Commercialising Public Research

NEW TRENDS AND STRATEGIES

OECD

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BETTER POLICIES FOR BETTER LIVES

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Foreword

Public research is the source of many of today's technologies. Public research institutions (PRIs) and universities are also a breeding ground for entrepreneurial ventures, from biotech start-ups to student start-ups such as those that led to Internet giants like Google. Today, globalisation, greater openness in accessing research data, and new forms of financing such as crowd funding for research are changing the way institutions promote the transfer and commercialisation of public research results. This report presents new trends and policies for the transfer and commercialisation of public research in OECD countries and regions, including Australia, Canada, the European Union and the United States.

The report was carried out under the auspices of the OECD's Working Party on Innovation and Technology Policy (TIP) of the Committee for Scientific and Technological Policy (CSTP). It draws on a review of the literature and quantitative indicators as well as a survey of government policies and programmes. National governments submitted case studies of government and institutional approaches. The report also draws on the contributions from experts and discussion at four thematic events: the TIP-OECD *Thematic Workshop on Knowledge Networks and Markets* held on 15 June 2011; the TIP *Thematic Workshop on Financing R&D and Innovation in the Current Macroeconomic Context* held on 7 December 2011; a joint TIP-RHIR (Working Party on Research Institutions and Human Resources) *Expert Workshop on Knowledge Transfer, Exploitation and Commercialisation* held on 5 October 2012; and a joint EPO-OECD-TUM (European Patent Office and the Technical University of Munich) conference *on Creating Markets from Research Results* held on 6-7 May 2013.

This report has been drafted by members of the Secretariat, principally by Daniel Kupka, with original contributions from Mario Cervantes, Jin Joo Ham and Ester Basri. Mario Cervantes provided overall supervision and co-ordination for the activity under the guidance of Dominique Guellec.

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Acronyms and abbreviations

EC	European Commission
EPO	European Patent Office
EU	European Union
GDP	Gross domestic product
HRST	Human Resources in Science and Technology
ICT	Information and communication technologies
IP	Intellectual property
IPRs	Intellectual property rights
NIS	National innovation systems
PCT	Patent Co-operation Treaty
PPP	Purchasing power parity
PRI	Public research institutions (the terms “PRI” and “PRO” are used interchangeably depending on national practise; here: government research laboratories and establishments engaged in activities such as administration, health, defence and cultural services, excluding universities)
PRO	Public research organisations (all institutions and public bodies that conduct research primarily funded with public resources, i.e. universities, other higher education institutes, PRIs, hospitals, etc.)
R&D	Research and development
S&E	Science and engineering
S&T	Science and technology
SME	Small and medium-sized enterprises
WIPO	World Intellectual Property Organization

Country abbreviations

ARG	Argentina	FIN	Finland	NLD	Netherlands
AUS	Australia	FRA	France	NOR	Norway
AUT	Austria	GBR	United Kingdom	NZL	New Zealand
BEL	Belgium	GRC	Greece	POL	Poland
BRA	Brazil	HUN	Hungary	PRT	Portugal
CAN	Canada	IND	India	RUS	Russian Federation
CHE	Switzerland	IRL	Ireland	SVK	Slovak Republic
CHL	Chile	ISL	Iceland	SVN	Slovenia
CHN	People’s Republic of China	ISR	Israel	SWE	Sweden
CZE	Czech Republic	ITA	Italy	TUR	Turkey
DEU	Germany	JPN	Japan	USA	United States
DNK	Denmark	KOR	Korea	ZAF	South Africa
ESP	Spain	LUX	Luxembourg		
EST	Estonia	MEX	Mexico		

Executive summary

Public research in universities and public research institutions (PRIs) are the source of many of today's technological innovations from recombinant DNA technology, the Global Positioning System (GPS) and the MP3 technology to Apple's Siri voice recognition technology. But recent data on the number of patents, licenses and companies created at universities and PRIs show a general slowdown since the late 2000s. This has raised concern among policy makers and practitioners about the effectiveness of commercialisation policies and mainstream technology transfer practices at universities and PRIs. This has in turn generated interest in new approaches to turn science into business as well as in new indicators for measuring the two-ways flows of knowledge and technology between public research and business.

Between 2001 and 2005, the average annual growth rate in patent applications by universities fell from 11.8% to 1.3% between 2006 and 2010. PRIs even experienced a negative growth of -1.3% over the latter period, compared to 5.3% growth between 2001 and 2005. Data on invention disclosures, that is, the first official recording of an academic invention – measured per USD 100 million in research expenditures show a slight drop on average from 2004-07 to 2008-11. University spin-offs have not significantly expanded either, despite continued policy support; in the United States, the number of spin-offs per university per year among 157 universities is low, averaging four. Data on spin-off companies formed per USD 100 million in research expenditures show on average a low in 2008 in major OECD countries, while the ratio stabilised in 2009-11 to pre-2008 levels. On the other hand, licensing income has remained relatively stable in OECD countries; however, only a small number of universities account for the bulk of total licensing income. In Europe, 10% of universities accounted for approximately 85% of total licensing income.

While patents, licenses and spin-offs remain important channels for commercialising public research, other channels such as collaborative research, (e.g. public-private partnerships), student and faculty mobility as well as contract research and faculty consulting appear to be increasing in importance. Student entrepreneurship has emerged as a focus of efforts to promote knowledge transfer and commercialisation.

Technological progress in ICTs combined with greater openness in public research and business innovation are also broadening the channels for commercialisation. A key driver is the push by science funding agencies for greater access to publicly funding research results and data.

Technology licensing and transfer offices (TTOs), which have long been central to university and government efforts to commercialise research, are also evolving in the search for more effective operational models. Many universities have sought to reform TTOs or to create new models such as regional hub-and-spoke TTOs that service multiple research institutions. In additions, some universities are also exploring new approaches to IP ownership by vesting some rights with the academic inventor while maintaining university ownership.

New approaches to financing commercialisation are also emerging. Many universities and PRIs are complementing government funding for university start-ups by setting up their own proof-of-concept (PoC) and seed funds. Examples include the Chalmers

Innovation Seed Fund, the Gemma Frisius Fonds KU Leuven and the Imperial Innovation Fund. Additional sources of finance such as IP collateral-based funding, corporate venturing activities and crowd funding for research are also boosting finance for research and commercialisation activities.

A key message from this report is that national policies and strategies for the commercialisation of public research should be strengthened not only with regard to patenting and licensing efforts but especially towards emerging channels like student entrepreneurship. Governments, research ministries and business must work more closely together to develop a more coherent set of policies for commercialisation and avoid overlap or duplication. Policies and incentives for the transfer of knowledge commercialisation should not be limited to patents and licensing from technological inventions; advances in the social sciences and humanities also contribute to innovation.

Introduction

Public research – i.e. research primarily funded with public resources and carried out by public research institutions (PRIs) and research universities (hereafter both referred to as public research organisations [PROs]) – plays an extremely important role in innovation systems. Its sphere of influence touches education, training, skills development, problem solving, creation and diffusion of knowledge, development of new instrumentation, and the storage and transmission of knowledge. But public research has been also the source of significant scientific and technological breakthroughs that have become major innovations, sometimes as by-products of basic scientific research goals and sometimes with no vision of any direct application to a valuable commercial activity. Well-known examples include recombinant DNA techniques, the Internet, the scanning electron microscope and superconducting magnets. While it is inherently difficult to quantify the impact of public research, it has been suggested that around a tenth of innovations would have been delayed in the absence of public research (Mansfield, 1991). In some sectors – such as pharmaceuticals and semiconductors – innovation is far more dependent on public research results.

Shifting missions and growing demands

Awareness of the substantial economic benefits from public research, and demands by governments to reap those benefits, have changed the rationales for supporting PRIs and universities in particular. This has led to increased efforts – and a growing number of approaches – toward more direct engagement in downstream commercialisation activities. In large part, this awareness reflects the recognition that in some cases, simply placing public sector knowledge on the market for knowledge is not sufficient to generate social and economic benefits from research. While public research continues to be considered central to advancing scientific training and supporting social needs, generating knowledge to support innovation, it is no longer considered independently from commercialisation purposes.

The idea that pubic research should contribute more directly to economic growth and society is not new. The notion has been discussed most notably in relation to the concepts of “mode 2”, the “triple helix approach” and the “engaged university”, of which all take an activity-oriented and goal-oriented view of public research (see Brehm and Lundin, 2012 and, for an overview, Mowery and Sampat, 2005). Indeed, the move toward engagement in commercialising public research can be seen as a consequence of a longer-term shift towards a knowledge economy. For example, interactions between university professors and industry in the chemicals sector can be dated back to the 19^{th} century (Meyer-Thurow, 1982). Foray and Lissoni (2010) argue that neglecting the potential of commercialisation of public research may be seen as lost opportunities, as some of the most radical innovations may not have been disclosed.

Some observers argue that public research has become too responsive to commercialisation incentives at the expense of core university missions, such as the dissemination of knowledge and teaching, or has added to the multitude of missions of universities and PRIs (i.e. the risk of a “mission creep”) (OECD, 2011). Moreover, academic inventions tend to be far from marketable, and substantial further innovative effort is needed to turn them into commercial products.

Others point out that because public funds are used to support public research, researchers and PROs should not only be held accountable to society for their results, but also be concerned about achieving a higher social and private rate of return from public investments in research.

Driving factors for the increased focus on commercialisation

The role of PROs in contributing more actively to the transfer and commercialisation of public research is being driven by various factors. Some have been pursued more actively by governments, while others have followed changing corporate policies (i.e. open innovation) or have been subject to external factors such as budgetary pressures on universities. The list below highlights some of the longstanding and more recent drivers (OECD, 2002, 2003, 2008, 2012; Larsen, 2011; Deiaco, Hughes and McKelvey, 2012; Arora, Fosfuri and Gambardella, 2001; Chesbrough, 2003).

- **Willingness to improve national competitiveness in industry.** Many OECD countries are again expressing concern about the deterioration of national competitiveness, and in particular the increasing competition from emerging economies.
- **Dissatisfaction with the measurable and direct returns of public research results.** The dissatisfaction of policy makers with the measurable returns (e.g. in terms of academic patents, spin-offs and the licensing income generated) has increased interest in new ways to improve commercialisation results. In addition, downward pressure on funding for university research has led to increased pressure to demonstrate social and economic impact.
- **Legislative reform on ownership of public research results.** The Bayh-Dole Act in the United States allowed universities to own the patents arising from federal research funding, and provided incentives for their commercialisation. Bayh-Dole legislation has been emulated across and beyond OECD countries. As a result, policy makers and legislators are increasingly encouraging (and in some OECD countries requiring) universities to patent inventions and to pursue commercialisation activities.
- **The increasing costs of scientific research and budgetary pressure.** The increasing costs of scientific research and budgetary pressure have led PRIs and universities to search for additional funding sources, even though income from commercialisation activities for most PROs account for a small share of the overall budget. As OECD analysis shows, researchers pursue a growing proportion of their research funding from project funding, much of which supports mission research areas (e.g. health, defence, green), and from firms focused on applied research of commercial relevance.
- **Competition for human resources and funding.** The successful patenting and commercialisation of a number of academic inventions by US universities and some European universities have drawn attention to a potential income source from public research. In addition, it is perceived that this also enhances the visibility and status of PROs in industry and society, and may therefore help attract top students, faculty and funding.

- **Emergence of "open access and open research data".** The Internet and the societal push for greater transparency and accountability in government and public research institutions has increased calls for more openness in science. In light of the ICT-led transformation of research, PROs and researchers themselves are adopting open science tools to promote increased access to and sharing of research data and publications. For example, in the life sciences this model has been promoted by the research community and leading international organisations (e.g. UNESCO's Universal Declaration on the Human Genome & Human Rights, The International Organisation of the Human Genome [HUGO]).
- **"Open innovation".** Many firms at the end of the 20th century had closed, scaled back or outsourced their central R&D research facilities. Co-operative R&D alliances of all kinds were of much greater importance. To source external knowledge and widen their knowledge base, firms are increasingly looking to universities and PRIs for much of their basic or fundamental research, following an "open" or collaborative innovation process.

Report structure

This report presents the results of the TIP project and is structured as follows:

- Chapter 1 sheds some light on the various **channels of knowledge transfer and commercialisation**, and links those to different criteria.
- Chapter 2 provides a **statistical overview of knowledge transfer and commercialisation** based on both traditional and new indicators that cover a set of OECD countries and PROs over time.
- Chapters 3 and 4 present the findings from survey of country policies, case studies and an inventory of **new initiatives pursued by governments and PROs**. This qualitative information complements the data presented in Chapter 2 and helps contextualise patterns and trends.
- The report concludes with Chapter 5, which outlines a possible **future policy agenda**.

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Chapter 1

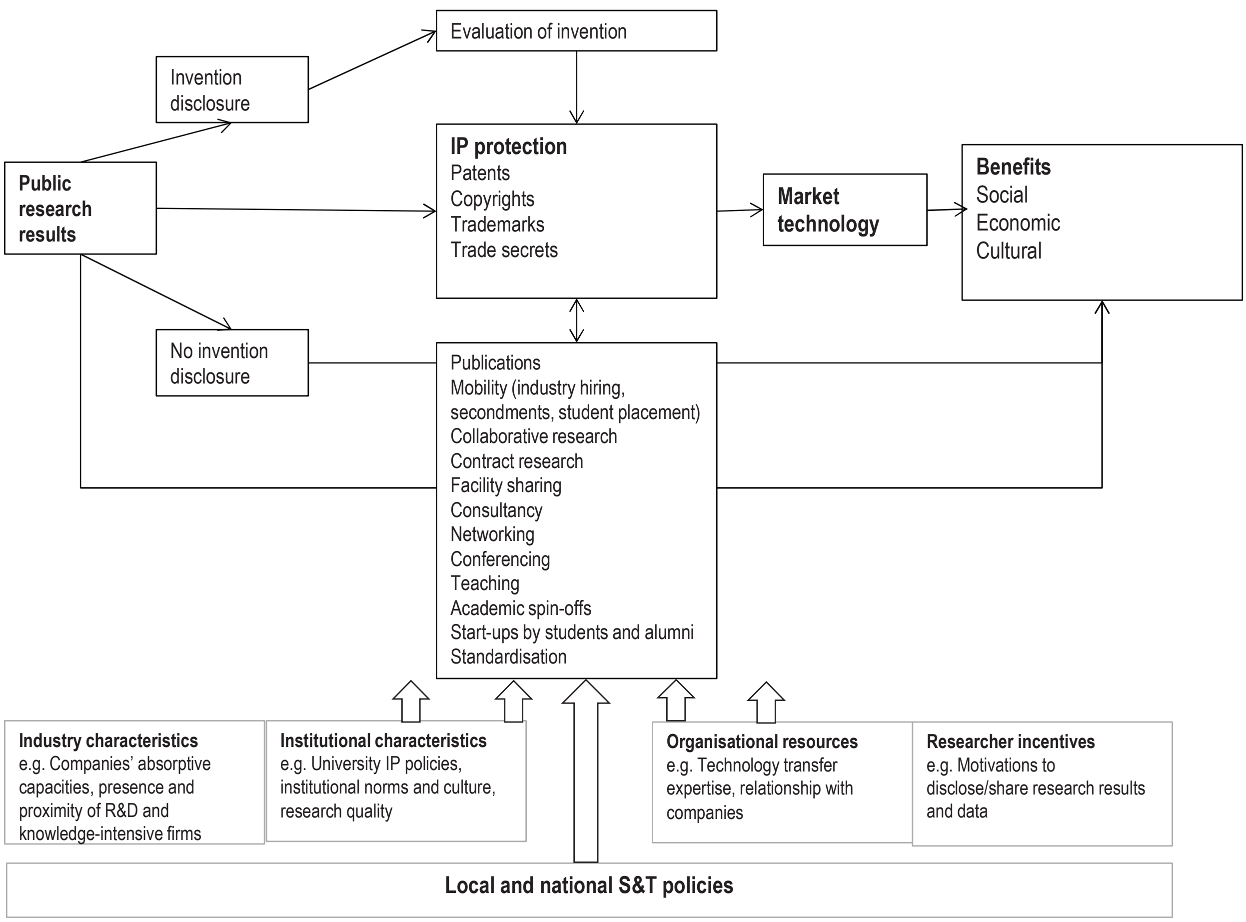
Knowledge transfer channels and the commercialisation of public research

This chapter describes the main channels of knowledge transfer and commercialisation and discusses their "relational intensity" (i.e. the degree of interaction between knowledge creators and receivers), their significance to industry, the type of knowledge involved, and their degree of formality. It shows that there are multiple ways in which public research knowledge can be transferred, exploited and commercialised that go beyond patents, licenses and spin-offs. For example, personal contacts and labour mobility are important channels for knowledge transfer and commercialisation.

Knowledge transfer and commercialisation of public research refer in a broader sense to the multiple ways in which knowledge from universities and public research institutions (PRIs) can be exploited by firms and researchers themselves so as to generate economic and social value and industrial development.[1] It is a multi-stage process involving different actors and a variety of channels (Figure 1.1). This understanding is in line with modern views of innovation as mostly interactive learning processes. It implies both the generation of new knowledge (i.e. supply of knowledge) and the integration of knowledge from external sources (i.e. demand for knowledge) (Brisson et al., 2010).

There are both structural factors and policy actions that characterise the structure of a country's or institution's system for the generation, transfer and commercialisation of knowledge. These range from funding structures and research activities to the institution's legal environment, the institutional setting, proximity to high-tech firms, the expertise and experience of intermediaries such as technology transfer offices (TTOs), and the presence of national and local science and technology (S&T) policies, among others.

Figure 1.1. Knowledge transfer and commercialisation system (simplified)



Typology of channels

There are many ways to characterise and categorise channels for knowledge transfer and commercialisation. Ponomariov and Boardman (2012) distinguish between four dimensions:

- **Extent of direct personal involvement (relational intensity).** Knowledge transfer tends to be associated with tacit and explicit knowledge. Tacit knowledge can be hardly codified and communicated. The transfer of knowledge requires close interaction between knowledge creators and users (i.e. researchers and/or industry). For example, a publication is associated with low relational intensity, while joint research would have a high relational intensity.

- **Significance to industry.** When seen from the perspective of industry, the relative importance of channels varies. Business surveys show that publications and collaborative research are rated highly significant, while patent and licensing-based channels are rated low.

- **Degree of knowledge finalisation.** Knowledge finalisation refers to the degree to which a research project provides a specific goal or can be contained in deliverables (e.g. contract research), as opposed to producing public sector knowledge and/or enlarging the stock of knowledge whose outcomes are difficult to measure/anticipate (e.g. conferencing).

- **Degree of formalisation.** Channels for knowledge transfer can be categorised as either informal channels – such as staff exchange or networks (involving tacit flows) – and formal channels that involve a contract between the public research organisation (PRO) and the firm, a license, a joint patent, or participation in a university spin-off. Channel formalisation refers to the extent to which the interaction is institutionalised and/or guided by formal rules and procedures.

Table 1.1 outlines the channels of transfer according to their relational intensity, industry significance, degree of finalisation and their formalisation. This differentiation is crucial as it provides policy makers with a more nuanced view of the diversity and the potential impact of knowledge transfer and commercialisation channels, and shows that there are multiple ways in which public research knowledge can be transferred, exploited and commercialised beyond patents, licenses and spin-offs.

It should be noted that knowledge transfer and commercialisation channels are not unidirectional. Channels often operate simultaneously or in a complementary fashion, underscoring the interaction between tacit and codified flows of knowledge as well as the multidirectional nature of flows. Knowledge flows not only from university to industry, but also in the other direction. For example, consulting services to industry may result in a more persistent and longer-term relationship between industry and science. This could lead to a longer-term collaboration in terms of ideas, funds, contract research and joint publications or joint patenting.

PROs exchange and use a variety of different forms of intellectual property rights (IPRs), not limited to patents but extending to copyrights and trade secrets. These other forms of IPRs have an important impact on how other channels, such as contract and collaborative research, operate and function. For example, most student start-ups are based on computer software or software-related inventions (e.g. mobile applications), which are copyright protected. In addition, an institution's ability to negotiate research and collaborative contracts with firms relies on IPR-related clauses in agreements (e.g. protection of proprietary data [trade secrets]). Hence, IPRs form the foundation ("grammar") on which other channels and modes of transfer and commercialisation function.

Table 1.1. Summary of selected knowledge transfer and commercialisation channels

Channels	Description	Characteristics			
		Degree of formalisation	Degree of finalisation	Relational intensity	Significance for industry
Publishing	Most traditional and widespread mode of transmission of knowledge; mostly limited to published papers	Low	High	Low	High
Conferencing, networking	Professional conferences, informal relations, casual contact and conversations are among the channels ranked as most important by industry; important across sectors	Low	Low	Medium	High
Collaborative research and research partnerships	Situations where scientists and private companies jointly commit resources and research efforts to projects; research carried out jointly and may be co-funded (in relation to contract research); great variations (individual or institutional level); these range from small-scale projects to strategic partnerships with multiple members and stakeholders (i.e. public-private partnerships [P/PPs])	Medium	Low	High	High
Contract research	Commissioned by a private firm to pursue a solution to a problem of interest; distinct from most types of consulting; involves creating new knowledge per the specifications or goals of client; usually more applied than collaborative research	High	High	High	High
Academic consulting	Research or advisory services provided by researchers to industry clients; most widespread activities – yet least institutionalised – in which industry and academics engage; three different types: research-, opportunity- and commercialisation-driven consulting; important to industry, which usually does not compromise university missions	Medium	High	High	High
Industry hiring, student placement	Major motivations for firms to engage in industry-science linkages with main benefit for universities; occurs through (e.g.) joint supervision of theses, internships, or collaborative research	Medium	Low	Medium	Medium
Patenting and Licensing	Ranked among the least important channels by both industry and researchers; substantial attention both in academic literature and among policy makers; little transfer of tacit knowledge	High	High	Low	Low
Public research spin-offs	Received substantial attention, although a rare form of "entrepreneurship" compared to alumni and student start-ups	High	High	Low	Low
Personnel exchanges/inter-sectoral mobility	May take many forms; usually university or industry researchers spending time in the alternate settings; most important form of "personnel mobility" is employment by industry	High	Low	Medium	Low
Standards (Box 1.1)	Documents based on various degrees of consensus; at least as important as patents as a knowledge transfer channel	High	High	Low	Medium

Source: Based on Ponomariov, B. and C. Boardman (2012), "Organizational behavior and human resources management for public to private knowledge transfer: An analytic review of the literature", *OECD Science, Technology and Industry Working Papers*, No. 2012/01, OECD Publishing, Paris; and adapted from Cohen, W.M., R.R. Nelson and J.P. Walsh (2002), "Links and impacts: The influence of public research on industrial R&D", *Management Science*, Vol. 48, pp. 1-23; Perkmann, M. and K. Walsh (2007), "University–industry relationships and open innovation: Towards a research agenda", *International Journal of Management Reviews*, Vol. 9, pp. 259-280 and others.

