Australia's National
Science Agency

Promoting Knowledge Transfer and Commercialisation

Strategies for Knowledge Transfer from Universities and Public Sector Research Organisations in Vietnam

Don Scott-Kemmis

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2 EXECUTIVE SUMMARY

Recognising that the next phase of Vietnam's development will involve a greater focus on innovation and on building innovation capability in enterprises, there is increasing policy interest in the role of universities in contributing to the development of innovative enterprises.

This report is intended to provide an overview of international studies of knowledge transfer from universities and public research organisations to industry and other users. It includes case studies of the development of knowledge transfer policy and performance in four countries: the United States, Australia, China and Taiwan. These case studies also draw on studies and the evaluations of government policies to identify the barriers that have been identified as impeding effective knowledge transfer.

2.1 Perspectives from International Knowledge Transfer and Innovation Experience

- Universities are playing increasingly active roles in a widening range of knowledge transfer channels and those roles are recognised as important for the performance of innovation systems - and for that reason are a focus for policy intervention at the national and regional levels.
- Many businesses interact with RTOs for business-related goals (support for improving management, strategy or operations) as well as innovation-related goals
- The technological relatedness between the new knowledge and the knowledge base of the enterprise, and the technological capability of the enterprise are two of the most important determinants of the success of knowledge transfer.
- The patenting/licensing channel accounts for only a small part of the knowledge transferred from RTOs to industry; and overall income from knowledge transfer– and hence too much focus on this channel can reduce overall knowledge transfer
- Only a small part of the knowledge created in research and technology organisations can be codified in patents
- Knowledge transfer organisations need to reach a critical size to retain the required range of staff to be effective
- Knowledge transfer organisations need to recruit qualified and experienced staff to be effective
- Most knowledge transfer organisations are cost centres, rather than revenue generators
- Knowledge transfer approaches that seek revenue maximisation can lead to knowledge transfer organisations becoming bottlenecks rather than facilitators of knowledge transfer
- For many companies, difficulty finding an RTO partner and concerns about a lack of capability for effective collaboration and knowledge acquisition are often major constraints for business enterprises
- Relatively few companies identify research and technology organisations as highly important sources of knowledge for innovation (although that proportion seems to be increasing), although many more have some form of interaction with research and technology organisations
- Few companies allocate significant resources and staff time to collaboration with research and technology organisations

- While both business and research and technology organisations play active role in developing and supporting interaction it is largely individual researchers and professional staff who help initiate and sustain relationships, emphasising the importance of the networks and social capital of individuals.
- Researchers need to be involved in knowledge transfer processes, particularly in the early stages and the participation of the key researchers is a determinant of the speed and success of knowledge transfer
- Researchers informal contact with industry and personal networks have an important role in with research and technology organisations -industry relationships and in knowledge transfer
- Forcing collaboration in the early stages of research, when the level of uncertainty over the potential of the technology remains very high, is a disincentive for researcher to disclose their discoveries
- The effectiveness of researcher led spin-offs as a channel for knowledge transfer is highly context dependent – and few environments provide the conducive conditions of regions like Silicon Valley

The development of commercialisation practice and policy in most OECD countries can be seen as evolving through four phases:

- **Phase 1: Patent-licence pipeline** - Confirmation of university ownership of Intellectual Property along with university responsibility for active commercialisation. This led to increasing patenting and licencing – and university-industry interaction.
- **Phase 2: Deepening research collaboration and increasing governance** - Disappointment with commercialisation performance and a growing awareness of the barriers to knowledge transfer. This led to the increased professionalisation of TTOs and to a wide range of government programs to stimulate and support research-industry research collaboration along with an increased focus on allocating research funding on industrial priorities.
- **Phase 3: Spin-offs and start-ups** – Increasing technology-based entrepreneurial opportunity stimulated a growth in spin-offs and initiatives to support the role of universities in supporting entrepreneurship and entrepreneurial systems.
- **Phase 4: Beyond the pipeline – rethinking the developmental university in innovation systems** - Rethinking how universities produce what talent and knowledge and how they engage as a partner with enterprises and other organisations in contributing to growth, sustainability and equality.

2.2 Assessing the Barriers to Knowledge transfer in Vietnam

While some major universities in Vietnam have a number of cases of technology transfer through licensing or spin-offs, the overall level of technology commercialisation is very limited and is not a source of significant revenue to universities.

2.2.1 Major Knowledge Transfer Barriers in Vietnam

Based on discussions with universities, government and other sources among the main barriers to knowledge transfer in Vietnam are:

- Ownership of IP- universities to not have ownership of IP generated by public funding and lack the freedom to operate in commercialising IP.
- Employment status of researchers as public servants limits their role in and incentive for most types of knowledge transfer, particularly commercialisation.
- Industry demand for new knowledge from universities is limited
- Universities lack the capabilities and resource for commercialisation
- There is a narrow focus on some knowledge transfer channels by some universities and by government

2.2.2 Knowledge Transfer Barriers in Vietnam and the Experience of the Case Study Countries

International experience and the experience of the four case study countries (USA, China, Taiwan and Australia) provide insights relevant to the development of knowledge transfer policies in Vietnam:

- Effective university-industry interaction is challenging in all countries - the cultural, organisational and motivational gaps are significant and hence the challenges are systemic.
- The primary role of universities in the past was teaching – and hence knowledge transfer through graduates, and this remains their key role.
- Most enterprises do not look to universities as sources of technology nor major sources of knowledge inputs for innovation.
- There is a clear trend in most countries to affirm university ownership of IP from public-funded research, to allow universities the freedom (and responsibility) to operate, to make them accountable for knowledge transfer performance and in many cases to assist them to develop the capabilities to manage knowledge transfer effectively.
- A more systems-oriented approach to knowledge transfer has developed in most countries and this is expressed in government policies aiming to shape and support the knowledge transfer system (strengthening links, improving capabilities and subsidising collaboration), with an increasing awareness of the need to address the demand side. This represents a more enterprise-centric perspective. It also expresses a realisation that talent investment in research in universities complements but cannot substitute for private investment[1]. These initiatives to promote university-industry links have generally been in parallel with an increase in funding for university research. However, many funding programs also seek to steer research toward areas with high application potential.
- The relative emphasis, within universities overall knowledge transfer activities, on the commercialisation of research results has declined in most of these countries.
- Industry demand for graduate recruitment, consulting, contract research and collaborative research is generally much higher than for licencing technology.
- Universities have become increasingly active in promoting entrepreneurship in the staff and students, in addition to any initiatives in supporting spin-offs. In many cases the activities in supporting entrepreneurship are developed in collaboration with regional governments.

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[1] Salter, A., D'Este, P., Pavitt, K., Scott, A., Martin, B., Geuna, A., Nightingale, P. and Patel, P., 2000. Talent, not technology: the impact of publicly funded research on innovation in the UK. *Science and Technology Policy Research*.

- Knowledge transfer organisations, incubators, joint research centres, science parks are institutional innovations that have been developed in response to the need to strengthen innovation systems.
- Knowledge transfer intermediaries, and policies to promote knowledge transfer, take time to become effective and the participants, managers, policy makers and funders learn what works.
- Regional governments have increasingly become partners with universities in developing innovation and entrepreneurial ecosystems, often funding network building and knowledge transfer facilities.

2.3 Policy Options for Strengthening Knowledge Transfer in Vietnam

2.3.1 Principles for Effective Knowledge transfer

The following principles, based on international experience, inform the policy suggestions of this report:

- The primary objective for knowledge transfer from universities is the creation of the maximum economic and social value, and this should be the criteria for assessing national knowledge transfer performance
- The impact of innovation on economic and social value creation is determined by the level of adoption and diffusion throughout the economy
- The economic and social value creation through innovation largely comes from incremental innovation enabled by the diffusion of knowledge and technologies[2].
- The effective management of knowledge transfer from universities is the responsibility of universities and they should have the 'freedom to operate', taking into account government policy goals, and be accountable for their performance.
- The knowledge transfer system is complex, all channels are important and an effective system requires strong supply, strong demand and flexible linkages. Hence, there are complementarities between research, innovation and industry policy that lead to challenges for coordination.
- In regard to knowledge transfer and knowledge acquisition, the level of ambition, capability and opportunity will be very different for different types of university and enterprise.
- The international experience demonstrates that the development of an effective knowledge transfer system involves a long learning process through which all participants, including policy makers, build understanding, capabilities and relationships.

2.3.2 Suggested Policy Options

The discussion in the body of report suggests five policy priority areas designed to respond to the identified knowledge transfer barriers, and for each sets out a possible framing objective, a set of issues to consider and a number of options for policy approaches. The following summary lists the

[2] Department for Business, Energy and Industrial Strategy, 2021, Evidence for the UK Innovation Strategy. UK BEIS; Comin, D. and Mestieri, M., 2014. Technology diffusion: Measurement, causes, and consequences. In *Handbook of economic growth* (Vol. 2, pp. 565-622). Elsevier.

suggested objectives for the five policy areas and only some of the more important suggestions for policy options.

Suggested Policy Objective	Suggested Policy Initiatives
Ownership of IP and Freedom to Operate	
Maximise the creation of economic and social value from the public investment in research, and in the development of research talent and facilities, by permitting universities to have ownership of the intellectual property and other knowledge assets generated by public-funded research, but also by ensuring that universities develop (taking into account their size and academic scope) comprehensive strategies and capabilities for knowledge transfer, including how they will engage with enterprises and other relevant organisations within their region.	• Enable universities to have full ownership of knowledge assets generated by public-funded research, to manage appropriately the commercialisation of those assets, and to retain earnings from that commercialisation. • Provide guidelines for the sharing of benefits from universities' commercial knowledge transfer activities and require that universities have clear and transparent policies for revenue sharing. • Encourage universities to allow academics a proportion of time to work in consulting associated with knowledge transfer and leave to work in spin-offs, and generally to remove unnecessary restrictions on how academics interact with enterprises.
Knowledge Transfer Strategy and Organisation Development Support Program	
Encourage universities to develop comprehensive strategies for knowledge transfer appropriate to their location and capabilities and to develop competent knowledge transfer organisations to pursue those strategies.	• Recognise that government has a role in assisting and guiding the development of knowledge transfer organisations. • Encourage universities to develop comprehensive strategies for knowledge transfer appropriate to their location and capabilities and to develop competent knowledge transfer organisations to pursue those strategies.
Support the development of a National Knowledge Transfer Organisation.	
Develop a national association of knowledge transfer organisation able to guide and support the development of individual knowledge transfer organisations through sharing of experience, training and best practice guides.	• Considering the current stage of development of knowledge transfer activities and knowledge transfer organisations in Vietnam, government initiate the foundation of a national knowledge transfer organisation and provide support for the formation and for a professional secretariat for the initial period of operation, perhaps five years.
Develop the Demand Side of Knowledge Transfer and Strengthen University-Industry Links	
Ensure that the potential for universities to effectively support enterprise capability development is actively pursued.	• Review how universities in Vietnam can best complement government programs aiming to develop managerial and technological capabilities in SMEs.

	• Consider international experience in supporting capability development in SMEs and how best to strengthen mutually beneficial links between SMEs and universities. • Assess the value of establishing university-based applied research and knowledge transfer centres, each with a specific technological focus and a primary objective of raising technological capability in industry. Such Centres would be linked to strategies for industrial upgrading. Similar international programs have often been awarded to universities on a competitive basis with selection based on research strengths, location, strategies for technology development and knowledge transfer and governance arrangements (usually involving an independent board with participation from industry). Typically, initial funding is for five years, with performance evaluation after one, three and five years. As such programs are challenging to design, manage and evaluate– and usually require coordination across agencies – begin with one or more pilot programs.
Addressing the Proof_of_Concept Gap	
Ensure that research outcomes with a high potential for significant value creation through innovation have an opportunity to demonstrate that potential.	• Establish a national Early-Stage Commercialisation (Proof_of_Concept) Program suitable both for university-based startups based on university developed technology, and projects aiming to develop technologies within a university, or projects conducted within companies based on university developed technologies and conducted in collaboration with the originating university.

3 INTRODUCTION

This report is intended to provide an overview of international studies of knowledge transfer from universities and public research organisations to industry and other users. It includes case studies of the development of knowledge transfer policy and performance in four countries: the United States, Australia, China and Taiwan. These case studies also draw on studies and the evaluations of government policies to identify the barriers that have been identified as impeding effective knowledge transfer.

The report is organised in three parts. Part A provides the body of the report, but draws on the more detailed analyses in Part B and Part C. Part B compiles an Evidence Base which draws on the now very extensive literature on technology transfer and the wider processes of knowledge transfer. Part C includes the case studies of the experience of knowledge transfer and the development of knowledge transfer policy in the United States, Australia, China and Taiwan. Part D sets out the Terms of Reference for the study.

Part A includes three sections:

- Framing Perspectives: This section discusses the concepts through which issues and policies are framed. These concepts have changed over time and there has been a substantial widening of what is seen as the scope of knowledge transfer. This section provides an introduction to the very extensive range of international studies of knowledge transfer performance, processes and policy.
- Assessing the Barriers to Knowledge Transfer in Vietnam: Draws on discussions in Vietnam and other sources to identify the main barriers to more effective knowledge transfer in Vietnam. It also assesses the extent to which the four case study countries have experienced and addressed similar barriers.
- Policy Options for Strengthening Knowledge Transfer in Vietnam: This section draws on the assessments in the preceding sections, and particularly on the detailed assessments in Part B, to suggest options for addressing the barriers to knowledge transfer in Vietnam.

Part B has one extended section:

- Key Findings from International Studies and Experience: This major section brings together the major findings of the initial review and the case studies. It also sets out a summary of the types of possible policy responses to the major barriers to effective knowledge transfer.

Part C has five sections:

- Introduction to the Case Studies: This section provides a brief introduction to some of the basic characteristics of the innovation systems in the three case study countries.
- Knowledge Transfer in the United States: This section discusses the extensive range of programs in the US that have long been exemplars for knowledge transfer policy in other countries. The section characterises the phases of the evolution of policy and performance.
- Knowledge Transfer in Australia: The development of knowledge transfer policy in Australia has been very similar to that in the US. However, due in large part to the characteristic of the innovation system the challenges for knowledge transfer are different in important respects.

- Knowledge Transfer in China: China has developed a knowledge transfer system and policy framework over the last 30 years from a starting point of very limited capability. The evolution of policy also provides insights into how organisations respond to changing incentives.
- Knowledge Transfer in Taiwan: Taiwan has similarities with Vietnam and significant differences. Both the similarities and the differences shape the policies for and the impacts of knowledge transfer and these lead to insights that are useful for Vietnam.

PART A

4 A.1: FOUNDATION PERSPECTIVES ON KNOWLEDGE TRANSFER

4.1 Introduction

Universities are increasingly seen as one of the engines for regional and national growth. In most countries, government innovation policies include an emphasis on the wider role or universities – the so called 'third mission'. Over the past 40 years most countries have introduced initiatives (at the organisation, regional and national levels) to strengthen links between industry and research organisations and to improve knowledge transfer. In relation to the technology transfer channel of knowledge transfer, Israel and the US were the early movers followed by other high-income countries and Japan and Korea by 2000. In the United States, from 1981 universities had the right to patent knowledge created through government funded research. Policies to promote technology transfer initially focused on IP management (and more broadly the culture and performance goals) in universities and research organisations. But as perspectives on the role of universities evolved, a broader view developed which envisaged universities playing a more economic and social developmental role and hence a new 'social contract', beyond teaching and research.

Definitions and Acronyms

Technology transfer *refers to the process of conveying results stemming from scientific and technological research to the market place and to wider society, along with associated skills and procedures, and is as such an intrinsic part of the technological innovation process*[3].

Knowledge Transfer *is the process of engaging, for mutual benefit, with business, government or the community to generate, acquire, apply and make accessible the knowledge needed to enhance material, human, social and environmental wellbeing*[4]

Knowledge transfer *(KT) is a term used to encompass a very broad range of activities to support mutually beneficial collaborations between universities, businesses and the public sector*[5].

