Chapter 3

Policies to enhance the transfer and commercialisation of public research

Within the past three decades, there has been a rise of initiatives by OECD member countries and public research organisations (PROs) to foster the transfer and commercialisation of public research results. This chapter sets out the context for the development of various initiatives, provides a taxonomy, and discusses recent trends, both at the institutional and governmental level. The strategies and policies reviewed include legislative initiatives, new bridging organisations, collaborative IP tools and patent funds, new technology transfer office (TTO) models, "open science" and "open research data" initiatives, monetary and non-monetary incentives to researchers to disclose and share research results, and initiatives to foster greater entrepreneurship in PROs.

The past three decades have seen a heightened focus on the commercial potential of public research. Over that time, a number of driving factors have led to the emergence of targeted initiatives at all levels to incentivise the transfer and subsequent commercial development of public research. This has required public research organisations (PROs) to get involved in the creation and management of intellectual property rights (IPRs), as well as entrepreneurial activities and forms of external engagement with industry. One of the most influential and well-known initiatives to stimulate commercialisation of public research is the Bayh-Dole Act in the United States, which was an outcome of and response to the changing policy environment. The drive continued elsewhere with many replications of this act; several European countries abolished the inventor ownership system ("professor's privilege").

In the United Kingdom, entrepreneurial activities in universities began to increase in the mid-1980s, when heavy budget cuts forced the universities to adopt more proactive approaches to commercialisation. This was accompanied by the establishment of technology transfer offices (TTOs). The UK government also began actively supporting university commercialisation in the mid-1990s. In Germany, commercialisation of public research has been a central concern for the government since the 1980s. In Sweden, numerous bridging and boundary spanning organisations were founded in the mid-1990s, such as science parks and national competence centres. At the same time, universities set up TTO structures. In Italy, in the early 1990s the government granted greater autonomy to universities, which led to their establishing commercialisation mechanisms in form of TTOs. Canada also has a long tradition of government involvement, for example to promote the use of public research with a large number of programmes at federal and provincial level.

Emerging OECD and non-OECD countries have also developed commercialisation policies. China, Brazil, Mexico, Malaysia and the Philippines have adopted explicit laws to provide the innovation system with the legal framework to commercialise public research results. And some, such as Mexico, have designed and implemented policy instruments to actively promote industry-science relationships (ISR), e.g. through the PROINNOVA programme, which funds collaborative R&D between SMEs and universities. Governments, as in China, are also attempting to measure the performance of universities by counting the number of spin-offs or start-ups (e.g. Intellectual Property Report of Chinese Universities conducted by the Ministry of Education in 2010; see Table A.1).

Different levers for accelerating transfer and commercialisation

Initiatives to enhance knowledge transfer and commercialisation of public research have become a multifaceted, multi-actor and multi-level endeavour. Owing to the recognition by policy makers of the broader channels resulting from public research beyond the mode of idea-patent-license, policies for knowledge transfer and commercialisation have expanded and are often combined with higher education, economic and regional policies to allow for broader systemic impacts and synergies.

New transfer and commercialisation initiatives have not only become institutionalised by governments, but also by PROs themselves. As a consequence of increased university autonomy and a changing global and local environment, institutions themselves are reforming and experimenting with initiatives that reflect each institution's legislative, financial and cultural context.

As indicated above, some of the initiatives may be induced top-down from the government and its agencies, while other initiatives are emerging bottom-up from entities inside PROs (Goldfarb and Henrekson, 2003) (Figure 3.1). The behaviour of researchers can also be considered bottom-up, as they have the contractual discretion to engage in commercialisation activities (Wright, Mosey and Noke, 2012a).

Figure 3.1. A policy maker's view on promoting knowledge transfer and commercialisation

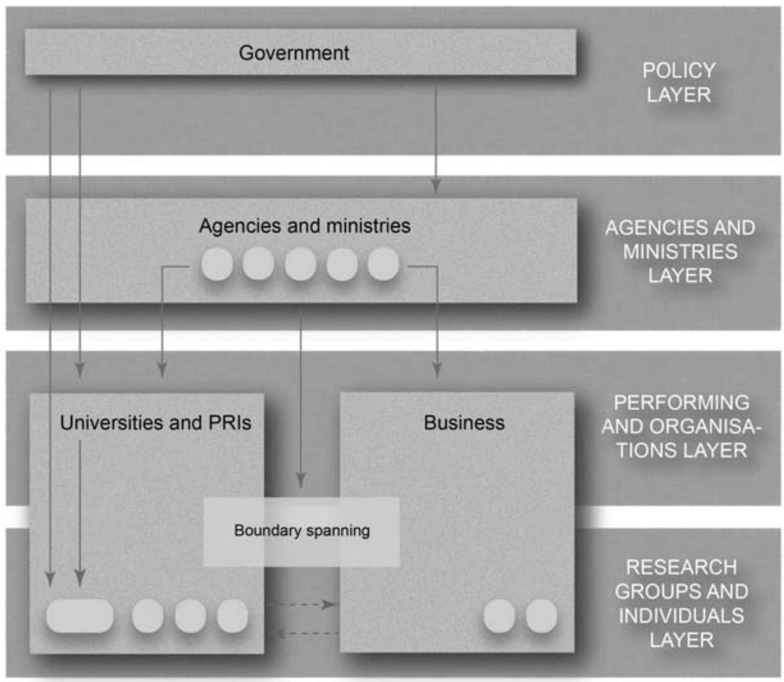
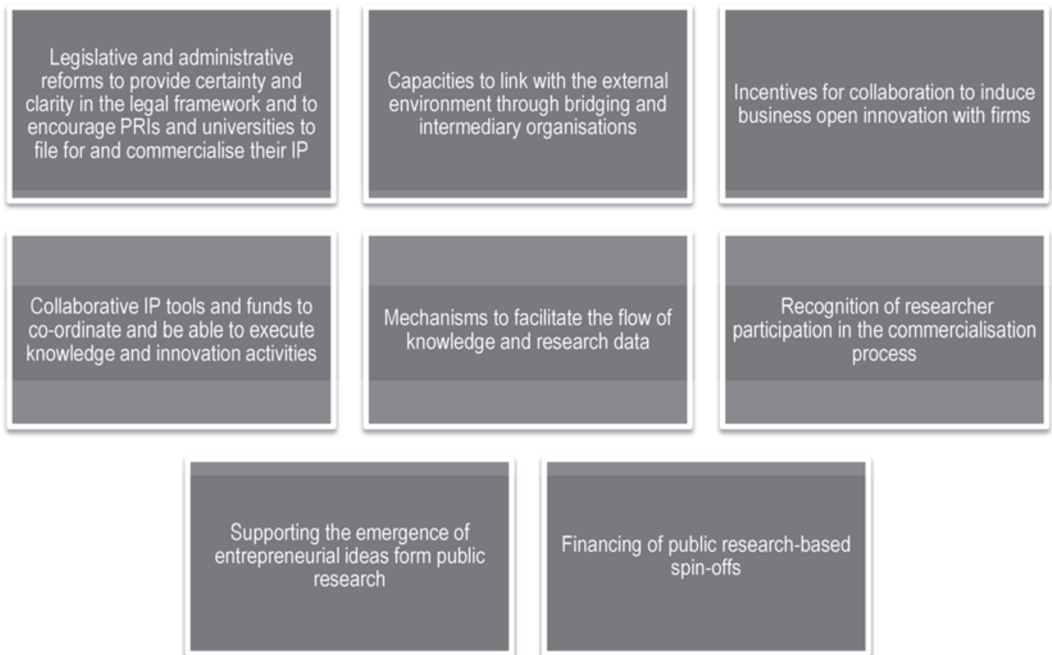


Figure 3.2 illustrates the range of programmes and initiatives pursued by governments and PROs. Many more, however, are along the lines of existing ones and so may not constitute new initiatives/programmes. In addition, at first glance all of these programmes/initiatives are in one way or another oriented towards the transfer and commercialisation of public research. But the mapping and classification of types proved to be more difficult because of their multidimensionality, and because a number of initiatives are rather heterogeneous and binary in nature. The following sections therefore contain programmes/initiatives supported by institutions and governments alike. For illustrative purposes, Tables B.1 through B.4 in Annex B provide a non-exhaustive list of programmes administered by OECD member countries, extracted from the *OECD Science, Technology and Industry Outlook 2012* questionnaire responses and the European Commission's Erawatch platform.

Figure 3.2. Strategies and policies for enhancing the transfer and commercialisation of public research



Legislative initiatives related to commercialisation and patenting

The legislative trend to incentivise the commercialisation of public research has clearly intensified. In the 1960s, Israel was among first countries to implement IP policies for universities (WIPO, 2011). By now, nearly all OECD countries have adopted specific legislative frameworks and policies (Geuna and Rossi, 2011). For example, 92% of Japanese national universities had drawn up an IP policy by 2008, following the Japanese version of the Bayh-Dole Act passed in 1999 (Okamuro and Nishimura, 2012). According to *Statistics Canada's* (2010) Survey of Intellectual Property Commercialization in the Higher Education Sector, 88% of Canadian universities were in 2008 actively engaged in IP management.

Ownership of academic inventions at PROs devolves to institutions to varying degrees in most OECD countries, and some still maintain a system of inventor ownership (Box 3.1). Ownership policies therefore reflect different historic, legal and structural characteristics of public research systems (Grimaldi et al., 2011). In Europe, several reforms have been introduced since the late 1990s. Most European countries moved towards a system of institutional ownership (e.g. Baldini, Grimaldi and Sobrero, 2006 for Italy; Della Malva, Lissoni and Llerena, 2008 for France; Meyer and Tang, 2007 for the United Kingdom; Geuna and Rossi, 2011 for Europe).

Box 3.1. Ownership of academic inventions

One of the commonly debated issues in commercialisation is the question of IPR ownership. Most OECD countries, with the notable exception of Sweden and Italy, have removed the so-called "professor's privilege" which exempt professors from employment or research funding rules that grant universities rights over IPR.

There are two main arguments in favour of the professor's privilege. The first concerns expertise vs. red tape and the second incentives for spin-offs and entrepreneurship. Both can cite supporting evidence but face counter-arguments. The expertise argument concerns the researcher-inventor's intimate knowledge of the invention compared to (often less experienced) TTO staff and potentially burdensome regulations. This line of argument is supported to some extent by the high hopes and meagre success of universities in many countries in building up, defending and profiting from their IP. Therefore, it is argued, it is better to let experienced researchers take care of their inventions and either create a firm or collaborate directly with firms that will offer a down payment and royalties to the inventor, who may then accumulate some personal wealth. One counter-argument in support of institutionalised IP portfolios is that universities are financed through taxpayers' money and provide the infrastructure and staff and a secure position for researchers, so that revenues from the invention should not belong to the individual inventor alone. Another argument is that universities need to know about their IP potential (and portfolio) in order to build a coherent transfer and commercialisation policy; however, an obligation placed on all staff to disclose inventions and ensuing deals would overcome this problem. The main counter-argument to the expertise argument seems to be that a long-term, highly professionalised transfer and commercialisation policy can succeed and contribute both to revenue streams to the university and to industrial development close to the campus.