Box 1.1. Standards and standardisation as a knowledge transfer channel

At their root standards are documents, based on various degrees of consensus, that set forth rules, practices, metrics or conventions used in technology, trade and society at large (OECD, 2011). Standards can be categorised in many ways; the driving forces include network effects, switching costs, government policy and IPRs, as well as other environmental factors (Blind, 2004; Narayanan and Chen, 2012 for an overview). Even if they are developed for a single purpose, they often serve several.

The setting of standards is mainly the responsibility of different types of standard setting organisations (SSOs): industry bodies (private) and governmental (public) and non-profit technical bodies (hybrid) (Funk and Methe, 2001; Blind and Gauch, 2008). Governments can act as facilitators and co-ordinators while industry bodies must be supported by firms as well as by governments. Standards may be developed by technical experts working in government agencies, but in most cases governments adopt standards developed by industry bodies for reasons of expediency and because of a lack of technical expertise.

According to Blind and Gauch (2009), various standards along the innovation chain – such as terminology, measurement, testing and interface standards – can be identified as knowledge transfer channels. Depending on the current research stage, the standardisation activities are initiated by the various stakeholders involved – i.e. researchers in PROs in defining the terminology, and industry in the later phases of the technology development.

Anecdotal evidence based on survey data from German researchers working on nanotechnology suggests that technical standards are considered as important as patents as a transfer channel, while publications were ranked as the most important (Blind and Gauch, 2009). Adding to the complexity of standards and standardisation, there is also an interplay between standards and patents and between PROs, industry and government (Berger, Blind and Thumm, 2012). The phenomenon of patents in standards occurs in those areas where standards relate to innovative technologies, e.g. in ICTs. Patent pools may mitigate the potential conflicts between the different parties involved, as the example of the MP3 standard shows (Blind, 2003).

There are also interdisciplinary differences in the intensity of transfer and commercialisation channels used. Empirical evidence shows that patents and licensing, publications, industry hiring, students' placements, and contract research are the most important channels for R&D-intensive sectors such as biomedical and chemical engineering. Patenting and licensing are very important for researchers working in the material sciences, whereas these channels are less relevant for computer scientists. The most relevant channels in the social sciences and humanities are personal contacts and labour mobility (Bekkers and Bodas Freitas, 2008). As engineering sciences (or the so-called "transfer sciences" – i.e. computer, aeronautical, mechanical engineering) and the social sciences support gradual and tacit transformation due to the characteristics of knowledge in question, tensions over proprietary rights are expected to be weaker than in the sphere of natural and physical sciences.

The available evidence and data on knowledge transfer and commercialisation via different channels provide valuable information about the supply and demand of knowledge flows. Evidence on the amount and type (Chapter 2) is an important input when considering the rationales for government intervention or changes in policy approaches.

Note

1. Due to the breadth of knowledge channels, the text will refer to "knowledge transfer and commercialisation". In recent years the term "knowledge exchange" has emerged, and is sometimes used in preference to "transfer". Terms as "research mobilisation", "public engagement", "research utilisation", "valorisation activities" and "knowledge exploitation" have been used synonymously (Kitagawa and Lightowler, 2013).

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Chapter 2

Benchmarking knowledge transfer and commercialisation

National-level data on knowledge transfer and commercialisation of public research provide a partial picture of how well universities and public research institutions (PRIs) perform in terms of patenting, licensing and spin-off activity. Data of key performance indicators show that growth has stalled in major OECD economies and regions in recent years. Attention is also drawn to surveys of other channels for knowledge transfer and commercialisation, such as the mobility of students and researchers between sectors, but also broader access to public research data. The need for new metrics is stressed.

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

How effective are universities and public research institutions (PRIs) in exploiting and commercialising their research? Despite the broad range of channels through which knowledge is exploited and commercialised, in most countries the statistical infrastructure for gauging the effectiveness of these channels remains limited. Nevertheless, several surveys provide an international picture of knowledge transfer and commercialisation activities, (see Annex A, Table A.1 for a list of national surveys). The focus in these surveys on patents, licenses and spin-offs is understandable as they constitute immediate, measureable market acceptance of outputs of public research for firms, universities, faculty inventors and policy makers (Markman, Siegel and Wright, 2008). Commercialisation outcomes with a high degree of codification leave codified inputs and outputs, and are easier to observe than other channels (Arundel and Bordoy, 2008).

In light of the limitations of measuring commercialisation performance based mainly on academic patent and licensing, there has been growing concern about relying solely on these metrics; it is felt they underscore or underestimate the importance of other channels. As a result, universities and PRIs are now trying to devise new metrics and indicators. For example, the Association of Public and Land-grant Universities (APLU), a collection of 218 US institutions, is in the midst of a multiyear effort to quantify knowledge transfer. To date, 11 measures have been proposed for near-term implementation with metrics such as student employment on funded projects, alumni in the workforce, and services to external clients. In another attempt, the European Commission's Expert Group on Knowledge Transfer Indicators undertook a feasibility study on the availability of cross-country data sets of channels based on people, co-operation and networks with the ultimate goal of constructing a composite indicator for knowledge transfer (Finne et al., 2011). The Association of Universities in the Netherlands (VSNU), for example, adopted the proposed indicators of the EC Expert Group; each university will embark on a process to establish their relevant set of indicators and define ways to measure them between 2013 and 2015.

At the institutional level, the University Industry Liaison Office at the University of British Columbia (UBC-UILO) is developing new metrics that take into account non-traditional impacts of the licensing portfolio, such as societal benefits in the area of human health (Bubela and Caulfield, 2010). In addition, some studies, mostly in the business literature, focus on individual firms or inter-firm interactions in an attempt to directly measure the learning aspects of knowledge transfer (Ponomariov and Boardman, 2012).

In the absence of comprehensive cross-country data on the full range of channels for the transfer and commercialisation of public research knowledge – many of which are difficult to monitor with statistically robust information that would be useful for policy making – this chapter presents a number of indicators that capture part of the phenomenon (Figure 2.1).

Figure 2.1. Main categories of (cross-)country indicators of knowledge transfer and commercialisation

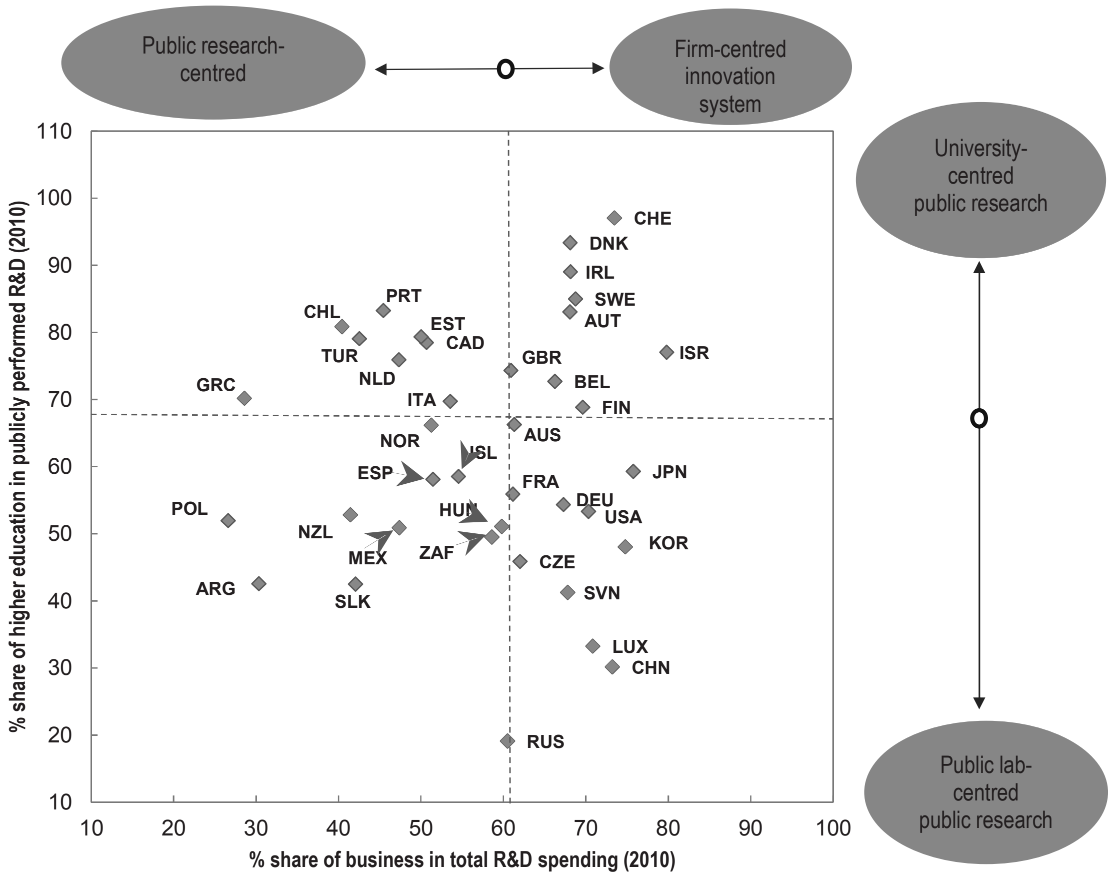
Indicators on the funding and collaboration between industry and science	• Business-funded R&D in the higher education sectors (Figure 2.3) • Business-funded R&D in the government sector (Figure 2.4) • CIS Survey on sources of knowledge for innovation by type (Figure 2.5) • Firms collaborating on innovation with higher education or government research institutions by firm size (Figure 2.6) • Co-authoring between industry and science (Figure 2.21)
Indicators of the commercial potential of knowledge, focusing on repositories of disclosed information	• Invention disclosures (Figure 2.7 and 2.8) • Patents filed by universities (Figure 2.9) • Patents filed by public research institutes (Figure 2.10)
Indicators on the use of public knowledge by firms and other parties	• Share of university patent applications and share of corporate patents citing university patents (Figure 2.11) • Patents citing non-patent literature (NPL), selected technologies (Figure 2.12) • Licensing income (Figures 2.13 and 2.14) • Creation of public research spin-offs (Figures 2.15 and 2.16)
Indicators of other channels of knowledge transfer such as mobility of skilled workers and networking	• Commercialisation activities by academics (Table 2.1) • Frequency of interactions by UK academics (Figure 2.17) • Inter-sectoral mobility of human resources in science and technology (Figure 2.18) • Inter-sector mobility of researchers in Japan (Table 2.2) • Doctorate holders having changed jobs in the last 10 years (Figure 2.19) • Cross-sector mobility of authors (Figure 2.20)

Co-creating new knowledge

In order to transfer or commercialise public research knowledge, it must first be created and accumulated. Of the range of indicators, R&D is probably the most widely used to illustrate efforts to increase the stock of knowledge. As an outcome, knowledge produced through R&D may spill over to other firms/sectors/countries and may in turn induce the process of knowledge transfer and commercialisation.

Most OECD countries at the technological frontier have experienced a slow shift from a system involving PRIs as the main "knowledge-generating institutions" to a system characterised by the research centrality of universities. There are variations but the direction of the trend is clear across most OECD countries (Figure 2.2). Some larger OECD countries have a more balanced R&D research system between universities and PRIs; examples include Germany, Japan and the United States. In recent years several emerging economies, China in particular, have become significant actors in investing in and generating public sector knowledge, in particular through their PRIs.

Figure 2.2. Archetypes of innovation systems, 2010



Source: OECD, Main Science and Technology Indicators (MSTI) Database, May 2012.

Business funding of R&D at universities and PRIs

The share of business-funded R&D in universities and PRIs is one proxy indicator of the intensity of the knowledge flows between the two sectors. Between 1981 and 2000, the share of business-funded R&D in the higher education sector increased in all selected OECD countries, but has flattened since 2000 (Figure 2.3 and 2.4). Germany has the highest share of business-funded higher education R&D with 14% in 2009. Canada (8% in 2011), the United States (6% in 2009), the United Kingdom (4.6% in 2010), Japan (2.5% in 2011) and France (1.8% in 2010) follow. The OECD average stands at 6% in 2009. The picture differs when one considers business-funded R&D in the government sector. Although funding to PRIs from industry has risen over time and some countries have explicit policies to encourage this (e.g. tax incentives – see OECD, 2011), it is still very low overall. Germany is ahead, with 10% in 2009. Businesses in the United Kingdom (8% in 2010) and France (7% in 2010) follow, while peers in Canada (3% in 2011) and Japan (0.7% in 2010) contribute relatively little funding of government research. The intensity of business funding of R&D in universities or PRIs may be influenced by a number of factors, such as the research landscape (e.g. dominance of PRIs or universities), the proximity and presence of R&D-intensive firms and fiscal incentives.

Figure 2.3. Business-funded R&D in the higher education sectors, 2000-11

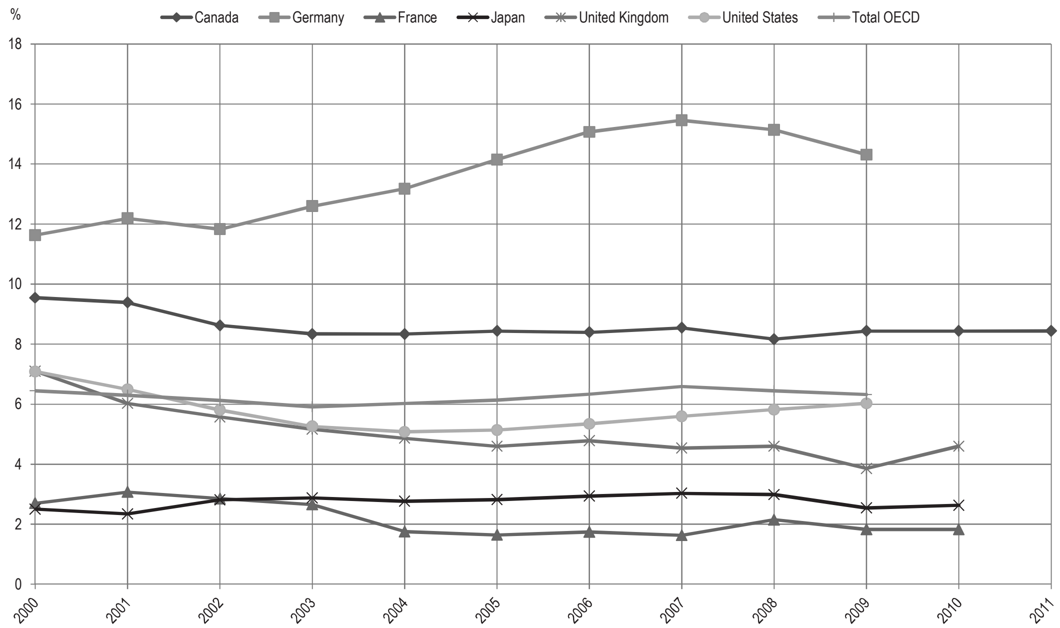
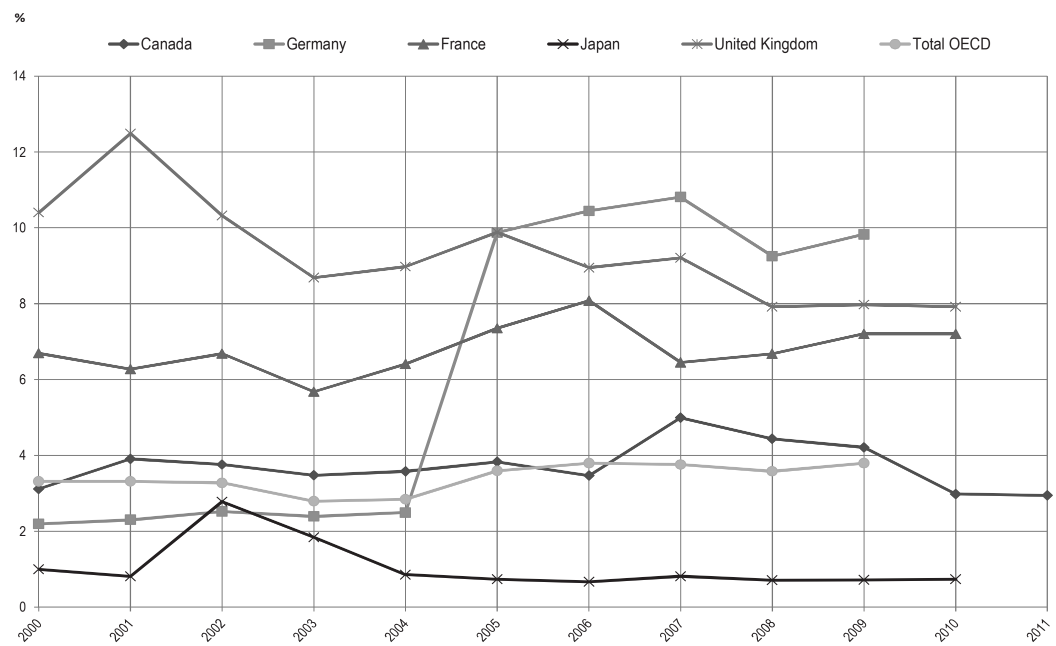


Figure 2.4. Business-funded R&D in the government sector, 2000-11

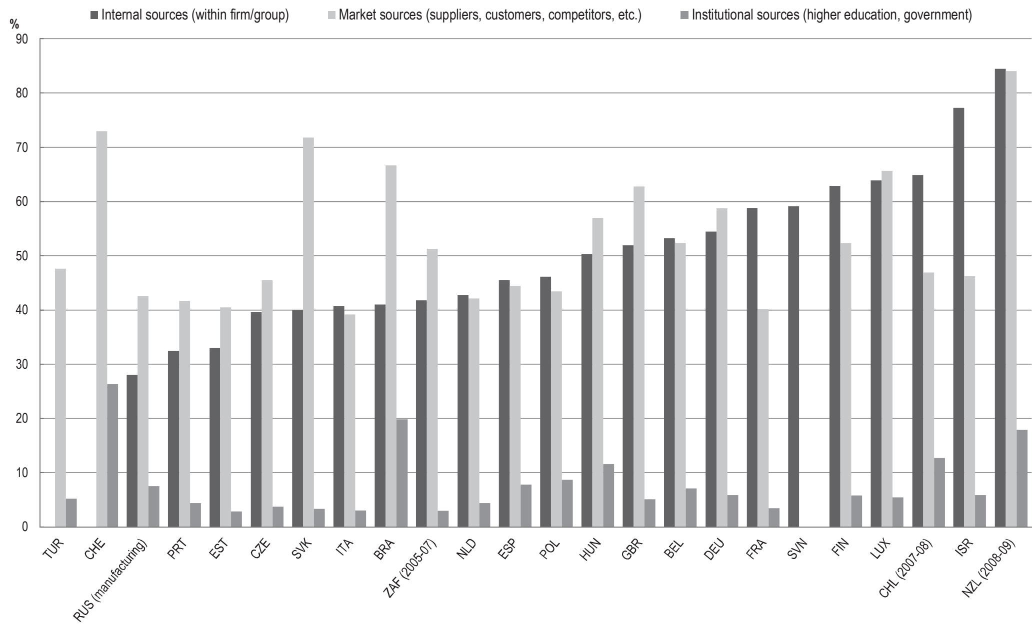


Note: No data availability for the United States in Figure 2.4.

Source: OECD, Main Science and Technology Indicators (MSTI) Database, June 2011.

Figure 2.5. Sources of knowledge for innovation by type, 2006-08

Percentage of innovative firms citing source as "highly important" for innovation

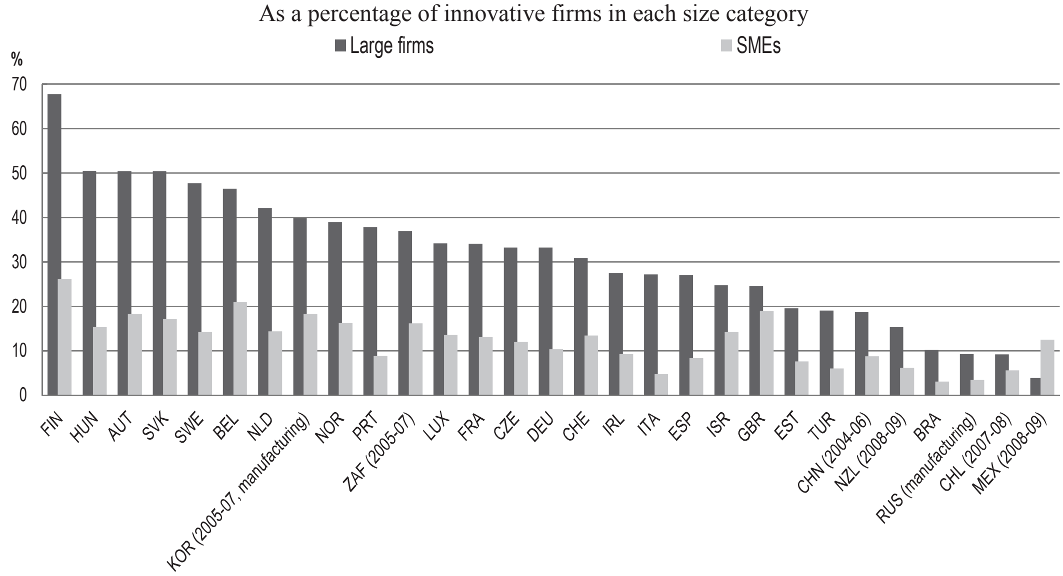


Note: In most countries, this question is only asked of companies that have reported being active in pursuing the implementation of a new product or process.

Source: OECD (2011), *OECD Science, Technology and Industry Scoreboard 2011*, based on Eurostat (CIS-2008) and national data sources, June 2011.

Figure 2.6. Firms collaborating on innovation with higher education or government research institutions by firm size, 2006-08

As a percentage of innovative firms in each size category



Note: In most countries, this question is only asked of companies that have reported being active in pursuing the implementation of a new product or process.

Source: OECD (2011), *OECD Science, Technology and Industry Scoreboard 2011*, based on Eurostat (CIS-2008) and national data sources, June 2011.

Demand for public research knowledge by firms

Evidence from innovation surveys (e.g. the 2008 Community Innovation Survey (CIS) in Europe) suggests that institutional sources of knowledge play a much smaller role than internal or market sources; generally, less than 10% of innovating firms rank them as "highly important" for their innovation activities (Figure 2.5).

Numerous empirical studies have also pointed out that interactions between universities and PRIs depend upon firm size. This is also confirmed by qualitative data (Figure 2.6). In most countries large firms are usually two to three times more likely than small or medium-sized enterprises (SMEs) to engage in industry-science relationships (ISR), for example. More than half of all innovating large firms in Finland, Hungary, Austria and the Slovak Republic collaborate with universities or PRIs, compared to less than one in ten in the Russian Federation, Chile and Mexico.