KT = Knowledge Transfer

KTO = Knowledge Transfer Office

TTO. = Technology Transfer Office

IP = Intellectual Property

PRO = Public Research Organisations

RTO = Research and Technology Organisation (i.e., PROs and universities)

KTM = Knowledge Transfer Mechanism (Channel)

STI = Science Technology and Innovation

NIS = National Innovation System

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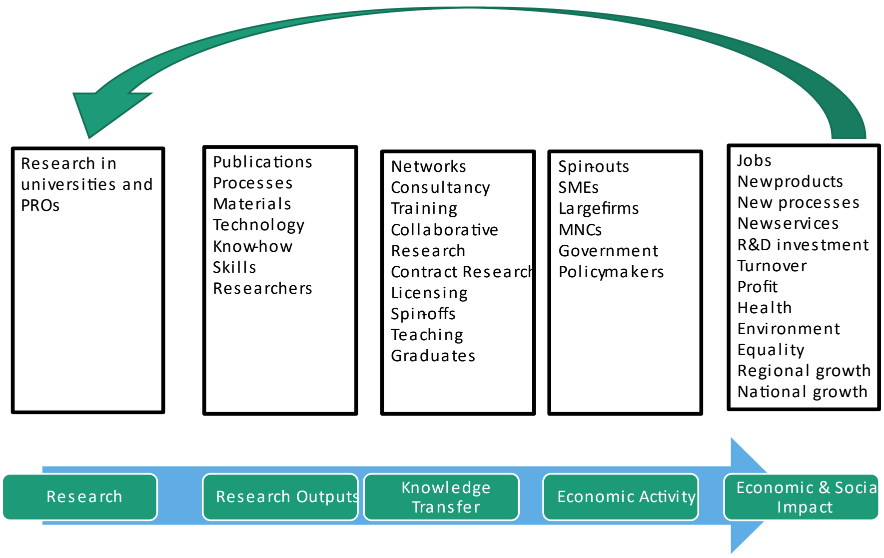
[3] https://knowledge4policy.ec.europa.eu/technology-transfer/what-technology-transfer_en

[4] PhillipsKPA, 2006. Knowledge Transfer and Australian Universities and Publicly Funded Research Agencies. A report to the Department of Education, Science and Training. Department of Education, Science and Training, Canberra.

[5] https://www.cam.ac.uk/research/news/what-is-knowledge-transfer. See also: Gopalakrishnan, S. & Santoro, M. D., 2004. Distinguishing Between Knowledge Transfer and Technology Transfer Activities: The Role of Key Organizational Factors. IEEE Transactions on Engineering Management 51(1):57 – 69

Over time the policies to support knowledge transfer widened to address complementary policy areas across the innovation system[6]. For this reason, this review will use the term knowledge transfer, which includes the more formal processes of transferring technology (i.e., technical knowledge) as well as the broader and often more informal interactions between researchers and industry (and other users) through which diverse types of knowledge flow (Figure A1.1).

Figure A1.1: An Overview of the Knowledge Transfer Cycle



Based on Schofield, 2013.

One of the reasons for introducing licensing of IP was to enable a company to have an **exclusive right** to use the IP, at least for a specified period of time, sector of the economy and geographical area. It was considered that a company investing in the possibly costly and risky process of commercialising a new product or process may have little incentive to undertake that process if other companies could then use the IP and compete by copying the product. The use of licenses became a model for Knowledge Transfer Organisations (KTOs) to manage a formalised relationship for knowledge transfer, even when registered IP was not involved.

There is considerable diversity in the regulations, policies and practices at the in Research and Technology Organisation (RTO) and national levels. While most governments see knowledge transfer from RTOs as a vitally important flow for a dynamic innovation system, there are a number of challenges for management and policy[7]:

- The culture and incentives that support excellence in knowledge creation are different from those that support knowledge application;
- As uncertainty and risk is an inherent aspect of innovation, and the outcomes of commercialisation can range from spectacular success to total failure, mechanisms for risk and benefit sharing need to be developed;

[6] Athreye, S. and Wunsch-Vincent, S., 2021 The Evolving Role of Public R&D and Public Research Organizations in Innovation, in by Arundel, A., Athreye, S., and Wunsch-Vincent, S. (Eds) Harnessing Public Research for Innovation in the 21st Century: An International Assessment of Knowledge Transfer Policies. Cambridge, England, UK: Cambridge University Press, 2021; Zuñiga, P., 2011. The State of Patenting at Research Institutions in Developing Countries: Policy Approaches and Practices. WIPO Economics Research Working Papers. Geneva: World Intellectual Property Organization.

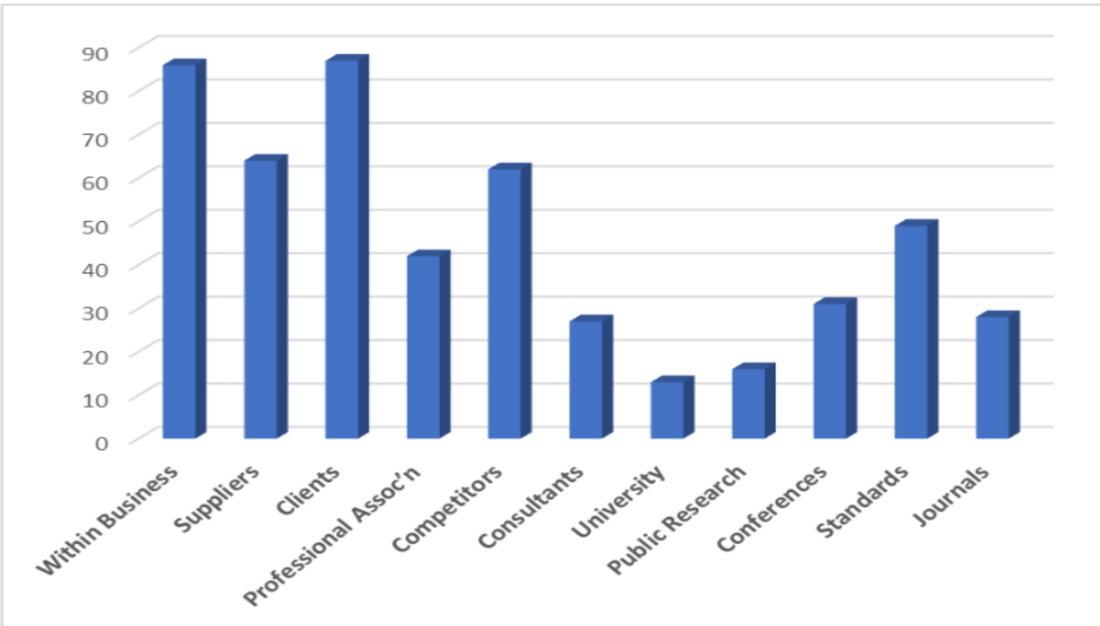
[7] Van Looy, B., P. Landoni, J. Callaert, B. van Pottelsberghe, E. Sapsalis, and K. Debackere, 2011. "Entrepreneurial effectiveness of European universities: An empirical assessment of antecedents and tradeoffs." Research Policy, 40(4): 553–64.

- There is no standard process of commercialisation – for example, the path to innovation may take months or several years, involve one partner or several, drive toward a selected objective or change objectives several times.
- Knowledge transfer requires capabilities, infrastructure and relationships that extend beyond the traditional academic domains of research, scholarship and learning and teaching.

4.1.1 What are the Main Knowledge Flows in the Overall Innovation Systems?

Knowledge flows in innovation systems are complex and there are marked differences between sectors and types of firm. For this survey two points of perspective are important. First, as shown in Figure A1.2, most firms do not use universities or research organisations as major sources of ideas or of information inputs for innovation. From this perspective it is not surprising that only a very small (although increasing) share of industry investment in R&D is for R&D carried out in RTOs – in OECD countries this proportion was 6.6% in 2007.
Second, for many firms, and particularly those with less developed economies, most innovation is through the acquisition of new process equipment or new product designs (often bundled together and sometimes involving licensing) with reliance on the supplier for support. This use of proven technology and support is a low-risk approach to innovation. However, many such firms will only slowly (if ever) develop the capabilities to significantly modify the product and process technology.

Figure A1.2: Importance of Sources of Information for Innovation – Ratings by UK Businesses
(Proportion of Businesses surveyed rating the source as of high or medium importance %)



Source: Volpi, 2016[8]

[8] Volpi, M., 2017. Sources of information for innovation: the role of companies' motivations. *Industry and Innovation*, *24*(8), pp.817-836.

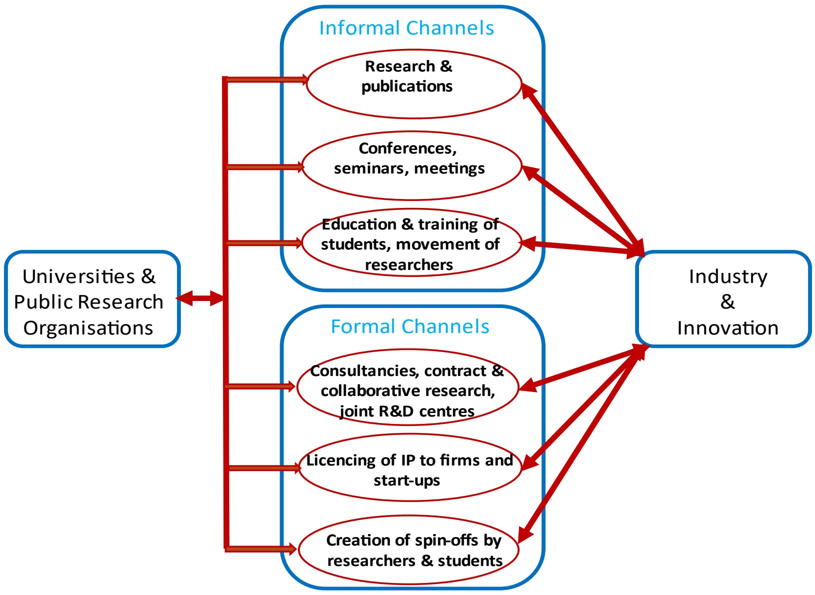
4.1.2 What are the most Important Knowledge Transfer Channels[9]?

Transfer of knowledge from RTOs to users (business, government) can flow through many channels. As shown in Figure A1.3, these may be channels that do not involve a formal relationship with the RTO. Such informal channels include knowledge transfer through graduates and staff mobility, publications, presentations at conferences, and personal contacts. Formal channels include licensing and research within collaborative or contractual arrangements.

Knowledge transfer might involve some or all of these channels. Informal and formal channels are often complementary so that combining more than one channel can contribute to more effective knowledge transfer. As noted, knowledge transfer from RTOs is a minor source of knowledge for innovation for most firms in most sectors.

As universities and PROs have become more involved in innovation systems the processes and organisation of knowledge transfer have become more complex. With the growth of channels such as consultancies, contract research and joint research, the relative role of patent licensing and spin-offs can decline[10].

Figure A1.3: Main Channels of Knowledge Transfer



Source: Arundel and Wunsch-Vincent, 2021, p.37

Generally, the most common channels are the informal channels (employment of graduates and staff, conferences, reading publications and personal contacts) followed by research contracts aiming to generate new knowledge. For example, in the UK the majority of the income to universities from knowledge transfer is from contract and collaborative research, while IP-related income accounts for only 2-4 per cent[11].

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[9] This section draws on inter alia: Arundel, A & Wunsch-Vincent, Sacha Evaluating Knowledge Transfer Policies and Practices: Conceptual Framework and Metrics in by Arundel, A., Athreye, S., and Wunsch-Vincent, S. (Eds)Harnessing Public Research for Innovation in the 21st Century: An International Assessment of Knowledge Transfer Policies. Cambridge, England, UK: Cambridge University Press, 2021.

[10] Mascarenhas, C., Ferreira, J.J. and Marques, C., 2018. University–industry cooperation: A systematic literature review and research agenda. *Science and Public Policy*, *45*(5), pp.708-718; Hall, J., Matos, S., Bachor, V. et al. (2014) 'Commercializing University Research in Diverse Settings: Moving Beyond Standardized Intellectual Property Management', Research Technology Management, 57/5: 26–34.

[11] Arundel, A & Wunsch-Vincent, Sacha Evaluating Knowledge Transfer Policies and Practices: Conceptual Framework and Metrics in by Arundel, A., Athreye, S., and Wunsch-Vincent, S. (Eds) Harnessing Public Research for Innovation in the 21st Century: An International Assessment of Knowledge Transfer Policies. Cambridge, England, UK: Cambridge University Press, 2021

While there has been a strong emphasis, in Knowledge Transfer (KT) policy, on the commercialisation of research outcomes through patenting and licences. A comprehensive knowledge transfer policy would address all channels, including publications, education and employment of graduates, collaborative and contract research, staff mobility and informal researcher contacts[12]. Some channels involve essentially short-term transactional relationships while others have greater 'bandwidth' and enable deeper strategic relationships. Different support approaches may be needed for effective knowledge transfer through different channels. This applies not only to organisational structures and policies, but as individuals are central to knowledge transfer, also the incentives for researchers[13]. Informal relations, through for example consulting or contacts through conferences and professional associations are often precursors to closer and more formal interactions[14]. These interactions also expose university researchers to technological problems identified by industry and can open research avenues that would not have emerged had researchers remained within the RTO 'world'[15].

4.1.3 What is the Role of Knowledge Transfer Offices?

From this wider perspective on the channels of knowledge transfer the roles of Knowledge Transfer Offices (KTOs) must also be wider. Table A1.1 provides an overview of the roles of KTOs in relation to the different channels of knowledge transfer.

In all countries barriers to knowledge transfer arise from:

- RTO policies for knowledge transfer and patenting that are under-developed
- a lack of incentives to researchers to patent and to actively participate in knowledge transfer
- knowledge transfer staff in RTOs lacking adequate skills, experience and networks
- a lack of demand from industry for IP from RTOs.

The role of a KTO within an RTO can only be effective if the overall policy framework in the RTO and the culture that this develops supports the work of the KTO. Studies of KTO performance indicate that policies should enable and support:

- a well-defined IP policy that is well understood and accepted within the organisation
- a culture that supports knowledge transfer
- the development of professional KT staff
- well understood policies setting out the RTOs objectives and strategies for KT
- professional approaches to business negotiations that ensure the development of trust
- incentives for staff so as to encourage them to disclose inventions and facilitate knowledge transfer, including by working with potential licensees
- entrepreneurship by researchers, such as through forming new ventures

[12] Salter, A.J., Martin, B.R., 2001. The economic benefits of publicly funded basic research: a critical review. Research Policy 30, 509–532; D'Este, P. and Patel, P. (2007) 'University Industry Linkages in the UK: What Are the Factors Underlying the Variety of Interactions with Industry?', Research Policy, 36/9: 1295–313; Kirchberger, M.A. and Pohl, L., 2016. Technology commercialization: a literature review of success factors and antecedents across different contexts. *The Journal of Technology Transfer*, *41*(5): 1077-1112.

[13] Perkmann, M., Tartari, V., McKelvey, M., Autio, E., Broström, A., D'este, P., Fini, R., Geuna, A., Grimaldi, R., Hughes, A. and Krabel, S., 2013. Academic engagement and commercialisation: A review of the literature on university–industry relations. *Research policy*,*42*(2): 423-442.

[14] Mathieu, A., 2011. University-Industry interactions and knowledge transfer mechanisms: a critical survey. *Centre Emile Bernheim, CEB Working Paper*, (11/015).

[15] D'Este P. and Patel, P., 2007. Op cit

- developing an approach to knowledge transfer and new venture development through support for innovation infrastructure, such as incubators and technology parks.

Table A1.1: Knowledge Transfer Channels and the Roles of KTOs

KT Mechanism	KTO Role or Activity	KTO Support Functions
1. Communication of research outputs through academic publications and conferences	Review publication or presentation for IP-related issues	Not relevant
2. Exploiting research outputs	Supporting knowledge transfer	KTO capability and influence
• Exploiting IP ('Technology Transfer')	Developing university IP policy IP advice for academics Patenting and managing IP Making/ supporting licensing deals, Establishing university spin-outs	Business liaison/ business development Marketing and communications Point of contact for businesses Business liaison /relationship management Changing RTO culture Internal communications Raising awareness among academics of importance of KT 'Selling' the KTO internally Disseminating KT best practice KT training Entrepreneurship education/training: for staff & students / for external organisations
3. Exploiting research capability and/or outputs	Supporting engagement and effective project management	
• Academic consulting	Supporting /managing academic consulting, contract research, collaborative R&D: • Identifying opportunities • Brokering teams • Supporting/writing bids • Agreeing contracts • Project management Customer relationship management	
• Contract research		
• Collaborative R&D (and other publicly-funded KT activities)		
4. Knowledge diffusion / networking (informal interactions)	Facilitating networking and knowledge diffusion	Events Newsletters / websites Alumni networks Networking with professional & trade associations Academic networking Public events Supporting regional development initiatives
5. Developing skills	Enabling access to recent graduates/ career services Providing access to CPD / lifelong learning Short training courses for businesses Business funded PhDs / Masters Work placements for students Joint curriculum development Temporary staff exchanges	
6. Community development/ public engagement	Public lectures/events /open days Newsletters Supporting local regeneration	
7. Exploiting RTO facilities	Enabling access to equipment and facilities Science parks/ incubators	

	Exchange/sharing of research materials	

Source: Developed from Technopolis, 2015

4.1.4 Who Uses Knowledge from or Collaborates with RTOs?

The firms that are the most active users of knowledge from RTOs are research-intensive firms. These are typically large firms but may also be small specialist research-intensive firms in for example medical or scientific instruments[16]. This means that there are major differences in the characteristics of knowledge transfer among industry sectors.
Most firms, and particularly firms in industrialising economies lack strong capacities to absorb, apply and gain a competitive benefit from new knowledge.
This has three important implications:

- The **demand** for knowledge from RTOs may be low where either few firms have sufficient absorptive capacity, or where there is a mismatch between the fields of research of the RTO and those of local industry.
- Where there are few research-intensives organisations that have a strong interest in commercialising new knowledge, there may nevertheless be a strong interest in knowledge acquired through the informal channels of graduate employment and personal interactions.
- In countries or regions with few research-intensive firms, and hence few potential partners for commercialising new knowledge, RTOs have a role in building the technological and innovation capacities of local firms. Even where some organisations are able to engage in knowledge acquisition through formal channels, a broader relationship involving also informal channels will often be necessary.