The second argument is that professional TTO structures reduce incentives for spin-offs, as there are clear incentives for TTO managers to license out IP to existing firms and receive quick and relatively safe returns. Spin-offs bring more long-term profit, as more patents appear to be actually used; the new firms may grow quickly and will probably be located close to the university, with the possibility of constant interaction with academics. Finally, successful entrepreneurs often donate generously to their former universities. Counter-arguments include the relatively low number of direct academic spin-offs and strong incentives for academic researchers to enter "cheap" personal IP deals with industry.

All in all, there are arguments for both forms of IP ownership. At the very least, it would seem prudent to have academics report their IP holdings to their universities. The difficulty with full institutional solutions is the need for a long period to build portfolios and for highly professional staff. The lack of institutional solutions is often cited as an argument for models that vest some rights with inventors, while maintaining institutional ownership ("Free Agency Model").

Source: OECD (2003), *Turning Science into Business: Patenting and Licensing at Public Research Organisations*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264100244-en; OECD (2013a), *OECD Reviews of Innovation Policy: Sweden 2012*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264184893-en.

Regulations and legislative reforms for technology transfer at universities and public research institutions (PRIs) have been also tied to more general reforms. These range from national decrees and ministerial acts and ownership clauses in patent law, labour law and government contracting laws to ownership clauses in the regulation of national R&D systems (i.e. higher education laws, regulation of research institute laws) and innovation and S&T laws (Zuñiga, 2011). To cite one relevant example, Sweden has amended its Higher Education Act to introduce the building of external partnerships into the mission of higher education institutions, together with education and research, and to encourage them to actively exploit research results (OECD, 2010).

In terms of policy frameworks regulating ownership of IPR derived from government-funded research, there is a policy convergence in vesting the rights to universities. A diversity of legal and policy approaches exists where universities can often overrule national university IPR regulations through university bylaws, for example to negotiate different IP arrangements with third parties. In some instances, universities are allowed to develop internal IPR regulations and processes. For example, the University of Cambridge did not enforce fully the university ownership right until 2001 (Geuna and Rossi, 2011).

International technology transfer also puts demands on IP management. Governments and universities are reviewing practices to institute safeguards against detrimental results of university patent licensing. For example, a nine-point plan has been advocated in 2007 by a number of US universities to ensure that patents do not produce undue burden for follow-up innovations (Box 3.2). In terms of cross-border technology transfer, legislation and practices regarding the access to technologies with broad social and economic benefits to poorer countries have been established (WIPO, 2011). In 2009, a consortium of six universities (Harvard, Yale, Brown, Boston University, the University of Pennsylvania, Oregon Health & Science University) and the AUTM endorsed the "Statement of Principles and Strategies for the Equitable Dissemination of Medical Technologies". These guidelines discuss best practices for universities; to date, 26 universities have endorsed the statement, including universities in Mexico, India and Turkey. With a view to harmonising IP practices and to increase the commercialisation of public research, the European Commission (EC) published the Code-of-Practice for universities and other PROs in April 2008 (Box 3.3).

In many OECD countries, public disclosure of the invention – including the patent applicant (e.g. universities, PRIs or researcher) – before filing a patent application destroys novelty and hence the ability to obtain a valid patent. Edmondson et al. (2013) found that more than half of TTO professionals surveyed feel at risk of losing patent opportunities due to prior disclosure of an invention. Many national patent systems, such as in Australia, Canada and the United States, have a legal "grace period" that allows disclosure of the invention in a referenced journal or conference and then a further 6 to 12 months to file a patent application.[1,2] Globally, the trend is towards expanding grace periods. For example, Japanese patent law amendments in 2012 have broadened the scope to include sales, any exhibitions, press releases, and broadcasting. Korea prolonged its grace period in 2012 from 6 to 12 months.

Box 3.2. Nine points to consider in licensing university technology

1. Universities should reserve the right to practice licensed inventions and to allow other non-profit and governmental organisations to do so.
2. Exclusive licenses should be structured in a manner that encourages technology development and use.
3. Strive to minimise the licensing of "future improvements".
4. Universities should anticipate and help to manage technology transfer-related conflicts of interest.
5. Ensure broad access to research tools.
6. Enforcement action should be carefully considered.
7. Be mindful of export regulations.
8. Be mindful of the implications of working with patent aggregators.
9. Consider including provisions that address unmet needs, such as those of neglected patient populations or geographic areas, giving particular attention to improved therapeutics, diagnostics and agricultural technologies for the developing world.

Source: S.A. Merrill and A.M. Mazza (2010), "Managing University Intellectual Property in the Public Interest", Committee on Management of University Intellectual Property: Lessons from a Generation of Experience, Research, and Dialogue, National Research Council.

Box 3.3. European Commission recommendation on the management of IP and Code of Practice for universities and other PRIs

The EC published the recommendation on the management of IP in knowledge transfer activities and the Code of Practice for universities and other PROs in April 2008. By adopting the IP Charter unanimously, the member states sent a clear and political high-ranking signal for a fair transfer of knowledge and equitable treatment in international collaborations. The Code of Practice is open for participation by countries outside the European Union (EU).

Issued on a voluntary basis, it provides for the first time on a European level a set of general principles and minimum standards for the management of IP. It also includes good practice principles for collaborative and contract research. The recommendation encourages member states and their regions to establish policy guidelines and frameworks in order to improve the way institutions manage their IP. The Code of Practice is directed at the level of individual institutions, emphasising the need for long-term strategies for the management of IP and knowledge transfer. Implementation of the IP Charter in the EU member states is monitored on a regular basis through institutional surveys.

The Knowledge Transfer Working Group of the European Research Area Committee (ERAC) has been established to support and promote active implementation of the IP Charter. The group acts as a strategic advisory body to ERAC, and is responsible for the exchange of information on the status and progress of national and Commission policies and initiatives to enhance knowledge transfer along the lines of the Recommendation and the Code of Practice.

Following the EC's recommendation, the Working Group issued guidelines on the management of IP in international research collaborations in June 2012. The guidelines emphasise the importance of setting considerations about IP and knowledge transfer management systems in the context of research collaborations with institutions and firms outside Europe. They describe key factors that should be considered before entering into collaboration, among others: a strategic risk-benefit analysis; provisions to ensure confidentiality; due diligence of the partner's activities and IP position; and an assessment of the contractual and IP legal framework in the country in question.

Source: European Commission (2008a), Commission recommendation of 10 April 2008 on the management of intellectual property in knowledge transfer activities and Code of Practice for universities and other public research organisations (notified under document number C[2008] 1329); European Commission (2008b), Council resolution on the management of intellectual property in knowledge transfer activities and on a Code of Practice for universities and other public research organisations (10323/08); European Commission (2012), "Interim Findings 2011 of the Knowledge Transfer Study 2010-2012", Bonn/Maastricht/Solothurn; European Area Research Committee (ERAC) Knowledge Transfer (KT) Group (2012), European Research Area Guidelines on intellectual property (IP) management in international research collaboration agreements between European and Non-European partners.

Encouraging industry engagement by granting licenses on IP rights free of charge

One approach in promoting the commercialisation of public research involves universities exchanging knowledge embedded in IP documents and contracts, particularly with industry. While universities have long interacted with industry and served as sources for technological advancement, this role has intensified in recent years.

The IP policy of universities sets the basic rules of governing the management of existing and generated IP. From the perspective of industry, the optimal outcome would be based on some form of exclusive licensing in order to obtain proprietary control of the technology. But non-exclusive licenses can be granted as well, depending on the scope, sector, or geography (e.g. a preference for licensing to local firms and SMEs, even if that does not maximise licensing revenues). For example, at the University of Geneva, if a local firm or SME can be found to further develop a technology, it may be preferred to an outside firm.

Industry-science relationships (ISR) concerning IPRs have reached a critical point. Anecdotal evidence suggests that universities pursue their negotiations with firms over IP more aggressively. As academic patenting is increasing in absolute numbers, PROs are more likely to be involved in patent litigation with firms, even though patent lawsuits are rare (but increasing).[3] In the same vein, firms are aggressively enforcing IPRs that were a result of collaborative work; actions include demands for “reach-through” rights, review and delay of publications, duration of protection, and future option rights.

The major issue of contention is the value and income from IP and overcoming the different perceptions of industry and universities (Hertzfeld, Link and Vonortas, 2006). The University of Glasgow, for example, introduced in 2010 the Easy Access Programme to provide free access to university inventions on a royalty-free and fee-free basis. In March 2011, the UK Intellectual Property Office backed a proposal from the universities of Glasgow, Bristol and King’s College London to develop a consortium of universities into the Easy Access Innovation Partnership.[4] The University of New South Wales in Australia and CERN (European Organization for Nuclear Research), a major inter-governmental research facility, have also adopted versions of the Easy Access IP framework. A similar approach has been followed by Penn State University in the United States, which is no longer required to own IP arising from industry-sponsored research.

Legislative and administrative procedures targeting research personnel and faculty

As universities can override existing national regulations by developing internal IPR regulations and processes, some have experimented with alternate settings. For example, some have decided to provide preferential treatment to researcher faculty staff wishing to license technologies they developed (Box 3.4). Others allow professors to establish new ventures, granting leaves of absence, or allow tenure clock stoppage for faculty staff, so that they can purse commercialisation activities (Grimaldi et al., 2011).

Some universities, such as Oklahoma State University in the United States, are considering taking into account the commercial track record of the faculty in the tenure process. A survey by Stevens, Johnson and Sanberg (2012) found that 16 universities (of 64) in the United States and Canada consider patents and commercialisation in tenure and promotion decisions. The University of Minnesota in the United States established a programme that allows leave of absence for faculty inventors who want to help an external organisation commercialise a product or service that uses universities’ IP or know-how. Eligible faculty could also be engaged in activities that demonstrate substantial institutional benefit, or in innovative and collaborative projects that further the public good.

Box 3.4. The University of North Carolina Express Licensing Agreement

The University of North Carolina (UNC) in the United States has sought to streamline the commercialisation process for technologies that result from research, through the adoption of a standard license agreement for spin-off formations. The license represents one set of terms that can be used for various widely divergent deals with minimal negotiation. In addition, the leadership of the University Committee established a set of guiding principles, as follows:

- Foster a collaborative spirit between the Office of Technology Development and the faculty involved in the process.
- Be a resource to help faculty license or transfer their technology to the outside world.
- Encourage entrepreneurial efforts by the faculty that will result in serial entrepreneurs and many newcomers.
- Encourage deal flow.
- Establish a fair deal for all parties involved.
- Be a tool to recruit faculty to UNC who are interested in entrepreneurial activities. The principles aim to provide a collaborative environment in which entrepreneurial faculty and the university can work together and avoid or minimise conflict and lengthy negotiations. The key provisions in the Carolina Express License Agreement include:
- A 1.0% royalty on products requiring FDA approval based upon human clinical trials;
- A 2.0% royalty on all other products;
- A cash payout equal to 0.75% of the amount paid to UNC upon a merger, stock sale, asset sale, or Initial public offering (IPO);
- Provisions that encourage broad commercialisation of the licensed technology, including making products available for humanitarian purposes in developing countries.
- No upfront fees.
- Six-month delay on obligation to begin repayment of patent costs.

The use of the Carolina Express License Agreement is possible under the following circumstances:

- A UNC faculty member, student, or staff member is a founder of the company.
- All IPRs are owned solely by UNC.
- A detailed business plan is reviewed and approved by UNC.
- The agreement is executed without modification. Start-up companies are not required to use the standard license agreement. A key goal of the agreement is to avoid a situation where arduous equity or royalty structures in a license can kill a firm either at a point in the future or when the deal structures inhibit the needs of future funders or buyout partners.

