Main findings and recommendations

Main findings

Challenges in assessing the impacts of science-industry knowledge transfer on innovation and new approaches

Science-industry knowledge transfer unfolds through various formal and informal channels, the relative importance of which varies across science fields and industry sectors. Formal channels include collaborative and contract research, academic consultancy, intellectual property transactions, labour mobility and academic spin-offs. Informal channels of interaction include conferencing and networking, facility sharing, and continuing education provided by universities to enterprises, to name a few.

Given such diverse channels and the differences in knowledge transfer across economic sector and research disciplines, assessing the impact of science-industry knowledge transfer on innovation to reach specific socio-economic objectives is challenging. Other difficulties arise for impact analysis, such as establishing the causal impacts of public research on innovation. Such efforts require gathering representative data to investigate the impact factors of interest, and applying the right analytical tools.

The impacts of science-industry knowledge transfer have typically been assessed using case study evidence, patent data and publications data. Such analyses, however, capture only specific channels, and tend to be biased towards certain disciplines and sectors (e.g. technical innovation in the case of studies based on patent data).

Several new approaches can help improve the evidence on knowledge transfer and its impacts:

Evidence from labour force surveys can help provide a more complete picture of knowledge transfer, given that i) they capture the flow of human capital from university to industry, often considered one of the most important channels of science-industry interaction, and ii) they capture the full spectrum of science fields and industry sectors.

New datasets and tools can also provide fresh insights into knowledge transfer. These include data on innovative start-ups and venture capital deals (e.g. provided by Crunchbase, a commercial database on innovative companies that contains information on their funders and founders). Semantic analysis also provides opportunities for innovation policy analysis, as explored in a recent OECD-TIP workshop (OECD, 2018).

New evidence regarding science-industry knowledge transfer and its impacts

A combination of different methods and data sources is necessary to assess the impact of knowledge transfer. New evidence presented in this report shows that:

- *The direct contributions of universities and PRIs to patenting remain modest, but are growing faster than those of inventions from firms.* Data on patent applications to the European Patent Office (EPO) show that the proportion of those filed by universities and PRIs represented 1.3% of total EPO patent applications over the period 1992-2014. However, the number of patent applications by universities and PRIs increased more than fivefold during that same period, while the number of patent applications of industry doubled.

- *Universities and PRIs increasingly engage in research collaboration with industry.* The number of EPO patent applications jointly filed by public research institutions and industry grew faster than university-owned patent applications. In 2014, the number of co-patent applications with industry made up 43% of all patents applications of universities and PRIs, compared to 24% in 1992.
- *Proximity to universities and PRIs matters for industry inventions.* Data on more than 2.5 million EPO patent applications for 35 OECD countries and China over 1992-2014 show that 50% of all inventive activity by industry occurred within a 30-kilometre distance from a research university. Results from an econometric analysis suggest proximity to universities has a positive significant effect on the growth rate of local industry EPO patent applications is moreover irrespective of local business dynamics or annual time trends.
- *Start-up firms founded by students or academics significantly contribute to commercialising knowledge developed through public research.* Academic start-ups account for around 15% of overall start-up activity. The share of academic start-ups is particularly high in science-based technological fields – for instance, they account for 23% of all innovative start-ups in biotechnology. Start-ups founded by PhD students and academic researchers are significantly more likely to patent than non-academic start-ups.
- *Labour mobility is a key channel of science-industry knowledge transfer, particularly in some disciplines and industry sectors.* New evidence based on labour force surveys provides insights on the contributions of social scientists to industry. Evidence shows that graduates in social sciences (which include economics, political science, sociology, geography, business studies and law) contribute to innovation in a wide range of service sectors, including highly dynamic ICT sectors.

A diversity of policy instruments are used for knowledge transfer

OECD countries use a range of policy instruments to support science-industry knowledge transfer. Examples include grants for collaborative university-industry research; tax incentives for firms that purchase services from universities; mobility schemes for researchers; and networking events. This report identifies 21 specific policy instruments that can be classified according to: i) whether they are financial, regulatory or soft instruments; ii) whether they target primarily firms, universities/PRIs, or individual researchers and research groups; iii) the type of knowledge transfer channels being addressed; and iv) the supply- or demand-side orientation of policy instruments.

While countries tend to use similar sets of policy instruments to support knowledge transfer, differences across countries appear in the relative importance accorded each type of policy instrument (e.g. in terms of budget or number of initiatives), and in the detailed design or implementation of each policy instrument (e.g. in terms of target groups, eligibility criteria, time horizon, monitoring methods, etc.).