4.1.5 What Benefits do RTOs gain from Knowledge Transfer?

Generally, knowledge transfer has the potential to generate high social and economic value but often not significant monetary return to the RTO – this is particularly the case for licencing of patents. Most RTOs use rather than generate resources from licencing - this is why there is a strong case for ongoing public support for the knowledge transfer function of RTOs. Table A1.2 provides an outline of the diverse range of potential benefits and costs from participation in knowledge transfer.

Table A1.2: An Outline of the Impacts of IP-based knowledge transfer policies on universities/public research institutes and firms

	Potential benefits	**Potential costs (or investments)**
Public research organizations	**Increased IP ownership facilitates entrepreneurship and vertical specialization** • Reinforces other policies aimed at academic entrepreneurship (e.g., enhancing access to finance) • Licensing and other revenues (e.g., consulting) can be invested in research 2) **Cross-fertilization between faculty and**	1) **Diversion of time away from academic research** • Distorts incentives for scientists, leading to changes in the type of research that is conducted • Reorganizes university processes and culture with a view to commercialization

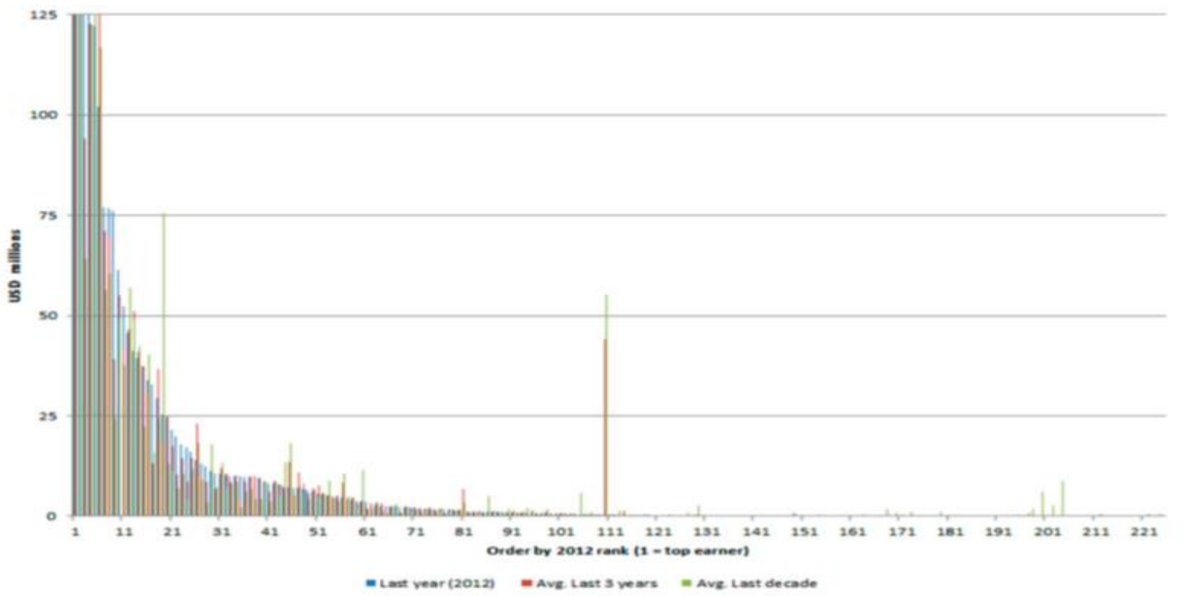
[16] Hughes, A. et al., 2022.The Changing State of Business-University Interactions in the UK. National Centre for Universities and Business; Laursen, K. and Salter, A., 2004. 'Searching High and Low: What Types of Firms Use Universities as a Source of Innovation?', Research Policy, 33/8: 1201–15; Bekkers, R. and Freitas, I.M.B., 2008. Analysing knowledge transfer channels between universities and industry: To what degree do sectors also matter? *Research policy*,*37*(10): 1837-1853.

	industry • Intangible benefits to university/public research institutes' reputation and the quality of research • Helps to identify research projects with a dual scientific and commercial purpose 3) **Increased student intake and ability to place students in firms**	2) **IP-related establishment and maintenance costs** • Cost of establishing and maintaining a KTO and related IP management, including investment in expertise and human resources • Cost of time on IP filings and knowledge transfer (even if contracted out to a KTO) • Additional financial and reputational costs associated with defense of IP rights
Firms	1) **Facilitates university–business linkages** • Enables firms to have access to top scientists and to collaborate in developing innovations within a clear contractual setting 2) **Enables the creation of a market for ideas and contracting with universities** • Framework diminishes transaction costs and increases legal certainty, facilitating investment by private sector • Securing an exclusive license increases incentives for further investment • Ability to specialize is a competitive advantage (vertical specialization) • Increases transparency through published databases on licensing and management practices • Improves content of patent databases 3) **Commercialization of new products, generating profits and growth**	1) **Barriers to access to university inventions** • Reduced free access to university inventions and research tools, except where they result from a sponsored contract • Lack of access if another firm has secured an exclusive license 2) **IP-based transaction costs and tensions in industry–university relationships** • University scientists lack an understanding of development costs and market needs, leading to a higher probability of bargaining breakdown • IP negotiations can interfere with establishment of joint R&D and university–industry relations when institutions act as revenue maximizers with a strong stance on IP.

Source: Arundel, A & Wunsch-Vincent, 2021

For most RTOs, licensing of IP is not a major source of revenue. As shown in Figure A1.4, only a small number of US universities gain significant income from patent licensing (and these cases are largely new pharmaceutical molecules) - for most this income is relatively very small (less than 5% of the RTO's annual R&D expenditure).

Figure A1.4: Distribution of Licensing Income – US Universities, 2012



There has long been a concern that an increased emphasis on knowledge transfer would detract from knowledge production. While there is some evidence that the growth of patenting, licensing and collaboration in universities can limit (and certainly delay) the openness (i.e., open publication and wide access to new knowledge) of research findings, major negative impacts can be managed by appropriate organisational policies and practices: (Arundel& Wunsch-Vincent, 2021, p49: "*Few studies have assessed the disadvantages of institutional IP strategies. Instead, studies show that often – and despite potential friction –university IP, collaboration, and research productivity go hand in hand. Universities that collaborate more with industry also tend to have the most patents".*

4.1.6 Summary Points of Perspective

Basic Perspectives from International Knowledge Transfer and Innovation Experience[17]

- Universities are playing increasingly active roles in a widening range of knowledge transfer channels and those roles are recognised as important for the performance of innovation systems - and for that reason are a focus for policy intervention at the national and regional levels.
- Many businesses interact with RTOs for business-related goals (support for improving management, strategy or operations) as well as innovation-related goals
- The technological relatedness between the new knowledge and the knowledge base of the enterprise, and the technological capability of the enterprise are two of the most important determinants of the success of KT.

[17] Geuna, A. and Muscio, A., 2009. 'The Governance of University Knowledge Transfer: A Critical Review of the Literature', Minerva, 47/1: 93–114; Perkmann, M., Tartari, V., McKelvey, M., Autio, E., Broström, A., D'este, P., Fini, R., Geuna, A., Grimaldi, R., Hughes, A. and Krabel, S., 2013. Academic engagement and commercialisation: A review of the literature on university–industry relations. *Research policy*,*42*(2), pp.423-442; De Wit-de Vries, E., Dolfsma, W.A., van der Windt, H.J. and Gerkema, M.P., 2019. Knowledge transfer in university–industry research partnerships: a review. *The Journal of Technology Transfer*, *44*(4), pp.1236-1255; Hughes, A. et al., 2022.The Changing State of Business-University Interactions in the UK. National Centre for Universities and Business.

- The patenting/licensing channel accounts for only a small part of the knowledge transferred from RTOs to industry; and overall income from KT– and hence too much focus on this channel can reduce overall knowledge transfer[18]
- Only a small part of the knowledge created in RTOs can be codified in patents
- KTOs need to reach a critical size to retain the required range of staff to be effective
- KTOs need to recruit qualified and experienced staff to be effective
- In most RTOs KTOs are cost centres, rather than revenue generators
- KTO approaches that seek revenue maximisation can lead to KTOs becoming bottlenecks rather than facilitators of knowledge transfer
- For many companies, difficulty finding an RTO partner and concerns about a lack of capability for effective collaboration and knowledge acquisition are often major constraints for business enterprises
- Relatively few companies identify RTOs as highly important sources of knowledge for innovation (although that proportion seems to be increasing), although many more have some form of interaction with RTOs
- Few companies allocate significant resources and staff time to collaboration with RTOs
- While both business and RTOs play active role in developing and supporting interaction it is largely individual researchers and professional staff who help initiate and sustain relationships, emphasising the importance of the networks and social capital of individuals.
- Researchers need to be involved in KT processes, particularly in the early stages and the participation of the key researchers is a determinant of the speed and success of knowledge transfer
- Researchers informal contact with industry and personal networks have an important role in RTO-industry relationships and in knowledge transfer
- Forcing collaboration in the early stages of research, when the level of uncertainty over the potential of the technology remains very high, is a disincentive for researcher to disclose their discoveries
- The effectiveness of researcher led spin-offs as a channel for knowledge transfer is highly context dependent – and few environments provide the conducive conditions of regions like Silicon Valley

[18] Hughes, A. et al., 2022.The Changing State of Business-University Interactions in the UK. National Centre for Universities and Business.

5 A.2: ASSESSING THE BARRIERS TO KNOWLEDGE TRANSFER IN VIETNAM

5.1 Context of Performance

While some major universities in Vietnam have a number of cases of technology transfer through licensing or spin-offs, the overall level of technology commercialisation is very limited and is not a source of significant revenue to universities[19].

For those universities that have developed significant interaction with business, income from consulting and technical services has been a far more significant than licensing of IP. At least one university has developed a significant entrepreneurship program with a capacity for incubation, mentoring and limited seed funding.

5.2 Major Knowledge Transfer Barriers in Vietnam

In all countries, differences in culture, organisation, regulation and motivations create challenges for developing and sustaining interaction between universities and industry. These challenges are greater in Vietnam where there is a limited history of interaction. These are pervasive challenges that affect all of the specific barriers, discussed below:

- **Ownership of IP**

At present, the Government, through the funding agencies, asserts ownership of any IP that is developed from government funded research. In addition, the Government requires that the *value* of that IP (or research results in general), in the form of financial income from any commercialisation, is returned to the government. However, the basis for determining the *value* of research results is unclear and does not depend on the outcome of financial transactions in the process of commercialisation. As a consequence, universities and researchers involved in commercialisation of research based on government funding run the risk of negotiating financial benefits that are later assessed by government to be less than the potential *value*. This situation has three negative outcomes. First, the uncertainties over the value of IP and the risk that researchers and universities may be judged by government to have commercialised a government asset at less than its assessed value, is a major disincentive to commercialisation. Second, the ownership of such IP by government substantially complicates the possible use of IP in negotiating equity shares in spin-offs based on government funded research. Third, the requirement to repay either the original funds for research or the financial returns (gross or net?) from commercialisation further reduces the incentives for researchers and universities.

- **Employment Status of Researchers**

Academics in public universities are public servants, employed under the framework of civil service regulations. As a result, the scope for researchers to participate in commercialisation (for example in negotiating financial aspects) through licencing or the formation of spin-offs is at best unclear and in many respects very limited. The scope for academics to participate in

[19] There are reports that some individual researchers, operating through informal relationships outside of university or government regulations have earned significant personal income from knowledge transfer.

placements in industry is also at best very limited. These regulatory restrictions add to the level of disincentive to participate in knowledge transfer. Regulations developed by university administrations often add to the level of restriction and uncertainty

- **Industry Demand for New Knowledge**

Universities find it difficult to find appropriate partners for commercialisation. Most smaller firms lack absorptive capacity and are risk averse. Even most larger firms are risk averse and prefer to purchase and implement proven technologies. This reluctance is often not irrational - in most cases the development of a technology from research in a university to the level of early commercial application is complex. It is almost always more challenging and more costly and often takes more time than estimated. The benefits to the commercialising enterprise are always uncertain. This is particularly the case when neither the enterprises nor the researchers have a great deal of experience in commercialisation.

- **Capabilities and Resource for Commercialisation**

Effective commercialisation from universities is often constrained by a lack of capabilities in such key competencies as assessment of market potential and originality, management of technology development and identification and assessment of potential partners. The availability in Vietnam of experienced professionals with such capabilities is very limited- and even if available the salaries offered by most universities would not attract them. University TTOs/KTOs have very limited funding – which must be sourced from the university (which usually has little flexibility in the use of funds) or from commercial activities. This greatly limits their role in developing KT activities. Many universities have neither a clear set of guidelines for managing commercial KT activities nor a formal KTO organisation. As a result of complex government and university-level regulations, and a lack of professional KTOs, enterprises prefer to deal directly with researchers.

An additional constraint is the lack of available funding to progress, to the point of being 'commercial ready', a potential technology based on research results[20]. There are two components to this gap. One, the 'proof of concept' gap, addresses the techno-economic development from research findings to a reasonable demonstration of the technical feasibility of the results along with an assessment of the commercial potential. This gap is likely to be deeper if the research was conducted with little or no awareness of current related technologies in use in industry. The second gap is the step from 'proof of concept' to early market introduction. In a robust innovation system, the expectation is that private investors (enterprises or venture investors) are likely to invest in further commercialisation if the proof of concept indicates that there is a significant potential. In Vietnam, the experience of universities suggests that the number of enterprises and investors with the motivations, capabilities and risk appetite to support 'proof of concept' to market introduction is very limited. Enterprises and investors will be even more risk-averse if the ownership of IP is not clear, if the 'freedom to operate' of universities in relation to IP-related negotiations is not clear, and if the regime for the enforcement of IP rights is not strong.

- **Narrow Focus on Some KT Channels**

The focus of interest in Vietnam on KT is on the commercialisation of IP, particularly through licensing, and to a lesser extent through spin-offs. Some universities have developed significant KT activities through the consulting and contract research channels. At least one has developed

[20] See: Mankins, J.C., 1995. Technology readiness levels. *White Paper, April*, *6*, 1995, p.1995.

a significant capacity to support entrepreneurship by students and staff, whether or not related to the application of research results.

Universities have few incentives to develop KT activities – earning from commercial activity leads to commensurate reductions in government funding and KT performance is not considered in university rankings.

This narrow focus is not appropriate for Vietnam. It results in a great deal of lost opportunity to support the flow of knowledge, the upgrading of capabilities in enterprises and other organisations and the formation of more new ventures.

5.3 Knowledge Transfer Barriers in Vietnam and the Experience of the Case Study Countries

It is essential to frame the following comparisons by taking into consideration several key points:

- Effective university-industry interaction is challenging in all countries. The cultural, organisational and motivational gaps are significant and hence the challenges are systemic. This is why bridging mechanisms on the one hand and inter-personal networks on the other are essential. To a large extent university-industry knowledge transfer, and particularly technology transfer, flows through people and trusted relationships.

- The primary role of universities in the past was teaching – and hence knowledge transfer through graduates. This remains their key role. Research became an increasingly important role of many universities over the last 80 years. More recently, there has been a growing social expectation that universities re-orient and more directly contribute to economic and social development. Universities are increasingly expected to be proactive in knowledge transfer through all the significant channels – and their performance in these dimensions is more often assessed. These changes are challenging for universities and the development of the required strategies, capabilities and relationships (internal and external) is an evolutionary process.