Invention disclosures and patents as indicators of commercialisation

Measuring inventiveness by tracking the invention disclosures registered by technology transfer offices (TTOs) may reflect a researcher's willingness to engage in commercialisation activities. The disclosure of invention represents the first official recording of the invention. Often, universities with a strong commercialisation policy require all employees to disclose all inventions made during the employment, though enforcement of rules vary. Depending on the specific policy, the requirement to disclose may go beyond employment contracts to include inventions made outside, such as during consulting activities.

Once a researcher discloses an invention, the TTO decides whether or not to file a patent. Out of the pool of disclosures that the TTO receives and processes, only a small share will be filed. A large number of disclosures are never patented. The reason for this is that patenting imposes a cost that, from an economic perspective, is only worth incurring if the royalties from licensing of those patents exceed the average cost of patenting (Shane, 2004). In the course of the evaluation, the TTO typically attempts to assess the commercial potential of the invention and the prospective interest from the private sector. If the TTO decides not to file for a patent, it may leave it up to the faculty to seek patent protection.

Thus, invention disclosures do not reflect any information about the commercial potential, unlike licenses executed, or about patentability requirements, unlike patent applications. It also does not reflect the judgement of the patent examiner or market needs, as would patents granted or licenses executed (Thursby and Thursby, 2010). Figure 2.7 illustrates the number of invention disclosers per USD 100 million in research expenditures in selected OECD countries. In order to control for differences, the outcomes are normalised and given per USD 100 million.[1] Invention disclosures per USD 100 million in research expenditures per year have stagnated over 2004-09, but recent data indicate that levels picked up slightly for Canada (from 35 in 2010 to 41 in 2011) and marginally in the United States (from 35 in 2010 to 36 in 2011). Figure 2.8 shows that universities and PRIs in the United Kingdom (for 2004-10) and Canada (for 2007-11) perform better in terms of invention disclosures than US institutions, and are significantly higher than in Australia and Europe.[2]

Figure 2.7. Invention disclosures, 2004-11

Per USD 100 million research expenditure

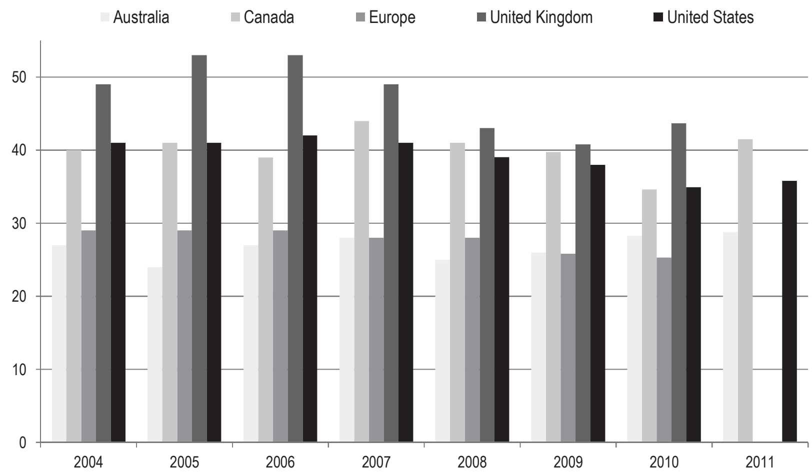
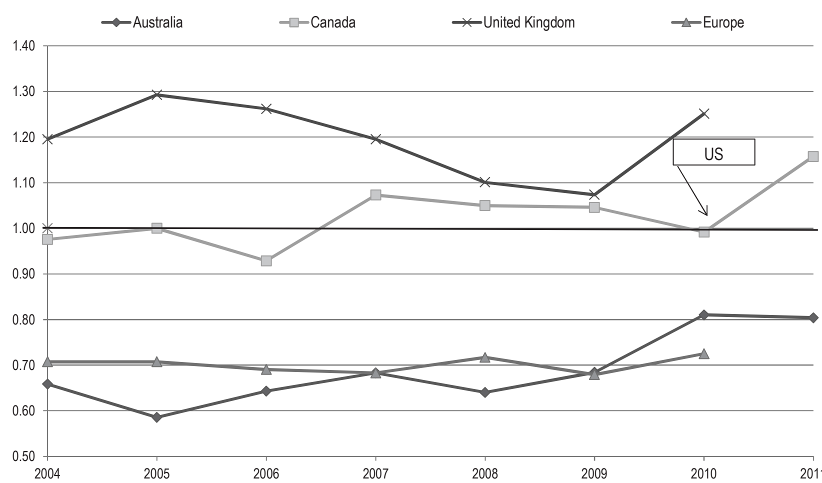


Figure 2.8. Invention disclosures, 2004-11

Relative performance to the United States (AUTM survey)



Notes:

1. Not all questions asked in the surveys in each country are directly comparable. Some surveys include PRIs, universities and hospitals whereas some include only universities (see Annex A, Table A.1 for further information). There are also differences in definitions of output and of R&D expenditures, as well as in treatment of missing values. (For discussion see Arundel and Bordoy (2008), "Developing internationally comparable indicators for the commercialisation of publicly-funded research", UNU Merit Working Paper Series; and Finne et al. (2009), "Metrics for knowledge transfer from public research organisations in Europe: Report from the European Commission's expert group on knowledge transfer metrics", project report, European Commission, Brussels, Belgium.)
2. Survey data (fiscal years): *United States* – US Association of University Technology Managers (AUTM) (2004-11); *Canada* – Canadian Association of University Technology Managers (AUTM) (2004-11); *Australia* – National Surveys of Research Commercialisation (NSRC) (2004-11); *Europe* – Association of European Science and Technology Professionals (ASTP) (2004-09), Proton Seventh Annual Survey Report (2009) and European Commission (2010); *United Kingdom* – Higher Education Business and Community Interaction Surveys (HE-BCIS) (2004-10).
3. Comparisons after adjusting for research expenditure (per USD 100m) and US dollar purchasing power parity, OECD database.
4. Europe – Survey data also include respondents from UK institutions.

Source: Based partly on calculations and data from Australia's Department of Innovation, Industry, Science and Research (DIISR) (2011 and 2012), "Australian National Survey of Research Commercialisation: 2008 and 2009" and "2010 and 2011"; European Commission (2012), "Interim Findings 2011 of the Knowledge Transfer Study 2010-2012", Bonn/Maastricht/Solothurn; US Association of University Technology Managers (AUTM) (2009-2012), "Highlights of the AUTM U.S. Licensing Activity Survey: FY2008 [through] FY2011"; Canadian AUTM (2009-2012), "Highlights of the AUTM Canadian Licensing Activity Survey: FY2008 [through] FY2011"; Higher Education Funding Council for England (HEFCE) (2009-2012), "Higher Education – Business and Community Interaction Survey 2007-2008 [through] 2010-2011."

Patent applications from PRIs and universities

Patents are one indicator of prospective commercialisation efforts. When using patent statistics, it is important to recall that not all academic inventions are owned by PROs. Academic researchers may appear as inventors in firms' patent filings as a result of (e.g.) contract research or through academic consulting. Lower academic patenting numbers in OECD countries therefore do not imply that they contribute less to countries' patenting activity, but rather that they are less likely to claim ownership of the patents they generated. This may depend on different IPR regulations, the institutional profile of the national research system, and on national specificities of industry-science relationships (ISR). For example, in Europe at least 60% of university patents are owned by business. In Denmark, France, Italy and Sweden the percentage of patents owned by universities is around 11% and less, with Netherlands and the United Kingdom showing over 20% (Lissoni et al., 2008; Lissoni, 2012). On the contrary, in the United States, estimates show that 67-74% of patents are assigned to the university (Markman, Gianiodis and Phan 2008; Thursby, Fuller and Thursby 2009). Generally, business-owned university patents escape statistics upon which most policy makers base their assessment of universities' contribution to the commercialisation of public research.

Bearing in mind that faculty in many European countries assign the patent to the firm that sponsored their research or for whom they consult, Figures 2.9 and 2.10 show the share of patent applications of PROs in OECD countries under the Patent Cooperation Treaty (PCT) per billion GDP (constant 2005 USD PPP). The number of PCT patents per billion GDP gives an approximate ratio of the output performance of the public research system. As patenting has become increasingly important to universities, the number of patent applications per billion GDP has risen considerably. Israel is ahead in university patent applications per billion GDP, followed some way behind by Estonia, Korea and Denmark. During 2006-10, university patent output saw a marked boost in Estonia and Korea, and doubled in Denmark, Ireland, Japan, Spain, Austria, Germany and Portugal (Figure 2.9). Taking absolute numbers, university-owned patent applications grow markedly between 2001 and 2005, with average annual growth rates of 11.8% for the OECD area, while growth dropped significantly between 2006 and 2010, with growth rates around 1.3%. Overall, average annual growth for the OECD area was 6.7% for 2001-10.

In comparison to university-owned patents, patenting by PRIs measured per billion GDP is less frequent for all OECD countries, except for France whose public research system is dominated by large PRIs. Japan, Israel and Australia evidenced on average a drop from 2001-05 to 2006-10, whereas PRI patenting measured per billion GDP rose in France and doubled in Korea. Although less pronounced as in the case of university-owned patent applications, PRIs in the OECD area showed strong patenting activity between 2001 and 2005 with annual growth rates of 5.3%, but growth turned negative (-1.5%) between 2006 and 2010. As a result, patenting growth by PRIs remained modest in the OECD area over the period 2001-10 (1.9%).

Even though for both universities and PRIs growth rates decreased over 2006-10, the percentage share on total patenting filed under the Patent Co-operation Treaty (PCT) has increased in the OECD area between 2001-05 and 2006-10. For universities the share rose from 1.8% to 2.6% and for PRIs from 0.77% to 0.82%. This can be explained mainly by the negative patenting growth of companies in the OECD area between 2006 and 2010. Due to the presence of the "professor's privilege", Sweden exhibits the highest percentage of patents owned by individual scientists, and is therefore not represented in Figures 2.9 or 2.10.

At the level of individual institutes, only a few have achieved a track record (Tables A.2 and A.3). The University of California, with 277 applications published in 2011, was the largest filer among universities. US universities account for 30 of the top 50 university patent applicants, followed by Japan and the Republic of Korea with 7 institutions each. In line with France's high share of government-owned patents, the French Atomic Energy and Alternative Energies Commission (CEA) was the largest filer, with 371 in 2011, followed by Germany's Fraunhofer Society (2nd, with 294 applications in 2011) and the French National Center for Scientific Research (3th, with 196 applications in 2011) (WIPO, 2012) (Box 2.1 for Fraunhofer's IP strategy).

Box 2.1. Fraunhofer's IP strategy: Taking the long-term view

Germany's Fraunhofer Society licenses out its IP and is also involved in patent pools. A hallmark of Fraunhofer research is its proved know-how, technological expertise and scientific excellence. In many collaborative and research projects – whether proprietary, publicly funded or in direct co-operation with industry – many high-value patents have been generated. This "background IP" makes the Fraunhofer Society an attractive place for industry partners to source new knowledge and expertise.

Each new project gives rise to further intellectual assets. This "foreground IP" evolves from specific orders while also strengthening the existing knowledge base. The interaction between background and foreground IP benefits both current and future research work.

The Fraunhofer Institutes use the following options to commercialise their IP:

- Contract research
- Out-licensing
- Use of IP to acquire new projects
- Spin-offs and company participation

In contract negotiations, the Fraunhofer Institutes face the difficulty that they might get the award for the contract research quite easily in return for offering a generous use of Fraunhofer's IP portfolio, which is endangering the consistency of the Society's IP foundation. The performance of future projects might become more difficult. Due to tensions between short-term advantages and long-term losses, the Fraunhofer Institutes have to follow an investment-oriented attitude, also in the area of contract research. As such, the collaborating firms receive the proprietary rights on products, prototypes and other materials developed with the Fraunhofer Institutes. In addition, firms receive a non-exclusive license for their specific application related to inventions, IPR and know-how ("foreground IP"). In exceptional cases, firms receive unlimited exclusivity related to "foreground IP".

Licensing out without a tied link to contract research is of less importance for most Fraunhofer Institutes. The reasons are: the attitude that licensing as such is not the core business of the Fraunhofer Society; the preference of not owning IPR is interesting for potential licensees; and the risk of irritating potential future clients missing know-how in commercialising IP. Consequently, possible licensing revenues are not fully exploited.

Licensing options:

Carrot licensing is the offer by the patent owner to license out the protected technology and to provide the necessary know-how. The license fee is agreed in advance of use. It is often granted exclusively to a particular application field.

Assertive licensing is granting a non-exclusive license to the user following detection of an unlawful use. In this sense, an unauthorised and unpaid use is transformed into an authorised, paid license ("ex-post licensing").

Patent pools are utilised via non-exclusive licenses by different patent owners in the pool. The pool management is addressing both potential licensees and is also investigating alleged violations. Patent pools are therefore a mixture of carrot and assertive licensing and represent a particularly efficient licensing option.

With this strategy, the Fraunhofer Institutes attempt: 1) to increases the Institutes' innovative potential, 2) to permit a wide range of applications of IP, 3) to protect firms' interest (hence the possibility of exclusive rights), and 4) to improve firms' and the Institutes' competitive position.

Figure 2.9. Patents filed by universities, 2001-05 and 2006-10

Patent applications under the Patent Cooperation Treaty (PCT) per billion GDP (*Constant* 2005 USD [PPP])

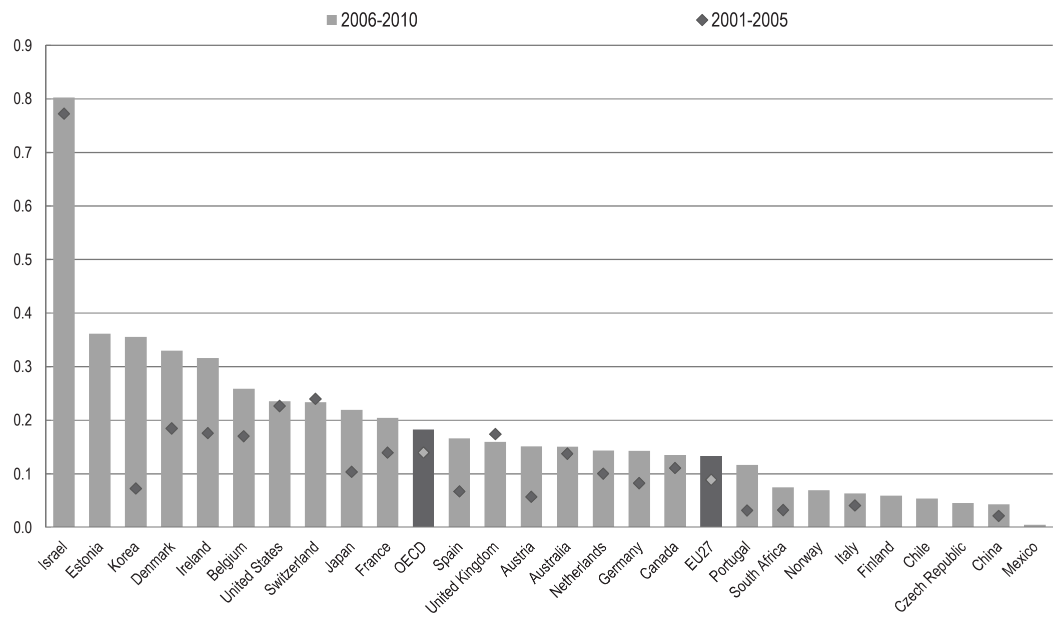
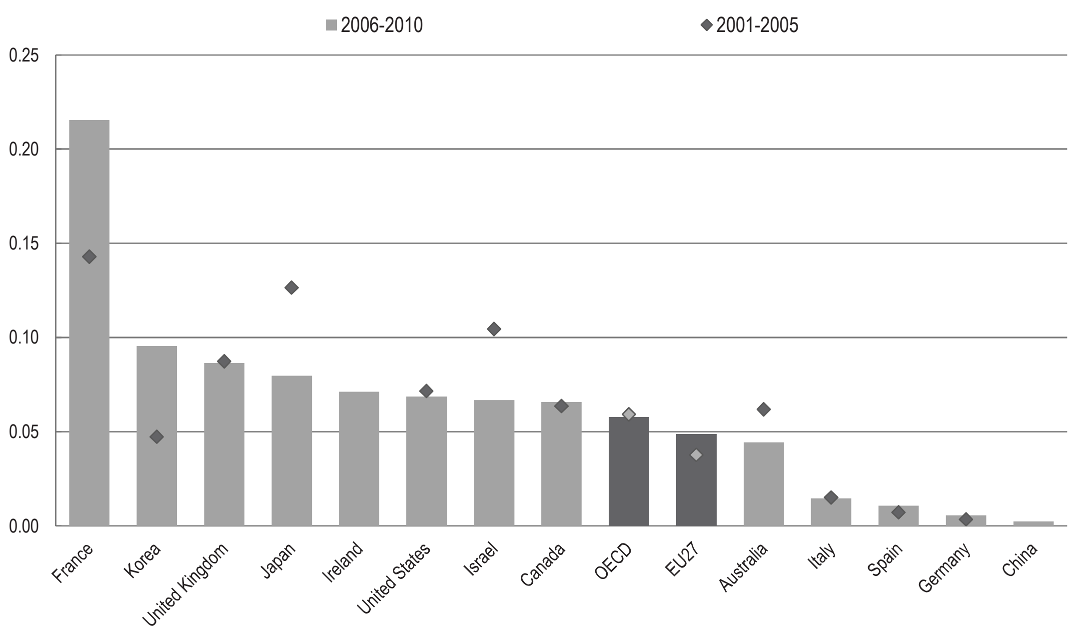


Figure 2.10. Patents filed by public research institutes, 2001-05 and 2006-10

Patent applications under the Patent Cooperation Treaty (PCT) per billion GDP (*Constant* 2005 USD [PPP])



Notes:

1. Patent applicants' names are allocated to institutional sectors using a methodology developed by Eurostat and *Katholieke Universiteit Leuven* (KUL). Owing to the significant variation in names recorded in patent documents, applicants are misallocated to sectors, thereby introducing biases in the resulting indicator. Only economies having filed for at least 30 patents over the period 2001-05 or 2006-10 are included in the figures.

2. Data broken down by priority date and residence of the applicants, using fractional counts.

3. Hospitals have been excluded.

Source: OECD Patent Database, February 2013.

Some technology fields are more prone to be protected by patents than others (e.g. Geuna and Nesta, 2006). In the United States, 30% of university patents in 2010 were granted in the field of biotechnology, reflecting continued growth since 1995. In contrast, university patents in pharmaceuticals – the second largest technology area for US university patents – declined, from nearly 450 a year in the late 1990s to about 300 in more recent years. University patents for measuring devices, semiconductors and optics have all increased gradually over the past two decades (US NSF, 2012). The importance of biotechnology and pharmaceuticals is not only typical for US academic patents, but also holds true for other OECD regions and countries.

Business sector use of university patents, licensing income and spin-offs

While inventions in the form of disclosures and patent applications display an inventive step, they are not yet exploited for commercial purposes or implemented otherwise (e.g. process innovation). The use by the business sector of university patents across OECD countries can indicate that status in addition to the amount of licensing income and the number of spin-offs created.

Figure 2.11 provides country differences in the share of business patents citing university patents and the share of university patent applications (measured as backward citations from corporate-owned patents towards university patents). National differences in the citation behaviour of corporate patents for university technology are one indication of the extent to which the corporate sector incorporates public sector knowledge – or the extent to which national systems are able to further develop these assets (Veugelers et al., 2012).

First of all, Australia and China exhibit relatively high shares of business patents citing university patents – 13% and 12%, respectively. Companies in Canada (9%), the United States (8%) and the United Kingdom (7%) also consider university technology an important knowledge source for their patenting activities. This is less the case in Korea (5%), France (3%), Japan (3%), Germany (3%) and Italy (3%).

Secondly, Australia, Canada, China and the United States combine high levels of university patenting with high levels of corporate patents citing university patents (Quadrant 1 in Figure 2.11). Countries such as Japan, Germany, France, Sweden and Korea have a low supply and demand of university patents (Quadrant 4 in Figure 2.11).

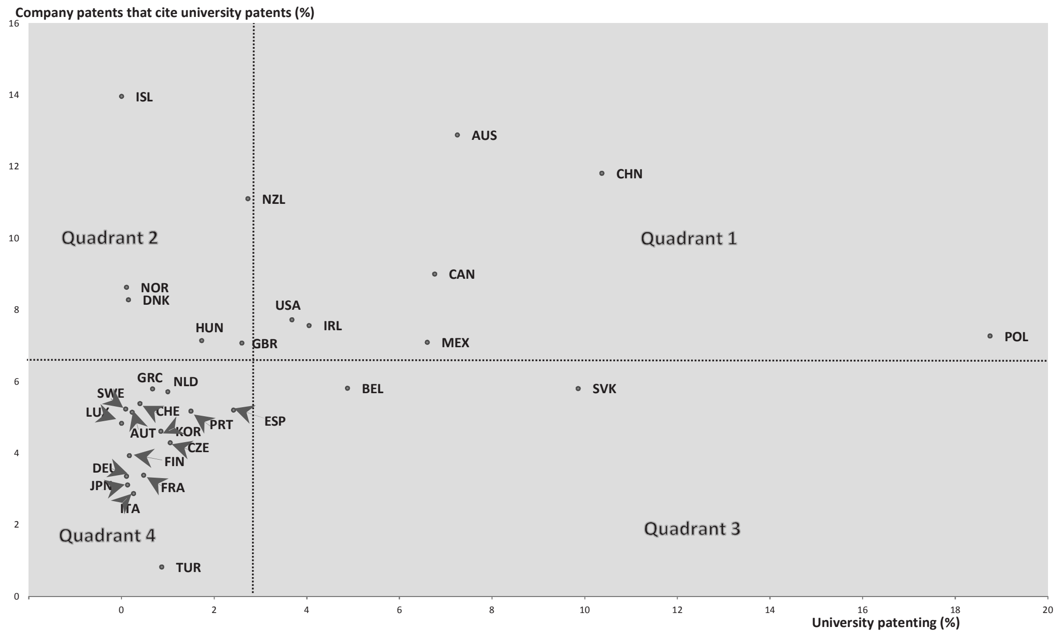
Academic publications cited in business patents give another indication of the meaning and value of public research results and their contribution to corporate innovation. However, there may be differences between backward citations to patent literature and those to non-patent literature (NPL) in terms of their effectiveness as a measure of knowledge transfer and flows. Backward citations to NPL can show how close a patented invention is to scientific knowledge, whereas forward patent citations can show the importance of a patent for the development of other technologies. Based on empirical evidence from Japan, Nagaoka, Motohashi and Goto (2010) found that backward citations to NPL may better predict knowledge transfer than those to patent literature. Backward citations to an earlier patent may be due to the importance of the claim stated, among others, and not to its technology.

