belenzon and Mark Schankerman, CEP Discussion Paper No. 779 (http://cep.lse.ac.uk/pubs/download/dp0779.pdf).

Mark Schankerman is professor of economics at LSE and director of CEP's research programme on productivity and innovation. **Saul Lach** is professor of economics at the Hebrew University of Jerusalem. **Sharon Belenzon**, a CEP research associate, is a postdoctoral research fellow at Nuffield College, Oxford.