Source: Kauffmann Foundation (2010), “Facilitating the Commercialization of University Innovation: The Carolina Express License Agreement”, *Ewing Marion Kauffman Foundation Research Paper*.

Table 3.1. Typology of intermediary and bridging organisations

Typologies	Mission statement/aim	Centrality of patenting and licensing	Regional development focus
Technology transfer office (TTO)	Supporting the academic staff to identify and manage the organisation's intellectual assets, including protecting intellectual property and transferring or licensing rights to other parties to enhance prospects for further development.	High	Low
Business incubator	Accelerating the growth and success of entrepreneurial companies through an array of business support resources and services that could include physical space, capital, coaching, common services, and networking connections (National Business Incubation Association).	Low	High
Business innovation centre	Offering a range of integrated guidance and support services for projects carried out by innovative SMEs, thereby contributing to regional and local development (European Business and Innovation Centre Network).	Low	High
Science park and technology hub	Promoting the economic development and competitiveness of regions and cities by creating new business opportunities and adding value to mature companies; fostering entrepreneurship and incubating new innovative companies; generating knowledge-based jobs; building attractive spaces for the emerging knowledge workers; enhancing the synergy between universities and companies (International Association of Science Parks).	Medium	High
Chamber of commerce special agency and laboratory	Furthering the development and expansion of technological innovation through the offer of services that meet the requirements of the firms associated with the Chamber of Commerce.	Low	High
Territorial development enterprise	Gathering and co-ordinating scientific, organisational and financial resources in the region in order to transfer acquired information into new production processes and research results to the entrepreneurial context.	Low	High
Topic centre	Promoting a specific industry or a specific technological area inside a geographical context.	Low	High
Multi-sector centre	Supplying diversified services to firms operating in several sectors.	Low	Medium
Industry Liaison Offices (ILO)	ILOs share large functional similarities with technology transfer offices (TTOs) in the sense that they also manage patenting and licensing activities, but ILOs perform a broader scope of activities. These include serving as a central contact point for industrial partners, conducting external/internal marketing, and creating networks and partnerships.	Medium	Medium
Proof of concept centres (PoC)	A PoC is an organisation working within or in association with the university, to provide funding, mentoring, and education i.e. the development and verification of a commercial concept, identification of an appropriate target market, and development of additional required protectable IP.	Low	Low
Libraries/Institutional repositories	Libraries and/or institutional repositories disseminate information and/or data resulting from research. Universities are developing institutional repositories (often managed by their libraries) to both archive and disseminate their research outputs.	Low	Low

Note: PRIs and borderline institutes (e.g. centres of excellence) have been excluded.

Source: Adapted and extended from Comacchio, A., S. Bonesso and C. Pizzi (2011), "Boundary spanning between industry and university: The role of Technology Transfer Centres", *The Journal of Technology Transfer*, Vol. 37, pp. 943-966; Maia, C. and J. Claro (2012), "The role of a proof of concept center in a university ecosystem: An exploratory study", *The Journal of Technology Transfer*, Vol. 38, pp. 641-650.

Universities in OECD countries increasingly face the issue of ownership of IP by graduate students and other non-faculty/employees engaged in research. In member countries, graduate students and those holding doctorates account for a growing share of non-faculty staff carrying out research activities in universities. While graduate students are generally not employees, they may work on research projects funded by university or outside resources. These may inevitably lead to tensions between universities and students over IPRs.[5] Owing to these changes and to avoid IP disputes between students and universities, in 2011 the University of Missouri in the United States established a policy that generally allows students to own any invention made during their enrolment. Students will be assigned ownership if they are not university employees and not using more university resources “than those generally available to all other students within the class or than those available to the student as part of his/her enrolment with the University” (Grimaldi et al., 2011).

Intermediaries and bridging organisations

A range of intermediary and bridging organisations have been institutionalised to lower the cultural distance and search costs between actors involved in knowledge transfer and commercialisation. Among the first intermediate organisations that executed bridging activities between universities and industry are the so-called Collective Research Centres (CRCs), which were created in most European countries after the Second World War to stimulate the technological development of business in the major industrial sectors through collective and collaborative research (Wright et al., 2008).

In addition, governments, sub-national governments and PROs have attempted to stimulate the formation of a range of bridging and intermediary institutions over the past three decades (Table 3.1). The mission statements in terms of knowledge transfer and commercialising differ significantly across intermediaries. For example, there is much variety in terms of the importance of patenting and licensing and some organisations have a strong focus to fulfil a regional development mission.

As a result of changing legislation across OECD countries, universities and PRIs have built up an extensive infrastructure of intermediaries in the form of TTOs, even if this is not the case at many of the smaller institutions. Today, TTOs are seen by most policy makers as the centre and primary driver of commercialisation efforts, and their size in terms of the number of full-time employees has steadily increased over the past two decades (e.g. see AUTM data for the United States). A wealth of studies have analysed the performance characteristics of TTOs. Among these, Siegel, Veugelers and Wright (2007) summarise the recent empirical studies on university TTOs and the key factors in their performance – such as size, age, expertise and experience of TTO staff.

The most common goals and missions associated with TTOs are the enhancement of licensing revenues; the maintenance or expansion of industrial research support; faculty retention; technology transfer; and to a lesser extent, regional development (Mowery et al., 2004). A survey of European TTOs found that generating licensing revenues (60% of respondents), enhancing industry-science relationships (ISR) (59%) and the diffusion of science and technology results (45%) constitute the main objectives of TTOs (European Commission, 2012).

Box 3.5. "From our pipeline to your bottom line": The YEDA story

Only a few top universities and PRIs across the world have meaningful income from the commercialisation of research. Israel's Weizmann Institute is such an organisation, although neither is it exceptionally big nor can it look back on a long tradition.

YEDA is Weizmann's TTO. It was founded in 1959 – decades before the US Bayh-Dole legislation – and it took several years to deliver returns. The office takes care of identification, application, licensing and protection of all Weizmann IP. Weizmanns' Vice President for technology transfer is YEDA's chairman, and YEDA is to be informed about researchers' inventions. YEDA is the exclusive channel for patenting, commercialisation and protection, and inventors have to co-operate and disclose relevant knowledge. Life sciences are the most important source of patents and revenues. If YEDA does not submit a patent, inventors can try to commercialise their invention on their own, but still have to repay part of any profits to YEDA. If YEDA decides to patent, they are in full charge of the process and – like nearly all TTOs – they focus on licensing contracts, often with Israeli firms. For some, like the pharmaceutical company Teva, Weizmann IP led to the development of blockbusters. Companies such as Adobe or Johnson & Johnson also profit from license agreements with YEDA. Revenue is distributed as follows: 40% to the scientists, 60% to the Institute (minus a commission for the TTO). Some researchers have become wealthy through these agreements.

YEDA has filed or participated in filing 1 400 patent families, has signed many licensing agreements, and established around 50 spin-off companies based on Weizmann knowledge and IP. Currently YEDA owns 660 live patent families. The total annual royalty-generating sales in 2010 amounted to USD 15 billion. The Weizmann budget is approximately USD 300 million. A third comes from the Israeli government for basic funding, while the rest comes from international donations, international and national competitive funding, and revenues from the Institutes' endowment. YEDA currently contributes USD 15-20 million a year to the Institute's budget, although its contribution was significantly higher in the mid-2000s. YEDA also organises money flows for pre-competitive research from industry to the Institute. A large industrial park next to the Institute hosts a number of successful firms.

A key lesson from Israel's experience is the need to work on a high professional level in order to commercialise research. All Israeli TTOs have clear missions and top staff. YEDA representatives know what researchers have accomplished and have more than 1 000 industry contacts a year. Finally, the Weizmann Institute shows that it pays to be not just a very good but a top academic environment with professional gateways to the outer world in order to attract top talent and industrial partners.

Source: OECD (2013a), *OECD Science, Technology and Industry Outlook 2012*, OECD Publishing, Paris, http://dx.doi.org/10.1787/sti_outlook-2012-en.

Box 3.6. Beyond technology transfer: The case of Inovacentrum (Czech Republic)

Inovacentrum is the TTO of the Czech Technical University (CTU), a 300-year-old university with 8 faculties and over 24 000 students based in Prague. CTU started its first programme to support business and innovation when it established BIC (the Business Innovation Centre) in 1991. In 2007, a discussion was opened at the CTU to engage in third mission activities. As an outcome, Inovacentrum was established in 2010.

The main mission of the centre stands on three pillars:

- educating people and cultivating innovative thinking and co-operation;
- connecting and bridging research with industry;
- supporting the transfer and commercialisation of research results.

Inovacentrum also manages the CTU Incubator by providing support to start-ups within CTU and other Czech universities. For example, Incubator companies receive professional training in business planning, marketing, accounting and other soft skills.

Inovacentrum also provides specialised education to academics and researchers at the university as well as to other technology transfer agents (e.g. seminars, lectures and courses for scientists and internships, and best practice exchange). The scope of themes ranges from IPR, through technology foresighting and road-mapping to seminars aimed at improving soft skills necessary for effective sales, networking, promotion, etc. Every year, Inovacentrum is the co-organiser with another renowned partner of a large-scale international conference, concentrating mainly on best practice exchange in areas important for effective innovation and transfer of technologies.

Among these, enhancing licensing revenues are found to be the most important criterion by which TTO offices measure their success (e.g. Thursby and Thursby, 2001), but abundant evidence suggests that most TTOs do not generate positive net returns (or break even) from patenting and licensing (Trune and Goslin, 1998; Nelson, 2001; Geuna and Nesta, 2006; Bulut and Moschini, 2009; Thursby and Thursby, 2007), although a small number of TTOs generate substantial revenues (Box 3.5). However, it is important to note that due to the long-time scales between invention disclosure and revenue return, especially for biotechnology- and pharmaceutical-related inventions, it is difficult to use revenue return as a measure of TTO success. In addition, given sometimes multiple goals within TTOs, it is difficult to have one objective measure of success.

Anecdotal evidence suggests that a large number of TTOs have expanded their activities from administrating technology transfer (invention disclosures, filing patents) to a wide range of IP management and supporting activities (e.g. patent scouts, consulting), marketing non-patent services, administering proof-of-concept (PoC) and seed funds for entrepreneurial activities, as well as promoting an innovation culture (Box 3.6). However, there is still much variety in the missions and models of TTOs as well as in the nature of the institution they serve. This is mainly due to variations in resource and infrastructure endowments among institutions, the scale and focus of research efforts, and experience in technology transfer.

Despite the various missions and activities of TTOs, evidence indicates a convergence across countries towards a common set of organisational and financial models for TTOs at PROs. Empirical evidence from Italy, for example, suggests that most universities tend to adapt the patent regulations of the leading universities, which has led to a fairly standardised set of practices (Baldini et al. 2010). Based on observations in the United States, Axanova (2012) distinguishes between operational-integrated (i.e. to whom TTOs report, e.g. financial or research administration), specialisation-integrated (i.e. the degree of task specialisation, e.g. "cradle to grave") and discipline-integrated TTO models (i.e. type of research discipline). Financial models range from filing patent applications on every invention, either provisional, regular or both ("protect it all"), to a case-by-case basis, depending upon risk/return frameworks ("business-like"), to models where a patent will be filed only when a licensee is found ("just-in-time") (Axanova, 2012).