- Most enterprises do not look to universities as sources of technology nor major sources of knowledge inputs for innovation. Enterprises are more likely to look to universities as sources of knowledge where the enterprise is operating near the global technology frontier, is R&D intensive with a capable in-house research and commercialisation expertise, has strong financial resources and has existing inter-personal links with a university. More enterprises look to universities as possible sources of services for problem-solving or contract 'research'. Many more will see universities as possible sources of qualified graduates.

- Some industries are much more strongly science-based than others. Those are the industries where firms are more likely to have links with universities. In most industries the role of new knowledge generated through public sector research is much more indirect – in these industries technology builds on technology. These less directly linked industries are particularly important in East Asia. On average patents from China, Korea and Taiwan draw significantly less on academic science than do patents from, for example, the US.

Table A2.1: Assessing Knowledge Transfer Barriers in Vietnam from an International Perspective

Major KT Barriers in Vietnam	Addressing Similar Barriers in the Case Study Countries			
	UNITED STATES OF AMERICA	CHINA	TAIWAN	AUSTRALIA
Ownership of IP	Ownership of IP from government-funded research vested in the university since 1981. But strong requirement for universities to actively commercialises.	IP from publicly funded research the property of the university or PRO, since 2007[21]. In China very few patents taken out by universities are subsequently licenced; in 2017 the rate of patent licensing from universities was equivalent to less than 3% of rate of patenting by universities[22].	Since 1999, universities have the right to commercialise technology and other assets created through public funding. Must pay 20% of licensing income to government, 40% to the university and 40% to the inventors. Recent initiatives address the problem of the different R&D and commercialisation regulations under the different ministries.	Ownership of IP from government-funded research vested in the university. But strong expectation for universities to actively commercialises.
Employment Status of Researchers	Researchers employed by university and universities set employment conditions. Universities generally permit faculty to spend some time on independent consulting, to take leave to work in enterprises and to own equity in ventures.	Researchers employed by university and universities set employment conditions. The new law required RTOs to develop management systems that allow academics to take leave and to keep their faculty position for up to three years when taking leave to create a new venture.	Universities have autonomy in personnel management and budgets, university-industry personnel exchanges. Universities had been civil service organisations and faculty public servants – with all of the regulations and restrictions that entails and were barriers to TT.	Researchers employed by university and universities set employment conditions. Universities generally permit faculty to spend some time on independent consulting, to take leave to work in enterprises and to own equity in ventures.
Industry Demand for Knowledge	Strong demand in some industries and regions and a long history of university-industry links. Many government programs promote the development of links and co-fund	Lack of demand from Chinese firms due to a lack of absorptive capacity limits knowledge transfer. Many government initiatives to support university-industry links.	Small proportion of patents licenced. Subsidies for university-industry collaboration through several programs of different Ministries.	Limited demand due to relatively high proportion of FDI and of SMEs. Many government initiatives to increase industry demand and

[21] In China, as in developing countries generally, the outcomes from IP reform have been disappointingly much lower than expectations. See: Mazzoleni, R. and Nelson, R.R., 2007. Public research institutions and economic catch-up. *Research policy*, *36*(10), pp.1512-1528; Zuñiga, P. 2011. "The State of Patenting at Research Institutions in Developing Countries: Policy Approaches and Practices." WIPO Economic Research Working Papers 4, World Intellectual Property Organization, Geneva; Brundenius, C., B. A. Lundvall, and J. Sutz. 2009. "The Role of Universities in Innovation Systems in Developing Countries: Developmental University Systems–Empirical, Analytical and Normative Perspectives." In Handbook of Innovation Systems and Developing Countries, edited by B. A. Lundvall, K. J. Joseph, C. Chaminade, and J. Vang, 311–25. Cheltenham, UK: Edward Elgar.

[22] Li, J. Yin, X. and She, S. China's Science-Based Innovation and Technology Transfer in The Global Context. Chapter 4.2 in Yip, G.S. and McKern, B., 2016. *China's next strategic advantage: From imitation to innovation*. MIT Press.

	university-industry collaboration. Licencing levels grew after 1980 and as KTOs developed capabilities.	One focus of a significant proportion of research contracts is the adaptation of foreign technology, often by reverse engineering.	Primary mechanism of interaction with industry education and training programs, followed by, contract research. Informal, short-term and inexpensive training programs were attractive to SMEs	to support collaboration- but limited improvement. Universities' focus on income from licencing became an obstacle to wider KT and to industry links.
Capabilities and Resources for KT	Many KTOs formed since 1980 and strong development of capabilities. National Association of University Technology Managers support training, information exchange and performance monitoring. A few universities have high income from licensing and spin-offs but most have no significant income. Generally, a strong culture of KT in universities and a wide range of federal and state programs that support university-industry collaboration.	Laws made knowledge transfer a legal responsibility of universities and PROs and required them to develop capabilities and processes to support KT and to report on their performance. Lack of capable KTO offices in many research organisations limits knowledge transfer. Patenting grew rapidly after it became a performance indicator but few of the patents were licenced. The network of Innovation Relay Centres provides an open platform of information on opportunities for knowledge transfer. Most KT agreements between RTOs and enterprises do not involve patented knowledge. Role of regional governments in supporting KT increasing.	KTOs have generally not been effective. Government moved to subsidise patenting costs and provide advice and support to KTOs. Regulatory changes in 2008 enabled the university to pay competitive salaries for TTO staff and as a result to recruit senior staff with industry experience – and this improved licencing rates. Technology market have developed particularly since 2006	KTO became more professional and supported Knowledge Commercialisation Australia, the association of KTOs. Some KTOs in small universities managed by experienced KTOs from larger universities. Performance in licensing and spin-off formation lower than expectations- few patents earn significant income. Several national programs to support collaboration and to address 'proof of concept' gaps.
Narrow Focus on Technology Commercialisation	Entrepreneurship and the development of links with the regional innovation/entrepreneurial ecosystem have become more important, with less of a focus on commercialisation. For most universities these links are far more	Strong policy focus on R&D and KT, with many programs to support research and collaboration. Gradually developing more of a systems perspective. Much interaction between RTOs and enterprises is through contract	Many programs support collaboration. Government funding to universities to support to firms in industrial parks and to develop application-oriented R&D.	A systems perspective is gradually influencing policy. This emphasised the critical requirement to develop the innovation strategies and capabilities of enterprises and

	important (and profitable) for achieving their goals than commercialisation of patents. Some outstanding examples of multidimensional university-industry links (MIT, Stanford)	research and consulting- rather than licensing. Government support for joint 'research' institute that provide technology services to business in the region. Provincial governments often provide land, funds, and buildings for 'research' institutes and Science Parks. Recent emphasis on approaches to an enterprise-centric innovation system.	Generally, income from contract research and technical services/consulting much higher than from licensing- which is also used to provide graduates with useful experience. Rewards funding for outstanding performance in industry–academia collaboration. Technical services and forms of cooperative 'research'- rather than technology licensing and start-ups - are the main channels of KT.	to strengthen linkages in the innovation system. Universities' income from research contracts and consultancies is many times higher than income from IP-related commercialisation

5.4 Insights from the Case Study Countries Regarding KT Barriers

- **Delegation with accountability**: In all the countries the clear trend has been to affirm university ownership of IP from public-funded research, to allow universities the freedom (and responsibility) to operate, to make them accountable for KT performance and, in most cases, to assist them to develop the capabilities to manage KT effectively. In the US and Australia national KTO associations provide support to individual KTOs. The same approach is usually also applied to the employment conditions of faculty- where the trend has been toward greater flexibility. Working conditions of low pay, high administrative loads, complex regulations and little flexibility are unlikely to provide strong incentives for researchers.

- **KT System**: A more systems-oriented approach to KT has developed in all the countries. This has stimulated an increase in government policies and programs aiming to shape and support the KT system (strengthening links, improving capabilities and subsidising collaboration), with an increasing awareness of the need to address the demand side. This represents a more enterprise-centric perspective. It also expresses a realisation that talent investment in research in universities complements but cannot substitute for private investment[23]. These initiatives to promote university-industry links have generally been in parallel with an increase in funding for university research. However, many funding programs also seek to steer research toward areas with high application potential.

- **Re-focusing on Overall KT**: There is a strong case for clarifying IP ownership and management laws and regulations in order to promote technology commercialisation from research. But it would be unrealistic to expect this to generate major benefits for the universities or the economy. The relative emphasis on the commercialisation of research results has declined in most of these countries. A re-balancing has renewed recognition of the core role in teaching and research, while also promoting an active role in all the KT channels[24]. These are significant challenges for the funding, governance, management and assessment of universities.

- **KT Demand from Industry**: Industry demand for graduate recruitment, consulting, contract research and collaborative research is generally much higher than for licencing technology. In general, most technology licensing by enterprises is for technology licences from other enterprises. The characteristics of enterprises demand for knowledge acquisition very across sectors, competitive context and types of enterprise.

- **Entrepreneurship**: Universities have become increasingly active in promoting entrepreneurship in the staff and students, in addition to any initiatives in supporting spin-offs. In many cases the activities in supporting entrepreneurship are developed in collaboration with regional governments.

- **Experiment, Institutional Innovation, and Learning**: KTOs, incubators, joint research centres, science parks are all institutional innovations that have been developed in response

23 Salter, A., D'Este, P., Pavitt, K., Scott, A., Martin, B., Geuna, A., Nightingale, P. and Patel, P., 2000. Talent, not technology: the impact of publicly funded research on innovation in the UK. Science and Technology Policy Research.

24 Hughes, A. and Kitson, M., 2012. Pathways to impact and the strategic role of universities: new evidence on the breadth and depth of university knowledge exchange in the UK and the factors constraining its development. Cambridge journal of economics, 36(3), pp.723-750.

to the need to strengthen innovation systems. All of the countries have developed some form of 'technology market' or broking capability. Behind these labels there is much diversity in structure, role and organisation – and performance. In all of the countries these organisations usually take time to become effective and the participants, managers and funders learn what works. One important area of experiment, particularly in the US and Australia, has been the challenge of 'proof of concept'/gap funding. Both countries have introduced a range of schemes in order to try to address this challenge. In most cases funding for this stage of commercialisation is restricted to technology developments in commercial contexts (i.e., where there is a collaboration with an enterprise, or, in the case of a new venture, an investor, or where there is an identified customer) where professionals with industry experience can guide the process.

- **Regional Government Partners**: Regional governments have increasingly become partners with universities in developing innovation and entrepreneurial ecosystems, often funding network building and KT facilities. This role complements the re-focusing on the many channels of KT and the building of relationships (many of which will be local) as universities move away from a focus on supply push.

6 A.3: POLICY OPTIONS FOR STRENGTHENING KNOWLEDGE TRANSFER IN VIETNAM

6.1 Principles for Effective Knowledge Transfer

The following suggestions for initiatives to address the barriers to effective knowledge transfer in Vietnam are informed by the assessment of international experience outlined above and in Part B. They are also shaped by seven principles, also informed by international experience:

- The primary objective for knowledge transfer from universities is the creation of the maximum economic and social value, and this should be the criteria for assessing national knowledge transfer performance
- The impact of innovation on economic and social value creation is determined by the level of adoption and diffusion throughout the economy
- The economic and social value creation through innovation largely comes from incremental innovation enabled by the diffusion of knowledge and technologies[25].
- The effective management of knowledge transfer from universities is the responsibility of universities and they should have the 'freedom to operate', taking into account government policy goals, and be accountable for their performance.
- The knowledge transfer system is complex, all channels are important and an effective system requires strong supply, strong demand and flexible linkages. Hence, there are complementarities between research, innovation and industry policy that lead to challenges for coordination.
- In regard to knowledge transfer and knowledge acquisition, the level of ambition, capability and opportunity will be very different for different types of university and enterprise.
- The international experience demonstrates that the development of an effective knowledge transfer system involves a long learning process through which all participants, including policy makers, build understanding, capabilities and relationships.

6.2 Suggested Policy Options

1. Ownership of IP and Freedom to Operate

Objective

Maximise the creation of economic and social value from the public investment in research, and in the development of research talent and facilities, by permitting universities to have ownership of the

[25] Department for Business, Energy and Industrial Strategy, 2021, Evidence for the UK Innovation Strategy. UK BEIS; Comin, D. and Mestieri, M., 2014. Technology diffusion: Measurement, causes, and consequences. In *Handbook of economic growth* (Vol. 2, pp. 565-622). Elsevier.

intellectual property and other knowledge assets generated by public-funded research, but also by ensuring that universities develop (taking into account their size and academic scope) comprehensive strategies and capabilities for knowledge transfer, including how they will engage with enterprises and other relevant organisations within their region.

Issues to Consider

- From a principle of delegation with accountability, universities would be responsible for managing KT activities, including the effective commercialisation of research outcomes, and developing employment conditions for faculty that encourage engagement in KT, compatible with their primary responsibilities in teaching and research.
- The level of potential economic and social value created will be related to the level of investment in research and the development of researchers.
- Based on the experience of OECD countries, the income from licencing for universities in Vietnam is likely to be less than one percent of total annual research expenditure. It would be counterproductive to require the payment of some proportion of such earnings to the funding Ministries. The funds returned will not be high and likely to be far less than the transaction costs in administering the accounting process.
- Clarifying and simplifying the regulatory environment for the participation of faculty in KT, including commercialisation of technology, would provide incentives for that participation, including through formal arrangements.
- Enabling universities to have ownership of knowledge assets generated by research, and to manage appropriately the commercialisation of those assets, would be far easier to pursue if the universities were autonomous and self-managing**.**
- The value of IP will be the determined by commercial negotiation during the process of commercialisation. A careful negotiation of licensing agreements by competent professional staff can help to ensure a share in future revenue streams based on the IP and also can ensure retention of IP ownership in the case of the failure of a new venture based on that IP.

Options

- Enable universities to have full ownership of knowledge assets generated by public-funded research, to manage appropriately the commercialisation of those assets, and to retain earnings from that commercialisation.

- Provide guidelines for the sharing of benefits from universities' commercial KT activities and require that universities have clear and transparent policies for revenue sharing.

- Encourage universities to allow academics a proportion of time to work in consulting associated with KT and leave to work in spin-offs, and generally to remove unnecessary restrictions on how academics interact with enterprises.

2. KT Strategy and KTO Development Support Program

Objective

Encourage universities to develop comprehensive strategies for KT appropriate to their location and capabilities and to develop competent KTOs to pursue those strategies.

Issues to Consider

- International experience indicates clearly that in universities with policies and strategies that support KT, and KTOs with strong capabilities, significantly improve KT performance, including commercialisation through licencing and spin-offs.
- International experience indicates that the development of links with industry requires pro-active strategies by universities and KTOs and importantly that networking by individual researchers is a key element in developing relationships with business.
- International experience indicates that an excessive focus on patenting and licencing can divert attention and effort from the other and more important channels of KT – and in some cases from the core mission of high-quality teaching and research.
- Evaluation of university performance based on appropriate indicators contributes to accountability; but evaluation (and incentives) based on inappropriate indicators risks encouraging unproductive behaviour.
- Many countries provide financial support for the establishment and/or ongoing operation of university KTOs and this assists employment of experienced professional staff, capability development and accountability.
- It would be unrealistic to expect all researchers to participate in commercialisation or contract research and technical assistance activities.

Options

- Recognise that government has a role in assisting and guiding the development of KTOs.
- Encourage universities to develop comprehensive strategies for KT appropriate to their location and capabilities and to develop competent KTOs to pursue those strategies.
- Develop a national program of funding support for KTOs, beginning with a pilot program for a few years. Such a program would be more effective if the allocation of funding was on a competitive basis and had a component for larger universities with strong KT activities and a component for those smaller universities with more limited KT activities and capabilities. If competitive selection required applicants to put forward a university's five-year KT strategy, supported by a systematic assessment of opportunities, needs and capabilities on which it was based, this would be an incentive for universities to develop informed and strategic approaches. Applicants might also be required to set out in the strategic plan, the performance indicators the university would use to monitor progress. Include in the assessment how a university will link with regional government organisations, how it's KTO will complement or incorporate existing intermediary organisations, how it will develop links with industry and the extent of co-funding by regional government, alumni, industry and other organisations.
- Alternatively, provide significant supplementary funding, for research and KT, to those universities with strong performance in KT, based on specified indicators, and comprehensive KT strategies.
- Consider requiring universities to form holding companies- owned by the university - with an independent board, chaired by an appropriate person independent of the university and including directors with extensive industry experience.

- Review international experience and develop a set of KT indicators relevant to Vietnam.
- Develop a program to encourage and support universities to strengthen links with SMEs through consulting and short courses in specific areas of expertise that are of interest to industry.
- Provide scholarships for early career researchers (junior faculty and graduate research students) to carry out their research in enterprises.
- Draw on the experience of expatriate Vietnamese researchers and entrepreneurs working on other countries – for example, by offering short sabbaticals (innovator/entrepreneur in residence, fellowships for researchers to return to Vietnam. Review the experience of other countries, including Taiwan, that have sought to engage expatriate researchers and entrepreneurs.