In general, the share of NPL in backward citations has increased over time, suggesting that patented inventions increasingly rely on scientific publications resulting from public research. The percentage of NPL cited in patent documents varies considerably across sectors and countries. Reliance on scientific knowledge is highest for biotechnology and in the BRIICS (Brazil, the Russian Federation, India, Indonesia, China and South Africa) during 2005-10 (Figure 2.12). However, it should be noted that data are usually biased in favour of domestic citations.

Figure 2.11. Share of university patent applications and share of business patents citing university patents (%)

Patent applications: European Patent Office (EPO) application years 1980-2000

Corporate patent citations: EPO application years 1990-2009



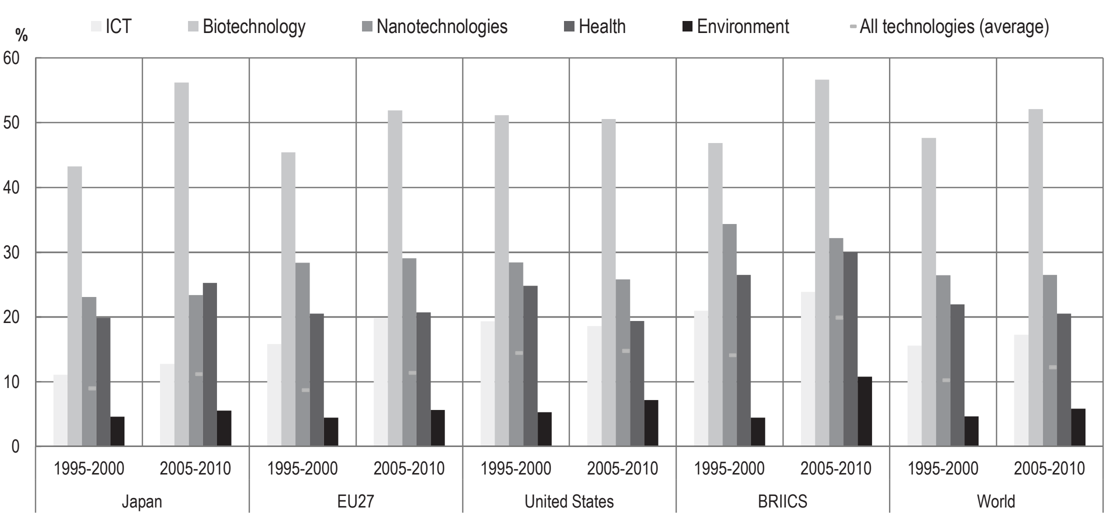
Notes: **Quadrant 1:** High number of university patent applications (%) and high industry demand of university patents (%). **Quadrant 2:** Low supply but high industry demand of university patents. **Quadrant 3:** High supply but low industry demand of university patents. **Quadrant 4:** Low supply and low industry demand of university patents.

2. Patenting varies greatly across fields. The biggest share of university patents can be attributed to pharmaceutical patents.

Source: R. Veugelers et al. (2012), "The participation of universities in technology development: Do creation and use coincide? An empirical investigation on the level of national innovation systems", *Economics of Innovation and New Technology*, Vol. 21, pp. 445-472.

Figure 2.12. Patents citing non-patent literature (NPL), selected technologies, 1995-2000 and 2005-10

Share of citations to NPL in backward citations, average



Notes: Data refer to the citations made in patent applications filed at the EPO during the search, according to the publication date and the inventor's country of residence. The average number of citations of NPL is compiled on citations received in EPO patents. Patents are allocated to technological fields using the International Patent Classification (IPC) or the European Patent Classification (ECLA) – tags Y01N and Y02.

Source: OECD (2011), *OECD Science, Technology and Industry Scoreboard 2011,* OECD Publishing, http://dx.doi.org/10.1787/sti_scoreboard-2011-en.

Figure 2.13. Licensing income, 2004-11

As a percentage of research expenditures

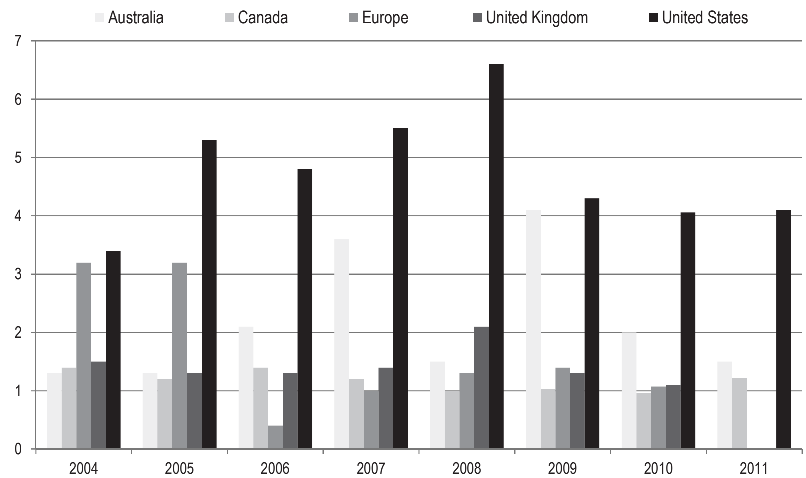
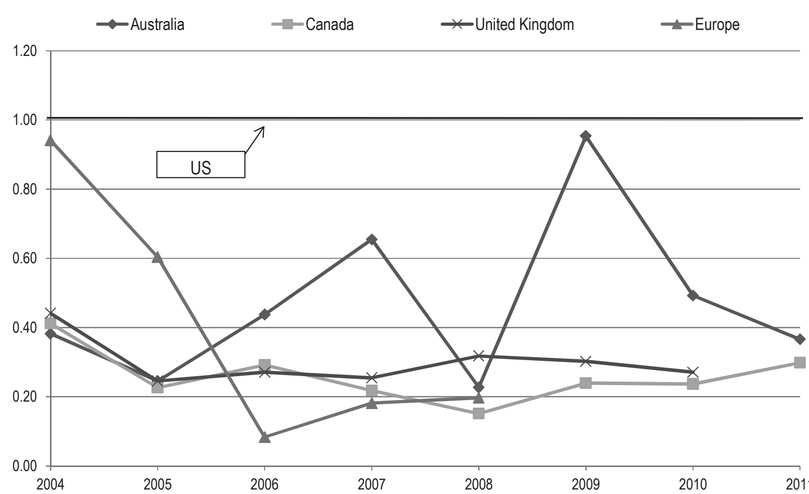


Figure 2.14. Licensing income, 2004-11

Relative performance to US (AUTM survey)



Notes:

1. Not all questions asked in the surveys in each country are directly comparable. Some surveys include PRIs, universities and hospitals whereas some include only universities (see Table A1.1 for further information). There are also differences in definitions of output and of R&D expenditures, as well as in the treatment of missing values. (For discussion see Arundel and Bordoy, 2008, "Developing internationally comparable indicators for the commercialisation of publicly-funded research", UNU Merit Working Paper Series; and Finne et al., 2009, "Metrics for knowledge transfer from public research organisations in Europe: Report from the European Commission's expert group on knowledge transfer metrics", project report, European Commission, Brussels, Belgium.)
2. Survey data (fiscal years): *United States* – US Association of University Technology Managers (AUTM) (2004-11); *Canada* – Canadian Association of University Technology Managers (AUTM) (2004-11); *Australia* – National Surveys of Research Commercialisation (NSRC) (2004-11); *Europe* – Association of European Science and Technology Professionals (ASTP) (2004-09), Proton Seventh Annual Survey Report (2009) and European Commission (2010); *United Kingdom* – Higher Education Business and Community Interaction Surveys (HE-BCIS) (2004-10).
3. Comparisons after adjusting for research expenditure (per USD 100m) and US dollar purchasing power parity, OECD database.
4. Europe – Survey data also include respondents from UK institutions.

Source: Based partly on calculations and data from Australia's Department of Innovation, Industry, Science and Research (DIISR) (2011 and 2012), "Australian National Survey of Research Commercialisation: 2008 and 2009" and "2010 and 2011"; European Commission (2012), "Interim Findings 2011 of the Knowledge Transfer Study 2010-2012", Bonn/Maastricht/Solothurn; US Association of University Technology Managers (AUTM) (2009-2012), "Highlights of the AUTM U.S. Licensing Activity Survey: FY2008 [through] FY2011"; Canadian AUTM (2009-2012), "Highlights of the AUTM Canadian Licensing Activity Survey: FY2008 [through] FY2011"; Higher Education Funding Council for England (HEFCE) (2009-2012), "Higher Education – Business and Community Interaction Survey 2007-2008 [through] 2010-2011."

Licensing income

Licensing income streams, usually measured as total income from all types of know-how and IP (patents, copyrights, designs, material transfer agreements, plant breeder rights, etc.), constitute a central impact measure of technology output, and hence a measure for the commercialisation of public research.

However, most royalties from licensing agreements accrue from a small number of highly successful "blockbuster" inventions and for a small number of institutions. This is in line with Scherer and Harhoff (2000), who noted that the value of innovation generally follows a highly skewed distribution where only minor numbers of innovations generate high returns. For example, the MP3 technology of Germany's Fraunhofer Society still yields a large share of total licensing income. Similarly, while Stanford's Office of Technology Licensing has received more than 8 000 invention disclosures, less than 1% of the Stanford disclosures have generated USD 1 million or more in cumulative royalties (Merrill and Mazza, 2010). In addition, data from the US Association of University Technology Managers (AUTM) for FY2011 have shown that 2.3% of running royalties generate more than USD 1 million, but only two Universities (Northwestern University and the University of California) accounted for 20% of total licensing revenues. According to a recent survey of European TTOs, 10% of universities accounted for approximately 85% of total licensing income (European Commission, 2012).

There is also ample evidence that licensing income can be relatively minor compared to other "third-stream" activities, such as contract research and consultancy services. Data from the UK Higher Education Business and Community Survey (HE-BCI) indicate that 1% of income of third mission sources originates from IP licensing, compared to 17% for contract research, 6% for consulting services and more than half of total income for the provision of continuous professional development services (HEFCE, 2012).

Bearing these caveats in mind, Figures 2.13 and 2.14 show licensing incomes across selected OECD countries as a share of public research expenditures. On average, income from university and PRI licensing is still marginal compared to total university and PRI funding or research expenditure. The United States' licensing income as a percentage of research expenditure compares favourably with other OECD countries. The average income as a percentage of research expenditure is 4.8% for the United States (2004-11), 2.2% for Australia (2004-11), 1.7% for Europe (2004-10), 1.4% for the United Kingdom (2004-10) and 1.2% for Canada (2004-11).

Public research spin-offs

Public research spin-offs are a mechanism for the exploitation and commercialisation of publicly developed R&D. They are defined here as the creation of a new venture, involving patents generated by researchers.[3] When established, the patent, which is transferred or exclusively licensed, is one of the most important intangible assets for the venture. For example, patents are often a precondition for spin-offs to obtain risk capital – be it in the first stages of financing or in succeeding stages (see Chapter 4).

Spin-offs provide academic entrepreneurs with an alternative pathway for commercialising research, often when they are unable to license the patent to other firms. The specific technology embedded in the patent may be too embryonic or too high-risk to attract licensees or investors.

The determinants of spin-off formation can be divided into four categories. These include *i)* individual characteristics of researchers; *ii)* organisational factors such as research and TTO capabilities; *iii)* institutional factors such as norms or university IP policies; and *iv)* external or environmental conditions such as the availability of venture capital or the endowment of infrastructure (Box 2.2).

Box 2.2. Determinants of spin-off formation

Institutional – One of the robust findings in the literature on spin-offs is that institutional policies and rules have pronounced effects on the rate of spin-off formation (Di Gregorio and Shane, 2003). The primary institutional factor that positively influences spin-off formation at universities is the flexibility of the licensing contract policy. Based on a case study of MIT's institutional support, O'Shea et al. (2007) found that cultural norms that support commercialisation activity will have higher levels of commercialisation and higher rates of spinoff activity. Similarly, O'Shea et al. (2005) found that at universities, previous success in commercialisation is a key determinant of a university's rate of spin-off formation. Evidence from UK universities shows that the number of spin-offs created was positively associated with university expenditure on IP protection, business development capabilities of its TTO, and the royalty regime of the university (Lockett and Wright, 2005).

However, university-level and contextual characteristics also shape the likelihood of individual scientists' establishing start-ups: Müller (2010) found that the main impediment for establishing firms by academics is usually the need to acquire complementary skills and assemble the appropriate teams; nevertheless, this process is greatly facilitated if the founders have access to university infrastructure/services and receive formal and informal support through their networks.

Organisational – Organisational university characteristics/services that appear significant in facilitating the creation of spin-offs include sufficient TTO staff, relationships between the TTO and external organisations, and support services provided by TTOs to faculty (Fini, Grimaldi and Sobrero, 2009; Nosella and Grimaldi, 2009). Related to the role of TTOs, Markman, Siegel and Wright (2008) found that the greater the innovation speed of TTOs, the greater will be the propensity to generate returns to the university via higher rates of start-up formation.

Individual – In addition to institutional and organisational-level factors, individual researcher characteristics are related with the likelihood of establishing or joining a spin-off. Researchers who are motivated to a greater extent by opportunities to commercialise research are also more likely to be involved in spin-off companies (D'Este and Perkmann, 2011), and "star scientists" are more likely to engage in spin-off company activity (Zucker, Darby and Brewer, 1999). In addition, Roberts (1991) found that researchers with outgoing, extroverted personalities were more likely to engage in the creation of a spin-off.

External and environmental – External and environmental determinants include the availability of venture capital, the endowment of relevant knowledge infrastructure, government policies (Chapter 3) and the industry structure. For example, while venture capital is crucial for the formation of high-technology spin-offs (e.g. spin-offs rate venture funds to be more important than internal funds), it is also the biggest resource constraint faced by universities (Florida and Kenney, 1988; Wright et al., 2006). Some universities have therefore established university venture funds, either fully funded or co-funded with university resources (see Chapter 4).

Source: Compiled from Ponomariov B. and C. Boardman (2012), "Organizational behavior and human resources management for public to private knowledge transfer: An analytic review of the literature", *OECD Science, Technology and Industry Working Papers*, No. 2012/01, OECD Publishing, Paris; and O'Shea, R.P., H. Chugh and T.J. Allen (2008), "Determinants and consequences of university spinoff activity: A conceptual framework", *The Journal of Technology Transfer*, Vol. 33, pp. 653-666.

The subject of spin-off creation has received substantial attention in the literature and policy circles, even if this remains one of the rare forms of start-ups (Wright, Mosey and Noke, 2012). For example, US AUTM data for FY2011 show that the number of spin-offs per university per year among 157 colleges and research universities is low, with the mean standing at 4 and a maximum at the University of California (58) (US AUTM, 2012).

Figure 2.15. Creation of public research spin-offs, 2004-11

Per USD PPP 100 million research expenditure

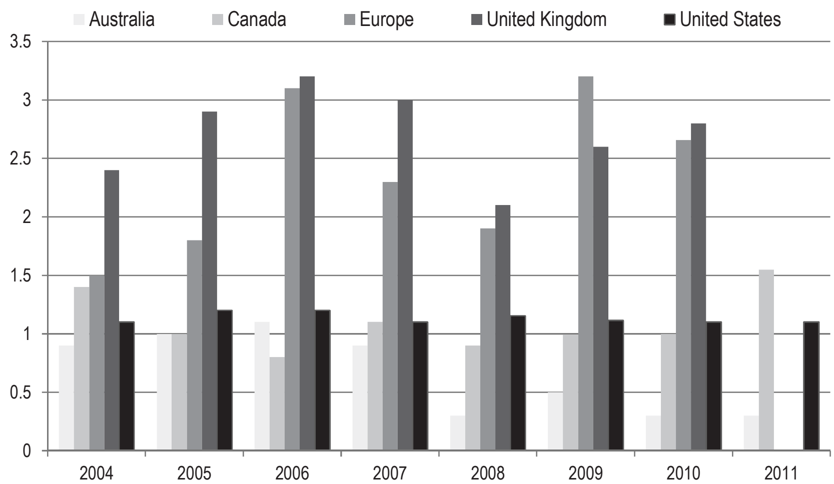
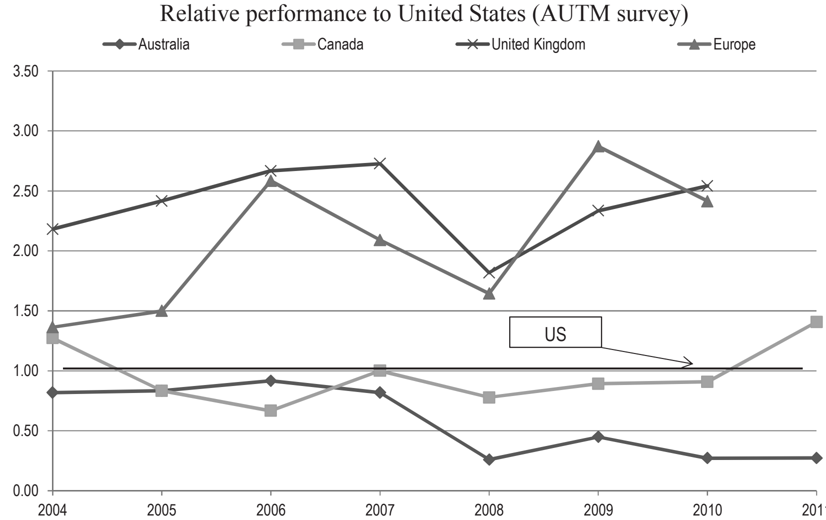


Figure 2.16. Creation of public research spin-offs, 2004-11

Relative performance to United States (AUTM survey)



Notes:

1. Not all questions asked in the surveys in each country are directly comparable. Some surveys include PRIs, universities and hospitals whereas some include only universities (see Table A1.1 for further information). There are also differences in definitions of output and of R&D expenditures, as well as in the treatment of missing values. (For discussion see Arundel and Bordoy, 2008, "Developing internationally comparable indicators for the commercialisation of publicly-funded research", UNU Merit Working Paper Series; and Finne et al., 2009, "Metrics for knowledge transfer from public research organisations in Europe: Report from the European Commission's expert group on knowledge transfer metrics", project report, European Commission, Brussels, Belgium.)
2. Survey data (fiscal years): *United States* – US Association of University Technology Managers (AUTM) (2004-11); *Canada* – Canadian Association of University Technology Managers (AUTM) (2004-11); *Australia* – National Surveys of Research Commercialisation (NSRC) (2004-11); *Europe* – Association of European Science and Technology Professionals (ASTP) (2004-09), Proton Seventh Annual Survey Report (2009) and European Commission (2010); *United Kingdom* – Higher Education Business and Community Interaction Surveys (HE-BCIS) (2004-10).
3. Comparisons after adjusting for research expenditure (per USD 100m) and US dollar purchasing power parity, OECD database.
4. Europe – Survey data also include respondents from UK institutions.

Source: Based partly on calculations and data from Australia's Department of Innovation, Industry, Science and Research (DIISR) (2011 and 2012), "Australian National Survey of Research Commercialisation: 2008 and 2009" and "2010 and 2011"; European Commission (2012), "Interim Findings 2011 of the Knowledge Transfer Study 2010-2012", Bonn/Maastricht/Solothurn; US Association of University Technology Managers (AUTM) (2009-2012), "Highlights of the AUTM U.S. Licensing Activity Survey: FY2008 [through] FY2011"; Canadian AUTM (2009-2012), "Highlights of the AUTM Canadian Licensing Activity Survey: FY2008 [through] FY2011"; Higher Education Funding Council for England (HEFCE) (2009-2012), "Higher Education – Business and Community Interaction Survey 2007-2008 [through] 2010-2011."

Spin-offs created on the basis of public sector knowledge also include ventures created through alumni or student start-ups, or through business channels via corporate spin-offs. For example, based on the US National Science Foundation (US NSF) Scientists and Engineers Statistical Data System (SESTAT), Åstebro, Bazzazian and Braguinsky (2012) show that start-ups by university graduates outnumber faculty spin-offs; they found that recent graduates are twice as likely as their faculty to create a business venture, and that these spin-offs are not of low quality. Using a longitudinal, multi-case approach, a study by the Kauffmann Foundation of ten MIT ventures concludes that students, not faculty, formed the initial idea for a new technology that constitutes the basis of a spin-off (Lubynsky, 2013). Similar results provided an analysis of Academic Enterprise Europe Awards finalists: the largest group of founders were doctoral students (38% of 28 interviewed founders) while professors were less numerous (Hoefer, Magill and Santos, 2013).

Researchers can also pursue academic entrepreneurship indirectly, by leaving their institution to work for corporations before they start their ventures. Empirical evidence in Sweden shows that the economic impact of corporate spin-offs is potentially more significant than that of university spin-offs. Wennberg, Wiklund and Wright (2011) argue that this may be due to founders' prior experiences in a corporate environment. Buenstorf (2007) shows that the survival rates of corporate spin-offs in the German laser industry are to be higher than those of academic spin-offs. Data on spin-off companies formed per USD 100 million in research expenditure show strong variations across OECD countries (Figure 2.15). On average, Europe (2.4 for 2004-10) has maintained a higher rate of spin-off formation than the United States (1.1 for 2004-11), Canada (1.1 for 2004-11) and Australia (0.7 for 2004-11) over most measurable years.

The superior position of Europe compared to the United States and other countries is illustrated in Figure 2.16. Performance-based measures such as survival rates, turnover and employment rates can be useful, though these are only partially captured in national surveys on commercialisation (e.g. AUTM and HE-BCIS on survival rates and (in more depth) by the Japanese Basic Survey Report on University Ventures).

Metrics beyond the number of patents and spin-offs

Some studies and surveys have attempted to capture the broader spectrum of codified non-patent-related channels for knowledge transfer. For example, firm respondents to the Carnegie Mellon Survey of Industrial R&D reported that the most important channels were publications, conferences, and informal exchanges. Patents ranked low in most industries except for pharmaceuticals (Cohen, Nelson and Walsh, 2002). Another example is the UK-US Innovation Benchmarking Survey. It reveals the importance of investigating a broad variety of channels through which knowledge transfer activity affects firm performance (Cosh, Hughes and Lester, 2006).

With regards to commercialisation activities by academics, Perkmann et al. (2012) have conducted a review of the extant evidence on the commercialisation behaviour of researchers across institutions and countries (Table 2.1). They found that the share of university researchers involved in patenting ranges from 5% to 40%. Equally large differences can be observed for the proportion of researchers involved in a spin-off, but generally fewer than 10% of researchers engage in a commercial enterprise. Although results may differ due to different sampling strategies, university cultures and scientific disciplines, Perkmann et al. conclude that only a minor share of researchers is actively involved in commercialisation activities.