New forms and models of bridging and intermediary organisations

A wider range of PROs as well as governments at all levels have discussed steps to invest or experiment with new bridging and intermediation structures. In Sweden, as part of the 2008 Research and Innovation Bill, there has been a steady growth of "innovation offices", and have these been further boosted in the new 2012 Research and Innovation Bill (Box 3.7).

Box 3.7. Innovation offices programme

The 2008 Research and Innovation Bill included the launch of "innovation offices" (*innovationskontor*) to facilitate the (commercial) utilisation of research results from universities. Their purpose is to support researchers and university management with a number of services, including innovation advice, business development, verification, management of intellectual assets, and awareness raising. In the first round, eight innovation offices linking a total of 11 Swedish universities were founded. A recent government review of innovation-stimulating activities at universities stresses the importance of innovation offices in increasing universities' ability to act innovatively. Accordingly, the new 2012 Research and Innovation Bill has increased the allocation of funding to innovation offices and announced the establishment of a further four offices to extend the scheme's reach to cover all universities.

Source: OECD (2013a), *OECD Reviews of Innovation Policy: Sweden 2012*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264184893-en.

Most of these discussions centred on replacing or improving TTO structures and services, including but not limited to Technology transfer alliances (TTAs), internet-based models, for-profit models or approaches to vesting some rights with inventors while maintaining university ownership (e.g. the Free Agency model).

- *Technology Transfer Alliances (hub-and-spoke models)* – Given the limited ability of mid-range universities to generate enough income to cover expenses of their TTOs, some proponents argue that it may be more efficient to share services in the form of TTAs. In theory, this would allow the bundling of inventions across universities, lower operation costs, and access to personnel with superior commercialisation expertise. It may, however, lead to higher co-ordination/ communication costs, competition among institutions, and capacity constraints of TTO personnel. In Germany, each federal state established with ministerial resources at least one regional patent agency (RPA) after the shift from an inventor to an institutional ownership system in 2002. While RPAs serve in some cases both universities and PRIs, many institutions still operate their own TTOs. Another example is the Innovation Transfer Network (ITN) in the United States, which was established in 2006 with state support. It serves as the TTO for 13 smaller colleges, each of which are represented on the ITN board.[6] In France, the French National Research Agency (ANR) has established a fund to create Technological Transfer Acceleration Companies (SATT) to reduce fragmentation of technology transfer services at the regional level. These companies are mainly owned by a consortium of universities and PRIs, and will assist in proof-of-concept funding and IP commercialisation. To date, 11 of such companies have been created across France.[7] In Ireland, a central Technology Transfer Office (cTTO) is currently being set up with the aim of acting as a central point of contact for firms looking for specific IP opportunities and research expertise at individual institutions. The cTTO will provide services complementary to already existing TTO structures.[8] In Russia, the IP centre "Skolkovo" has been established with the premise of serving as a best-practice model for local authorities setting up their own TTOs in regions of the Russian Federation (Box 3.8).

Box 3.8. Intellectual Property (IP) Centre "Skolkovo"

The Skolkovo initiative, a large innovation and education cluster implemented by former President Dmitri Medvedev, aims to stimulate innovation by attracting leading researchers, universities, and foreign high-tech companies (e.g. Microsoft, Cisco, Nokia and Siemens) to a small town near Moscow. It is intended to serve as a model for the promotion of innovative activities in Russia. The Skolkovo Innovation Centre includes five technology clusters: IT, biomed, energy efficiency, space and nuclear energy.

The Intellectual Property Centre "Skolkovo" is a subsidiary of the Skolkovo Foundation, which was set up as a limited liability company by the Russian government in 2010. The IP Centre was founded to provide the full range of professional services related to IPR in Russia and abroad.

The IP Centre is separated into three departments, namely the patent, legal and IT departments. The patent practice team files patent applications in Russia, the European Union, the United States and other jurisdictions. The main activities include patent searches, preparing patent landscapes and developing an overall patent strategy. The legal practice department is focused on providing Skolkovo researchers and third parties with legal services on due diligence, spin-offs, licensing, investment agreements, contracts and multijurisdictional transactions. The IP Centre also represents the interest of clients before state authorities. The IT practice department files patent applications for "computer-implemented" algorithms.

Since the date of its creation in 2011, the IP Centre has filed more than 200 patent applications. More than 25% of all IT-related patent filings by Russian applicants to the Russian Patent Office (*Rospatent*) in 2012 were prepared by the IP Centre. For the first 15 months, all IP Centre services were subsided by governmental funds and were free of charge for Skolkovo researchers and companies.

The IP Centre also offers educational and innovation services such as conferences, seminars and webinars as well as educational programmes – for example, on technology transfer activities in Russian institutions.

The Skolkovo Innovation Centre and the IP Centre neither claim any rights to the IP nor demand future royalty payments to Skolkovo residents. The key partners of the IP Centre are Thomson Reuters, IBM and *Rospatent*.

- *For-profit models* – Some PROs moved to or established privately funded TTOs for cost or efficiency reasons. These are institutionalised in the form of limited liability corporations. The rationale is that private agents might be better positioned to commercialise university inventions. Anecdotal evidence indicates that some universities increasingly implement private TTOs; in some cases these have been operating since the late 1980s, including in leading research universities (e.g. ISIS University Oxford in 1988, which is an independent company owned 100% by the University of Oxford, ranked 16th in PCT patent applications in 2011; see Table A.2). In Israel, the majority of TTOs operate under a limited liability model, partly or wholly owned by universities (e.g. Yissum, one of the first TTOs established in 1964, is owned by the Hebrew University of Jerusalem, ranked 22nd in PCT patent applications in 2011; see Table A.2). In addition to their traditional TTO, Stanford University has established a separate wholly-owned limited liability corporation (Stanford OTL-LLC) to allow Stanford's TTO to act as a licensing agent for other universities.
- *Internet-based models* – Advances in ICTs have also permitted mechanisms that complement existing internal TTO structures through Internet-based platforms. These platforms have been developed in response to the need of TTO professionals as well as application-oriented researchers to have easier access to knowledge and information in their working environment, and also to better showcase their technologies to the corporate sector. The University of British Columbia's Flintbox developed such a platform to market its technologies (Box 3.9). The France technology transfer (FTT) platform, created by the French TTO association and the French national innovation financing agency (OSEO),

takes a similar approach to increase the visibility of IP developed among French universities and PRIs. Another example is the “iBridge network” founded in 2005 by the Kauffman Foundation’s Innovation Network, aimed at researchers, universities and companies and entrepreneurs.[9] The online-enabled network allows the posting, search and retrieval of information on university inventions. Some inventions are available for online licensing.

Box 3.9. Flintbox – An open innovation software tool

Flintbox was developed at the University of British Columbia in 2003 as a response to the limited ability of traditional TTO operation to effectively handle non-patentable technologies. Flintbox is an online platform for marketing and licensing the outcomes of research. It allows organisations to describe and publish research projects online and associate products of this research for online license, purchase, and download. Through a single account, end-users can access multiple networks of research, available in a common format through the Flintbox platform. Wellspring Worldwide acquired Flintbox in 2010 and relaunched the new Flintbox in April 2010 as a platform for developing relationships and driving collaboration in the innovation community.

Source: www.flintbox.com and Rasmussen (2008), “Government instruments to support the commercialization of university research: Lessons from Canada”, *Technovation*, Vol. 28, pp. 506-517.

- *Free Agency model* – Some researchers regularly report their dissatisfaction with existing TTO operations. They view them as revenue maximisers and are generally reluctant to explore alternative commercialisation paths (Kenney and Patton, 2009). These led some observers to suggest a new model of vesting ownership with inventors but maintaining university ownership. In this case, researchers would be given the choice between their university TTO or an agent elsewhere (i.e. Free Agency model) (Litan, Mitchell and Reedy, 2007). In theory, the intended benefits should be to improve the efficiency and performance of TTOs by creating competition. However, many academics and practitioners question the usefulness of such an approach. Concerns include, among others, the limitations on adjusting TTO performance through competition, the potential capacity constraints of external university TTOs, regional and local economic development issues, overlapping interests and unclear payout schemes.

Business “open innovation” for sourcing public sector knowledge

Relationships between firms and PROs can be seen as part of the more general open innovation picture. PROs are an important external source of innovations for business – even if surveys indicate otherwise, per Figure 2.5 – but different industries have different patterns of interaction with external partners, depending on their needs and competencies. Empirical evidence from the CIS survey in Europe shows that firm collaboration with universities results in a higher percentage of innovations new to the market (Monjon and Waelbroeck, 2003; Belderbos, Carree and Lokshin, 2006). Collaboration on innovation has been shown to be important in manufacturing as well as services, and some industries (e.g. chemicals) show high levels of open innovation (note that these results are general and not specific to collaboration with universities or PRIs) (OECD 2008a; Mansfield, 1991; Cohen, Nelson and Walsh, 2002; Laursen and Salter, 2004; Hanel and St-Pierre, 2006). Patterns of interaction may not be obvious, however. For instance, data from Austria found industry sectors with the highest intensity of interaction with universities only partially corresponded with common rankings of knowledge-intensive sectors (Schartinger, Schibany and Gassler, 2001).

Firm size and scientific excellence also matter; large firms innovate more openly than small firms and are more likely to co-operate with higher education or government institutions on innovation (OECD, 2008a; 2009; Santoro and Chakrabarti, 2002; Hanel and St-Pierre, 2006 and others; see also Figure 2.6). Studies show that there is a strong positive correlation between scientific excellence and the intensity of industry contacts of individual researchers in Sweden (Bourelos, Magnusson and McKelvey, 2012).

Firms seek public sector knowledge for a variety of reasons (Table 3.2). There are different ways for firms to directly access public sector knowledge: among others, through licensing, collaborative research partnerships and research collaborations, contract research, and through consulting or indirect means such as through employment or people-based channels. The benefits and costs that arise for firms and PROs differ by the type of knowledge transfer mechanism. The main motivation for firms to collaborate with PROs is to leverage the profitability of corporate R&D programmes, avoid wasteful experimentation when working with complex technologies, or increasing firms' ability to identify, absorb and integrate external technological information. Engaging in open innovation or collaborative work with PROs may also have some drawbacks, such as the possibility of losing confidential knowledge in multi-actor collaborations. In addition to firms, there are also benefits and costs that arise for academic partners. While collaboration with industry may initiate new impulses for research, it will inevitably place some restrictions on publishing.