3. Support the development of a National KT Organisation.

Objective

Develop a national association of KTOs able to guide and support the development of individual KTOs through sharing of experience, training and best practice guides.

Issues to Consider

- Many countries have national membership-based KTO organisations that organise support services for member KTOs, including best practice guides[26], training, recruitment and advocacy. Examples include the US Association of University Technology Managers and Knowledge Commercialisation Australia.
- A national KTO organisation could also collaborate with any sector-specific KTO/linkage organisations that develop.
- There are also international KTO member organisations, in which a Vietnamese national KTO organisation could usefully participate.
- A national support organisation is particularly important for smaller universities, that will find it difficult to recruit experienced KT professionals.
- A national KTO organisation could play a valuable role in collecting and compiling information based on KT performance indicators.
- There are many virtual 'technology' markets, of different types. Examples include AUTM's Technology Transfer Databases, the Enterprise Europe Network (EEN), Innocentive, Innoget, Yet2 Marketplace, IBridge Network, IP Marketplace, and Patent Auction[27].

Options

[26] For example: WIPO, **Intellectual Property Valuation Manual for Academic Institutions**. Intellectual Property Valuation Manual for Academic Institutions (wipo.int); WIPO, A Practical Guide for Valuing Intangible Assets in Research and Development Institutions. A Practical Guide for Valuing Intangible Assets in Research and Development Institutions (wipo.int)

[27] Dushnitsky, G. and Klueter, T., 2017. Which industries are served by online marketplaces for technology? *Research Policy*, *46*(3):651-666.

- Considering the current stage of development of KT activities and KTO organisations in Vietnam, government initiate the foundation of a national KTO organisation and provide support for the formation and for a professional secretariat for the initial period of operation, perhaps five years.
- Assess the scope for developing, or further developing, a national 'technology market', drawing on experience within Vietnam and relevant international experience.

4. Develop the Demand Side of KT and Strengthen University-Industry Links – An Enterprise-Centric Perspective

Objective

Ensure that the potential for universities to effectively support enterprise capability development is actively pursued.

Issues to Consider

- An effective role by universities in KT largely depends on a strong demand for knowledge from enterprises and a strong absorptive capacity[28] for new knowledge by enterprises.
- In addition to broad measures to encourage closer interaction between universities and industry, the goal of a greater contribution of universities to industrial development will be more likely to be achieved in the context of well-developed Industry Technology and Capability Development Strategies, whether at the national or regional level, that focus on priorities and address both demand and supply-side drivers and barriers.
- Recognising this, many countries have programs that aim to stimulate enterprise demand for knowledge. There is a diverse range of programs. One example is 'Technology Vouchers', which are awarded to selected firms and can be used to purchase support services (consulting, training, contract research) only from universities[29]. Other programs provide funding (on a competitive basis) to enterprises for specific innovation projects, but require that the applicant set-out how they will work with a university for the project.
- Universities can make valuable contributions to national programs for upgrading industry participation in global value chains, for upgrading in specific core technologies, including those for Industry 4.0, and for addressing industry innovation and capability for achieving SDG. Industry development initiatives to support upgrading in value chains will be more effective if they are designed to engage universities.
- It would be reasonable to expect MNCs in Vietnam to contribute to raising the capability of Vietnamese enterprises and to formalise those commitments through MOUs with

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[28] Scott-Kemmis, D., Jones, A.J., Arnold, E., Chitravas, C. and Sardana, D., 2007. Absorbing innovation by Australian enterprises: the role of absorptive capacity. Report on the Project for the Department of Industry, Tourism and Resources. https://immagic.com/eLibrary/ARCHIVES/GENERAL/AU_DIISR/I070402S.pdf

[29] Caloffi, A., Freo, M., Ghinoi, S., Mariani, M. and Rossi, F., 2022. Assessing the effects of a deliberate policy mix: the case of technology and innovation advisory services and innovation vouchers. *Research Policy*, *51*(6), p.104535; Ivashchenko, A., Kornyliuk, A. and Polishchuk, Y., 2021. Innovation Vouchers as a Modern Financial Tool for the Development of SMEs. *Baltic Journal of Economic Studies*, *7*(5), pp.78-87: Sala, A., Landoni, P. and Verganti, R., 2016. Small and Medium Enterprises collaborations with knowledge intensive services: an explorative analysis of the impact of innovation vouchers. *R&D Management*, *46*(S1), pp.291-302.

government. There would be opportunities to link Vietnamese universities with those activities.

- Coordination among the several government Ministries that fund research in universities and have policies, regulations or programs that significantly influence the KT system, is a challenge in many countries, including Vietnam. Many countries have addressed the problem of coordination by establishing high level (i.e., chaired by or reporting to the Prime Minister) organisations with a capacity to coordinate within government, and to some extent beyond. One approach is to form a 'Council' of relevant Ministers and representatives of major private and public sector organisations, supported by a professional secretariat. Such a Council can carry out or commission studies and reviews of issues, but its role is essentially awareness raising and advisory. An alternative approach is to form an agency empowered with the assessment and funding capability to launch significant new programs in STI that intersect with a number of Ministries[30].
- It would be unrealistic to expect a high proportion of enterprises to look to universities as major sources of technology. Recognise that levels of ambition, opportunity and capability are very different for different types of university and enterprise.
- Recognise that not all SMEs will choose to embark on the path of investment and change to upgrade capability.
- A significant proportion of innovation in all firms, including in Vietnam, is non-technological, and involves, for example, managerial, organisational or marketing innovation. Hence, KT activities need to involve academics and researchers beyond S&T.

Options

- Review how universities in Vietnam can best complement government programs aiming to develop managerial and technological capabilities in SMEs.
- Consider international experience in supporting capability development in SMEs and how best to strengthen mutually beneficial links between SMEs and universities.
- Assess the value of establishing university-based applied research and knowledge transfer centres, each with a specific technological focus and a primary objective of raising technological capability in industry. Such Centres would be linked to strategies for industrial upgrading. Similar international programs have often been awarded to universities on a competitive basis with selection based on research strengths, location, strategies for technology development and knowledge transfer and governance arrangements (usually involving an independent board with participation from industry). Typically, initial funding is for five years, with performance evaluation after one, three and five years. As such programs are challenging to design, manage and evaluate– and usually require coordination across agencies – begin with one or more pilot programs.
- Assess international experience in how to encourage MNCs to collaborate with universities in order to support KT and entrepreneurship.

[30] Glennie, A. and Bound, K., 2016. How innovation agencies work. *London, Nesta*.

5. Addressing the Proof_of_Concept Gap

Objective

Ensure that research outcomes with a high potential for significant value creation through innovation have an opportunity to demonstrate that potential.

Issues to Consider

- There is considerable frustration among researchers in Vietnam that promising research results are often not developed due to a lack of funding for pre-commercial proof_of_concept work involving technology development and systematic assessment of technical feasibility and market potential. In practice this gap is more than only a funding gap. It is a phase of potential commercialisation that bridges the context of university research and the context of industry innovation. Hence it usually also involves a re-orientation of the technology development project to new objectives and priorities, areas of expertise and time horizons.
- As universities retain earnings from KT activities, possibly including income from licencing and spin-offs, and as KTOs develop capabilities and resources, there will be an internal capacity to direct some funds to proof_of_concept projects.
- Many countries have developed forms of proof_of_concept funding for potential technologies developed in universities. These funding programs are competitive, focus on high potential projects, usually require co-funding by the applicant, and usually require that the proof_of_concept work is at least co-managed by professionals with industry and/or commercialisation experience.

Options

- Establish a national Early-Stage Commercialisation (Proof_of_Concept) Program suitable both for university-based startups based on university developed technology, and projects aiming to develop technologies within a university, or projects conducted within companies based on university developed technologies and conducted in collaboration with the originating university. Such a program might have two stages of support. An initial stage that provides modest funds for KTOs/researchers to carry out systematic assessments of technical and commercial feasibility, assess demand by approaching potential customers and developing a ‘path to market’. Decisions for this low cost first stage could be rapid, but nevertheless require some evidence of an assessment technical and commercial feasibility. Those projects that clearly demonstrate both potential and a convincing strategy would be candidates for the second stage, which could co-fund the implementation of the applicant’s plan.
- Develop for universities, and for the management of such a program, guides on the assessment and development of early-stage technologies and startups.

PART B

7 B. 1: THE EVIDENCE BASE: KEY FINDINGS FROM INTERNATIONAL STUDIES AND EXPERIENCE

7.1 The Scope of this Review of Evidence

The literature on technology transfer and knowledge transfer is very extensive. However, most studies of knowledge transfer are from mature economies with well developed (if not always high-performing) innovation systems with a significant number of research-intensive firms. The review draws largely on systematic reviews of conceptual and empirical studies, including those outside the OECD economies.

7.2 Changing Roles of Universities

The rising importance within national and regional STI policies on effective knowledge transfer has led to a reformulation of the social contract with universities and public research organisations. It is now expected that universities will develop a 'third mission', in addition to education and research. This 'third mission' has been defined as: *"…all activities concerned with the generation, use, application and exploitation of knowledge and other university capabilities outside academic environments"*[31]. As a result of these changes the senior managers of a university have a critical role in the development of policies and incentive structures that support a comprehensive approach to knowledge transfer and a culture that supports entrepreneurship and close industry interaction[32].

7.3 Enterprise Innovation- Sources of Information for Innovation

Enterprises generally draws on both internal and external knowledge sources in their innovation activities. While the knowledge and experience of employees and managers is critical for successful innovation, the external sources that are most often used by enterprises are customers, suppliers and other enterprises. Other sources, such as consultants, conferences, publications, government advisors and universities are usually less important sources for most firms. The importance of different sources tends to vary depending on the sector, size of firm and the strategy of the firm. As a generalisation, the importance of universities as sources of information for innovation increases with the size of firm and level of R&D. For knowledge-intensive enterprises with significant R&D activity, universities are likely to be much more important sources of knowledge for innovation, than is the case for enterprises in general[33]. Figure B.1.1 shows the proportion of firms placing a high level

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31 Galas-Mollart, J. et al. 2002: "Measuring Third Stream Activities. Final Report to the Russell Group of Universities", SPRU Science and Technology Policy Research

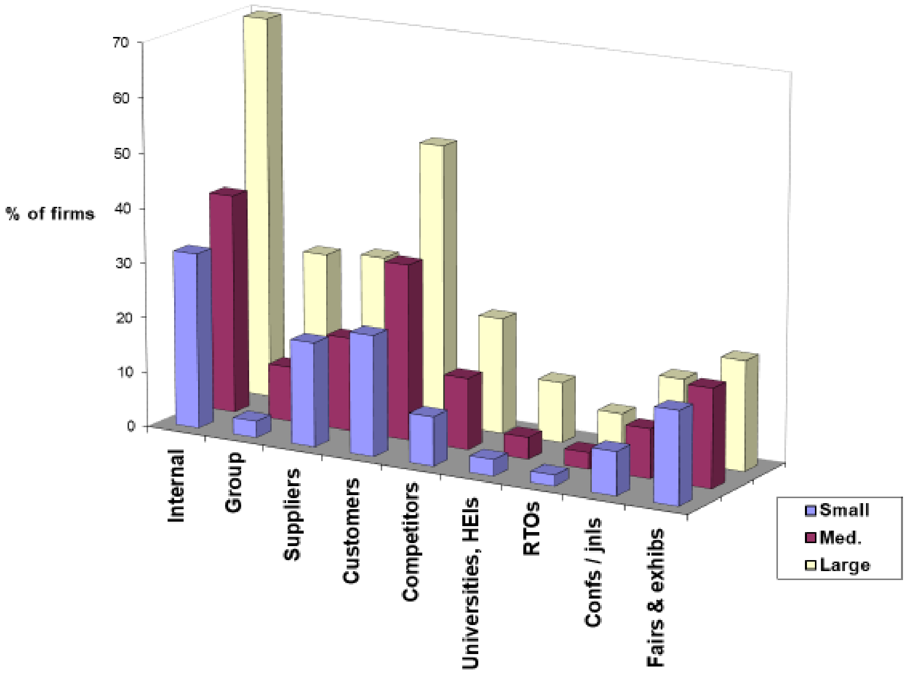
32 Di Gregorio, D. and Shane, S., 2003, 'Why Do Some Universities Generate More Start-ups than Others?', Research Policy, 32(2): 209–27.

33 See also: Mohnen, P. and Hoareau, C., 2003. What type of enterprise forges close links with universities and government labs? Evidence from CIS 2. Managerial and decision economics, 24(2-3), pp.133-145; Rõigas, K., Mohnen, P. and Varblane, U., 2018. Which firms use universities as cooperation partners?-A comparative view in Europe. *International Journal of Technology Management*, *76*(1-2), pp.32-57; Fitjar, R.D. and Gjelsvik, M., 2018. Why do firms collaborate with local universities?. *Regional Studies*, *52*(11): 1525-1536.

of importance on different sources[34]. The figure shows that the importance attached to universities and research organisations declines with the size of the enterprise.

In countries in which competitiveness is based primarily on resources (‘factor driven economies’) or low production costs due to low-cost labour and production scale (‘efficiency-driven economies’) the demand for knowledge is different from the that in innovation-driven economies. Even in OECD economies, the capacity of most firms to absorb new knowledge is generally low, as is their demand for new research-based technologies from universities. In less developed economies even few firms are innovating near the global innovation frontier and even fewer firms have strong absorptive capacities. The primary demand for most firms is for capable graduates – which will also increase absorptive capacity for knowledge[35].

Figure B.1.1: Main Sources of Information for Innovation in the EU, (Manufacturing)



Source: EU, CIS, 1998-2000

7.4 Industry Motivations in Interacting with Universities.

For many firms a key motivation in closer links with universities is the opportunity to recruit qualified and capable graduates. Access to knowledge that can solve problems and access to specialised facilities are key motivations for some firms[36]. Leading firms are attracted to interact with

34 The data that informs understanding of the sources of information for innovation in these studies is based on the Community Innovation Survey that is conducted every several years in all EU countries.

35 Marozau, R., Guerrero, M. and Urbano, D., 2021. Impacts of universities in different stages of economic development. Journal of the Knowledge Economy, 12(1), pp.1-21.

36 Peters, L. & K. Fusfeld, 1982, University-Industry Research Relationships, National Science Foundation, USA; Geisler, E. & A. Rubenstein, 1989. ‘University- Industry Relations: A Review of Major Issues’, in Albert Link & Gregory Tassey (eds), Cooperative Research & Development, Kluwa Academic Publishers.

universities based on the quality of their research and the reputation of their researchers, rather than, for example, proximity[37]. Other motivations for industry to interact with universities include[38]:

- access to research results from which new products and processes might evolve
- solutions to specific problems or specialised expertise
- access to facilities, not available in the company
- assistance in continuing education and training
- obtaining prestige or enhancing the company's image.

In interacting with universities firms are concerned about the potential costs of the processes of discovering useful new knowledge, negotiating access to that knowledge and acquiring and effectively applying that knowledge. The reputation of a university (and of a researcher) as a source of advanced and specialised knowledge, and as an effective knowledge transfer partner, attracts industry support[39].

7.5 University and Researcher Motivations for Interacting with Industry

The motivations for universities to develop closer interaction with business include[40]:

- finding a new source of money for university research - perhaps with less bureaucracy than government funds
- developing opportunities for students to learn about and work on 'real world problems'
- accessing funds from government that require collaboration with industry.

For individual researchers, recognition within their research community is often a major driver of behaviour and hence a community that values publications but not participation in direct knowledge transfer may provide disincentives for researchers to allocate time and resources to industry interaction. Accessing additional funding for research can be a strong driver where public funding sources are limited. Gaining greater personal income is usually a secondary driver, unless the salaries of researchers are relatively very low, the values of the research community support entrepreneurial activity[41].

7.6 Channels of Knowledge Transfer

Knowledge transfer between industry and universities or PRIs occurs through a wide variety of formal and informal channels. Licensing of patented knowledge is only one pathway through which research results can be used to create value, and in most cases one of the least important. Alternative pathways include: spin-offs, collaborative and contact research, ad hoc advice, teaching

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[37] Meyer, M., 2006, 'Are Patenting Scientists the Better Scholars?: An Exploratory Comparison of Inventor-Authors with Their Non-Inventing Peers in Nano-Science and Technology', Research Policy, 35/10: 1646–62; Mansfield, E. and Lee, J.-Y., 1996, 'The Modern University: Contributor to Industrial Innovation and Recipient of Industrial R&D Support', Research Policy, 25/7: 1047–58; Bruno, G. S. and Orsenigo, L. (2003), 'Variables Influencing Industrial Funding of Academic Research in Italy: An Empirical Analysis', International Journal of Technology Management, 26/2: 277–302.