Table 2.1. Commercialisation activities by academics in selected OECD countries

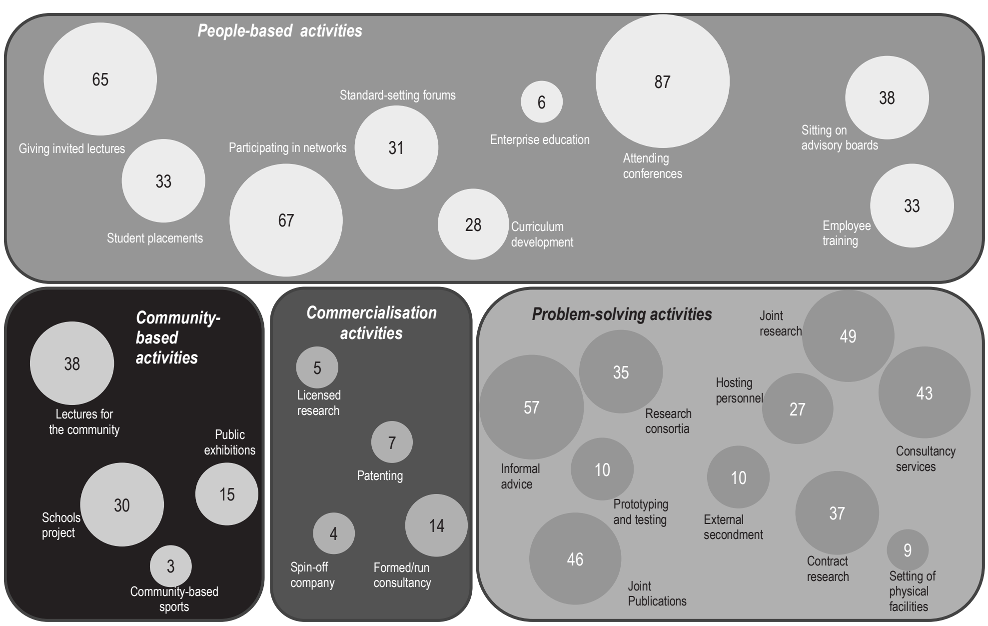
Population	Time-frame	Collaborative research	Consulting	Sponsored research	Contract research	Patenting	Spin-off creation
Academics in Sweden	Entire career		51%	44%	45%	12%	12%
Academics in Ireland	Entire career		68%	68%	69%	26%	19%
Tenured university professors in Norway	5 years	21%	31%	21%		7%	7%
Academics at US research universities	12 months	17%	18%			5%	3%
UK physical & engineering sciences investigators	2 years	44%	38%		47%	22%	12%
Academics in Germany	12 months	20% (joint publications)	17%				
Life scientists in Germany and the United Kingdom	12 months		20%			40%	9%

Notes: See source for individual studies. The figures indicate the percentage of academics involved in the specified activities, unless otherwise indicated.

Source: Perkmann et al. (2012), "Academic engagement and commercialisation: A review of the literature on university-industry relations", *Research Policy*, Vol. 42, pp. 423-442.

Figure 2.17. Frequency of interactions by UK academics

Percentage of academics reporting interaction with an external organisation in the previous three years



Source: Hughes et al. (2010), "Cambridge Centre for Business Research Survey of Knowledge Exchange Activities by UK Academics", *UK Data Archive Study*, No. 6462.

The Cambridge Centre for Business Research Survey of Knowledge Exchange Activity by United Kingdom Businesses shows that the most frequent forms of interaction with external organisations are related to people-based activities, such as participating in networks or attending conferences. Commercialisation-based activities have been ranked low by UK researchers (Hughes et al., 2010) (Figure 2.17).

Mobility of skilled personnel and flows of knowledge embodied in people

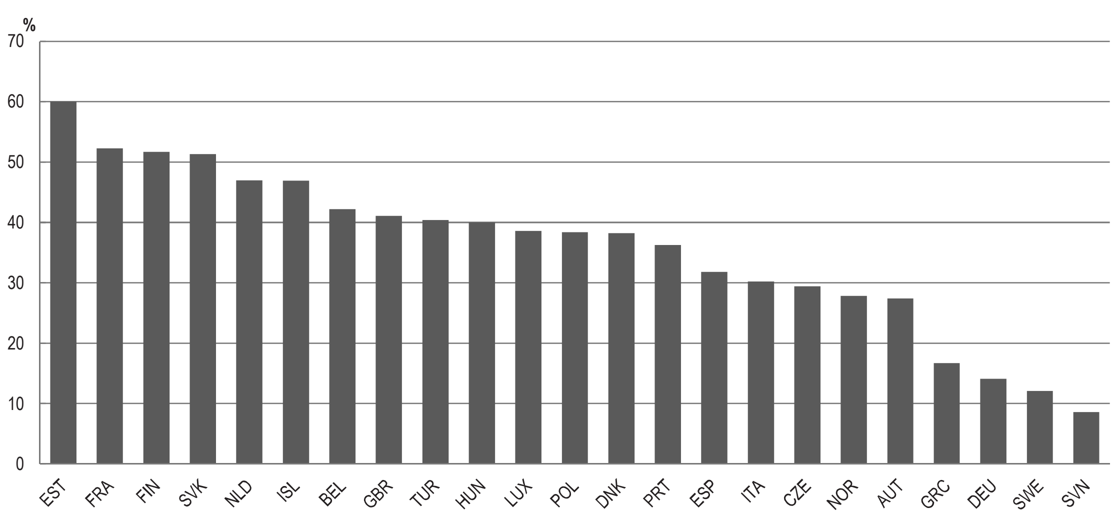
Human resources are central to the transfer and commercialisation of public research, yet their role is often underestimated (OECD, 2002). The mobility of people among different sectors of the economy is an important channel for knowledge diffusion, and can increase a firm's research productivity.

Figure 2.18 shows that in Estonia, France, Finland and the Slovak Republic, more than 50% of human resources in science and technology (HRST) who moved reported a change in their sector of economic activity from 2009 to 2010. In contrast, most HRST mobility in Germany, Sweden and Slovenia occurred within sectors.

OECD data from the Careers of Doctorate Holders (CDH) project can also be used to track mobility. Figure 2.19 shows that overall, total mobility rates vary extensively across countries, from a high of 78% in Germany to a low of 13% in Romania. However, in all of the countries shown in the figure, the mobility rate for non-researchers is higher than for researchers. Auriol, Misu and Freeman (2013, forthcoming) offer a number of explanations. For example, non-researchers are mainly employed in business enterprises and there may be higher turnover in this sector, or improved opportunities for career development outside of research positions. They also suggest that doctorate holders may change jobs frequently until they secure a research post, and this may be especially prevalent at the start of their career.

Figure 2.18. Inter-sectoral mobility of HRST, 25-64 year-olds, 2010

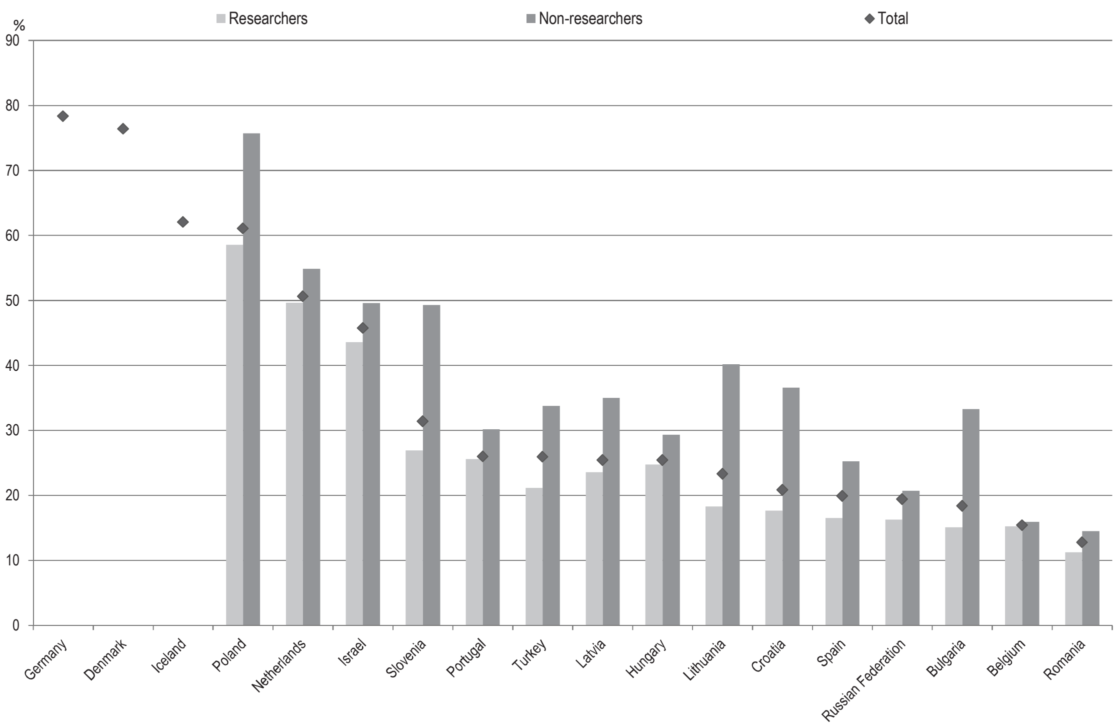
As a percentage of HRST changing employer



Source: OECD (2011), *OECD Science, Technology and Industry Scoreboard 2011*, based on ad hoc tabulations of European Labour Force Surveys, Eurostat, May 2011.

Figure 2.19. Doctorate holders having changed jobs in the last 10 years, 2009

Percentage



Notes: Data for Belgium, Germany, Hungary, the Netherlands and Spain refer to graduation years 1990 onwards. For Belgium, Malta and the Russian Federation, data for the 65-69 age class include doctorate holders aged 70 and above. For the Russian Federation, data relate only to those doctoral graduates employed as researchers and teachers. For Spain, there is limited coverage of doctorate holders for the years 2007 to 2009. Data for Turkey exclude foreign citizens.

Source: The OECD Careers of Doctorate Holders Database, www.oecd.org/sti/cdh.

Other survey data provide equally interesting insights on the sectoral mobility patterns of researchers. The Mobility and Career Paths of EU Researchers (MORE) project (IDEA Consult, 2010) found that 17% of respondents working in the higher education institute sector have moved between the public and the private sector, whereas 42% of the industry sample moved between the public and the private sectors at least once. A 2010 national survey of researchers in Japan showed that only 1% of Japanese researchers who moved to the business sector came from the higher education sector, while 7% of researchers from the higher education sector originated from the business sector (Table 2.2). Fixed-term contract-based academic employment is, however, very common in most OECD countries, particularly with the rise of project funding streams. Therefore, data on intra-institutional sector movements merit careful attention.

Table 2.2. Inter-sector mobility of researchers in Japan

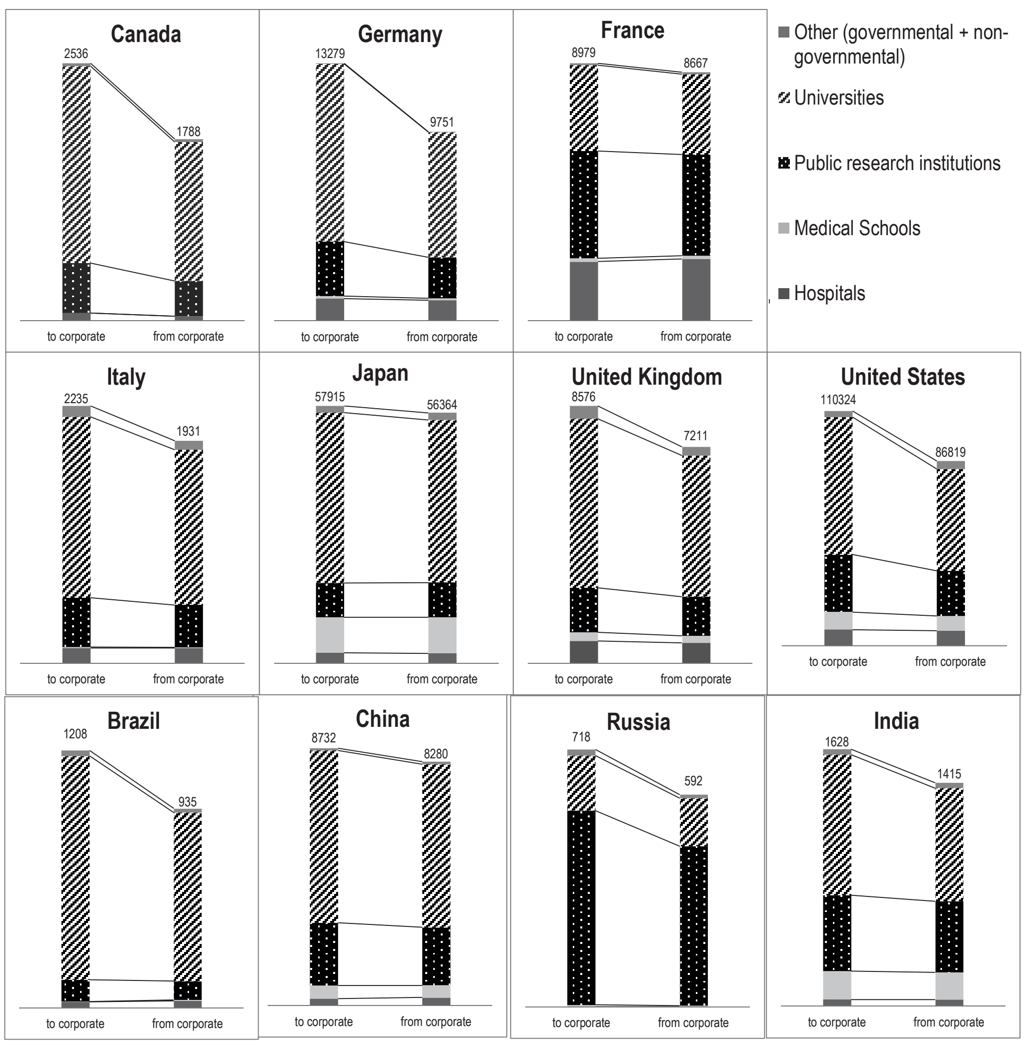
Sector	Inter-sector mobility as a percentage of researchers changing employer in 2010			
	From companies	From public institutions	From universities and colleges	From other sectors
Companies	94%	1%	1%	4%
Public institutions	12%	65%	12%	11%
Universities and colleges	7%	22%	42%	29%

Source: Japanese Ministry of Internal Affairs and Communication research & development survey.

Cross-sector linkages can also be measured through bibliographic indicators.[4] For example, a recent report by the UK Department of Business, Innovation and Skills (Elsevier, 2011) used the author affiliation profile in Scopus, a bibliographic database, to trace the number of authors who moved to and from the corporate sector in a selected number of countries for the period 1996-2000.

Figure 2.20 shows the number of authors moving to and from the corporate sector in 11 countries. In the United States, for example, around 110 000 authors with a non-corporate affiliation moved to a corporate entity from 1996 to 2000. Around 60% of these authors were from a university and 25% from a PRI. During the same period, around 87 000 authors with a corporate affiliation moved to a non-corporate entity. The most common destination was a university (55%), followed by a research institute (25%). Apart from France and Russia, these patterns are markedly similar across countries.

Figure 2.20. Cross-sector mobility of authors, 1996-2010



Note: The graph is based on author affiliation addresses in the published literature and on movements from one affiliation type to another during that period.

Source: Elsevier (2011), *International Comparative Performance of the UK Research Base* – 2011, report prepared for the Department of Business, Innovation and Skills.

Business research and co-authored scientific publications

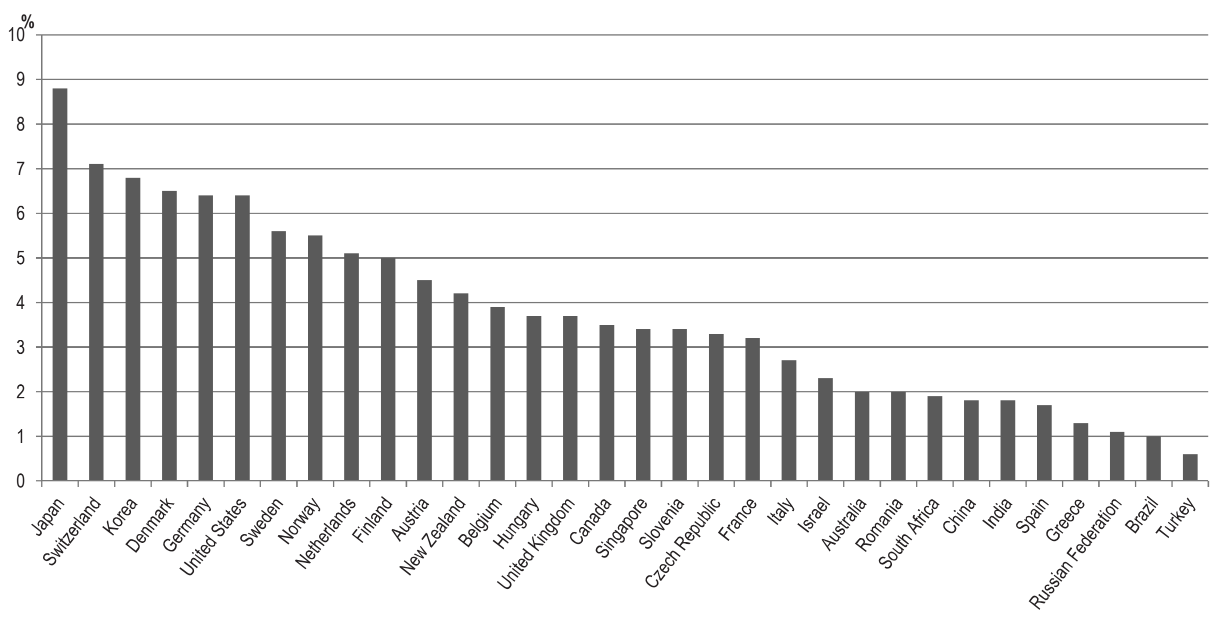
Published articles are a major output of scientific research, and their numbers are used extensively to assess different facets of scientific activity. This extends to research co-operation between the private and the public sector. As such, active research collaboration between firms and PROs and their results can be traced by measuring co-publications. Article co-authorship between academic researchers and firms has been shown to be an effective method of determining the extent of inter-sectoral cooperation and associated knowledge transfer. Tijssen (2012) estimates that 4.2% of Thomsen Reuters' Web of Science (WoS)-indexed publications are attributed to industry-science co-publications, amounting to some 50 000 publications per year worldwide.

While there are indications that the share of articles published by industry is decreasing compared to the academic sector,[5] a significant share of firms' publication output is co-authored with academic researchers, especially in sectors such as the life sciences. Gittelman's (2007) analysis of biotechnology firms' co-authorships shows, for example, that over 90% of the firms' research partners were PROs.

Generally, co-authored publications can indicate the degree to which business absorbs or integrates public research knowledge into business and R&D operations. It may be a result of research partnerships or associated interactions such as contract research, academic consulting or personal acquaintance, and thus at the micro level is a potential measure of open innovation activities of firms. For example, Cockburn and Henderson (1998) find that co-authorship with university employees increases R&D productivity of pharmaceutical firms.

Figure 2.21. Industry-science co-publications, 2006-10

% of industry-science co-publications in total research publication output



1. Countries with at least 2 000 WoS-indexed publications and 500 industry-science co-publications in 2006-10.

Source: Centre for Science and Technology Studies (CWTS), Leiden University, using Web of Science (WoS) database.

Figure 2.21 depicts country-level data of industry-science (both universities and PRIs) co-publications. Viewed nationally, Japanese researchers and business seem to co-publish more intensively compared with other large OECD countries such as Korea, Germany and the United States. Among the smaller OECD countries, Switzerland and Denmark have relatively higher shares of co-published research articles. As co-publication data refer to the country in which the firms are located, the variations can be largely explained to the presence (or absence) of R&D-intensive industries (e.g. pharmaceuticals in Switzerland; electronics and telecommunications in Japan and Korea). Other factors that affect co-publication rates, though of less importance, are local and national framework conditions (e.g. a country's science landscape) or the co-publication rates of individual universities and PRIs (Tijssen, 2012) (see Table A.4 for percentages of co-authored publications with industry by individual universities).

The number of publication downloads may also indicate inter-sectoral knowledge flows. An Elsevier study (2011) for the UK Department of Business, Innovation and Skills shows that more than 70% of all downloads of corporate-authored articles came from users in the academic sector. On the other hand, more than 40% of all downloads by users in the business sector were for university-authored articles. To a lesser extent, the remaining downloads by business comprised in equal shares research institute-, hospital- and corporate-authored articles.

Notes

1. Another comparable performance indicator is the number of outputs per level of inputs measured in research personnel or TTOs. Such standardised indicators may provide an approximation of average productivity levels (Arundel and Bordoy, 2008).
2. Relative performance is measured against US institutions; these are widely considered to lead in terms of commercialisation outputs in comparison to institutions in other OECD countries.
3. There is no standard definition of a public research-based spin-off (or start-up). In the narrow view, it may be defined as any new firm that includes a public sector or university employee as a founder. In the broader view, it may be defined as any new firm including a public sector or university employee or student/alumnus or former public sector employee as a founder, based on a patent and/or other forms of IP (e.g. copyright) and/or non-technical innovations (e.g. business model improvements).
4. A range of bibliometric indicators can be used to analyse activity and impact profiles in science and technology. Bibliometric analysis uses parameters such as publication output (productivity/activity), co-authorship (collaboration), citations rates (reception/impact), co-occurrences of words/classifications/citations (cognitive structures), or a combination thereof.
5. For example, in the United States the academic share of science and engineering (S&E) articles rose from 71.6% to 76.1% between 1995 and 2010, while that of PRIs (7.9% to 6.1%) and industry (8.1% to 5.8%) declined (US NSF, 2012 using the Web of Science [WoS] database).