Table 3.2. Potential benefits and costs of open innovation strategies for knowledge transfer and commercialisation

	Potential benefits	Potential costs (or barriers)
Universities/PRIs Departments/ Research units Individual researchers	**Intellectual** Ideas for further collaborative projects New impulses for research (e.g. challenging research questions) Knowledge/information sharing Reputation **Economic** Sharing of equipment/instruments Provision of research inputs Financial resources	**Intellectual** Capacity constraints from other activities (teaching, basic research, administration) "Freedom of research" Restrictions on publishing **Economic** Lack of incentives (e.g. performance-based research evaluations) Bureaucratic regulations and civil servants law
Firms	**Capabilities based on R&D** Acquisition of complementary R&D Acquisition of substitute R&D Use of resources available at PROs Increased profitability of corporate R&D programmes **Capabilities based on innovation activities other than R&D** Acquisition of fundamental scientific knowledge to solve production problems Increase in firms' ability to find and absorb technological information Acquisition of information about trends in R&D Access to qualified human resources	**Capabilities based on R&D** Lack of absorptive capacity (lack of own qualified R&D personnel) **Economic** Transaction and search costs in spending too much time looking for adequate science partners **Intellectual** Unclear IPR Fear of losing confidential knowledge in multi-actor and horizontal collaborative models Difficulty anticipating the potential value of public research knowledge

Source: Adapted and extended from Veugelers, R. (2013), "Industry science cooperation", *Workshop Presentation on "Financing Knowledge Transfer in Europe*, Bologna, 11 June 2013; De Fuentes and Dutrénit (2012), "Best channels of academia-industry interaction for long-term benefit", *Research Policy*, Vol. 41, pp. 1666-1682.

Box 3.10. Examples of open innovation between Japanese universities and firms

Osaka Gas Co., Ltd. (natural gas industry)

- Co-operation agreements with Kyoto University and joint research course with Osaka University.
- Continuous search for public research partners since 2009 (92 collaborations newly started during 2009-11).

ROHM Co., Ltd. (semiconductor industry)

- Co-operation agreements with Ritsumeikan University, Doshisya University and Kyoto University.
- Collaborative work system was set up at the Tshinghua University (China). Among other things, it invites researchers from Tshinghua University to work for one month at ROHM.

Daikin Industries, Ltd. (air conditioner manufacturer)

- In 2006, “Osaka University-Daikin Industries (Fluor Chemicals) Research Chair” was established at Osaka University, which resulted in follow-up collaborative research agreements.
- Internal R&D institutions are to be integrated into “the Technology and Innovation Centre”.

Hitachi, Ltd. (electric machinery industry)

- Global R&D framework in China, Europe, North America and Asia.
- Co-operation agreements not only with professors but also with universities (13 domestic, 1 overseas).

Toyota Motor Corporation (car industry)

- In 2003, a “Global Production Centre (GPC)” was established for talent training; local GPCs were also established in the United States, the United Kingdom and Thailand.
- In March 2006, “Tsinghua University-Toyota Research Centre” was established and collaborative research was promoted in the fields of environment, energy, automobile safety and material.

Sharp Corporation (electronics industry)

- In March 2009, a co-operation agreement was established with the University of plant cultivation and waste recycling.

Shiseido Company, Ltd. (cosmetics industry)

- In 2008, the Open Innovation Group was launched.
- Shiseido is working on “distributed creativity” (i.e. customer design contests, crowd sourcing, open innovation networks) as well as on R&D collaborations with external partners (i.e. suppliers, universities, joint ventures).
- Matching events: Open Innovation Seminars at the Japan Science and Technology Agency.
- Sourcing outside knowledge via contract research and consulting.

Astellas Pharma Inc. (pharmaceutical industry)

- In May 2011, establishment of a public open innovation site “a^3” (a-cube)” to support collaborative research on drug discovery with domestic universities and PRIs.

Takeda Pharmaceutical Company, Ltd. (pharmaceutical industry)

- In February 2011, the new Shonan Research **Centre** was opened as the nucleus of Takeda’s global research network.
- The “TK Project” was created, with the Kyoto University as a drug discovery facility.

Mitsubishi Chemical Corporation (chemical industry)

- Collaborating with various academic institutions, including the UCSB**,** Dalian University of Technology, Kyoto University, Tokyo Institute of Technology and Osaka University, in order to develop new materials and devices for information and electronics, biotechnology and automobile fields.

The number of joint R&D projects between PROs and business has increased, as did business funding of R&D in the higher education sector over the past 30 years (see Figures 2.3 and 2.4). According to the Japanese National Institute of Science and Technology Policy (NISTEP), joint R&D partnerships rose from 56 in 1983 to 2 568 in 1998 and 14 303 in 2008 (Okamuro and Nishimura, 2012) (Box 3.10 provides examples of partnerships).

Leveraging open innovation through co-operative research

Many governments provide incentives for business to engage in alliances and co-operative research efforts. In some OECD countries, these policies have been driven mostly by a desire to turn research into socio-economic results and to boost private sector productivity via innovation. The Collective Research Centres (CRCs) are a case in point.

Whether or not open innovation is part of the policy discourse, an increasing proportion of public funding granted by the various regional and national authorities is directed at co-operative research efforts rather than at individual organisations. There are many types of partners eligible for research co-operation: firms (clients, suppliers, competitors); private organisations (consultants, R&D laboratories); and universities/ PRIs.

Co-operative research funding is promoted in the United States via various federally funded schemes provided by research councils and government departments. The Technology Strategy Board, the United Kingdom's innovation agency, has designed innovation vouchers for SMEs in particular to work with "knowledge suppliers", including universities and colleges. Germany has programmes in place to foster joint university-SME projects. In Europe, the framework programmes (FP) of the European Commission provide resources for collaborative projects involving universities and firms. Since 2009, the federal government of Canada provides grants to encourage new research partnerships between researchers and firms; the grants support short-term R&D projects addressing a firm-specific problem. In order to strengthen its manufacturing sector, Russia provides grants for collaborative projects between universities and manufacturing companies. It is specified that at least 20% of these funds should be used as R&D expenditures (Table B.3).

Due to the growing complexity of technologies, the formation of strategic government-university-industry R&D consortia, sometimes involving NGOs and government funding, has intensified in recent years in OECD and non-OECD countries. The aim is to address the lack of core technological competences and longstanding grand challenges that can hamper promising development paths. Germany's National Platform for Electric Mobility, Japan's global nanotechnology complex Tsukuba Innovation Arena (TIA), China's industry-research strategic alliances and Belgium's Interuniversity Microelectronics Centre (IMEC) are such examples. In the United Kingdom, consortia of universities and firms with governmental support have developed the Knowledge Transfer Box (KT-Box), which aims to turn public research into practical tools to support the creation and management of service operations and reduce the potential risks involved.

Firms can also source knowledge through people-based channels (Table 1.1). One method is to enhance the inter-sectoral mobility of researchers between science and industry. This may be particularly beneficial to small firms as they seem more likely to use personal contracts to interact with university researchers (Bodas Freitas, Geuna and Rossi, 2013). In addition, survey data from Herrera, Muñoz-Doyague and Nieto (2010) suggest that the mobility of Spanish researchers from the higher education sector to the corporate sector is shown to accrue positive benefits for firms' innovation processes. Despite these positive benefits, the university sector in particular lacks the legal and regulatory framework and the financial incentives to encourage the mobility of highly skilled personnel. A 2002 report noted labour laws could restrict the ability of academic researchers to work with other partners (OECD, 2002). A study of mobility of human resources in science and technology (HRST) highlighted the large number of policies aimed at encouraging international mobility of researchers; however, a relatively large share of the policies surveyed focused on mobility within the higher education/public research sphere (OECD, 2008b).

The EC has been an active proponent of industry-science mobility on a pan-European scale, through the framework programme "Marie Curie Industry–Academia Strategic Partnership" scheme. In addition, the EC supports national and regional initiatives in this respect. The new research, development, and innovation (RDI) State Aid Regulations now also allow member states to support knowledge transfer by subsidising the (temporary) deployment of highly qualified personnel from research organisations to SMEs. In Denmark, an industrial PhD programme has been operating since the 1970's i) to educate PhD researchers in business aspects of R&D; and ii) to establish personal networks for the exchange of knowledge between firms and PROs. Only France and (more recently) Norway have similar programmes. The Norwegian scheme has also been extended to university professors.

Collaborative IP tools and funds

There have been efforts at national funding agencies (e.g. model contracts for R&D collaboration) and individual institutions to develop standard licensing agreements for academic inventions, and to use collaborative IP mechanisms such as patent pools, IP clearinghouses, government-backed patent funds and IP sharing agreements to create new commercial opportunities (Table B.2).

There is targeted support for IP management at PROs through funding, guidelines for successful IP management, and skills training. For example, in Norway, new educational schemes for IP at universities have been created since 2009. In South Africa, the government is establishing the National Intellectual Property Management Office (NIPMO) to support capacity building in technology transfer and commercialisation of IP, including via partnerships with UK TTOs and staff secondments.

Some OECD countries started to sponsor the creation of patent funds specifically for PROs, either directly or through state-owned banks, which fund the acquisition of patent rights among other possible activities. These publicly initiated patent funds share some features with private sector funds, whose business model is to invest in the acquisition of titles to patents from third parties, with a view to achieving a return by monetising these patents through sale, use of security interest, licensing or litigation (OECD, 2013b) (see also Chapter 4). Patent funds with a focus on PRO-generated patents have been implemented in France (*France Brevets*), Japan (*Life Sciences IP Platform Fund*) and Korea (*IP Cube Partners*) (Box 3.11). Discussions are ongoing in Europe to create a "European patent fund" with a view to acquiring patents, organising them into technological families, and licensing them out.[10]

Box 3.11. Examples of publicly backed patent fund initiatives

Korea – IP Cube Partners (2010)

Funding – Funding from the state-owned Korea Development Bank (USD 15 million) and membership fees from its members, which also include universities and some Korean enterprises.

Services provided – IPC is organised into three different business areas: invention development (long term) of inventions principally from Korean universities and R&D labs, developing a strategic portfolio in selected technologies based on customer requirements; IP incubation and brokerage (short term) – focused on technology transfer, collaboration with academia and government, and providing IP intelligence and patent database mining services; and current activity focused on patent acquisition and assistance to partners.

Objectives – Incubate, harvest and protect inventions by "Filing the best inventions in selected global countries and ensuring adequate compensation of IP owners and inventors, promoting valuable IP through global marketing channels, acquiring patents and connecting with the potential buyers and helping Korean patents into the global market for IP sale and licensing".

France - France Brevets (2010)

Funding – EUR 100 million investment fund (split between the state, EUR 50 million and the *Caisse des Dépôts et Consignations*, a public sector investment corporation, EUR 50 million.

Services provided – The Fund is focused on patent monetisation and matching SMEs and PROs that hold patents with potential licensees. In some cases it also funds patent generation, finances the maintenance of the patents, and covers the costs associated with litigation. The three main services provided cover: aggregation (reducing transaction costs in licensing agreements), mutualisation (finding potential licensees and preparing the negotiations); and financing the time gap to market. Since 2011, the fund has been active in the areas of ICT, life sciences and space.

Objectives – Its stated aim is to enable universities, schools of engineering and research bodies, as well as private companies, to exploit their patents more effectively on an international scale, primarily through the operation of patent clusters for licensing purposes, and also by promoting cross-fertilisation in the management of public and private sector patents.

Japan – Life Sciences IP Platform Fund (LSIP) (2010)

Funding – The fund was set up by the Japanese Intellectual Property Strategy Network, Inc. (IPSN) and the Innovation Network Corporation of Japan (INCJ). INCJ is a public-private partnership that provides financial, technological and management support for next-generation businesses. It invested JPY 600 million (EUR 6 million) in the LSIP when the fund was established, and may make additional investments over the following years up to a maximum of JPY 1 billion (EUR 10 million). A number of private companies, mainly large-scale pharmaceutical companies, are also investing in the LSIP.