[38] Peters, L. & K. Fusfeld, 1982, *op cit*

[39] Mansfield, E. and Lee, J.-Y., 1996, op cit; Schartinger, D., Rammer, C., Fischer, M. M., and Frohlich, J., 2002, 'Knowledge Interactions between Universities and Industry in Austria: Sectoral Patterns and Determinants', Research Policy, 31/3: 303–28; Mora-Valentin, E. M., Montoro-Sanchez, A., and Guerras-Martin, L. A., 2004, 'Determining Factors in the Success of R&D Cooperative Agreements between Firms and Research Organizations', Research Policy, 33/1: 17–40.

[40] Peters, L. & K. Fusfeld, 1982, *op cit*

[41] Di Gregorio, D. and Shane, S., 2003, 'Why Do Some Universities Generate More Start-ups than Others?', Research Policy, 32(2): 209–27; Link, A.N. and Siegel, D.S. (2007) *Innovation, Entrepreneurship, and Technological Change*, Oxford University Press, Oxford, UK

and supervision of graduate researchers, publications, staff exchanges, joint student supervision and informal external engagement. The movement of people is most important mechanism for knowledge transfer, as new graduates are employed by enterprises and other organisations – it is the core of university-industry knowledge transfer. It is also often the case that postgraduate students who go on to be employed in companies maintain links with their university, contributing to ongoing interaction. Closer university-industry interaction is also likely to modifying the curricula toward a stronger orientation to applied knowledge and research[42].

This role can be strengthened by approaches to education that improve the role of graduates in knowledge application, by for example:

- Ensuring that the curriculum includes elements relevant to the trajectory of innovation in industry
- Having capable specialists from industry provide input into course design
- Having capable specialists from industry provide lectures as elements of courses
- Include in the curriculum a number of alternative approaches to problem solving
- Provide opportunities for some exposure to or experience in industrial firms
- Include in the curriculum elements that develop entrepreneurial and particularly enterprise skills[43]

Licensing is not a significant source of income for most RTOs. Income to universities from licencing is highly variable across universities and across time. For US universities the annual average gross income over recent years is about 5% of annual research expenditure. For universities in the UK, Canada and Australia the income from licencing is usually in the 2-3% range[44]**.** The experience of the past 30 years has shown that in creating economic and social value from knowledge transfer a narrow focus on maximising revenue from licensing is counterproductive. Maximising the overall benefits to the economy, and the RTO, is more likely to be achieved when the full spectrum of knowledge transfer channels are developed.

Several studies have found that an increase in the emphasis on the patent/license channel has led to a reduction in research collaboration: *"..in some cases serious distributional conflicts arise with industrial partners. These in part come about by the unrealistic expectations held by universities about the commercial potential of university research, which can result in their overvaluing IP. Such conflicts with TTOs and university administration may put a significant strain on industrial collaborations and perhaps deter firms from collaborating with universities*"[45].

Table B.1.1: Channels for Knowledge Transfer

KT Mechanism	KTO Role / Activity
1. Exploiting research outputs	Facilitating research exploitation
Exploiting IP ('Technology Transfer')	Developing university IP policy IP advice for academics Patenting and managing IP Making/ supporting licensing deals, Establishing university spin-outs
Academic consulting	

[42] Link, A.N. and Siegel, D.S., 2007 *Innovation, Entrepreneurship, and Technological Change*, Oxford University Press, Oxford, UK.

[43] Scott-Kemmis, D., 2017. *The Role of VET in the Entrepreneurial Ecosystem*. National Centre for Vocational Education Research Ltd. PO Box 8288, Stational Arcade, Adelaide, SA 5000, Australia.

[44] Rigby, J. & Ramlogan, R. 2013. Support Measures for Exploiting Intellectual Property. Compendium of Evidence on the Effectiveness of Innovation Policy Intervention. NESTA and The University of Manchester.

[45] ibid.

Contract Research Collaborative R&D (and other publicly funded KT activities)	Academic consulting Supporting /managing academic consulting, contract research Collaborative R&D: Identifying opportunities Brokering teams Supporting/writing bids Agreeing contracts Project management Customer relationship management
Other KT activities that support all of the above Business liaison/ business development Marketing and communications Point of contact for businesses Business liaison /relationship management Changing university culture Internal communications Raising awareness among academics of importance of KT 'Selling' the KTO internally Disseminating KT best practice KT training Entrepreneurship education/training: for staff & students / for external organisations	
2. Knowledge diffusion / networking (informal interactions)	Facilitating networking and knowledge diffusion Events Newsletters / websites Alumni networks Networking with professional organisation / trade associations Academic networking
3. Developing skills	Enabling access to recent graduates/ career services Providing access to CPD / lifelong learning Short training courses for businesses Business funded PhDs / Masters Work placements for students Joint curriculum development Temporary staff exchanges
4. Community development/ public engagement	Public lectures/events /open days Newsletters Supporting local regeneration
5. Exploiting the physical assets of universities	Science parks/ incubators Enabling access to equipment and facilities Exchange/sharing of research materials

Source: Technopolis, 2015

There is strong evidence that **interpersonal networks and relationships** across universities and enterprises are of vital importance to knowledge transfer, including commercialisation – and are usually more important than formal channels. Hence, network development is a critical component of university KT strategies[46]. Researchers who are active in external networks are more likely to

[46] Technopolis, 2021. Knowledge exchange and place: A review of literature. Technopolis (See Section 3.3); Hughes, A. et al., 2016. 'The Changing State of Knowledge Exchange: UK Academic Interactions with External Organisations 2005 -2015', NCUB, London.

recognise the commercial potential of new knowledge. This awareness enables them to be more active in knowledge transfer also in recognising the potential for commercialisation through a spin-off[47]. Network development can be facilitated by, for example: employee training services, workshops, consulting, conferences, guest lecturers, placements on advisory boards and student placements.

Contract research and consultancy is usually provided in response to firm needs for problem solving or a need for specialised expertise. Consultancy services generally apply the existing knowledge resources of university staff, whereas contract research involves some level of search for new information, possibly involving research. In many (perhaps most) cases contract research and consulting generates substantially greater income than does licencing[48].

The rate of university **spin-off formation** in the US, UK and Canada grew strongly in the 1990, but more slowly in the 2000-2010 period, despite an increase in the overall level of R&D expenditure. Research indicates that strong performance in the rate of spin-off formation is associated with: clear and proactive strategies of the university; the quality of leading researchers; the business capabilities of TTO personnel; IP protection; involvement of experienced VC investors; networking capabilities of the spin-off; and the support (including equity investment) of the university[49].

7.6.1 Developing Effective Knowledge Transfer

At the level of the university, a wide range of factors influence the effectiveness of a university's knowledge transfer activities – Table B.1.2. Most of the factors in this table are those that are within the scope of a university's management, although some are essentially factors outside this scope, for example, the level of government funding and the IP regime.

One of those factors within the scope of university management is the role of TTOs. In view of the significant differences in values, culture, organisation etc between universities and industry, TTOs, as intermediary organisations that can bridge these gaps, play a vital role – if they are staffed, guided and funded adequately.

Table B.1.2 Performance drivers of university technology transfer[50].

Category	Performance drivers
Human resources	The quality of faculty members.
	The number of faculty members
	The number of faculty members of scientific and technological departments.
	The number of postdoc fellows and full-time researchers.
	The number of full-time equivalent employees in university technology transfer offices.
Institutional/culture resources	The entrepreneurial-oriented culture and tradition of university.
	The age and the experience of university technology transfer offices.

[47] Baron, R. A. and Markman, G. D., 2003, 'Beyond Social Capital: The Role of Entrepreneurs' Social Competence in Their Financial Success', Journal of Business Venturing, 18/1: 41–60; Colyvas, J., Crow, M., Gelijns, A., Mazzoleni, R., Nelson, R. R., Rosenberg, N., and Sampat, B. N., 2002. 'How Do University Inventions Get into Practice?', Management Science, 48/1: 61–72; Feldman, M. P. and Desrochers, P., 2004, 'Truth for Its Own Sake: Academic Culture and Technology Transfer at Johns Hopkins University', Minerva, 42/2: 105–26.;

[48] Perkmann, M. et al 2013, op cit. Many universities allow academics to work on consultancies for a part of their time, sometimes with a requirement to share the income with the university and/or research group. It is recognised that such personal links are vital for developing wider university-business interaction.

[49] Rothaermel, F.T., Agung, S.D. and Jiang, L., 2007. University entrepreneurship: a taxonomy of the literature. Industrial And Corporate Change, *16*(4), pp.691-791.; Rigby, J. & Ramlogan, R. 2013. Support Measures for Exploiting Intellectual Property. Compendium of Evidence on the Effectiveness of Innovation Policy Intervention. NESTA and The University of Manchester.

[50] Rybnicek, R. and Königsgruber, R. 2018.What makes industry–university collaboration succeed? A systematic review of the literature. *Journal of Business Economics,* 89: 221–250

University's location	Universities in locations characterized by a relative high concentration of technology firms, industry research, and an entrepreneurial climate.
	University-wide incentive program for faculty members to become involved in activities related to technology transfer.
	Interdisciplinary research Interdisciplinary research centers or interdisciplinary research projects of universities.
	Entrepreneurship development programs
	Entrepreneurship development programs to deliver entrepreneurship education.
Financial resources	Industry funding Industry funding to support university research.
	Government funding to support university research.
	A university's expenditure on associated intellectual property protection.
	Funding on the commercialization of intellectual property.
Commercial resources	Incubators
	The number of university invention disclosures
	The faculty members' entrepreneurial capability
	The faculty members' entrepreneurial experience
	The university's connection between industry, venture capitalists, academia, and government
	The international and domestic patent protections.
	University inventions with proofs of concept or prototypes.

Source: Rybnicek and Königsgruber, 2018

7.6.2 The Roles and Capabilities of KTOs

In an RTO with a comprehensive strategy for knowledge transfer KTOs have a demanding range of roles[51]:

- IP management and licensing (receiving invention disclosures, assessing potential and patentability, IP protection, market research, licensing negotiation, revenue distribution
- Managing the RTO patent portfolio
- Liaison with business (information acquisition and dissemination, promotion and marketing, networking, research contract negotiation)
- Liaison with other KTOs
- Liaison with relevant government agencies at local, regional and national level
- Supporting spin-offs/ entrepreneurship, developing an incubator, links with VCs and business angels
- Proof of concept and seed funding
- Professional development

KTOs have to strike two challenging balances:

- Between technology push – promoting the transfer of RTO knowledge to industry – and demand pull- responding to the problems and needs of industry
- Between pursuing the interests of the RTO as defined by senior management and the interest of the researchers generating the knowledge to be transferred

[51] Speser, P.L., 2012. The art and science of technology transfer. John Wiley & Sons; Breznitz, S.M. and Etzkowitz, H., 2016. University Technology Transfer. Routledge; Hockaday, T., 2020. University Technology Transfer: What it is and how to Do it. JHU Press.

In many universities, newly established TTOs are not effective, due to: the lack of experienced and professional staff, lack of incentives for researchers to disclose inventions, and unclear policy at the level of the university /research organisation[52]. As, only quite large research-intensive universities or large PROs can maintain a range of TTO staff with the full suite of required knowledge and skill, drawing on external expertise (eg for patenting, marketing, decisions regarding new ventures etc) is often essential. Many universities and PROs lack capabilities to support staff and students who aim to develop a spin-off from their research. Older KTOs with more experienced staff and staff with prior industry and marketing experience have stronger KT performance[53]

KTO strategies also need to take into account the motivations of researchers in KT activities. Although motivations will vary with the context, some studies have found that academics are motivated to engage with industry largely to further their research rather than to commercialise it. Similarly, involvement in contract research, joint research, and consultancy is often motivated by the objective of obtaining funding to pursue research goals[54]. Where the income of academics is relatively low, financial motivations are likely to be stronger. Provision of financial incentives for university staff has a positive effect on KT performance[55].

To be effective TTOs need to be active intermediaries. This involves building close links with the researchers in the RTO to understand their research and assess its potential for (and approach to) commercialisation and to develop a relationship of trust, and also building networks with business in the local area and beyond. It is essential to realise that the active participation of the lead researchers/inventors in cases of commercialisation of new technology contributes significantly to higher and faster commercial success[56].

Recognising the need for the professional development of KTO staff there are now many initiatives for staff development. The US Association of University Technology Managers (AUTM), the European Association of Research Managers and Administrators (EARMA), Praxis Unico and ISIS Innovation in Oxford provide knowledge transfer consulting and training[57].

To have a foundation for effectiveness KTO require[58]:

- A clear and well communicated RTO strategy for TT, based on institutional goals and priorities supported by the leadership.
- An institutional culture that values translational research and commercialisation, supported by recognition and support for those involved.
- Allocation of staff and other resources based on strategic choices regarding the modes of knowledge transfer (licensing, spin-offs, collaboration) and the relative importance of

[52] Wright, M., Clarysse, B., Mustar, P., Lockett, A., 2008. Academic Entrepreneurship in Europe. UK Edward Elgar, Cheltenham.

[53] Siegel, D. S., Waldman, D. and Link, A., 2003. 'Assessing the Impact of Organizational Practices on the Relative Productivity of University Technology Transfer Offices: An Exploratory Study', Research Policy, 32/1: 27–48; Conti, A. and Gaule, P., 2011. 'Is the US outperforming Europe in University Technology Licensing? A New Perspective on the European Paradox', Research Policy, 40/1: 123–35; Barjak, F., Es-Sadki, N. and Arundel, A., 2015. The effectiveness of policies for formal knowledge transfer from European universities and public research institutes to firms. *Research Evaluation*, *24*(1): 4-18.

[54] Perkmann et al., 2015; D'Este and Permkann, 2011

[55] Siegel, D. S., Waldman, D. and Link, A., 2003. 'Assessing the Impact of Organizational Practices on the Relative Productivity of University Technology Transfer Offices: An Exploratory Study', Research Policy, 32/1: 27–48; Friedman, J. and Silberman, J. (2003) 'University Technology Transfer: Do Incentives, Management, and Location Matter?', The Journal of Technology Transfer, 28/1: 17–30.

[56] Link, A.N., Scott, T. and Siegel, D.S., 2003 'The economics of intellectual property at universities: an overview of the special Issue', *International Journal of Industrial Organization*, Vol. 21, No. 9, pp.1217–1225; Siegel, D.S., Waldman, D., Atwater, L. and Link, A.N., 2004 'Toward a model of the effective transfer of scientific knowledge from academicians to practitioners: qualitative evidence from the commercialization of university technologies', *Journal of Engineering and Technology Management*, Vol. 21, Nos. 1–2, pp.115–142.

[57] See also https://attp.global/

[58] Phan, P.H. and Siegel, D.S., 2006. The effectiveness of university technology transfer. *Foundations and Trends in Entrepreneurship*, *2*(2): 77-144.

regional economic development. Funding, whether from internal or external sources to support commercialisation process.

- Knowledge/Technology Transfer Offices with capable and experienced staff and with leaders with the standing to champion the process and win support from both researchers and business.
- Incentives for researchers are critical for effective technology transfer and the evidence suggests that approaches that direct a high share of revenue to the inventors are more successful. However, in considering revenue shares it is essential to also consider the (direct, transaction and opportunity) costs of patenting and commercialisation.
- Approaches to incentives and support that do not involve a significant administrative burden for researchers.
- Strong relationships and good formal and particularly informal communications between TTOs and researchers.

The following section of this review focuses on the types of barrier that impede effective KT from universities. Table B.1.3 brings together, for different dimensions of the KT context, identification of factors that support KT and those that are barriers to effective KT[59]. This Table lists many of the issues raised in this section of the review and expands on the previous table by identifying additional KT performance factors beyond the control of individual universities.

Table B.1.3: Summary of critical success factors for knowledge-transfer university-industry collaborations

Dimension of KT	**Enabling Factors**	**Barriers**
Knowledge Context	• partners' mutual confidence • strong translational focus • alignment of research objectives and with partners' strategic objectives	• industry's ambitions to commercialize results in a short-term • misalignment between research and commercialization objectives
Organizational Context	• university ranking • support at the senior level • network assets • policies and incentives for knowledge transfer activities • risk taking propensity • well-developed IP strategy	• difficulties to identify project ownership • complex organizational structure • low buy-in at a junior level • lack of resources and protected time • difficulties in delegation and controlling results • risk aversion
Decision making Context	• support at senior management level • decision on project ownership at an early stage	• institutional bureaucracy • lack of ownership • multiple priorities

[59] Schofield, T., 2013. Critical success factors for knowledge transfer collaborations between university and industry. *Journal of Research Administration*, *44*(2), pp.38-56.