The impacts of single instruments depend not only on the features of the instrument but also on other policies in place. Besides the composition of the policy mix, the interactions (both positive and negative) among its elements are critical to outcomes. Synergies reinforce positive outcomes while trade-offs may counteract any positive impacts of policies. This means that a country's choice of financial, regulatory and soft instruments to promote knowledge transfer needs to be coherent so that the different policy instruments reinforce each other rather than result in contradiction, confusion or excessive complexity (Table 1).

Table 1. **Types of interactions between policy instruments**

Type of interaction	Description
Positive interactions	
Precondition	X is necessary in order to implement Y (i.e. the sequence by which policy instruments are introduced matters).
Facilitation	X increases the effectiveness of Y, but Y has no impact on X.
Synergy	X increases the effectiveness of Y, and vice versa.
Negative interactions	
Contradiction	X decreases the effectiveness of Y, and vice versa.
Complexity	Using too many policy instruments results in confusion for target groups, operational difficulties, and increased administrative costs.

Case study evidence illustrates the synergies and trade-offs at play among policy initiatives that support academic spin-offs. Business support – including in the form of marketing or training support – can enhance the effectiveness of financial support measures for spin-offs. In terms of trade-offs, an overly complex set of instruments creates complexity and raises administrative costs, and thus can prove less effective than single policies.

Key trends affecting science-industry knowledge transfer include the following:

- *Creation of new intermediary organisations* – Such organisations include, among others, R&D centres for science-industry collaboration, business incubators, and regional technology transfer organisations. These aim at building bridges between science and industry and differ widely, e.g. in terms of their funding structure, functions and organisational profiles. New approaches include building larger technology transfer offices formed in alliance with several universities and more specialised intermediaries to cater for specific business needs. These TTOs pool services to improve the efficiency and quality of knowledge transfer services with a sectoral or regional focus. Several countries have also developed specific intermediary organisations specializing in the needs of SMEs.
- *Greater emphasis on knowledge co-creation* – Public support for science-industry collaboration is shifting towards more intense "co-creation" relations, which involve the joint creation of knowledge by industry, civil society and research. These may take different forms, such as the creation of joint infrastructures, sharing of resources and engagement in joint research projects. Besides strategic long-term research partnerships and joint labs, co-creation may involve knowledge transfer channels such as the mobility of human capital. This entails building conditions allowing for two-way mobility of researchers from public research institutes and higher education institutions to temporarily join industry, and for industry researchers to temporarily participate in university activities.
- *Adapting knowledge transfer policies to the digital transformation* – New forms of open digital innovation enable more intense collaboration between firms and universities. These include online communities of experts, tournaments, open calls and crowdsourcing. Digital platforms help match supply of and demand for

technology by connecting firms with global networks of public research centres, individual scientists and freelancers to solve specific technological problems. In addition, research results and data are becoming more easily (and freely) available through open data and open access practices, while interactions between science and civil society are being enhanced through open science.

Governance mechanisms to promote knowledge transfer

The effectiveness of the policy mix for knowledge transfer depends on the quality of the governance of public research (i.e. the institutional arrangements that govern policy action regarding publicly funded research in universities and PRIs). Instruments will operate differently depending on how universities and PRIs are empowered (or not) in shaping their own ways of reaching the targets set. Interaction among different levels of governance (e.g. national vs. regional) may create synergies but may also lead to duplications and unnecessary complexity in the absence of efficient co-ordination mechanisms. Therefore, when assessing a country's policy mix for knowledge transfer, it becomes critical to analyse the institutions and governance systems that determine how policy instruments are designed and implemented.

The new OECD Database on Governance of Public Research Policy (stip.oecd.org/resgov), built for this TIP project, shows evidence of the following key governance practices that influence science-industry knowledge transfer:

- *Universities and PRIs are autonomous in a large number of OECD countries.* This allows them to deploy their own support programmes for knowledge transfer, on top of those offered across the board by the national or regional governments. In particular, universities and PRIs across many OECD countries can create their own functional units (e.g. technology transfer offices) and legal entities (e.g. spin-offs); decide on the recruitment and promotion of academic staff; and establish the rules that determine the share of IP revenues that researchers may receive.

- *Performance contracts set out the contributions of autonomous universities and PRIs to national innovation objectives as set out in STI strategies*. Performance-based funding systems often include targets related to knowledge transfer, such as collaborative research projects, income from patent licensing, the number of spin-off companies created or income from contract research.

- *The private sector and civil society are participating in shaping how universities engage with industry and are also engaging more actively in policy decision making.* In 25 of 34 OECD countries (or 74%), representatives from industry (e.g. large firms and, increasingly, smaller private firms) are participating in the governing boards of universities. In 26 of 31 OECD countries with research and innovation councils (or 84%), they also participate in policy decision making by participating in research and innovation councils.