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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

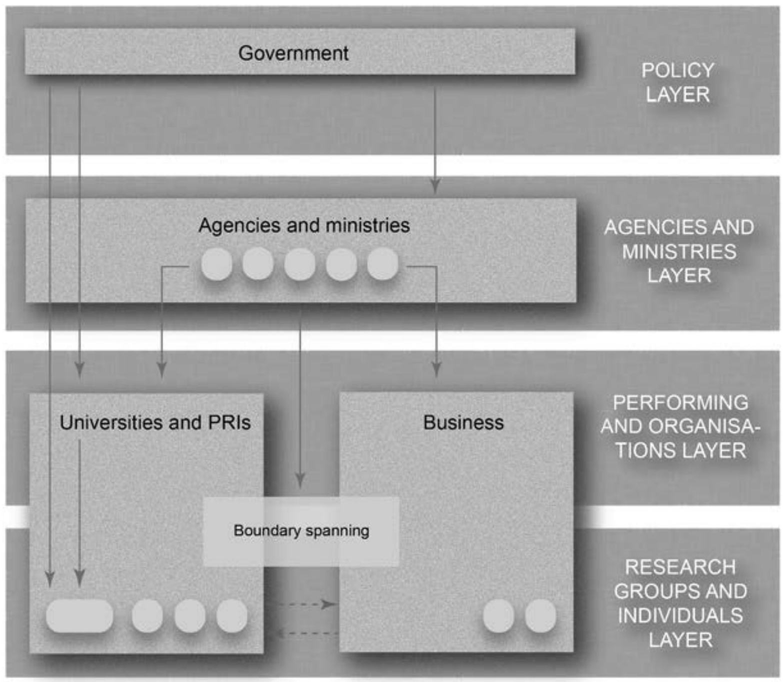
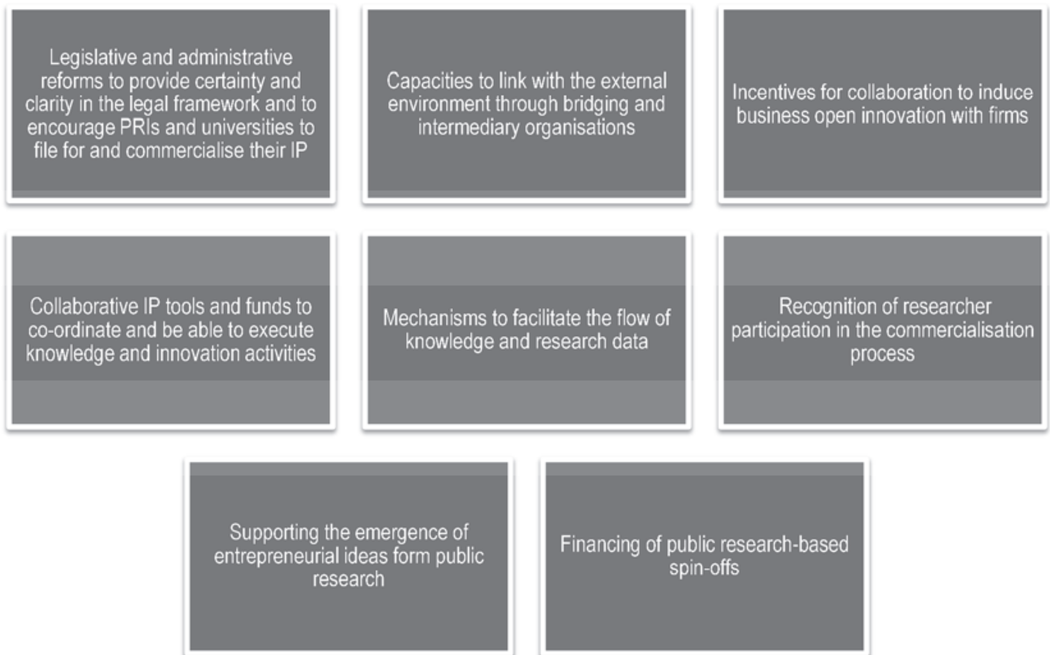


Figure 3.2 illustrates the range of programmes and initiatives pursued by governments and PROs. Many more, however, are along the lines of existing ones and so may not constitute new initiatives/programmes. In addition, at first glance all of these programmes/initiatives are in one way or another oriented 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 techno-logical 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, all-campus 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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Chapter 4

Financing of public research-based spin-offs

The financing of public research-based spin-offs – from research to market – takes place at various stages in the firm development cycle. National policy instruments have focused on the seed funding stage, but support has shifted to proof-of-concept and prototype funding. Universities and PRIs are also providing institutional support, ranging from institutional risk capital funds, mentoring and incubation support to IP assessment services and business development plans. Corporate venturing, research crowdfunding and using IP for financing purposes represent additional sources of financing for public research spin-offs, but the scale of financing remains limited in most cases.

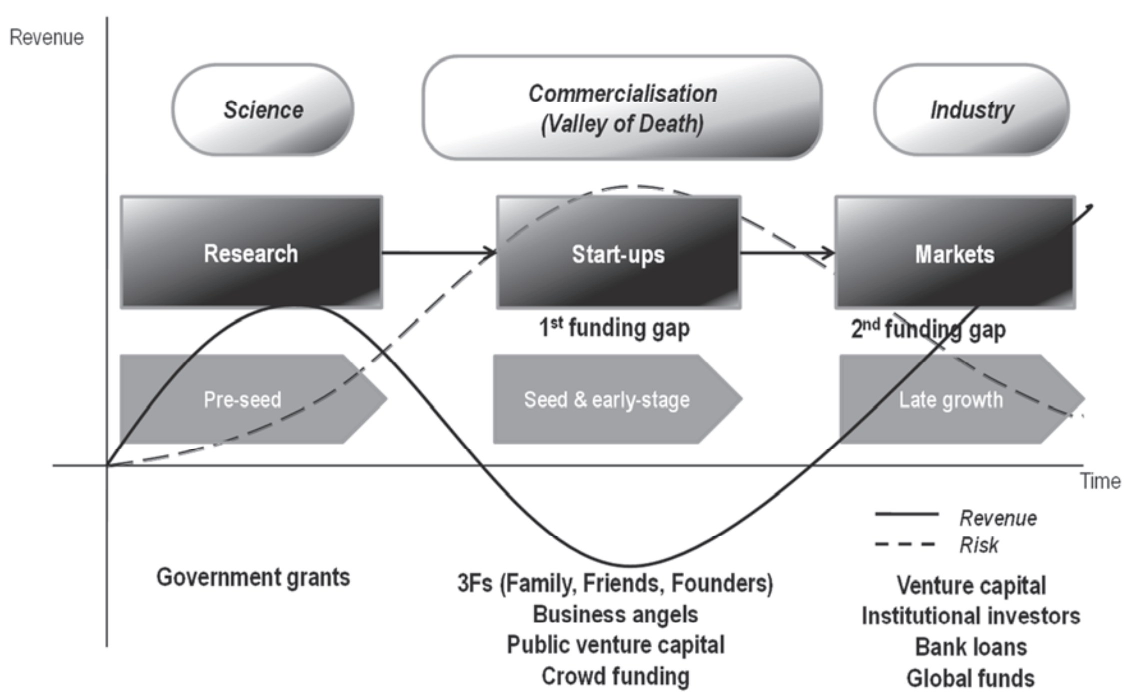
Constraints in financing public research spin-offs

The financing of innovation from invention through to commercialisation requires long-term capital commitments. New ventures, particularly technology-based public research spin-offs, face the liabilities of newness and smallness, which impede their access to resources such as financial capital. The economic and financial crisis has accentuated the difficulties for early-stage firms to finance their innovation activities, and in addition reduced confidence in the ability of markets for complex products to address information asymmetries and align risks and rewards.

Traditional financing techniques based mainly on debt and guarantees, as well as mezzanine finance, have only limited relevance for research spin-offs, due to uncertain technological success and typically because most spin-offs have not reached profitability. Broad empirical evidence has found that public research-based spin-offs and start-up firms in R&D-intensive and high-technology industries face a higher cost of capital (e.g. due to asymmetric information between inventor/entrepreneur and investor) than their larger competitors and firms in other industries (Hall, 2009). In addition to higher capital costs, failures in financial markets and the inherent risks with regard to the outcomes of public research results have justified public support to academic entrepreneurs.

This gap between the need for resources to develop entrepreneurial ideas into commercial products and services and the availability of funding is often referred to as the “valley of death” (Auerswald and Branscomb, 2003; see Figure 4.1). The existence of a funding gap that limits the possibility to turn research results into commercially viable products and services and to attract private investors has led governments and, increasingly, individual institutions to provide financing to public research spin-offs.

Figure 4.1. Financing tools for different stages of research commercialisation



National-level support

There has been a rise in specific national financial schemes that target certain stages of the spin-off process (Table B.4), but also an increase in funding for advisory and technical services. Generally, the different types of national support for research spin-offs vary in terms of their size, scope, and degree of interaction, and can be distinguished between 1) proof-of-concept (PoC), 2) pre-seed and 3) seed funding (Table 4.1). Rasmussen and Sørheim (2012) observe that spin-off programmes have developed away from offering funding in the form of seed schemes and toward initiatives that tackle technological and organisational uncertainties, which may inhibit the diffusion and adaption of new technologies.

Table 4.1. The main characteristics of different types of government funding for public research spin-offs

	Proof-of-concept	Pre-seed	Seed
Goal	Reduce the technological uncertainty of the project by verifying its technological feasibility	Reduce the organisational uncertainty of the project by preparing it organisationally for further investment	Reduce the investment risk associated with the project by providing funding that accepts a higher risk than would most private actors
Approach	Demand-side: increase the attractiveness of university spin-offs for investors	Demand-side	Supply-side: increase the supply of early-stage funding
Type of government support	Usually 100% grant-based	Usually grant based but sometimes convertible to equity	Usually equity or loans
Manager of funds	Usually government agency	Varies, but often regional agent	Usually private agent or independent government unit
Funding decision	Usually by application and panel review, similar to research funding	Varies, but usually made at regional level	Investment decision accepting high risk
Type of activity supported	Technology development at project level	Market and management development by entrepreneurs or consultants	Venture launch
Main criteria for funding	Market potential of technology	Combination of individual and project characteristics	Growth potential of the new venture
Anticipated outcome	University spin-off or license to existing firm	University spin-off	High-growth university spin-offs

Note: Based on observations from Canada, Finland, Ireland, Norway, Sweden and the United Kingdom.

Source: Rasmussen and Sørheim, 2012.

In Germany, for example, support for university spin-offs was developed through the EXIST programme. EXIST consists of three components: culture of entrepreneurship, business start-up grant, and transfer of research. These initiatives focus primarily on encouraging commercialisation of research results generated by universities and research institutes, and provide both grants and coaching for scientists, university graduates and students at early-stage start-ups, who develop their ideas into a marketable product (Box 4.1).

In Austria, the Federal Ministry for Transport, Innovation and Technology (BMVIT) supports new technology-based firms through the Seed Financing programme (operated by Austria *Wirtschaftsservice* – AWS) and spin-offs through the AplusB – Academy plus Business programme, operated by the Austrian Research Promotion Agency (FFG). The former promotes high-technology start-ups before and during the establishment phase. The criteria for allocations are novelty, technological intensity, development potential and willingness to risk. The Seed Financing programme provides mezzanine capital for high-growth technology-based SMEs and guarantees for venture capital. As a sponsoring bank, the AWS – which covers all forms of business-related support for economic operators – offers several programmes in this context: subsidies, favourable interest rates on credits from the AWS-administered agency fund ERP, assumption of liability, backing, and advice (*Eigenkapitalförderung*, Protec 2002+, etc.). AWS provides soft aid programmes, especially to SMEs, to support inward technology transfer ("protec TRANS") and innovation management ("protec INNO"). The AWS has a special funding programme, High-Tech Double Equity, which doubles private equity or venture capital via a 100% guarantee for a bank loan.

The Netherlands has experimented with several schemes for the creation of new firms and SMEs. The Dutch TechnoPartner Seed Facility – introduced in 2005 as part of the overall TechnoPartner programme to raise the number and quality of high-technology start-ups by improving access to capital and providing specific information and coaching – seeks to eliminate the equity gap frequently faced by Dutch high-technology start-ups. Drawing on experience with related schemes in the United States and the United Kingdom, this facility aims to stimulate small business investment companies (SBICs) established by private parties. Own capital brought into the SBICs is matched by government loans.

In the United States, the Small Business Innovation Research (SBIR) programme, which was launched in 1982, aims to encourage novel R&D with a high-risk focus on creating a new venture, serving as a bridge between universities and markets. The SBIR programme is highly decentralised, as is most US R&D funding, spread across 11 agencies with different missions and sizes and no formal budget process. SBIR funding is equal to 2.5% of federal R&D funding, a percentage that will rise to 3.2% by 2017. In addition, the Small Business Technology Transfer Research (STTR) funds high-risk R&D with commercial potential, enabling researchers to overcome financial barriers. A key criterion for funding is that small businesses must formally collaborate with PROs. Participating agencies set aside 0.3% of their R&D budgets to support the programme.

The United Kingdom provides support for the commercialisation of university-based research with programmes such as the University Challenge, Science Enterprise Challenge and Higher Education Fund. In Russia, the START programme was launched in 2004 to stimulate spin-off activity from universities and PRIs. Similar to the SBIR programme in the United States, it consists of three phases over three years. The programme targets filling the funding gap particularly for young, small start-ups at seed and early stages.

Canada's Idea to Innovation Grants (I2D) aims to accelerate the pre-competitive development of technology originating from public research by providing funding to researchers to support the creation of spin-offs. Eligible activities for proof-of-concept funding include (but are not limited to) verifying applications, conducting field studies, preparing demonstrations, building prototypes and performing beta trials.

Norway's FORNY2020 has been streamlined into two funding schemes: basic funding and proof-of-concept funding. The basic funding targets Norwegian technology transfer offices (TTOs); the aim of the PoC scheme is to reduce technological and commercial risks to such an extent that existing industry and/or venture capitalists are willing to buy into the project and bring it to fruition. Projects applying for funding must originate from publicly funded R&D institutions. PoC funding from FORNY2020 requires that the projects have as their target the development of products, processes or services that are new to the international market. The scheme is technology-neutral. TTOs receive basic funding; other bodies focusing on commercialisation and representing publicly funded R&D institutions and micro enterprises originating from publicly funded R&D institutions may apply.

Box 4.1. Examples of national programmes supporting public research spin-offs

Commercialisation Australia (Australia)

Commercialisation Australia is a government flagship initiative for the Australian entrepreneurs. The programme places emphasis on turning IPs into a commercial reality, and provides financing as well as mentoring. It is a competitive, merit-based program and constitutes key four components:

- Skills and knowledge: grants up to AUD 50 000, to access expert advice and services, on an 80:20 basis, up to one year.
- Experienced executives: grants up to AUD 350 000 over two years, to engage an experienced chief executive officer (CEO) or other executives, on a 50:50 basis.
- Proof of concept: grants from AUD 50 000 up to AUD 250 000, to assist with establishing the commercial viability of a new product, process or service, for a year (up to 18 months, if agreed), on a 50:50 basis.
- Early stage commercialisation: grants from AUD 50 000 up to AUD 2 million, to undertake activities focused on bringing a new product, process or service to market, for two years, on a 50:50 basis.

EXIST programme (Germany)

The EXIST Culture of Entrepreneurship supports a variety of projects at universities to nurture entrepreneurship on a three-year basis. The EXIST Business Start-up Grant aims to support early-stage start-ups from universities and public research institutions (PRIs). The maximum period of support is one year and the grant varies from EUR 800 to EUR 2 500 per month, depending on the level of degree.

- Doctorate holders: EUR 2 500/month; graduates: EUR 2 000/month; undergraduates: EUR 800; child supplement: EUR 100/month/child.
- Material expenses: up to EUR 10 000 for individual start-ups; up to EUR 17 000 for teams.
- Start-up related coaching: EUR 5 000.

The EXIST Transfer of Research promotes technology-based business start-up projects in the pre-start-up and start-up stages from universities and research institutes. It complements the broadly targeted EXIST Business Start-up Grant with an excellence-oriented measure for high-tech start-ups.

- Phase I: up to EUR 60 000 at pre-start-up stage for material expenses; staff cost separately paid, up to 18 months, enabling start-ups to provide proof of the technological feasibility of their product idea.
- Phase II: up to EUR 150 000, at start-up stage, but at most 75% of the project-related costs, allowing them to continue the product design and the prototype realisation.

…/…

Box 4.1. Examples of national programmes supporting public research spin-offs *(cont'd)*

***START Programme* (Russian Federation)**

The START programme aims to stimulate commercialisation, focusing on spin-offs from universities and PRIs. The three-year budget totals USD 250 000, and about 400 new teams join the programme each year, out of approximately 1 500 applications. Around 25-30% of the 400 graduate to the second year, and about 70% qualify to receive financing in the third year.

- 1st year: financing up to USD 40 000, to cover R&D and convince private investors of the commercial potential of the new venture.
- 2nd year: financing is granted only if private investors participate on a 50:50 basis.
- 3rd year: financing is granted only if developments are in line with the business plan and sales have already started in addition to the co-financing on a 50:50 basis.

SBIR programme (United States)

The SBIR programme finances early-stage R&D projects in small firms (a number of which are spin-offs from PROs) in two steps, through a merit-based open competition. Only about 14% receive Phase I awards and 40 out of these receive Phase II awards.

- Phase I: USD 150 000 total costs up to 6 months for a feasibility study.
- Phase II: USD 1 000 000 total costs up to 2 years, granted only to Phase I awardees to continue the R&D efforts initiated in Phase I.
- Phase III: pursue commercialisation of projects resulting from Phases I and II, with non-SBIR funds through either procurement fund from federal agencies or private investments.

Institutional-level support

Many PRO administrations are taking further steps to complement national programmes by setting up their own PoC and seed funds (i.e. institutional risk capital funds), either fully funded or co-funded with institutional resources. The first pioneering experiences were in the United States after the Second World War to sustain technology-based spin-offs from MIT (Lerner, 2005). In 2011, there were about 70 universities in the United States that had established internal gap funding programmes (Johnson, 2011). In Europe, around 73 university and PRIs oriented seed funds and 48 PoC funds have been identified. Typically, most gap funding programmes, whether PoC or seed funds, also provide business and advisory services, incubator space, market research and educational training.

There is however a wide heterogeneity in gap funding programmes, in terms of which stages of commercialisation they support (e.g. from proof-of-concept funding to post-seed funding), governance (e.g. managed by internal or external TTO, investment professionals or a venture capital [VC] firm) and business models (e.g. investment focus, number of serviced institutions). Some funds also share features with private sector patent and IP funds. For example, the Karolinska Development Fund in Sweden invests money raised from the capital market back into the 26 partly owned portfolio spin-offs.

The available empirical evidence of the positive impact of institutional gap funding programmes is mixed. Lerner (2005) states that governments and institutions should be cautious about the success of later-stage equity funds, given the limited number of ventures generated. By analysing Boston University's VC subsidiary and ARCH initiative of the University of Chicago, Lerner (2009) concludes that this type of instrument runs the risk of generating a limited deal-flow or backing unsustainable ventures. For the United Kingdom, Nightingale et al. (2009) find that public schemes, including from universities, have a positive impact on firm performance but the size of their impact remains modest. In addition, they find that the recipients of university seed funding seem to be characterised by a higher likelihood to be acquired than other types of VC-backed new ventures. Exploratory results by Munari and Toschi (2013) indicate that a minimum efficient scale in terms of fund size and specialised competences from the management team are required to positively impact firm performance. In addition, publicly funded risk capital funds may encounter a recurring set of problems (Box 4.2).

Box 4.2. Publicly financed and managed risk funds – performance and stylised facts

- The managers of public funds are often civil servants. As such, they may lack the experience and skills required to successfully select and support investee firms.
- Incentive systems in publicly owned funds may fail to attract suitably skilled venture fund managers. They may also fail to encourage good performance in ways that private venture funds would, for instance through performance-linked bonuses.
- Public funds may displace private funds. This is especially likely if public schemes finance projects at below-market rates. Displacement is not only financial: public investment expertise will also displace private expertise, which is likely to be more skilled. There is evidence both for and against the proposition that public funds “crowd out” private funds.
- If public funds forego commercial objectives so as to meet other policy goals, the ability to attract private investments and professional fund managers might be limited. In such cases, the sustainability of the programme will be in jeopardy.

Source: OECD (2013), *OECD Reviews of Innovation Policy: Sweden 2012*, OECD Publishing, Paris, http://dx.doi.org/10.1787/9789264184893-en;
Leleux and Surlemont (2003), “Public versus private venture capital: Seeding or crowding out? A pan-European analysis”, *Journal of Business Venturing*, Vol. 18, pp. 81-104.

Spin-offs created on the basis of a patent usually enter a licensing agreement with the PRO, which is the owner of the patent. After a spin-off completes the license agreement, the PRO usually requires upfront licensing fees or a fee for patent-related expenses before it has had time to repay this through income streams. This may constitute a serious problem for undercapitalised spin-offs. While some PROs provide patent assistance programmes, some have begun to take equity shares or shares of future revenues instead. Case study evidence from Canadian and US universities shows that the financial reward of taking equity is more than ten times the average annual income from a traditional license, and is significantly higher than the amount usually received as a license issue fee (Bray and Lee, 2000). Survey results in Europe show that 48% of PROs take equity shares and 46% shares of future revenues (European Commission, 2012).

Closely tied to financing is the provision of facilities and equipment through bridging organisations such as technology/business incubators and science parks (Chapter 3.2 for overview). Created by PROs and in most cases assisted with government funding, business incubators and science parks attempt to create environments in which new ventures can flourish. The creation of science parks (and their synonyms such as technology and research parks) in the late 1970s and early1980s was followed in the 1990s by increasing efforts to establish business incubators. Clarysse et al. (2005)

analysed business incubation strategies at European PROs; they distinguish between three models: *i)* low selective (oriented towards maximising the number of spinoffs created); *ii)* supportive (oriented towards generating revenue from spin-offs); and *iii)* the incubator model (oriented towards a financial gain at the point of exit). However, whether science parks and business incubators prove to be effective in terms of incubating successful spin-offs remains unclear (Salvador, 2011).

Alternative and new sources of financing

Venture capital investors are generally willing to provide financing to spin-offs that have not yet reached positive cash flows. Not only do they play a crucial role by providing capital investments, but they also emerge as critical for establishing networks with suppliers and customers and increasing the managerial competencies of the spin-off team. Survey evidence from Ortin-Angel and Vendrell-Herrero (2010) indicates that public research spin-offs are more likely to obtain venture capital investments than other late-stage start-ups (see also Toole and Czarnitzki, 2007). The authors conclude that this may be due to the lack of managerial skills, which usually venture capital investors are able to provide. Providing platforms to connect spin-offs with venture capital firms or experienced entrepreneurs can be thus an effective mechanism to provide the necessary financial funds and management expertise. CoFoundersLab is such an example, where a large group of entrepreneurs is looking to join a start-up or be joined on their venture, allowing the entrepreneurs to access resources and network relationships.[1]

While venture capital tends to attract the bulk of the attention from policy makers, the primary source of external seed and early-stage equity financing in many countries is angel financing, not venture capital (OECD, 2011). Angel funding can be an alternative, in particular as the mobilisation of angel funding is becoming easier as structures form. However, while angel funding represents an alternative, angel investors appear to remedy the funding gap only marginally, as they usually raise smaller amounts of capital than other investors (Wright et al., 2007).

The Internet has also contributed to an alternative or new source of early-stage equity capital, such as crowdfunding –"democratised" or highly distributed capital raisings. Crowdfunding, in all its varieties, is a potential source of pre-seed and seed capital, loans, revenue and donations. According to Crowdsourcing.org, almost USD 1.5 billion was raised world-wide in 2011 by crowdfunding platforms, some of them operating to fund public research ventures. *#SciFund Challenge*, for example, brings researchers together to raise money directly from society at large; it aims to fund research activities in new ways and to connect the ordinary citizen to the excitement of doing science. At the institutional level, the University of Utah's TTO entered an exclusive agreement in 2013 with crowdfunding platform RocketHub. The aim is to streamline university crowdfunding under a new web portal and to showcase promising university spin-offs that would otherwise have had inadequate funding to demonstrate the viability of their technology.[2]

There is an active debate surrounding the potential of crowdfunding to alleviate the financing gap faced by research-based ventures. Currently, equity-based crowdfunding is not allowed in most OECD countries, largely due to the lack of institutionalisation. In the United States the JOBS Act, passed in 2012, allows businesses to raise equity capital from crowdfunding, thus providing an exemption from Securities and Exchange Commission (SEC) regulations for transactions. This may be a significant signal about the institutionalisation of crowdfunding.