	• framework for assessing feasibility of international collaborations	
Individual Context	• relative academic freedom • academic champion • entrepreneurial expertise • personal motivation • personal goals	• lack of incentives • lack of personal motivation • time pressure • multiple competing objectives
Project Management	• flexibility and adaptability • strong project management • industry early involvement in the process • past experience of partners • effective communication	• process complexity • multiple stakeholders with different objectives • geographic distance • complex information flow and logistics • time pressure
Market Context	• supportive national Government • absorption capacity and ability to learn from best practice • strong market knowledge • thorough due diligence analysis • risk assessment and mitigation strategies	• uncertainty related to long-term development • emerging markets bureaucracy • political context • complex legal framework • limited knowledge transfer experience in emerging markets • lack of national benchmark to evaluate successful collaboration
Relational and Cultural Context	• knowledge of national culture • trust and openness • long-term commitment • knowledge of local language	• lack of cross-cultural understanding • different cultural values • different levels of business skills and acumen between partners • focus on quick wins

Source: Schofield, T., 2013.

7.7 Key Barriers to Effective Knowledge Transfer

A wide range of barriers continue to limit effective knowledge transfer in all countries- Figure B.1.2.

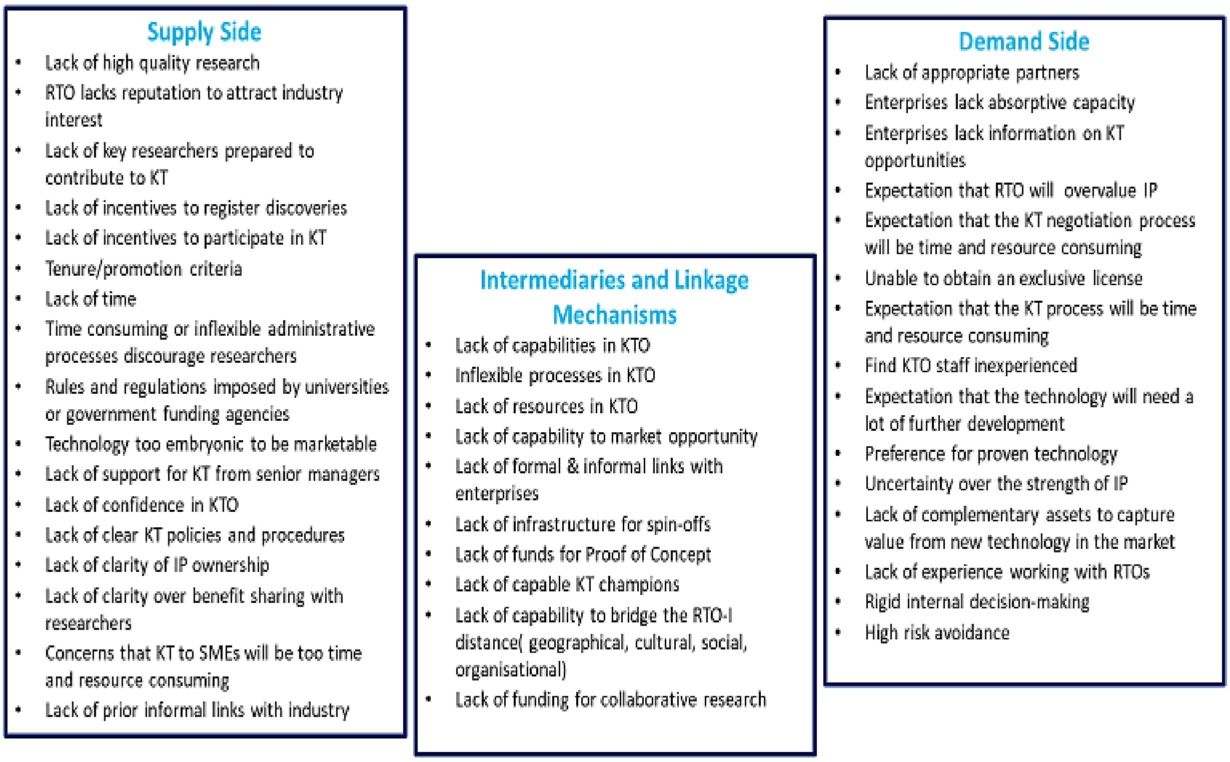
Behind these specific barriers are several fundamental factors that create systemic challenges for effective KT:

- **Information Asymmetries.** Good communication is vital for initiating and managing knowledge transfer, but a fundamental challenge arises from information symmetry- enterprises often have difficulty evaluating both the potential of IP or new knowledge and the challenges of commercialisation. Researchers may have difficulty communicating their findings in terms that identify practical implications and are understood by industry and also difficulty assessing the commercial potential of their new knowledge. This makes a foundation of shared trust and confidence particularly important.

TTOs cannot know all of the potential industry partners nor what their potential to use new knowledge might be. Potential industry partners cannot know all of the potentially valuable new knowledge in research organisation, nor what the full range of applications of that knowledge might be. Neither can know all the challenges that effective commercialisation might face.

- **Uncertainty.** Uncertainty is a challenge for all participants in knowledge transfer. There are several sources of uncertainty:
  - Technological – will the technology developed using the new knowledge perform as expected
  - IP – is the ownership of IP (including background IP) and the principles for the sharing of the benefits of commercialisation sufficiently clear
  - Capability – will the partners have the technological capabilities to enable effective commercialisation
  - Managerial - will the partners have the managerial capabilities to enable effective commercialisation
  - Inter-organisational – will the partners in the commercialisation collaborate effectively
  - Market and competition – will innovation based on the new knowledge be successful in the market

Figure B.1.2: Barriers to Effective Knowledge Transfer from Universities and PROs



Source: Authors compilation

- **Differences in Objectives, Organisation and Culture.** RTOs and enterprises have important differences in many dimensions, including time horizons, attitudes to confidentiality/secrecy, personal motivations. Relationships developed overtime usually reduce the level of the barriers that are due to these types of 'distance'. This leads to a greater risk of a lack of understanding between the parties to the knowledge transfer. These are reasons why the 'soft infrastructure' of KTOs, based on networking, personal interactions and personnel exchanges, play a key role in supporting knowledge transfer[60]. Proximity (geographical, cognitive, cultural and organisational) generally supports effective knowledge transfer. To some extent, this is one reason why many researchers find it easier to develop initial communications with SME than with large firms, as the informality of small firms contrast with the formality of large firms[61] - See Box 7.1

- **The Role of Trust.** It is very difficult to develop effective knowledge transfer relationships without a foundation of trust[62]. Commercialisation usually involves significant uncertainty – uncertainty that the technology will perform as expected, that the market demand exists, that the partners have the required capabilities and can collaborate effectively etc. Formal contractual agreements cannot address all possible issues and eventualities with no ambiguity. Transparency, communication, clarity and alignment of objectives contribute to trust in knowledge transfer relationships: "..if the parties do not have a sufficient foundation of relationship and a shared understanding of each other's values, goals, needs and drivers, this can inhibit both the contract process and the prospects for collaborative success."[63] But it is unlikely to develop well without a background of shared values and understanding based on having worked together previously, even if informally.
  Strong relationships built over time from experience generally enable a two-way flow of knowledge, leading to deeper understanding of each party's interests and capabilities. These relationships can develop into genuine strategic alliances, whereas interactions where relationships are weak tend to be transactional with a one-way flow of knowledge[64]. Individual researchers able to communicate well, and develop trust-based relationships with collaborators have a positive impact on knowledge transfer. The development of trust is a particularly important aspect of inter-personal and inter-organisational (which are still essentially inter-personal)[65]. Successful knowledge transfer often involves an ongoing involvement by the principal research and hence the preparedness of that individual to communicate and commit time to the knowledge transfer process may be critical.

60 Battistella, C., De Toni, A.F. and Pillon, R., 2016. Inter-organisational technology/knowledge transfer: a framework from critical literature review. The Journal of Technology Transfer, 41(5):1195-1234; De Wit-de Vries, E., Dolfsma, W.A., van der Windt, H.J. and Gerkema, M.P., 2019. Knowledge transfer in university–industry research partnerships: a review. The Journal of Technology Transfer, 44(4): 1236-1255.

61 Battistella, C., De Toni, A.F. and Pillon, R., 2016. Inter-organisational technology/knowledge transfer: a framework from critical literature review. The Journal of Technology Transfer, 41(5), pp.1195-1234.

62 Fountain JE, 1998. 'Social capital: a key enabler of innovation', in Branscomb LM and Keller JH (eds), Investing in Innovation: Creating an Innovation Policy That Works, The MIT Press, Cambridge Massachusetts

63 Higher Education Research Commercialisation IP Framework: Consultation Framework. 2021. Department of Education, Skills and Employment. https://www.dese.gov.au/higher-education-reviews-and-consultations/resources/higher-education-research-commercialisation-intellectual-property-framework. p.19

64 Finardi, U., Rolfo, S. and Bianco, I., 2021. Technology Transfer Activities in Universities and Public Research Organizations: A Literature Overview. CNR-IRCrES, Torino. Hence there is a strong element of cumulativeness and positive feedbacks in building effective RTO-industry interaction; Battistella, C., De Toni, A.F. and Pillon, R., 2016. Inter-organisational technology/knowledge transfer: a framework from critical literature review. The Journal of Technology Transfer, 41(5): 1195-1234; Geuna, A. and Muscio, A., 2009. 'The Governance of University Knowledge Transfer: A Critical Review of the Literature', Minerva, 47/1: 93–114.

65 Oliver, A. L., Montgomery, K., & Barda, S., 2019. The multi-level process of trust and learning in university–industry innovation collaborations. The Journal of Technology Transfer.

Box 7.1: Intermediaries and Inter- Organisational Distance

"*..transferring technology and knowledge across dissimilar actors is challenging. Innovation projects in collaboration with public research organizations are more likely to fail... university spin-offs meet significant barriers when they enter the business world. and university licenses are typically related to embryonic technologies….Actors that are cognitively proximate perceive, interpret, understand, and evaluate the world in similar ways …Organizations with similar routines and rules may collaborate more easily because of organizational proximity. Actors that have developed trust, friendship, kinship, and common experiences are socially proximate….A minimum level of cognitive proximity is required for collaboration to take place. In cognitively distant collaborations, the collaborating parties less efficiently recognize and absorb external knowledge because it is grounded in norms, principles, and concepts that differ from their own ... Hence, effective and efficient communication and transfer of knowledge depend on some degree of similarity in collaborating partners' frames of reference*." (p.87) *".., intermediary organizations– located at the boundary between different institutional fields – perform specific tasks to mitigate the cognitive, geographical, social, and organizational distance experienced by cooperating parties….intermediary organizations can purposefully reduce cognitive, organizational, geographical, and/or social distance…[S]tudies have found that technological proximity was more relevant than geographical proximity in favouring knowledge and technology exchange….intermediary organizations represent an important tool by which proximity dimensions can be managed in U–I collaborations [if they are]….skilled at using strategic activities that result in reduced cognitive, organizational, geographical, and social distance between actors and, therefore, make collaboration more efficient."*[66]

- **Valuation of IP.** Long delays in reaching an agreement over IP terms, or university actions to maximize their potential revenue can discourage university–industry collaboration. Potential licensees often consider that RTOs overvalue their IP. There has been a strong trend in RTOs in OECD countries to shift their knowledge transfer focus from maximising the returns from licensing – by, for example, vigorous negotiation over royalty rates – to maximising the overall benefits from interaction with industry. This wider view considers the benefits to the core mission of universities (teaching and research) and the core mission of both universities and PROs (social benefit) beyond short term income. One expression of this re-orientation is the Easy Access IP project in the UK, through which firms can obtain access to universities' IP, so maximizing knowledge transfer from universities for the overall public benefit.
- **Transaction Costs.** Problems that arise due to, for example, poor communication, cultural and organisational differences, and significant differences in assessed value of the IP, can lead to difficult and protracted negotiations. For enterprises, bureaucracy and inflexible processes, slow decision making and inexperience project management in RTOs, cause delays and raise uncertainty. This raises the transaction costs for both parties. Uncertainties over the inherent potential of a technology and the path to market add an underlying anxiety in the industry partner. It is not uncommon for enterprises that have experience high transaction costs with a particular RTO to avoid dealing with that RTO in the future.

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[66] Villani, E., Rasmussen, E. and Grimaldi, R., 2017. How intermediary organizations facilitate university–industry technology transfer: A proximity approach. *Technological forecasting and social change*, *114*, pp.86-102, p98

- **Guidelines for IP Negotiation and Management.** Difficulties in reaching agreement over the IP-related aspects of knowledge transfer contracts are frequently a barrier to effective collaboration. Many factors can contribute to misunderstanding and disagreement and raise the cost of negotiation and ongoing cooperation. In order to try to reduce these costs and contribute to more effective knowledge transfer relationships many organisations have developed principles, guides or toolkits that can serve as models for agreements[67].

7.8 Knowledge System Development and Strengthening

The US Bayh-Dole Act of 1980 provided a legal framework of property rights that enabled US universities to own inventions derived from federally funded research and to grant exclusive licences for the application of those inventions. This framework replaced the previous complex arrangement in which different agencies had different regulations. The Act also required universities to be active both in taking out patent protection and in encouraging the commercial application of that IP. Since 1980 most OECD economies and many others have introduced legislation modelled on the Bayh-Dole Act[68]. Patenting by universities has grown strongly since the 1990s – although in many OECD economies that growth slowed more recently. Patenting by universities in Korea and China grew remarkably rapidly in the 2000's.

Governments aim to ensure that the knowledge assets of universities, including intellectual property generated through research, is used as effectively as possible to contribute to social and economic development. Government programs that provide incentives for university-industry links and collaboration can be effective, but must be designed for the specific context[69].

Many governments have provided support for the development and performance of the technology transfer, typically through:

- Support for developing capabilities and infrastructure, such as KTOs;
- Support for coordination among KTOs;
- Support to assist commercialisation of research, particularly early-stage support for 'proof of concept' in technology development projects and the 'pre-seed' stage in entrepreneurial ventures based on research outcomes[70]. Support for KTO development and/or operation is sometimes based on competitive selection but support for early stage 'proof of concept' projects always is.

Gap Funding

A challenge in all countries is the funding of early-stage commercialisation, whether in a project within a research centre or TTO in a university, or in a new venture based on new knowledge. In the early stages of commercialisation the levels of uncertainty (for both technical and commercial feasibility) are high and consequently the levels of risk discourage external investors. Precisely

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[67] See also: Australian Research Council, 2018; Association of European Science & Technology Transfer Professionals, 2021. US Association of University Technology Managers (n.d); British Private Equity & Venture Capital Association) (n.d.); Cornell University, Institut Européen d'Administration des Affaires & World Intellectual Property Organization (2020); UK Intellectual Property Office (2018); IP Australia (2016) ; WIPO (n.d.); WIPO (n.d. b) *IPAG (Intellectual Property Agreement Guide) model agreements,* (https://www.wipo.int/amc/en/center/specific-sectors/rd/ipag/); WIPO (n.d. c) Intellectual property policies for universities, (https://www.wipo.int/about-ip/en/universities_research/ip_policies/); https://www.gov.uk/lambert-toolkit

[68] For example, see: Geuna, A. and Rossi, F., 2011. Changes to university IPR regulations in Europe and the impact on academic patenting. *Research Policy*, *40*(8): 1068-1076.

[69] For example, one of the several programs supporting knowledge transfer in the UK was reviewed in 2015: https://www.gov.uk/government/publications/the-knowledge-transfer-partnership-programme-an-impact-review

[70] Technopolis, 2015.

because of uncertainty and risk, not all commercialisation projects where there is a roadblock due to the need for support for 'proof of concept' can be funded. While there is a strong case for public investment to address the 'proof of concept' gap, assessment is essential to focus on the cases with the highest potential. This is why in all countries the programs that aim to address the problem of gap funding are based on competitive selection. There is considerable diversity in programs for early-stage funding, but many address both technological and non-technological dimensions (eg market research), and many require some form of project governance by personnel with extensive experience in commercialisation[71].

7.9 From Technology Transfer to Knowledge Transfer

The role that universities can, and increasingly are expected to, play in the development of an economy go beyond teaching, research and technology transfer. Knowledge transferred through all of the channels contributes to the diffusion of knowledge stimulating problem-solving, productivity improvement and innovation in the private and public sectors. Generally, knowledge transfer through consulting, contract research, collaborative research, personnel exchanges and other informal interactions is far more important (and a more significant source of income to universities) than technology transfer.