Services – The LSIP is a fund that invests in life science-related intellectual property. The fund focuses on four areas: biomarkers, stem cells, cancer, and Alzheimer's disease, and works with universities, public research and other institutions to bundle together their intellectual property, add value to it, and then license it so that the life science sector may develop through application of new technologies and the creation of venture businesses.

Objectives – The LSIP's stated missions are: a) increasing the value of IP in universities and ventures; b) raising the probability of success by universities and ventures in commercialising their advanced technology; c) developing IP human resources in Japan; d) promoting a two-way technology transfer in the world, especially in Asia, through the construction of networks; and e) achieving a "creative IP industry".

Chinese Taipei – IP Bank (2011)

Funding – By October 2011, Chinese Taipei's Industrial Technology Research Institute (ITRI, a quasi-government agency) had raised TWD 50 million (EUR 1.3 million) for the preliminary operation of the new company and another TWD 200 million (EUR 5.1 million) to be used as a guidance fund to draw more investment from the industry. According to ITRI, within six months of its establishment the IP bank is expected to raise its first counterclaim fund, on a scale of TWD 500 million (EUR 12.75 million). Meanwhile, another fund of roughly TWD 1 billion (EUR 25.6 million) will be used to devise better international IP strategies for Chinese Taipei technology firms. The IP bank is intended to assist local manufacturers with the creation of patent portfolios and patenting strategies in the R&D phases, while defending them from suits as they seek to expand their market share. Furthermore, in cases where a domestic firm will face a patent infringement lawsuit filed by its competitors or a patent assertion entity, the IP bank will provide patents in support of defensive actions among other facilitating strategies. In addition, the company, via ITRI, can use other funds to tap into the intellectual property of Chinese Taipei universities.

Source: OECD (2013), "Knowledge Networks and Markets", *OECD Science, Technology and Industry Policy Papers*, No. 7, OECD Publishing, Paris, http://dx.doi.org/10.1787/5k44wzw9q5zv-en

A large share of university and PRI patents remain commercially unexploited. For example, the PATVAL-I survey estimates that about 17% of European patents are "sleeping patents" that are neither licensed nor used internally, nor held for purely defensive purposes. The share of sleeping patents is particularly high in PROs (23% for PRIs and 27% for universities) (Ménière, 2012). One way to address the issue of "sleeping patents" is to allow preferential access to unexploited patents. The French National Centre for Scientific Research (CNRS) has established the "PR2 - Enhanced Partnership SME Research programme", in which patents will be offered to SMEs on favourable terms (CNRS ranks 3rd among PRIs, with 196 patent applications in 2011 – see WIPO, 2012). In the United States, the Department of Energy's (DOE) Next Top Energy Innovator eases access for start-ups and SMEs to use inventions and technology developed at DOE's 17 national laboratories and the Y-12 National Security Complex. Start-up companies can apply for one of the Energy Department's thousands of unlicensed patents at reduced cost and red tape. The University of North Carolina Express Licensing Agreement also offers preferential treatment to researchers and students who are willing to pursue a spin-off based on the institutions IP (see Box 3.4).

The creation of standard licensing agreements has become a popular instrument among PROs and governments (e.g. the United Kingdom's Lambert Toolkit, Germany's model R&D co-operative agreements, Denmark's Schlüter model agreements, DESCA model consortium agreement for FP7 projects) to address industry claims of difficulties negotiating license agreements with PROs. They often involve "model" technology co-operation agreements that limit the potential of IP-related conflicts and disputes. For example, the Lambert Toolkit consists of five model research collaboration (one-to-one) agreements as well as of four multi-party agreements. An anticipated benefit of model agreements is to simplify and facilitate the negotiation process and therefore encourage joint development. A survey of 200 companies on their collaboration with universities found that only 10% of the respondents had used the Lambert Toolkit, although of those, 60% found it to work very well (Andersen, De Silva and Levy, 2013). According to Hertzfeld, Link and Vonortas (2006), standard agreements on licensing and research collaboration are bound to be successful only to the extent that the clauses used provide a minimum acceptable standard.

"Open science" policies

New digital technologies and global ICT networks have brought about large reductions in the costs of copying, storage and distribution of data and information. As a result, ICT tools are providing a new wave of mechanisms that not only facilitate the mechanical transmission of data, information and knowledge, but also change the way publicly funded research can be produced, transferred, managed, accessed, used and reused. Since in many instances the primary role of PROs, in particular for universities, remains knowledge creation and dissemination via publications and data, ICT tools have created fundamentally new channels for disseminating this knowledge to a broad range of potential users.

While there have been historical movements to foster sharing of public research data and results prior to the rise of ICTs, the low-cost feature of ICT tools has empowered researchers, institutions and governments to manage, store and transfer data and publications to the scientific community in an unprecedented way that can tackle new and unsolved problems.

In an environment where knowledge has become more abundant and freely available, the concept of "open science" has emerged to describe the policies and practices of carrying out science in an inclusive and collaborative way, including as regards the sharing of all kinds of research data and results (RIN and NESTA, 2010). In particular, the rise of open access publishing since the mid-1990s has created new avenues for diffusing research results, which allows cumulative research processes to occur. However, there is still much confusion on what "open" means and entails (Box 3.12).

Box 3.12. Defining "open"

Open innovation – This concept describes the "use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation". This includes proprietary-based business models that make active use of licensing, collaborations, joint ventures, etc. Here, "open" is understood to denote the arm's-length flow of innovation knowledge across the boundaries of individual organisations.

Open source model – Most commonly linked to the provision of free software by a community of contributors, this term is now applied to designate innovations, often jointly developed by different contributors, available royalty-free to anyone and without significant restrictions on how they are to be used. A possible restriction is that derivative work also has to be provided on the same basis.

Open educational resources (OERs) – were identified and defined at UNESCO in 2002 as "teaching, learning or research materials that are in the public domain or released with an intellectual property license that allows for free use, adaptation and distribution".

Open access (OA) – This term generally describes the possibility of accessing peer-reviewed scientific research articles (published in academic journals) and scientific research data (underlying publications and/or raw data), on line, free of charge to the reader, and free of most copyright and licensing restrictions. There are variations on the concept of open access across countries. The key issue concerns different paths to open access with different levels of the rights of use and reuse. Open access generally comes after the decision to publish; it is not an obligation to publish research results. It requires posting results on the Internet with consent of the author or copyright holder. OA is a term increasingly applied to data provided by profit-driven operators, who develop business models that enable them to obtain a source of revenue bundled alongside information provided on a free and open basis.

Open access archives – The archives or repositories do not perform peer review, but simply make their contents freely available to the world. They may contain un-refereed preprints, refereed post-prints, or both. Archives may belong to institutions, such as universities and laboratories, or disciplines, such as physics and economics. Authors may archive their preprints without anyone else's permission. Most journals already permit authors to archive their post-prints. When archives comply with the metadata harvesting protocol of the Open Archives Initiative, they are then interoperable and users can find their contents without knowing which archives exist, where they are located, or what they contain.

Green open access (also called self-archiving or the green route) – means that the published articles or the final peer-reviewed manuscript is archived by the researchers after or alongside its publication. Access to the article is often delayed (embargo period). Publishers recoup their investment by selling subscriptions and charging pay-per-download/ view fees during an exclusivity period. Funding agencies increasingly request or mandate that researchers self-archive peer-reviewed manuscripts.

Gold open access (also called open access publishing, or author pays publishing) – means that a publication is immediately provided in open access mode by the scientific publisher. Associate costs are shifted from readers to the university or research institute to which the researcher is affiliated or the funding agency.

Open data – This term refers to a practice of making data freely available to everyone in standard and re-useable format, without any IPR control. The goals are similar to those of open source and open access, but the term is often used as a synonym for "open government data". The nature of the data differs, as it entails data collected by public administrations. "Data" in this case refers to everything from electoral statistics to the location of schools or parking lots.

…/…

Box 3.12. Defining "open" *(continued)*

Open science – This term is often used to describe a movement that promotes greater transparency in the scientific methodology used and data collected. It ensures the public availability and reusability of data, tools and materials, and argues for broadly communicating research (particularly when publicly funded) and its results. In many ways, open science in the modern sense can be seen as promoting extended access to the *outputs* of public research but also to some of the *inputs*, whether scholarly articles, notebooks or data.

Sources: OECD (2013), "Knowledge Networks and Markets", *OECD Science, Technology and Industry Policy Papers*, No. 7, OECD Publishing, Paris, http://dx.doi.org/10.1787/5k44wzw9q5zv-en; European Commission (2013), Background note on open access to publications and data in Horizon 2020, Directorate General for Research and Innovation, Unit B6; Suber, P. (2012), *Open Access*, The MIT Press Essential Knowledge Series; Krichel, T. and C. Zimmerman (2009), "The economics of open bibliographic data provision", *Economic Analysis and Policy*, Vol. 39, pp. 143-152.

Facilitating access to public research results

Access to public research results has become a key issue, reflecting increasing interest in improving the accessibility of scientific research findings in general and in particular the results of publicly funded research, which institutional and private users often have to pay for separately in order to secure access. Miguel, Chinchilla-Rodriguez and de Moya-Anegón (2011) found that nearly 60% of Scopus journals do not have open access publication policies, while among that do, less than 10% have a full open access policy. In light of the increasing profit margins of publishers, it is not surprising that this is the subject of intense academic and policy debate, particularly in a time of limited research funds.

Realising the full potential offered by greater collaboration and ICT tools in research will require the identification and removal of technical barriers (e.g. around the creation and manipulation of research data, standards) and institutional barriers in existing policy, both within OECD countries and internationally. Governments, as key funders of public research, play an important role in developing the legal frameworks for fostering greater access and use of scientific research. For example, legislative initiatives and policies of funding agencies can foster greater access to publications and sharing of data by creating the necessary incentives for researchers. Public policies can also provide guidance to researchers on how to comply with the various policies governing access and sharing (e.g. IPR, privacy and confidential issues). They can also help research institutions promote better management of research data through infrastructure development and training.

The most common policy instrument is the requirement to publish in digital format. For example, the US National Institutes of Health (NIH) has made its public access policy mandatory: all funded researchers must submit an electronic version of their final peer-reviewed manuscripts to PublicMed Central (OECD, 2010) (Box 3.13). As of 2013, the Canadian Institutes of Health Research (CIHR) expresses in its policy on open access that "all research papers generated from CIHR funded projects are freely accessible through the Publisher's website or an online repository within 12 months of publication".[11] New Zealand and Spain also require publication of publicly funded research results in digitised format in an open access repository. The Office of Science and Technology Policy (OSTP) of the White House in the United States issued in early 2013 a policy memorandum to federal agencies with more than USD 100 million in research expenditures to make published research results and digital scientific data more accessible to the public. In the United Kingdom, the government announced in July 2012 that it has accepted the recommendations of the Working Group on Expanding Access to Published Research Findings. In the European Union, the EC strategy is to develop and implement open access to research results from projects funded by the EU Research Framework Programmes, namely FP7 and Horizon 2020, based on support to both "green open access" and "gold open access".

Box 3.13. National Institutes of Health (NIH) Public Access Policy (United States)

The NIH Public Access Policy ensures that the public has access to the published results of NIH-funded research. It requires scientists to submit final peer-reviewed journal manuscripts that arise from NIH funds to the digital archive PubMed Central upon acceptance for publication. To help advance science and improve human health, the policy requires that these papers be accessible to the public on PubMed Central no later than 12 months after publication.