Despite doubts on the sustainability of crowdfunding for research and commercialisation due to regulatory and legal impediments as well as practical challenges (e.g. lack of funding scale), there may be ancillary effects, signalling to larger investors that there is a potential market for public research-based technology. Another and perhaps more important effect of crowdfunding for research is that scientists are becoming more active in disclosing their ideas and promoting their research findings to potential investors and to society. At the same time, there may also be ethical concerns; researchers may be tempted to oversell their research outcomes in order to attract funding, for example.

External corporate venturing activities, such as joint venturing, acquisitions and corporate venture capital (CVC) also constitute a potential source of financial capital and managerial expertise for public research spin-offs. For example, Qualcomm, a major semiconductor company, funds the research of public research spin-offs and start-ups against a target for generating a number of patents. They can exercise the right to acquire up to half of these patents for a price agreed in advance.

While many corporate venturing programmes came to an end after the bursting of the Internet bubble and the economic and financial crisis in 2008, recent years have seen an increase in corporate venturing activities. In order to encourage and strengthen these activities, a report by the UK Royal Society of Arts (RSA) (2012) recommends a number of policy measures, such as venture connectivity forums, co-investment funds/schemes and fiscal incentives.

The market for IP rights for financing purposes

Spin-offs seeking debt financing may find that their most valuable property for use as collateral is their trademarks, copyrights, patents or prototypes (e.g. Harhoff, 2011; Audretsch, Bönte and Mahagaonkar, 2012). Rights to intellectual assets can be used, at least in principle, to secure funding for business activities of public research spin-offs. This could provide in some cases a much-needed source of collateral, particularly for firms with a limited track record such as public research spin-offs. Established companies are increasingly implementing strategies and business models to use knowledge-based capital assets as a mechanism for raising finance in multiple forms.[3] For example, a EUR 1.6 billion loan financing deal was recently secured by Alcatel-Lucent using its extensive patent portfolio as collateral.[4]

IP equity funds, for example, invest money raised from the capital market in promising inventions; especially in inventions related to future-oriented technologies (see also Chapter 3 for government-backed IP funds). These entities acquire rights to a number of invention sources, such as universities, PRIs, individual inventors and spin-offs. Large investment banks and boutique private equity (PE) firms alike have been involved in these activities targeted at IP and other intangible assets. Investors in the fund themselves may not have specific interests with regards to the use of the IPRs, but it is in their interest that the IPRs are fully utilised to maximise revenues for the fund (OECD, 2013a).

Notes

1. www.cofounderslab.com (accessed 16 February 2013).
2. www.techventures.utah.edu/news/2012/12/university-of-utah-embraces-crowdfunding-to-develop-technologies/ (accessed 16 February 2013).
3. Yanagisawa and Guellec (2009) discuss different types of companies that provide IP-based financial instruments. These have also been examined by Ellis (2009) and Nikolic (2009).
4. www.ft.com/intl/cms/s/0/0e2b714e-45dd-11e2-b780-00144feabdc0.html (accessed 13 May 2013).

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Chapter 5

Looking ahead: National policy implications

Government policies and institutional practices have an important impact on the commercialisation of public research. This concluding chapter on policy implications finds that there is a strong policy bias in favour of codified flows in the form of patents and licenses. Drawing on new survey findings, case studies, statistical analysis and an inventory of cutting-edge initiatives pursued by governments and public research organisations, it makes the case for a more holistic approach to policy making that recognises the importance of people-based channels such as student entrepreneurship and the mobility of staff for the transfer, exploitation and commercialisation of public research results. It also calls for policies to support two-way flows of knowledge between industry and academia.

This report on new strategies and polices for the transfer, exploitation and commercialisation of public research results gathered a wealth of material and showed that this area has undergone much change and experimentation in recent years. The evidence presented shows a levelling off in academic patenting and licensing activity as new channels, notably student-led entrepreneurial ventures and the commercialisation of public research outputs via open science and data initiatives, gain in importance. At the same time, commercialisation activities have become more sophisticated and complex in response to technological complexity and convergence, but also in response to the integration of public research organisations (PROs) in both regional clusters and global innovation networks. Governments and respective ministries and agencies are developing policy strategies and instruments that can boost these institutes' effectiveness in providing better services to fulfil their missions, one of which is engagement in commercial activities.

The institutions and infrastructures that support the networks and markets for transferring and commercialising public research results are being reviewed across many OECD countries, as traditional approaches and models are facing considerable limitations and may be restraining further scientific advance and broader innovation. For example, the narrow focus on faculty inventors, natural/physical sciences and patenting/licensing; the apparent mismatch between the supply and demand of public sector knowledge; less easy financing for new ventures; limited evidence and metrics for assessing changes, benchmarking institutions, or making international comparisons all inhibit a good interplay among relevant actors and initiatives at different levels. Given these barriers and ongoing changes in organisational structures, orientations, linkages and more, it is important to regularly take stock of these and to understand them in depth.

Tailoring national policies or strategies for the transfer and commercialisation of public research is inherently complex, a fact highlighted by previous OECD work. A 2002 report, *Benchmarking Industry-Science Relationships,* generally regarded governments' role as setting the basic rules and institutional frameworks that reflect the public interest and providing the right incentives to firms, public researchers and PROs (OECD, 2002). Policy goals will differ according to countries' public research environments, as these vary greatly in their ability to turn funding into commercial outcomes. Studies show that academic excellence and commercial success are not incompatible but in fact can be mutually reinforcing. In this respect, countries on the research frontier may be most interested to increase firms' absorptive capacity, while those further behind the research frontier may seek to reduce undesirable duplication of investment and improve the responsiveness of public research to industry needs.

In addition to providing sound framework conditions, policy makers will need to further differentiate the types of commercialisation paths used by various types of PROs. This will require taking into account evidence on the extent to which different activities and channels complement each other.

Management at universities, professional organisations, governments and the private sector should co-ordinate efforts to develop a more balanced set of policies to improve understanding of the process and its performance, as multiple national policy strategies and instruments can result in conflicting goals and incentives. Government initiatives, including the funding of networks and forums or supporting programmes to increase awareness, could help improve the implementation of national and institutional policies.

To be effective, awareness strategies must go beyond addressing information asymmetries; they should help promote the active engagement of PROs and encourage institutional experimentation, in particular in ways PROs organise their relationships with industry. For example, few universities give a clear policy mandate to innovation and commercialisation strategies that recognise different pathways to commercialisation, although university policies and rules have pronounced effects on how TTOs, researchers and students engage in these practices.

However, governments and institutions should design and implement support systems that meet their own needs, resources, and objectives in a realistic manner. Considering the heterogeneity of PRIs and universities and the different local and regional contexts, there is a need to ensure that national and institutional policies are consistent with the local and global research environment. To start, the differences between (and within) countries, national innovation systems (NIS) and PROs mean that successful policy and institutional approaches from one environment may not work in another. History, social and political factors do matter. The system in the United States, for example, would be difficult to duplicate elsewhere as it has a long history of informal interactions (especially consulting and contract research) and of universities serving local needs and orienting towards industry (Gray, 2011). These issues stem from the general complexity of national innovation systems and their linkages. This can lead to national policies having unexpected effects – Howells and Edler (2011), for instance, suggested that policies to introduce "structural innovations" (such as new governance models) can go wrong if the interactions of actors in the system are not well understood. Therefore, governmental and institutional support to new models of commercialisation will have to demonstrate – possibly through pilot experiences – their ability to ensure quality, participation and adequate rewards to those who contribute to the research, peer review and dissemination effort.

Incentive mechanisms play a fundamental role in the effectiveness of knowledge transfer and commercialisation strategies. The overall challenge for policy makers in this respect is to allow for the potential of commercialisation while retaining the fundamental integrity of research institutions, in particular for universities, and to find useful arrangements to link teaching, research and commercialisation. Top-performing institutions are already learning how to operate broad commercial activities without undermining the integrity of core commitments such as research and education. Research funding agencies and respective ministries do have a major role to play in defining key policies concerning access to research results, data and instruments, as well as policies regarding awareness raising, training and creating links between PROs and firms. It is of particular importance to ensure that those who generate ideas and inventions, from professors to students, have relevant incentives and assistance to share and disclose their findings, so that a relevant validation, development and exploitation strategy can be identified and implemented. Clear assignments of government oversight of academic incentives could help here to remedy imbalances and conflicts.

A relatively unexplored domain of analysis is the role of current and former students as key actors in the exploitation and possible commercialisation of knowledge generated, in universities in particular. Acknowledging this role and understanding what drives it and what the main barriers are could prove a particularly fruitful area of future analysis, comparing the level of support and training that PROs provide to promote research-based entrepreneurship among students. In the same vein, evidence of the effectiveness and impact of financial instruments dedicated to the support of academic entrepreneurs, such as university seed funds, could help improve the identification of solutions and approaches for addressing the funding gap.

The question of how researchers are influenced to participate in knowledge transfer and commercialisation by their institutional environment, as suggested by Ponomariov and Boardman (2012), could be another interesting avenue for future work. The authors suggested it would be instructive to further analyse informal contacts, consulting and collaborative research, as these channels are important to industry. Understanding researchers' involvement in these activities requires knowing more about their mindset/ motivations and competences, and the institutional culture and leadership in their workplace. Some evidence on these factors is available, but future research at the individual and institutional level could improve policy making.

Given the growing interest from policy makers in the impact of commercialisation activities, there are greater efforts to evaluate polices at a variety of levels (e.g. individual/firm/institutional/system level). There is no standard approach or solution. Indicators of impact at the level of individuals and institutions are likely to grow in importance. This will create a significant challenge for policy makers, as the impacts of policies can take a long time to materialise and the mechanisms can be several and diverse, and not necessarily captured by available metrics and data infrastructures.

Our current understanding of the pattern of scientific knowledge flows and their impact relies rather heavily on traditional bibliometric sources. Future developments in indicators are bound to draw attention to economically and socially important uses of research outputs, recognising that the information and knowledge they produce can be used by actors beyond the traditional research community. Users include business large and small, entrepreneurs, and the general public. Beyond traditional qualitative and quantitative evaluation methods, emerging Internet-based indicators of use and reuse of publications and data may provide additional insight into the scope and intensity of the impact and effects of scientific knowledge on innovation and the broader economy.

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Annex A

National periodic surveys and institutional data on patent applications and industry-university co-publications

Table A.1. Periodic or occasional surveys of knowledge transfer activities in universities, public research institutions (PRIs) and hospitals – selected OECD and non-OECD countries

Country	Most recent survey title	Survey organisation	Publication year	Reference year	First year data available	Responses	Universities	PRIs	Hospitals
Australia	National Survey of Research Commercialisation (NSRC) 2008-09	DIISR	2012	2010-11	2003-04	72	✓	✓	✓
Canada[1]	Survey of Intellectual Property Commercialization in the Higher Education Sector	Statistics Canada	2010	2008	2005-08	101	✓		✓
Canada	AUTM Canadian licensing activity survey: FY2010	Canadian AUTM	2012	2011	2000	39	✓	✓	✓
Denmark	Public Research Commercialisation Survey – Denmark 2010	DASTI	2011	2010	2000	14	✓	✓	✓
Europe	The ProTon Europe Seventh Annual Survey Report	ProTon Europe	2012	2010	1991	320	✓	✓	✓
Europe	Summary Respondent Report ASTP Survey for Fiscal Year 2008	UNU-MERIT for ASTP	2010	2008	2003	99	✓	✓	✓
Norway	Indicators of the commercialisation of research: The case of Norway	NIFU	2008	1998-2004	1998	16	✓	✓	
Switzerland	swiTTreport 2011	swiTT	2011	2010	2005	21	✓	✓	✓
United Kingdom	Higher education-business and community interaction survey 2011-2012	HEFCE	2013	2011-12	1999-2000	161	✓		
United Kingdom	Sixth Annual Survey of Knowledge Transfer Activities in Public Sector Research Establishments (PSREs)	Technopolis for BIS	2011	2008-09	2003-04	132		✓	✓
United States	AUTM US licensing Activity Survey: FY2010	US AUTM	2012	2011	1991	186	✓	✓	✓
Europe	Interim Findings 2011 of the Knowledge Transfer Study 2010-2012	Empirica, UNU-MERIT and FHNW for EC	2012	2010	2010	430	✓	✓	✓
Italy	*Potenziamo la cantena del valore*	NetVal	2011	2009	2009	57	✓	✓	✓
Spain	*Informe de la encuesta RedOTRI 2009*	RedOTRI	2012	2011	2003	65	✓	✓	✓

Table A.1. Periodic or occasional surveys of knowledge transfer activities in universities, public research institutions (PRIs) and hospitals: Selected OECD and non-OECD countries *(continued)*

Country	Most recent survey title	Survey organisation	Publication year	Reference year	First year data available	Responses	Universities	PRIs	Hospitals
Ireland	2009 Irish Commercialisation Survey	Enterprise Ireland	2010	2009	2009	26	n/a	n/a	n/a
France	*Les activités de recherche contractuelle et de transfert de technologie dans les établissements français d'enseignement supérieur*	BETA for MESR	2010	2007	2003	111	✓	✓	✓
Europe	The CEMI Survey of University Technology Transfer Offices in Europe	CEMI	2008	2007	2007	211	✓		
China	Intellectual Property Report of Chinese Universities	MOE	2010	2009	2006	783	✓		
Japan	State of University Technology Transfer in Japan	MEXT	2010	2009	2002	141	✓		
Japan	Basic Survey Report on University Ventures	METI	2009	2008	2001	525	✓	✓	
Korea	Survey on University-Industry Cooperative Activities in 2010	NRF	2011	2010	2006	153	✓		
Korea	Survey on the Technology Transfer of Public Research Institutes	MOTIE	2012	2011	N/A	275	✓	✓	✓

Notes:

1. The Statistics Canada survey was terminated in 2012.

2. Survey Organisations: *Australia* – Department of Innovation, Industry, Science and Research (DIISR); *Canada* – Canadian Association of University Technology Managers (AUTM); *Denmark* – Danish Agency for Science, Technology and Innovation (DASTI); *Europe* – ProTon Europe; United Nations University - Maastricht Economic and Social Research Institute on Innovation and Technology (UNU-MERIT) for the Association of European & Technology Transfer Professional (ASTP); Chair of Economics and Management of Innovation (CEMI); Empirica, UNU-MERIT and University of Applied Sciences and Arts Northwestern Switzerland (FHNW) for European Comission (EC); *Norway* – Nordic Institute for Studies in Innovation, Research and Education (NIFU); *Switzerland* – Swiss Technology Transfer Association (swiTT); *United Kingdom* – Higher Education Funding Council for England (HEFCE); Technopolis for the UK Department for Business, Innovation & Skills (BIS); *United States* – US Association of University Technology Managers (AUTM); *Italy* – Italian Network for the Valorisation of University Research (NetVal); *Spain* – Spanish Network of University Knowledge Transfer Offices (RedOTRI); *France – Bureau d'Economie Théorique et Appliquée, Université Louis Pasteur de Strasbourg (BETA)* for the Ministry of Higher Education and Research (MESR); *People's Republic of China* – Ministry of Education (MOE); *Japan* – Ministry of Education, Culture, Sports, Science and Technology (MEXT); Ministry of Economy, Trade and Industry (METI); Korea – National Research Foundation of Korea (NRF); Ministry of Trade, Industry and Energy (MOTIE).

Source: Updated and expanded from Finne et al. (2009), "Metrics for knowledge transfer from public research organisations in Europe: Report from the European Commission's expert group on knowledge transfer metrics"; Piccaluga et al. (2011), "ProTon Europe, The ProTon Europe Seventh Annual Survey Report (fiscal year 2009)".

Table A.2. Patent Co-operation Treaty (PCT) applications by top national universities

Rank	Applicant name	Country of origin	2009	2010	2011
1	University of California	United States	321	304	277
5	Korea Advanced Institute of Science and Technology	Korea	43	51	103
7	University of Tokyo	Japan	94	105	98
16	ISIS Innovation Limited (University of Oxford)	United Kingdom	45	46	62
22	Hebrew University of Jerusalem	Israel	33	43	51
25	National University of Singapore	Singapore	32	24	50
44	Technical University of Denmark	Denmark	38	24	36
44	Tsinghua University	China	27	24	36
48	University of Sydney	Australia	26	24	35

Note: Only one top university per country listed. For complete top 50 list, see source.

Source: WIPO (World Intellectual Property Organization) (2012), "PCT yearly review – The international patent system", *WIPO Economics & Statistics Series.*

Table A.3. Patent Co-operation Treaty (PCT) applicants by top national public research institutions (PRIs)

Rank	Applicant name	Country of origin	2009	2010	2011
1	Atomic Energy and Alternative Energies Commission (CEA)	France	238	308	371
2	Fraunhofer Society for the Advancement of Applied Research	Germany	265	297	294
3	French National Centre for Scientific Research (CNRS)	France	149	207	196
4	Agency of Science, Technology and Research	Singapore	148	154	180
5	Spanish National Research Council (CSIC)	Spain	86	126	120
6	China Academy of Telecommunications Technology	China	N/A	N/A	119
7	MIMOS BERHAD (MIMOS)	Malaysia	90	67	108
8	Electronics and Telecommunications Research Institute of Korea	Korea	452	174	104
9	National Institute of Advanced Industrial Science and Technology (AIST)	Japan	109	91	100
10	United States Department of Health and Human Services (HHS)	United States	107	113	98
12	Dutch Organization for Applied Scientific Research (TNO)	Netherlands	134	116	82
15	Council of Scientific and Industrial Research (CSIR)	India	63	56	53
18	Commonwealth Scientific and Industrial Research Organisation (CSIRO)	Australia	56	61	48
22	National Research Council Canada (NRC)	Canada	21	45	35
27	Technical Research Centre of Finland (VTT)	Finland	34	48	31

Note: Only one top institution per country listed. For complete top 30 list, see source.

Source: WIPO (World Intellectual Property Organization) (2012), "PCT yearly review – The international patent system", *WIPO Economics & Statistics Series.*

Table A.4. Industry-university co-publications (IUCs) by individual universities, publication years 2007-11

% of industry-university co-publications in total research publication output

University	Country of origin	% of IUCs	% domestic IUCs
Eindhoven University of Technology	Netherlands	15.6%	53%
Chalmers University of Technology	Sweden	14.0%	49%
Tokyo Institute of Technology	Japan	12.9%	77%
Technical University of Denmark	Denmark	12.8%	45%
Norwegian University of Science and Technology	Norway	11.4%	55%
Aalto University	Finland	11.4%	45%
George Mason University	United States	10.9%	54%
Pohang University of Science and Technology	South Korea	10.8%	69%
Paul Sabatier University	France	10.1%	43%
Medical University of Vienna	Austria	9.9%	16%
Politecnico di Milano	Italy	9.2%	51%
Dresden University of Technology	Germany	9.1%	47%
University of Basel	Switzerland	8.8%	23%
Imperial College London	United Kingdom	8.8%	25%
University of Leuven	Belgium	7.5%	16%

Notes:

1. The Leiden Ranking is based on data from the Web of Science database of Thomson Reuters. For methodology and computations: www.cwts.nl/pdf/UIRC_Technical_Notes_20130416.pdf.
2. Only one top university per country listed. For complete list, see source.

Source: Centre for Science and Technology Studies (CWTS), Leiden University, May 2013.