Policy recommendations

The following are core policy recommendations for knowledge transfer policies to support innovation and socio-economic development goals:

Set knowledge transfer policies that respond to industry and research needs

- *There is no "one-size-fits-all" policy approach to knowledge transfer.* The importance of specific knowledge transfer channels varies across countries, science fields and industry sectors, and over time with the maturity of science-industry linkages. This means that countries need to consider their economic structures and areas of public research strengths when designing knowledge transfer policies. For example, patenting and academic start-ups are relevant knowledge transfer channels in science-based technological fields (e.g. biotechnology), whereas social scientists contribute to a wide range of service sectors through labour mobility. Consequently, more attention should be placed on adapting the policy mix to the institutional and economic structure of each country.
- *Policies should support public research institutions in developing knowledge transfer activities that are aligned with their research strengths.* Overemphasis on specific channels – often encountered with patenting – may neglect certain strengths, such as the potential to promote student entrepreneurship and academic spinoffs. Patenting and academic start-ups, while very useful for science-based sectors, are concentrated in leading academic institutions, with the leading 100 universities worldwide producing 45% of all academic start-ups. Other institutions may be better at developing student start-ups (which are less science-based) and supporting knowledge transfer through the mobility of students to industry. In the latter case, it is important that academic curricula are regularly revised to respond to emerging industry needs (e.g. strengthening digital skills, setting up more interdisciplinary programmes).
- *Policies should take advantage of opportunities for knowledge transfer offered by digital technologies*. Most innovative approaches to open innovation, enabled by digital technologies, include online communities of experts, open calls and crowdsourcing. Such opportunities can help spur new collaborations and bolster the international competitiveness of the research base.
- *Policies should support strategic, long-term-oriented forms of co-creation.* New policy approaches to promote science-industry links are progressively shifting away from the linear short-term model of knowledge transfer between industry and research in support of economic priorities, and toward a more interactive, longer-term model of knowledge "co-creation" that involves multiple stakeholders from industry, civil society, research and government, and that additionally aims to solve wider societal challenges. Policy initiatives relevant to co-creation include joint research laboratories (e.g. CoLABS in Portugal); the two-way mobility of researchers across organisational boundaries (e.g. through industrial PhDs); the establishment of new intermediary institutions (e.g. Catapult Centres in the United Kingdom); and the development of new guidelines for intellectual property management. The OECD TIP will be launching a 2019-20 project on "Co-creation between industry and science" (DSTI/STP/TIP(2018)16), to explore co-creation and relevant policy approaches.

Strengthen the policy mix for knowledge exchange

- *Countries should increase synergies and reduce complexity in the policy mix for knowledge exchange*. Synergies can be created when different policy instruments complement and mutually reinforce each other. This may be the case with different programmes that support different stages of commercialisation and business support measures, including entrepreneurial training for young start-ups. It is also important to streamline the policy mix, as employing too many policy instruments often results in confusion for target groups, operational difficulties, and increased administrative costs.

- *Policy makers should consider the interactions among policy instruments when designing and evaluating knowledge exchange policies*. Greater efforts are necessary to move towards policy design and evaluation methods that consider the combined effects of policy instruments, as well as potential redundancies, contradictions and remaining problems that could be addressed with new instruments.

- *Giving HEIs and PRIs more autonomy in how they organise knowledge exchange allows for diversification of approaches*, reflecting differences across institutions.

- *New regulatory frameworks should be revised to facilitate the participation of industry and civil society in the governing boards of HEIs and PRIs,* and to promote stakeholder consultations in the decision-making processes of these institutions. Such revision would ensure that the interests and demands of industry and civil society are taken into consideration, including those relating to research directions, teaching curricula, and the local engagement of institutions. This can help make institutions more responsive to business and societal needs.

- *Exploit the potential of new data sources and methodologies to assess knowledge transfer.* Better metrics are necessary to better assess knowledge transfer. This includes combining commonly used data sources and methodologies (e.g. patent and publications data) with new data sources and techniques. For example, text-mining may allow more systematic analysis of the content of scientific publications and patents, revealing the extent to which a publication is truly novel, or whether a patent is related to a particular social concern. (See outcomes of the recent OECD-TIP workshop on semantic analysis for innovation policy in OECD, 2018.) More can also be learned from using more labour force and employer-employee surveys to unveil the contributions of labour mobility to knowledge transfer – often considered the main channel of science-industry interaction.

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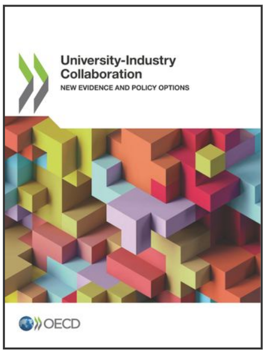

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