This policy aims to increase the return on the government's investment in research by ensuring that the results are more easily and equitably accessible to those who can use them. It operates in parallel to agency efforts to license patented inventions that result from government-funded research.

It was developed after extensive consultation with the stakeholder communities, including a public request for information and a public meeting. Following implementation of a voluntary public access policy in 2004, legislation passed by the US Congress in late 2007 made the policy mandatory for recipients of NIH funding.

The policy applies to NIH-funded scientists, who are required to deposit (or have deposited on their behalf) their manuscripts into PubMed Central. In practice, more than 3 000 scientific journals have agreements in place to deposit articles into PubMed Central on behalf of NIH-funded researchers (many of those journals deposit all of their articles in PubMed Central, whether or not the investigators were funded by NIH).

Investigators are obligated to submit their manuscripts, although (as noted above) publishers may assist in the process. Implementation is sometimes assisted by the libraries of research universities and public research organisations.

There has been significant collaboration between the NIH and participating institutions in Canada and the United Kingdom to develop similar repositories for manuscript deposit, and to allow the sharing of deposited materials among them. At this point, these policies have been in place sufficiently long to allow an assessment of their impact on access to government-funded research results and on subscriptions to peer-reviewed journals.

A number of countries are promoting the use of free licenses by PROs. Public research funding in Estonia, for example, covers the costs of publishing in open access journals (OECD, 2012a). Similarly, the German Research Foundation (DFG), Germany's largest research funding organisation, operates three funding programmes for researchers and individual institutions alike to facilitate open access publishing. One funding programme supports the development of alternative business and organisational models.

Open science also requires an enabling infrastructure. The EC has supported the building of repositories and infrastructure through the Framework Programmes for Research and Technological Development, including Digital Repository Infrastructure Vision for European Research (DRIVER), DRIVER II, Open Access Infrastructure for Research in Europe (OpenAIRE) and OpenAIREplus initiatives. The push towards open access has also led to the emergence of new co-operative models. One is the initiative developed by Co-Action Publishing with Lund University, the National Library of Sweden and Nordbib to adopt online guides to open access publishing and self-archiving for researchers. Another is the creation of a Directory of Open Access Journals, to rank countries' national policies on access (OECD, 2012a).

Similar to the open access movements, the notion of "open data" promotes the idea that government data should be freely available to the public at large. Many OECD countries have adopted such an approach with regard to government databases with the launch of open-data government initiatives, such as Data.gov.uk; the Australian government's Data.gov.au; Austria's gov.opendata.at; and Canada's Data.gc.ca website.

Challenges for open access and data

The processes for producing knowledge and its diffusion face several challenges. First, science is increasingly data-driven and expensive, but access to scientific data is subject to legal, administrative and privacy rules and financial constraints (e.g. state and local laws, copyright law, and international standards). At the same time, ICTs – notably advances in computing power – have increased the amounts of data generated in scientific research, creating other challenges around the verification and storage of such "big data". In the same vein, the lack of incentives for researchers due to limited opportunities for acknowledgement for data (e.g. no standard practices for data citation) and difficulties in formatting it in ways that can make it usable by others can act as barriers.

Other limits on openness in science include growing pressure to protect results of research and weak incentives for researchers to share data, which can also act as a barrier to the replication and validation of scientific experiments. Researchers and policy makers also have few incentives or mechanisms to share or interlink cleaned datasets. Access to these data is restricted "by a patchwork of laws, regulations, and practices that are unevenly applied and interpreted" (Haak et al., 2012).

While access also requires an adequate infrastructure and repositories, there are concerns about duplicating publicity funded repositories and archives. Open access repositories may also in general be more expensive and inefficient than those run by publishers. In addition, requirements for open access have significant financial implications. A shift to "gold" open access – a publication is immediately provided in open access mode and the institution or authors pay upfront fees to open access publishers – will require universities or funding agencies to set aside funding. The benefits may outweigh the costs, but costs and benefits should be demonstrated. For example, the UK Department for Business Innovation and Skills (BIS) (2013) estimates additional costs of gold access at around 1% of the Science Budget, which averages from GBP 40 million (EUR 46 million) to GBP 50 million (EUR 57.5 million) per year.

There are also tensions around the importance of scientific publishing in journals and publishing in scientific commons. Peer-reviewed scientific journals are the basis for promoting excellence in research through competitive forces. In addition, scientific citations of publications are used to assess the performance of researchers and institutions as well as to make funding decisions.

Researchers' incentives for knowledge and invention disclosure

Researchers are in principal creators and suppliers of knowledge, in the sense that they discover new knowledge while conducting publicly funded research. The ability of public research systems to benefit from the dissemination and transfer of knowledge generated by researchers depends not simply on the incentives for researchers to carry out R&D and innovation activities. It relies also on their incentives to i) use the knowledge provided; and ii) disclose their own research results whether of commercial interest or not, in a way that can be accessed, used and reused by future researchers as well as by TTOs and industry.

In terms of invention disclosures, studies confirm that high-quality inventions are scarce and are usually not disclosed to third parties (e.g. Jensen, Thursby and Thursby, 2003). In another study, Thursby and Kemp (2002) found that less than half of faculty inventions with commercial potential are disclosed to the TTO. This may be because those involved do not realise the commercial potential of their inventions. The incentives may be also influenced by the perceived costs of interacting with the TTO (e.g. concerns of publication delays) and by institutional environments and norms (e.g. whether or not university management supports commercialisation; disclosure behaviours of department chairs and peers) (Owen-Smith and Powell, 2001; Bercovitz and Feldman, 2008).

Designing incentives to encourage disclosure is a difficult undertaking (Markman et al., 2004). Policy makers, agencies responsible for academic incentives and TTOs need to take into account a range of variables and interests. There are a variety of mechanisms, non-monetary and monetary, used to influence invention disclosure behaviour by researchers. The role of disclosure incentives should not be considered as being limited to technology disclosure alone, but also to knowledge disclosure (e.g. data sharing).

Monetary mechanisms and incentives

Monetary incentives to encourage researchers to disclose may include a fixed rate of revenues generated from the exploitation of IP and other technological activities, or it can be a non-linear rate. It can also be a lump-sum payment. Other incentives to encourage researchers include awards, recognition in curricula, equity participation in spin-offs, additional research funds for department, and salary upgrade (Zuñiga, 2011). According to a survey of European universities, the most common incentive mechanism for researchers is the rate of revenues generated from IP (84% of respondents) with the inventor receiving on average 41% of the income. Other incentives are less common, such as social rewards (47%), provision of additional funding (35%) and lump-sum payments (31%) (European Commission, 2012).

While increasing monetary incentives may have a positive impact on the willingness to disclose inventions – and, if successfully licensed out, on licensing income (e.g. Lach and Schankerman, 2008 for the United States; Caldera and Debande, 2010 for Spain) – they can be detrimental to other commercialisation outputs and university missions. Di Gregorio and Shane (2003) show that allocating a higher share of inventors' royalties can be detrimental to spin-off activities, as increased opportunity costs lower incentives for spin-off formation (see also Markman et al., 2004). Researchers may also devote too much effort to tasks providing the highest return at the expense of other university missions, such as teaching (Cockburn and Henderson, 1998).

Non-monetary mechanisms and incentives

Mechanisms and incentives such as access to research funding, interaction with research colleagues from other disciplines, size of research teams and challenging ideas from industry (to name a few) can be just as (or even more) important for knowledge and invention disclosure than monetary incentives (Panagopoulos and Carayannis, 2013).

First and foremost, research collaboration among researchers increases the probability of sharing knowledge, skills and techniques. Given the increasing complexity of research, often no single individual will possess all the knowledge required to achieve a particular research objective. This necessarily requires researchers to engage in collaborative activities through correspondence or discussions – at conferences, by visiting each other, or by performing parts of a project separately and then integrating the results.[12] But scientific collaboration is a complex phenomenon with multifaceted motivations, benefits and challenges, and policies to enhance collaboration among researchers may come via various channels (e.g. funding and research agencies, promotion of interdisciplinary research and infrastructure provision, university governance and organisation, inter-institutional mobility, etc.).

In addition, university guidance to researchers on how to comply with rules on data access and sharing may help facilitate knowledge and data disclosure. Rusbridge and Lyon (2010) argue that in order for the role and value of data management to be internalised by researchers in some disciplines, there needs to be a more explicit link between the effort that is required to manage and share data and career recognition and rewards. However, researchers' compliance with data-related funding policies in the post-award phase is not especially well monitored and sanctions for non-compliance are rarely applied.

Researchers and students at universities and PRIs often lack awareness of IPR. Therefore, the development of an IP culture may increase the rate of invention disclosures. Raising awareness and informing students and researchers about the IP system at universities and PRIs consist primarily in organising IP-related events and producing leaflets and other materials to disseminate IP-related information (e.g. IP Wall of Fame) in a user-friendly manner. For example, the patent teaching kit was designed by the European Patent Academy to help promote patent awareness at universities.

Researchers are sometimes not willing to disclose their inventions because it may delay their publications or it may be very time-intensive to interact with TTO personnel in follow-up commercialisation activities. Researchers may also find it difficult to assess the commercial profitability of their inventions. The Göteborg University and Chalmers University in Sweden provide an idea evaluation service for inventors and entrepreneurs through a multidimensional approach (Box 3.14). One of the more common approaches is to hold business plan competitions, which not only provide educational training but also help students and researchers to evaluate the commercial potential of their inventions. In another example, Panagopoulos and Carayannis (2011) propose that TTOs can achieve full disclosure by allowing researchers to self-license their invention in return for some form of non-monetary "insurance'', just in case they fail in self-licensing their technology.

However, it should be noted that even when disclosure incentives are addressed through appropriate incentive schemes and policies, two problems occur: i) firms cannot asses the quality of inventions *ex ante* due to asymmetric information problems; and ii) only a minority of invention disclosures will have the potential to generate revenues that justify the costs of patenting. Firms' actions on the universities' behalf in filing the patent (e.g. funding the costs, drafting complete patent applications) or effective use of industry representatives can help reduce the problems but these put additional demands on TTOs, and firm's actions may be biased by their own interests.

Box 3.14. Disclosing and assessing university innovations: Idea evaluation

The Göteborg University and Chalmers University in Sweden offer a free-of-charge idea evaluation service for early stage innovations. The service – now upgraded with a multidimensional approach for evaluation – supports research utilisation for academic and industry innovators, and is conducted within the Chalmers' PhD- and master's-level course in Idea Evaluation.

Selected innovation projects are assessed by teams of five supervised master's/PhD students, applying tools and frameworks in the areas of IP strategy, market and risk analyses, business model design and environmental sustainability. The idea provider will – by submitting the invention for review – agree to a total of two to three hours for calls/meetings with the analysis team.

After analysis and presentation, the holder of the invention receives a full report along with recommendations for further incubation of the innovation. All information is handled with secrecy through non-disclosure agreements, and the reports stemming from the process are not public but intended only for the idea provider (and any innovation advisor connected to the idea) to receive. Ideas, early innovations, research patents and projects can now have this thorough IE-analysis free of charge. The Idea Evaluation service is a tool for research utilisation and without further commitment for the idea provider.

The innovation idea is evaluated using the criteria of IP, Market, Time, Biomimicry, Concept-Knowledge (C-K) Theory and Sustainability. In 2012, the focus is on innovation ideas having a potentially high transformative impact and contributing to sustainability.