Annex B

Selected national programmes to support knowledge transfer and commercialisation of public research

Table B.1. National programmes to support knowledge transfer and commercialisation of public research

Country programme/initiative *(ordered after 1st priority)*	Stated policy priorities			Funding mechanism		Target groups								
	1st priority	2nd priority	3nd priority	Direct support to entities	Indirect support to entities	Industry in general	SMEs	Start-ups	University spin-offs	Public research institutions	Higher education institutions	Hospitals	Scientists (as individuals	Others (e.g. NGOs, colleges)
Canada – NSERC Intellectual Property Policy	Consultancy/ Regulatory tools and/or financial incentives for the use of IP	Open science/ knowledge dissemination			•	•				•	•			
Finland – Tuli Programme	Consultancy/ Regulatory tools and/or financial incentives for the use of IP	Support to innovation management and advisory services		•	•								•	
Germany – SIGNO Programme	Consultancy/ Regulatory tools and/or financial incentives for the use of IP	Support to innovation management and advisory services	Raise awareness and/or provide general information and best practice		•		•				•		•	
Netherlands – The Collective Labour Agreement (CAO)	Consultancy/ Regulatory tools and/or financial incentives for the use of IP	Strategy policy documents			•						•			
Sweden - Key Actors Programme	Consultancy/ Regulatory tools and/or financial incentives for the use of IP	Support to innovation management and advisory services			•						•			
South Africa – National Intellectual Property Management Office (NIPMO)	Consultancy/ Regulatory tools and/or financial incentives for the use of IP	Support to innovation management and advisory services			•	•				•	•	•		
United Kingdom – Intellectual Asset Management Guide for Universities (IAMGU) and Lambert toolkit (LT)	Consultancy and/or financial incentives to the use of IP	Support to innovation management and advisory services				•						•		
United Kingdom – Fast Forward Competition	Consultancy/ Regulatory tools and/or financial incentives for the use of IP	Industry-science R&D co-operation												
United States – NIH Start-Up Exclusive License Agreements	Consultancy/ Regulatory tools and/or financial incentives for the use of IP	Support to sectoral innovation			•			•						

Table B.1. National programmes to support knowledge transfer and commercialisation of public research *(continued)*

Country programme/initiative *(ordered after 1st priority)*	Stated policy priorities			Funding mechanism		Target groups								
	1st priority	2nd priority	3nd priority	Direct support to entities	Indirect support to entities	Industry in general	SMEs	Start-ups	University spin-offs	Public research institutions	Higher education institutions	Hospitals	Scientists (as individuals)	Others (e.g. NGOs, colleges)
United States – DOE's Next Top Energy Innovator	Consultancy/ Regulatory tools and/or financial incentives for the use of IP	Support to sectoral innovation			•			•						
Australia – Linkage Scheme (ARC)	Industry-science R&D co-operation	Industry-science mobility		•		•				•	•			
Canada – Applied Research and Commercialization Initiative	Industry-science R&D co-operation			•			•				•			
Canada - Partnership Workshops Programme	Industry-science R&D co-operation			•		•					•			
Canada – Engage (EG)/Interaction (IG) Grants	Industry-science R&D co-operation			•		•				•	•			
Germany – Research Bonus Programme	Industry-science R&D co-operation			•		•	•			•	•			
Israel – Magnet Consortium	Industry-science R&D co-operation	Cluster and/or regional development		•		•				•	•			
Netherlands – Regional Attention and Action for Knowledge Circulation (RAAK)	Industry-science R&D co-operation	Cluster and/or regional development	Raise awareness and/or provide general information and best practice	•			•				•			
United Kingdom – Collaborative Research and Development	Industry-science R&D co-operation			•		•				•	•			
United States – Small Business Technology Transfer (STTR) Programme	Industry-science R&D co-operation			•			•			•	•		•	•

Table B.1. National programmes to support knowledge transfer and commercialisation of public research *(continued)*

Country programme/initiative *(ordered after 1st priority)*	Stated policy priorities			Funding mechanism		Target groups									
	1st priority	2nd priority	3nd priority	Direct support to entities	Indirect support to entities	Industry in general	SMEs	Start-ups	University spin-offs	Public research institutions	Higher education institutions	Hospitals	Scientists (as individuals)	Others (e.g. NGOs, colleges)
Australia – Pre-Seed Fund	Pre-seed capital/proof-of-concept support for start-ups/university spin-offs	Support to innovation management and advisory services		•	•								•	
Canada – NSERC Idea to Innovation (I2I) Programme	Pre-seed/proof-of-concept support for start-ups/university spin-offs	Support to innovation management and advisory services		•	•								•	
Germany – EXIST	Pre-seed/proof-of-concept support for start-ups/university spin-offs			•				•	•					
Israel – Tnufa	Pre-seed/proof-of-concept support for start-ups/university spin-offs			•	•			•					•	
Netherlands – TechnoPartner Seed Facility	Pre-seed/proof-of-concept support for start-ups/university spin-offs	Risk capital		•										•

Table B.2. Consultancy/regulatory tools and/or financial incentives for the use of intellectual property (IP): Selected country examples

	Canada – NSERC Intellectual Property Policy	Finland – Tuli Programme	Germany – SIGNO Programme	Netherlands – The Collective Labour Agreement (CAO)
Year	2009-	2008-2013	2008-	Current CAO to December 2012
Oversight	Natural Science and Engineering Research Council (NSERC)	TEKES (Finish Innovation agency)	Federal Ministry of Economics and Technology – (BMWi), Projektträger Jülich (PtJ)	Universities remain fully autonomous in implementing the process of appropriation of any intellectual right developed inside
Stated goals/ objectives	"Encourage the utilization of research results and support the publication of research results in the open literature. Ensure that a student's graduation is not impeded by IP issues and support a researcher's right to use his/her research results for non-commercial purposes in future research and in teaching"	"Help scientists and the public research system to evaluate the commercial potential of their research results, and then support the process of its commercialisation through license agreements, know-how transfers (between research institutions and between research institutions and companies), and business establishment"	"Overcoming information and financial barriers to use IPRs by SMEs and individual inventors and to raise awareness about the relevance of IPRs for commercialising innovations"	"Any employee of a Dutch university is obliged to comply with provisions reasonably laid down by the university with regard to patent right and copyright"
Target groups	Industry Higher education institutions Public research institutions	Scientists (as individuals)	SMEs Higher education institutions Scientists (as individuals)	Higher education institutions
Funding modes	-	Total budget for 2008-13: EUR 50 million Researchers, students and research groups are able to receive funding and versatile expert services in all fields of commercialisation.	2008: EUR 16 million; no direct funding. Subsidised loans (including interest allowances), guarantees, tax incentives	-
Operation	IP agreements, arising from and related to an NSERC award, contain clauses that address five elements: 1) Timeliness of exploitation 2) Confidential Information 3) Research results cannot be secret 4) Academic progression 5) Rights for future research and teaching.	The programme was developed in co-operation with the R&D and innovation services of universities and research institutes that have the mission of finding and developing research-based inventions and business ideas.	The programme consists of 3 sub-programmes: Signo Universities, Signo Enterprises and Signo Inventors.	According to the Collective Labour Agreement (CAO), a Dutch university employee who creates a possibly patentable invention is obliged to report this and to transfer these rights to the university if so requested. When the university makes use of these rights, the employee is entitled to reimbursement (e.g. 25% of revenues).
Evaluation	Revised in 2009 based on the results of a survey of stakeholders (university and industry representatives) and the recommendations of an Expert Panel	N/A	An evaluation of SIGNO in 2010 concluded that, overall, the funding system differentiated by the target group has been proved successful.	N/A
More information	www.nserc-crsng.gc.ca	www.tekes.fi/programmes/Tuli	www.ptj.de/signo-en	

Table B.2. Consultancy/regulatory tools and/or financial incentives for the use of intellectual property (IP): Selected country examples *(continued)*

	Sweden – Key Actors Programme	South Africa – National Intellectual Property Management Office (NIPMO)	United Kingdom – Intellectual Asset Management Guide for Universities (IAMGU) and Lambert toolkit (LT)
Year	2006-15	2010-	IAMGU: 2011 (latest version) LT: 1994
Oversight	Swedish Governmental Agency for Innovation Systems (VINNOVA)	NIPMO has not only a regulatory (compliance monitoring, review and enforcement) function, but also an administrative and supporting function on behalf of government.	UK Intellectual Property Office
Stated goals/ objectives	"Contribute to the development of skills, methods and structures to make universities in Sweden more professional, with regards to cooperation with enterprises and other actors in the surrounding society, as well as in valorisation of knowledge and commercialisation of research outcome"	"Providing for more effective utilisation of intellectual property emanating from publicly financed research and development; to establish the National Intellectual Property Management Office and the Intellectual Property Fund; to provide for the establishment of offices of technology transfer at institutions"	IAMGU: "Help university managers set strategies to optimise the benefits from the intellectual assets created by their staff and students" LT: "Encourage university and industry collaboration and the sharing of knowledge"
Target groups	Higher education institutions	Spin-off Higher education institutions Public research institutions	Industry Higher education institutions
Funding modes	2006: EUR 22.6 million		
Operation	Individual universities/university colleges, selected according to four criteria: relevance, quality, implementation and commercialisation potential, using a peer-review process.	Provide guidance on ownership of IPR, IP protection and maintenance, conflict of interest, IP asset management, commercialisation of research results, revenues or benefit sharing, government IPR, privately funded research and IP Rights as well as dealing with spin-off companies and licensing. An additional IP fund was established to provide financial support to institutions for the statutory protection and maintenance of IPR.	IAMGU: The Guide does not provide an IP strategy that can be applied across all institutions. Instead, it assists in the generation of a strategic blend of approaches to IP specific to each individual institution's strengths and missions. LT: The toolkit consists of a set of five Model Research Collaboration (one to one) Agreements. Their use is optional.
Evaluation	The programme started with an invitation from VINNOVA to the universities to perform a self-assessment and a peer review of each university's knowledge transfer and commercialisation activities, according to guidelines provided by VINNOVA.	N/A	LT: Survey results indicated that there has been widespread use of the suite of resources by public sector knowledge transfer professionals, with the majority reporting that the model agreements have produced savings in money and time.
More information	www .vinnova.se	www.nipmo.org.za	www.ipo.gov.uk

Table B.2. Consultancy/regulatory tools and/or financial incentives for the use of intellectual property (IP): Selected country examples *(continued)*

	United Kingdom – Fast Forward Competition	United States – NIH Start-Up Exclusive License Agreements	United States – DOE's Next Top Energy Innovator
Year	2012 (latest version)	October 2011 - September 2012	2012-
Oversight	UK Intellectual Property Office	The National Institutes of Health (NIH) through the Office of Technology Transfer	US Department of Energy
Stated goals/ objectives	"Encourage university and industry collaboration and the sharing of knowledge"	"Facilitate licensing of intramural NIH and Food and Drug Administrative (FDA) inventions"	"Ease access for start-ups to use inventions and technology developed at the U.S. Department of Energy's 17 National Laboratories and the Y-12 National Security Complex"
Target groups	Higher education institutions Public research institutions	Start-ups	Start-ups
Funding modes	The 2012 competition has a prize fund of up to GBP 760 000, which makes individual awards of between GBP 10 000 and GBP 100 000. This is not funding for research or commercialisation of individual products, but awards for projects that improve management of IP and knowledge exchange.	-	Start-up companies can submit a business plan and use this template agreement to obtain up to three patents from a single lab for USD 1 000.
Operation	A total of 53 entries were received for the 2012 Fast Forward competition, of which 13 were funded.	Two agreements: exclusive Start-Up Evaluation License Agreement (Start-up EELA) and a Start-up Exclusive Commercial License Agreement (Start-up ECLA). These NIH Start-up Licenses are offered to assist start-up companies less than 5 years old, with less than USD 5 million in capital raised, and with fewer than 50 employees to obtain an exclusive license from the NIH for early stage biomedical inventions. The certainty and structure provided by these financial terms are intended to facilitate and ease the burdens of start-up companies when they commit to develop NIH and FDA early-stage technologies into commercial products. Additionally, these NIH Start-up Licenses are intended to reduce the negotiation time leading to an earlier executed license agreement.	Start-up companies can apply for one of the Energy Department's thousands of unlicensed patents at reduced cost and with less red tape. The Energy Department's 17 national laboratories currently hold more than 15 000 patents, and applying for them usually costs between USD 10 000 and USD 50 000. Selection has been made in February 2012 by the public through using Facebook's "like" function. In addition to the number of "likes" cast for each company, an expert panel from the Energy Department Experts conducted a separate review of the companies and scored them based on their potential economic and societal contributions.
Evaluation	N/A	N/A	N/A
More information	www.ipo.gov.uk/fastforward.htm	www.ott.nih.gov/startup/	www.energy.gov/science-innovation/innovation/americas-next-top-energy-innovator

Table B.3. Industry-science R&D co-operation: Selected country examples

	Australia – Linkage scheme (ARC)	Canada – Applied Research and Commercialization Initiative	Canada – Partnership Workshops Programme
Year	2011-12 (ongoing scheme)	2010-12 (pilot scheme)	N/A
Oversight	Research Council	Federal Economic Development Agency for Southern Ontario	Natural Sciences and Engineering Research Council (NSERC)
Stated goals/ objectives	"Enable public and private sector organisations to develop and undertake research projects jointly with university-based researchers"	"Addressing the gap between research and commercialization in southern Ontario by encouraging collaboration between SMEs and post-secondary institutions"	"Bring together academic researchers with non-academic end users and create new partnerships through workshops that develop collaborations addressing research and technology needs identified by the user community"
Target groups	Industry Higher education institutions Public research institutions	SMEs Higher education institutions	Industry Higher education institutions
Funding modes	2011-12: AUD 157.7 million. Partner organisations are required to support the research financially, in cash and/or in kind.	CAD 15 million	Grants are valued at USD 25 000 and are valid for one year. Contributions from the non-academic partners are strongly encouraged.
Operation	Partner organisations are required to enter into arrangements with the university regarding intellectual property, and may use the research findings and share in any intellectual property created, consistent with those arrangements. Australian Postdoctoral Fellowships (Industry) and Linkage Industry Fellowships are available under the ARC's Linkage Projects scheme to encourage the mobility of human resources between universities and industry.	The initiative has brought 24 colleges, universities and polytechnics across southern Ontario together with more than 300 businesses.	The NSERC-funded Workshops are intended for small, highly focused groups, with attendance expected to range from 20 to 40 participants from multiple Canadian universities and non-academic organisations. The workshops must be organised and championed by at least one university and one non-academic leader. The university leader may hold an academic appointment or an administrative position at the university. Workshop participation is normally by invitation only and must include academic researchers and members of non-academic end user organisations. Workshop discussions are intended to find common grounds among the participants, with topics that include: - research priorities and knowledge gaps from the perspectives of industry, government and the university; - current research capacity and future needs; - HQP training and skills needs; - knowledge/technology transfer potential; - funding challenges and opportunities; - existing and potential new collaborations; - next steps for proceeding toward collaborative activities.
Evaluation	N/A	N/A	N/A
More information	www .arc.gov.au	www.feddevontario.gc.ca	www.nserc-crsng.gc.ca

Table B.3. Industry-science R&D co-operation: Selected country examples *(continued)*

	Canada – Engage (EG)/Interaction (IG) Grants	Germany – Research Bonus programme	Israel – Magnet Consortium
Year	EG: N/A IG: 2009-	2007-09 (pilot scheme)	1994-
Oversight	The Natural Sciences and Engineering Research Council (NSERC) is responsible for both grants.	Federal Ministry of Education and Research	Ministry of Industry, Trade and Labour
Stated goals/ objectives	EG: "Foster the development of new research partnerships between academic researchers and companies that have never collaborated together before" IG: "Opportunity to meet and identify a company-specific problem they could solve by collaborating in a subsequent research partnership"	"Mobilise additional scientific potential for broad cooperation with industry, particularly small and medium-sized enterprises (SMEs)"	"Encourage university and industry collaboration and the sharing of knowledge; lay the ground for technological cluster development"
Target groups	Industry Higher education institutions	Industry SMEs Higher education institutions Public research institutions	Industry Higher education institutions Public research institutions
Funding modes	EG: A maximum grant of CAD 25 000, over a period not exceeding six months, will be awarded to the academic researcher to cover the direct project costs associated with the research activities needed to address the identified problem. IG: up to CAD 5 000 over three months to support expenses associated with travel and meetings in order to allow academic researchers to establish contact with one or several companies.	EUR 24 million	2011: Total budget USD 53 million. Grants are up to 66% of the approved budget for industry and up to 80% for the academic institution. No royalty payments are required. The programme was originally open only to Israeli institutions, but since 2000 it is open (without financial support) to foreign organisations.
Operation	EG: Engage projects must be focused with specific short-term objectives. They must be aimed at solving the company-specific problem through the generation of new knowledge, or the application of existing knowledge in an innovative manner. IG: Applicants must clearly spell out the objectives of the intended meeting(s) and explain how the targeted partners are relevant to the applicant's expertise, as well as the likeliness and the potential nature of the envisioned future research collaboration. A detailed expense budget is requested.	The scheme was paid to universities and research institutions carrying out research and development (R&D) for SMEs. The programme offered a 25% bonus to the total sum of R&D contracts received by a public research organisation from firms with less than 1 000 employees. In total, 920 projects were funded.	The programme operates in both a top-down and bottom-up manner. Some of the consortia are based on ideas from academia or industry, while others are suggested by Magnet personnel. Once Magnet personnel are convinced there is enough interest in a new direction, they issue calls to industry and universities to join the consortium. After members of the consortium sign an agreement, part of which promises all parties the rights to the intellectual property created by the consortium, the project goes to the Magnet Committee, which decides whether to approve funding. Most consortia are limited to a three-year programme, but this can be extended for another three years.
Evaluation	N/A	Available on request	N/A
More information	www.nserc-crsng.gc.ca	www.bmbf.de	www.moit.gov.il

Table B.3. Industry-science R&D co-operation: Selected country examples *(continued)*

	Netherlands – Regional Attention and Action for Knowledge Circulation (RAAK)	**United Kingdom – Collaborative Research and Development**	**United States – Small Business Technology Transfer (STTR) Programme**
Year	2004-	2004-	1992-2011
Oversight	Foundation Innovation Alliance (SIA - *Stichting Innovatie Alliantie*) with funding from the Ministry of Education, Culture and Science (OCW).	Technology Strategy Board (TSB)	Small Business Administration (SBA)
Stated goals/ objectives	"Encourage university and SME collaboration and the sharing of knowledge; generate and distribute policy relevant information and best practices regarding new and existing forms of collaboration"	"Assist the industrial and research communities to work together on R&D projects in strategically important areas of science, engineering and technology"	"Expansion of the public/private sector partnership to include the joint venture opportunities for small business and the premier non-profit research institutions"
Target groups	SMEs Higher education institutions	Industry Higher education institutions Public research institutions	SMEs Higher education institutions Public research institutions Scientists (as individuals)
Funding modes	To be eligible for funding, the RAAK requires involvement of at least 5 SMEs and/or at least 2 public institutions (or one overarching organisation). The duration of a subsidised project is max. 2 years, which can be funded up to EUR 300 000.	Projects range in value from GBP 10 000 to over GBP 100 million. Over 900 projects are currently being supported with a combined business and government investment of over GBP 1 billion (with just over half the funds committed by business). Over GBP 150 million will be invested by TSB in 2011-12.	Following submission of proposals, agencies make STTR awards based on small business/nonprofit research institution qualification, degree of innovation, and future market potential. Small businesses that receive awards then begin a three-phase program. Phase I: Max. USD 100 000 (6 months) to evaluate concept Phase II: Max. USD 750 000 (1-2 years) for principal R&D Phase III: Commercialisation expected by private sector
Operation	This scheme awards subsidies to regional innovation programmes that are aimed at the exchange of knowledge, and are executed by a consortium of one or more education institutes and one or more businesses. These regional innovation programmes have to focus on innovation demands from SMEs in the region.	The TSB holds regular competitions for funding of collaborative R&D projects, and each competition focuses on a distinct technology area. Examples of current and forthcoming competition areas include fuel cells, smart power, building performance evaluation, marine energy, low carbon vehicles, and sustainable manufacturing for the process industry. The scope of the collaborative R&D competitions has been expanded recently to support large projects as well as smaller projects approved within faster time scales.	Each year, five federal departments and agencies are required by STTR to reserve a portion of their R&D funds for award to small business/nonprofit research institution partnerships. Department of Defense Department of Energy Department of Health and Human Services National Aeronautics and Space Administration National Science Foundation These agencies designate R&D topics and accept proposals.
Evaluation	An elaborate evaluation study was executed in 2008. A study by EIM (Economic Institute for SMEs) concluded that each euro of innovation (collaboration) subsidy resulted in EUR 5 of additional investment from participating firms. It is expected that the economic effect of the investments will further increase. An evaluation study was executed in 2008, which recommended increasing the scope and depth of the programme (by starting the RAAK-PRO programme), development of a professional monitoring system, and the use of advisors for applicants in the preparatory phase.	N/A	N/A
More information	www.innovatie-alliantie.nl/?id=492	www.innovateuk.org	www.sba.gov

Table B.4. Proof-of-concept/pre-seed support for research spin-offs

	Australia – Pre-Seed Fund	Canada – NSERC Idea to Innovation (I2I) programme	Germany – EXIST
Year	2002-	N/A	1999-2013
Oversight	SciVentures (government backed)	NSERC	Federal Ministry of Economics and Technology (BMWi)
Stated goals/ objectives	"Encourage researchers in universities and public sector research agencies to consider the commercial opportunities of their research discoveries"	"Support the researchers to develop the idea in order get a company interested or to create a spin-off themselves"	"Improve the entrepreneurial environment at universities and research institutions and increase the number of technology and knowledge based business start-ups"
Target groups	Scientists (as individuals)	Scientists (as individuals)	Spin-offs, start-ups
Funding modes	AUD 104.1 million in capital, of which the Australian government is providing AUD 72.7 million. The rest comes from private sector investors, universities and public sector research agencies.	The I2I programme can provide funding in two phases. Phase I is in the proof-of-concept stage and has funding available for up to 12 months, at a maximum of CAD 125 000. Phase II consists of two funding opportunities. For the creation of a spin-off company, the Early Stage Investment Partner can support up to two-thirds of the costs of the project. Funding should not exceed an average of CAD 125 000 per year. For further co-operation with an existing company, NSERC may fund up to half the cost of the project with the company, providing the other half through a combination of cash and in-kind contributions. Funding requested should not exceed CAD 350 000 over 2 years.	Annual budget of EUR 32 million is co-financed by funding of the European Social Fund (ESF).
Operation	Selected companies and projects must be established in Australia but not yet generating sales revenue. They must be engaged in the commercialisation of research and either be controlled by a university, a public sector research agency or a qualifying researcher, or use intellectual property that is at least 50% owned by a university, a public sector research agency or a qualifying researcher.	Eligible research and development activities include (but are not limited to): (1) refining and implementing designs, (2) verifying application, (3) conducting field studies, (4) preparing demonstrations, (5) demonstrating proof-of-concept, (6) building engineering prototypes, and (7) performing beta trials. Eligible technology transfer activities include (but are not limited to): (1) market studies, (2) consulting fees (for business plan, market survey), (3) patenting expenses (with limitations), and (4) expenses associated with creating a partnership (travel)	EXIST is divided into three action lines: EXIST Culture of Entrepreneurship; EXIST Business Start-Up Grant; and EXIST Transfer of Research.
Evaluation	A 2008 review for the Australian government, Venturous Australia, recommended that the government immediately establish a second group of pre-seed funds. One major problem with the scheme had been the AUD 1 million cap imposed on investments by the pre-seed funds. The policy intent of the cap was to ensure that investments remained at the very early stage. However, the cap had had the unintended consequence of stranding investee companies when follow-on funding had been difficult to find in a timely manner. The review therefore recommended that the current AUD 1 million cap per investee firm should be changed to a maximum of AUD 1 million cap on the first tranche of investment, recognising the high-risk nature of the early stage of investment. The review also recommended that four new funds be established at a cost of AUD 100 million over 15 years.	N/A	In 2011, BMWi carried out an evaluation study analysing the effectiveness and efficiency of EXIST Business Start-up grants and EXIST Transfer of Research. The evaluation report had a positive assessment for both EXIST action lines. It proved that EXIST has closed a significant funding gap for innovative start-ups originating from science. Both action lines have been rated as well-implemented, with support measures making a decisive contribution to bringing an innovative technology to the market. In the absence of EXIST, most start-ups either would have failed to complete their business plan or would have entered the market only with significant delay.
More information	www.ausindustry.gov.au	www.nserc-crsng.gc.ca	www.exist.de

Table B.4. Proof-of-concept/pre-seed support for research spin-offs *(continued)*

	Israel – Tnufa	**Netherlands – TechnoPartner Seed Facility**
Year	N/A	2004-
Oversight	Ministry of Industry, Trade & Labor	SenterNovem administers the seed facility.
Stated goals/objectives	"Assists individual inventors and start-up companies during earliest stages of projects"	"Encourage and mobilise the bottom end of the Dutch risk-capital market in such a way that technostarters are able to meet their capital requirements"
Target groups	Start-ups Scientists (as individuals)	Others (here: venture capital funds)
Funding modes	Grants of up to 85% of approved expenses for a maximum of USD 50 000 for each project.	2007-11: Overall budget EUR 210 million
Operation	Evaluation of technological and financial feasibility, preparation of patent proposal for submission to authorities, construction of prototype, preparation of business plan, establishing contact with the appropriate industry representatives as well as attracting investors.	Closed-end venture capital funds are eligible for the seed facility; participation funds that invest in high-risk technostarter businesses can apply for a loan at TechnoPartner. A loan the amount deposited by the fund itself, up to a maximum of EUR 4 million; From the moment revenues are generated, the fund will only have to pay back 20% until it has earned back its investment.
Evaluation	N/A	N/A
More information	www.moital.gov.il	www.technopartner.nl

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