Source: IdeaEvaluation, Chalmers University of Technology.

Encouraging the emergence of entrepreneurial ideas among faculty and students

Business building and entrepreneurship are particularly important for academic entrepreneurs. Studies point to the lack of relevant human capital of these firms, such as managerial skills, experience, commercial social capital and networks (e.g. Wright, Clarysse and Mosey, 2012b). Thus, approaches to nurture entrepreneurship that focus only on the funding gap (see Chapter 4) without addressing these kinds of challenges will most likely inhibit the rise of successful entrepreneurial ideas from universities and PRIs.

Entrepreneurship training programmes have been used primarily by institutions as a means of encouraging students and faculty to establish a firm on the basis of public sector knowledge. A survey of European institutions found that entrepreneurial training is available to 71% of students, but shares are higher for larger institutions. Entrepreneurship education witnessed a dramatic increase; a number of universities are investing in new educational programmes that engage a much wider cross-section of the university population to create awareness of and skills for entrepreneurship. These include work-study programmes, internships, mentoring relationships, workshops, seminars, allȥcampus initiatives (Nelson and Beyrs, 2010), business plan competitions and (more recently) free online entrepreneurship courses. Educational training programmes have also been supported by ministries and funding agencies such as the US National Science Foundation (US NSF) Innovation Corps (I-Corps) programme, which is modelled after Stanford's Lean LaunchPad class.

Furthermore, a university's larger eco-system also plays a critical role in providing resources and enhancing the competencies of faculty and students interested in establishing a start-up. For example, the business environment, entrepreneurial culture and institutions' endowment (e.g. tangible, such as physical infrastructure, corporate physical assets, and R&D laboratories; and intangible, such as human capital, routines, norms, research excellence, etc.) can prove important determinants for the establishment and growth of start-ups (Fini et al., 2011) (see also Box 2.2 on determinants of spin-off formation), which are very difficult to replicate.

Box 3.15. Entrepreneurial framework conditions at the Massachusetts Institute of Technology (MIT)

MIT was founded in 1861. Nowadays one of the most prestigious universities in the world, it is also known to be an entrepreneurial hotbed. Several factors can be identified in its success in generating a vast number of start-ups. Among these are:

- MIT's high-quality research in a number of applied and interdisciplinary research areas has been a strong foundation for creating the knowledge that start-up companies have exploited. For example, MIT alumni companies are primarily knowledge-based companies in software, biotech, and manufacturing. This is also reflected in employment numbers in MIT alumni firms: 30% of the jobs are in manufacturing, which is greater than the 11% of manufacturing employment in the United States overall.
- Since its founding in 1861, MIT's culture of "mens et manus" (mind and hand) resulted in strong internal and external networks between government, industry, and academia. These networks have increased and leveraged research and industry funding at MIT, but also helped students after leaving MIT. Based on survey data, 85% of alumni entrepreneurs reported that their association with MIT helped their credibility with suppliers and customers. Similarly, 51% of the entrepreneurs also felt that their association with MIT helped in acquiring funding.
- MIT has a number of dedicated and experienced organisational structures such as its technology licensing office (TLO) and formal and experiential entrepreneurship programmes. The TLO, for instance, meets regularly with venture capital firms to discuss the potential of technologies and start-ups. With regard to entrepreneurship programmes, the MIT Venture Mentoring Service, established in 2000, supports entrepreneurial activity by matching prospective entrepreneurs with skilled volunteer mentors.
- MIT has a strong mission of commercialising public research. The stated mission of MIT is to "advance knowledge and educate students in science, technology, and other areas of scholarship that will best serve the nation and the world in the 21st century". This mission is supported by consistently applied policies that support and encourage start-up formation by academics and students.
- Students and academics within MIT have positive attitudes to commercialising research and establishing start-ups. Student-run activities such as the MIT USD 100 000 Business Plan Competition and student clubs are one reason for the vast number of student start-ups. These start-ups are often established with help of faculty as team members. Survey data show that 23.5% of alumni had founded at least one company in their lifetime. This environment also attracts entrepreneurship-inclined students and faculty. By the 1990s, as high a share as 42% of graduates who formed companies claimed to go to MIT because of its entrepreneurial environment.
- MIT is located on the Boston's Route 128, which is one of the leading high-tech clusters in the world. It provides access to expertise to leading high-tech firms and corporations (e.g. DuPont, Kodak), universities (e.g. Harvard) and PRIs, and resources such as access to venture capitalists.

Source: O'Shea, R.P. et al. (2007), "Delineating the anatomy of an entrepreneurial university: The Massachusetts Institute of Technology Experience", *R&D Management*, Vol. 37, pp. 1-16; Roberts, E.B. and C.E. Eesley (2009), *Entrepreneurial Impact: The Role of MIT*, the Ewing Marion Kauffman Foundation.

In fact, initiatives toward greater entrepreneurship in universities have been criticised for being largely based on anecdotal evidence of successful examples from US universities such as Columbia University, Stanford University and Massachusetts Institute of Technology (MIT), and for having neglected the larger eco-system in which they are embedded. For example, according to the Stanford Innovation Survey, the entrepreneurial environment at Stanford led to the development of 39 900 active companies by alumni, which created an estimated 5.4 million jobs and generate annual world revenues of USD 2.7 trillion (including Google, Nike, Cisco, Hewlett-Packard, Charles Schwab, Yahoo!, Gap, VMware, IDEO, Netflix and Tesla). Such an entrepreneurial environment may in turn attract individuals who wish to be entrepreneurs. The survey indicated that among respondents who became entrepreneurs in the past decade, 55% reported choosing to study at Stanford because of its entrepreneurial environment (Eesley and Miller, 2012). In addition, data on venture capital deals found that Stanford's alumni companies raised a total of USD 4.1 billion across 203 financings, followed by Harvard (including the Facebook deal) and the University of California. A study by MIT, which has a unique entrepreneurial culture – its very first start-ups by alumni date back to the early 20th century (Box 3.15), found that as of 2006, there were 25 600 companies created with total annual revenues of some USD 2 trillion (Roberts and Eesley, 2009). There are also numerous initiatives and approaches to creating a favourable eco-system for research spin-offs at individual institutions beyond the miracle of Stanford and MIT. For example, the Aalto Centre for Entrepreneurship (ACE) at the Aalto University in Finland provides a systems approach to nurture university spin-offs and start-ups, which consists of offering not only PoC funding but also entrepreneurship education, IP management and innovation services (Box 3.16). Case studies show that even with unfavourable conditions such as low R&D expenditures, low research/financing capacities and low venture capital availability, universities can achieve high entrepreneurial activities through smart programme designs (Åstebro, Bazzazian and Braguinsky, 2012).

Box 3.16. Aalto Centre for Entrepreneurship (ACE), Finland

The Aalto Centre for Entrepreneurship (ACE), which is also the technology transfer office (TTO) of Aalto University, aims at creating business success stories from the science and art within the Aalto community. ACE offers innovation, commercialisation and start-up services for Aalto University researchers, students and other stakeholders. In addition, it facilitates innovation and growth entrepreneurship by developing research and education in these areas across all Aalto schools. The key tasks within its four principal spheres of activity are:

Growth entrepreneurship education

- Build higher awareness and appreciation of growth entrepreneurship
- Increase willingness of graduates to establish a company and/or join an existing growth company
- Increase understanding of the market dynamics of start-ups and growth companies, and ultimately increase tolerance for risk

Growth entrepreneurship research

- Promote the production of world-class growth entrepreneurship research
- Become a hub for international growth entrepreneurship professors and researchers

Innovation services

- Create world-class commercialisation models, services and programmes
- Facilitate the in-bound flow of capital and talent to boost Aalto-born innovations

…/…

Box 3.16. Aalto Centre for Entrepreneurship (ACE), Finland *(continued)*

Start-up services

- Catalyse research- and student-based start-up companies
- Facilitate the emergence of a strong venture capital environment
- Facilitate in-bound flow of capital and talent

ACE is operating as part of Aalto University's permanent activities. While ACE was operationally launched in September 2010, it has a long background as the former Otaniemi International Innovation Centre (OIIC).

As Aalto University has been a national "project", offering its services to all national universities. The ACE receives EUR 3 million from Aalto University and EUR 2.2 million from Tekes. Pre-seed funds are provided on a EUR 0.3 million per-case basis.

ACE is closely collaborating with Tekes and its new programmes:

- TULI – The Tuli programme helps researchers and research communities to evaluate the commercial potential of research-based inventions or ideas and aids in the process of their commercialisation
- IKK – The Development of Innovation Capabilities of Research Organisations
- VIGO / NIY programme – Accelerator and Young Innovative Companies programmes
- Tempo – Mobile Services programme

Besides the ACE, the Aalto University runs a diversity of initiatives to support entrepreneurship, including the Start-up Sauna, the Aalto Entrepreneurship Society, the AppCampus, the Start-up Centre and the Aalto ventures programme.

Notes

1 . The grace period generally does not protect against independent disclosures made by third parties prior to the filing date.

2 . See Edmonson et al. (2013) for a list of 38 countries worldwide that have a grace period, including 12 with very limited grace periods that do not protect against pre-filing publication by the inventor.

3. For example, Cornell University sued Hewlett-Packard over a computer-processor patent and a jury awarded the university USD 183 million in 2009; the award was later reduced to USD 53.5 million.
Source: http://arstechnica.com/tech-policy/2012/12/jury-slams-marvell-with-mammoth-1-17-billion-patent-verdict/ (accessed 16 February 2012). In another example, Micron Technology, Inc., a multinational semiconductor corporation, decided to stop hiring University of Illinois graduates due to a patent infringement that UIUC filed against Micron. See www.patentlyo.com/patent/2013/04/although-without-tact-microns-retaliatory-decision-to-stop-hiring-university-of-illinois-graduates-is-not-illegal.html (accessed 13 April 2012).

4. www.easyaccessip.org.uk

5. An example is furnished by Chou v. University of Chicago (2001). Dr. Chou, a postdoctoral student at the University of Chicago, co-discovered a vaccine for the herpes virus; her supervisor, Dr. Roizman then concealed and excluded her from his patent application. Chou sued for correction of inventorship, fraudulent concealment and related charges. The state court ruled she had no standing to sue because she was required by her employment contract to assign her rights to the university, but the Federal Circuit reversed that decision because she had a pecuniary interest to 25% as an inventor under the policy.

   For more examples see www.ipadvocate.org/forum/dispute.cfm?Type=Disputes (accessed 16 February 2013).

6. www.innovationtransfernetwork.org/ (accessed 16 February 2013).

7. www.enseignementsup-recherche.gouv.fr/cid67054/satt-les-societes-d-acceleration-de-transfert-de-technologies.html (accessed 29 February 2013).

8. www.enterprise-ireland.com/EI_Corporate/en/Research-Innovation/Companies/IPP-Putting-public-research-to-work-for-Ireland.pdf (accessed 15 May 2013).

9. See www.ibridgenetwork.org/.

10 . http://ec.europa.eu/enterprise/policies/innovation/policy/intellectual-property/index_en.htm (accessed 10 May 2013).

11. www.cihr-irsc.gc.ca/e/32005.html (accessed 16 February 2013).

12. Benefits are likely to be largest when the collaboration involves partners from more divergent scientific backgrounds.

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