Knowledge transfer involves many processes and channels and many actors with diverse capabilities and motivations whose behaviour is shaped by a wide range of policies, many designed to pursue other objectives. What could be considered the knowledge transfer system is multidimensional and complex. International experience with regional and national policies to support knowledge transfer suggest that:

- a comprehensive and systemic approach is needed that addresses the development of legal frameworks, funding and capabilities, and the reduction in barriers, throughout the system
- the approach should ensure coherence at the national, regional, industry and RTO levels
- policies and programs need to evolve as all actors develop experience and capability and new issues are identified
- policies should be informed by performance evaluation based on relevant indicators and systematic surveys and focused assessments of the impacts of specific policies and programs.

Governments in OECD countries are increasingly expecting universities to develop and implement comprehensive and systematic KT strategies, including the development of capabilities for more effective KT[72]. The major types of national and regional policies to support knowledge transfer include[73]:

- National programs to support collaborative RTO-industry research- Support the development of national information resources and intermediary mechanisms that enable

[71] The international experience is that the management of the proof of concept stage should not be left to researchers/entrepreneurs without extensive industry or commercialisation experience. Technopolis, 2015

[72] This shift in orientation toward overall KT, rather than a focus on TT, is captured in the concept of the 'third mission' and also the various approaches to the 'entrepreneurial university'.

[73] Based in particular on: Kochenkova, A., Grimaldi, R. and Munari, F., 2016. Public policy measures in support of knowledge transfer activities: a review of academic literature. *The Journal of Technology Transfer*, *41*(3): 407-429; Sandström, C., Wennberg, K., Wallin, M.W. and Zherlygina, Y., 2018. Public policy for academic entrepreneurship initiatives: A review and critical discussion. *The Journal of Technology Transfer*, *43*(5): 1232-1256; Siegel, D.S., 2012. Academic entrepreneurship: Lessons learned for university administrators and policymakers. In *Creating Competitiveness*. Edward Elgar Publishing; Barbolla, A.M.B. and Corredera, J.R.C., 2009. Critical factors for success in university–industry research projects. *Technology Analysis & Strategic Management*, *21*(5): 599-616; Schofield, T., 2013. Critical success factors for knowledge transfer collaborations between university and industry. *Journal of Research Administration*, *44*(2): 38-56.

business (including SMEs) to locate potentially relevant knowledge and RTOs and negotiate mutually beneficial KT agreements, for example, the US Cooperative Research Act, Small Business Innovation Research program and the US National Science Foundation's industry-university cooperative research centres program.

- Support the development of science parks and similar initiatives that foster collaboration
- National programs to support high potential commercialisation projects with industry participation
- Establishing a national competitive Proof of Concept fund
- Establishing a national competitive Start-up Seed fund, or collaborate with VCs to establish a joint Seed fund for start-ups
- National programs to support KTOs through funding and central professional development, for example, Canada's Commercialisation Management Grant program.
- Provide government funding to RTOs to develop professional KTOs by hiring staff and developing management systems, and possibly also covering some patenting costs (for example Ireland's Technology Transfer Strengthening Initiative, 2007-2016).
- KTOs in different RTOs be encouraged to form membership organisations to organise shared training and policy development and advocacy (for example, Knowledge Commercialisation Australia (KCA) is jointly run by the universities and PROs and organises information sharing and training; Israeli Technology Transfer Organisation (ITTN) coordinates the work on KTOs on policy issues.)
- Creating a national organisation to provide support services (training, professional development, policy communication) to KTOs in the RTOs. Such central organisations might also develop searchable databases of licensing opportunities and research experts for industry (for example Knowledge Transfer Ireland)
- Creating a national KT organisation (for example Exploit Technologies Pte Ltd in Singapore) to serve some or all RTOs
- Supporting the development of an association of KTO (KT Alliance), through which they can share experience, information and jointly organise training
- Develop appropriate KT performance indicators and implement a regular KT survey
- Including KT performance into the assessment and funding of RTOs
- Monitor and evaluate national KT policy effectiveness through formal evaluations each 5 years to ensure effective policy learning and continuous improvement
- Organising national or regional events to raise awareness of the potential for KT
- Strengthening innovation capabilities in industry: absorptive capability (i.e., the capability to identify, acquire and apply new knowledge) and more generally the capabilities for innovation and competitive production. Developing policies for knowledge transfer from RTOs are likely to have very limited results of local industry has no demand for new

knowledge or lacks the capabilities to apply new research-based knowledge that has not been commercialised.

- Policies to support startups and spinouts including support for incubators.

7.10 Knowledge Transfer Policies- Policy Instruments

Knowledge transfer systems are complex and are shaped by the past and current policies and behaviour of organisations in the private and public sectors. Even within the government sector, coordination among agencies is often a major challenge. As KT is a vitally important aspect of the performance of national and regional innovation systems, government have been developing an increasingly wide range of policy instruments that aim to strengthen KT systems and influence the behaviour of actors, both organisations and individuals. Table YYY provides an overview of the main KT policy instruments and indicates both the KT channel the instrument is focused on and whether it is directed to the supply (university, PROs and VC investors) side or the demand (largely enterprise) side[74].

7.10.1 Learning, Monitoring and Evaluation

Policies for KT system development and performance have been and continue to evolve [see Appendix 2: Case Studies]. The broad trends in KT policy are outlined below[75]:

- A stronger recognition that KT policies are a subset of national STI policies and that KT performance will be strongly influenced by the overall STI context.
- Recognising the key role that the characteristics of the business sector have for KT policies and performance there has been an increasing emphasis on the demand side, i.e., on stimulating industry demand for knowledge
- A recognition that an effective knowledge transfer system will require long term investment in building linkages.
- Regional governments are playing an increasing role in promoting and supporting knowledge transfer.
- The number and diversity of intermediary organisations, including KTOs and incubators, has grown and with experience have become more effective – this represents forms of (ongoing) institutional innovation that support KT.
- Recognition that encouraging patenting does not contribute significantly to KT – and may reduce the extent of KT through other more significant channels. Much more important is the mobility of people between industry and universities.
- A recognition to relying one or a few indicators of KT performance (eg publications, or patents, or licencing revenue or startups) is likely to have adverse effects by encouraging excessive emphasis on those channels.
- Support for academic spin-offs has increasingly focused on support for high-potential startups rather than increasing the number of spin-offs.

[74] OECD, 201), "Policy instruments and policy mixes for knowledge transfer", in University-Industry Collaboration: New Evidence and Policy Options, OECD Publishing, Paris

[75] These observations are based largely on trends in OECD economies. OECD, 2019. Science-Industry Knowledge Exchange. OECD: Paris. Rigby, J. & Ramlogan, R. 2013. Support Measures for Exploiting Intellectual Property. Compendium of Evidence on the Effectiveness of Innovation Policy Intervention. NESTA and The University of Manchester.

- Digital platforms are increasingly being used to support industry-research interaction.
- The number of programs that support collaborative R&D, particularly in joint research facilities, has increased.
- Toolkits, Guidelines and 'model contracts' have been developed to support knowledge transfer by lowering the costs and uncertainties in commercial arrangements between firms and universities[76].

Knowledge transfer systems in the case study countries and more generally have become more effective over time through many incremental improvements in policies and regulations, the slow development of capabilities and through cultural change[77]. Growing capabilities in enterprises that increase absorptive capacities lead to a stronger demand for knowledge and collaboration. Enabling these improvements is a process of learning at many levels, for example, learning about:

- What policies are effective in the national and sectoral context and stage of development
- How to manage collaboration with industry (for RTOs)
- What universities and research organisations have to offer and how to work with them (for business).

Table B.1.4: Taxonomy of Policy Instruments to Support Knowledge Transfer

Type of policy instrument	Main channels	Supply vs. demand
Financial instruments		
1. R&D and innovation subsidies or grants	Collaboration	Supply
2. Tax incentives	Collaboration, contracts, consulting	Supply
3. Financial support to academic spin-offs	Spin-offs	Supply
4. Grants for IP applications	IP Licencing	Supply
5. Financial support to recruit PhDs or post-docs	Researcher mobility	Supply
6. Financial support to host industry researchers	Researcher mobility	Supply
7. Public procurement of technology	Collaboration, contracts	Demand
8. Innovation vouchers	Contracts, consulting	Demand
9. Public-private partnerships creating joint research laboratories	Collaboration	Demand/ Supply
10. Performance-based funding systems	Spin-offs, IP Licencing, Publications	
11. Funding of infrastructures and intermediaries	IP Licencing, Spin-offs, Collaboration, Networking	Demand / Supply
Regulatory instruments		
12. IP rights regime	IP Licencing, Spin-offs	Demand
13. Regulation of spin-offs founded by researchers and students	Spin-offs	Supply
14. Career rewards for professors and researchers	All Channels	Supply
15. Sabbaticals and mobility schemes	Researcher mobility, Spin-offs	Supply
16. Open access and open data provisions	Publications	Supply

76 For example: https://www.praxisauril.org.uk/resource/university-knowledge-exchange-ke-framework-good-practice-technology-transfer-mcmillan-2016

77 Plewa, C., Korff, N., Johnson, C., Macpherson, G., Baaken, T. & Rampersad, G., 2013. The evolution of university–industry linkages—A framework. *Journal of Engineering and Technology Management*, *30*(1): 21-44; Hughes, A. et al., 2022.The Changing State of Business-University Interactions in the UK. National Centre for Universities and Business.

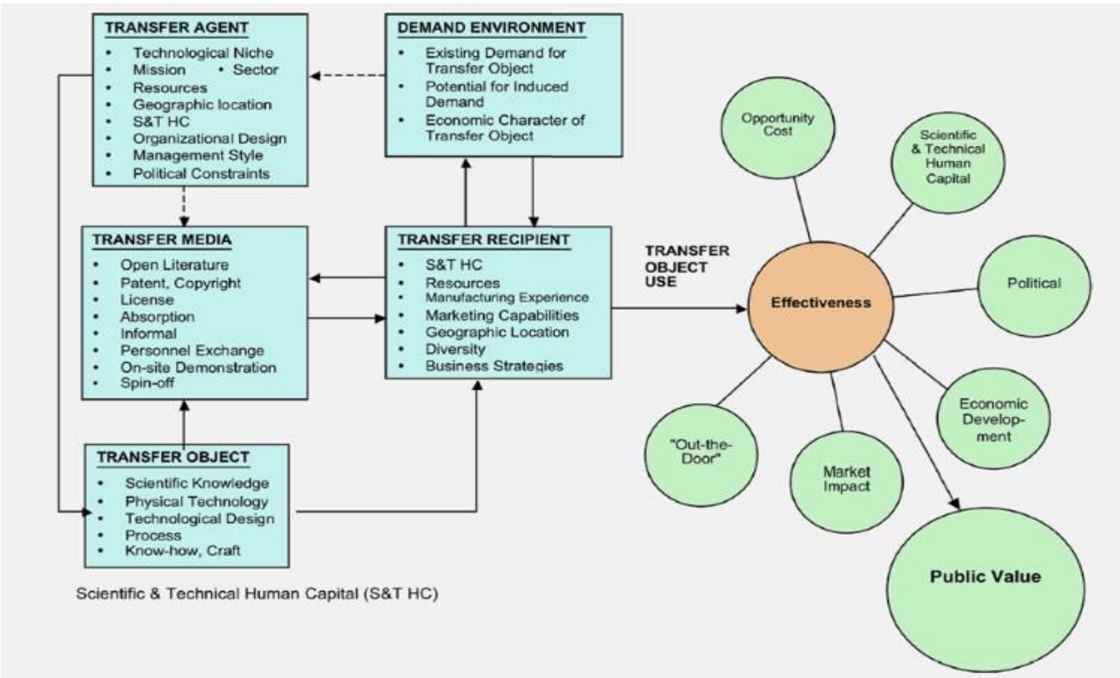
Soft instruments		
17. Awareness raising	All Channels	Demand / Supply
18. Training programmes	All Channels	Supply
19. Networking	Networking	Demand / Supply
20. Collective roadmapping and foresight exercises	Networking	Demand / Supply
21. Voluntary guidelines, standards and codes of conduct	IP Licencing	Demand / Supply

Source: Guimón, J. and Paunov, C., 2019. Science-industry knowledge exchange: A mapping of policy instruments and their interactions. OECD.

To support this learning, it has been found to be important to develop sound mechanisms for monitoring performance (based on appropriate indicators) and evaluating experience in an open learning environment.

While what should be assessed should be based on what is most important, it is often based on what is easily measurable. As indicated in Figure 2.6, a comprehensive approach to assessment would consider the full range of significant impacts to assess overall effectiveness.
A growing number of countries are collecting statistics, but usually only on the more formal aspects of knowledge transfer. The most widely used indicators for KTO performance are similarly narrowly based the formal and easily measured dimensions of knowledge transfer – Table B.1.5.

Figure B.1.3: A Model of the Knowledge Transfer Process



Source: Bozeman, Rims & Youtie, 2015[78]

Table B.1.5: Knowledge Transfer Indicators for Technology Transfer Surveys

[78] Bozeman, B., Rimes, H. and Youtie, J., 2015. The evolving state-of-the-art in technology transfer research: Revisiting the contingent effectiveness model. *Research Policy*, *44*(1): 34-49.

Statistic	Definition
1 Number of invention disclosures	Descriptions of inventions or discoveries that are evaluated by the KTO staff or other technology experts to assess their commercial application
2 Number of patent applications	New priority patent applications. Exclude double-counting, such as a patent application for the same invention in more than one patent jurisdiction
3 Number of patents granted	Technically unique patents granted. Count a patent grant for the same invention in two or more countries as one technically unique patent. If a technically unique patent grant has been counted in a previous year, it may not be counted again
4 Number of research agreements	All contracts where a firm funds the university or public research institute to perform research on behalf of the firm, with the results usually provided to the firm. Include collaborative agreements where both partners provide funding and share the results. Exclude cases where the firm funds a research chair or other research of no expected commercial value to the firm
5 Number of licenses executed	Include all licenses, options and assignments (LOAs) for all types of IP copyright, knowhow, patents, etc. Count multiple (identical) licenses with a value of less than EUR 500 each as one license. A license grants the right to use IP in a defined field of use or territory. An option grants the potential licensee a time period to evaluate the technology and negotiate the terms of a license. An assignment transfers all or part of the right to IP to the licensee
6 Number of startups	A new company expressly established to develop or exploit IP or knowhow created by the university/PRO and with a formal contractual relationship for this IP or knowhow, such as a license or equity agreement. Include, but do not limit to, spinoffs established by the institution’s staff. Exclude startups that do not sign a formal agreement on developing IP or knowhow created by the institution
7 Total license revenue earned	Total income from all types of knowhow and IP (patents, copyright, designs, material transfer agreements, confidentiality agreements, plant breeders’ rights, etc.) before disbursement to the inventor or other parties. Include license issue fees, annual fees, option fees, and milestone, termination and cash-in payments. Exclude license income forwarded to other institutions than those served by the KTO or to companies

Source: Arundel & Wunsch-Vincent, 2021, p.53-55.

7.11 University Strategies for Knowledge Transfer

Commercialisation of research results and active engage in KT is a deliberate decision for a university. KT requires investment in capabilities and relationships, reviews of incentive for academics and staff, and hence the development of a strategic framework. There have been very few studies that systematically assess the impacts of different KT strategies in different types of university. The available evidence indicates that in view of the differences among universities in terms of local and national context, resources, level of specialisation in research and teaching, experience and culture, there cannot be a best practice, uniform, strategy for KT[79].

The objective of improving KT performance is stimulating ongoing change (institutional innovation) in universities. One, more radical and potentially more transformative proposal is that of the entrepreneurial university concept[80]. The entrepreneurial university concept, which developed in Europe in the 1990s, emphasises the connection of the university with the organisations in its region, with the objective of enabling economic and social development. Support for entrepreneurship by university academics and students, and in the wider community, is a particularly important aspect of the concept. The concept implies a significant re-orientation of a university's culture and organisation.

Appropriate performance indicators are also useful for KT management in universities and also to inform organisations that support and engage with universities. For example, in the UK, the application of the Knowledge Exchange Framework (KEF) provides a range of information on the knowledge exchange activities of Higher Education Providers (HEPs) in England. The information collected through the KEF provides data and explanations of the different ways that universities work with their external partners, from businesses to community groups, for the benefit of the economy and society**.** The KEF also aims to assist universities to better understand and improve their own performance in knowledge exchange, as well as provide businesses and other users with more information[81].

7.12 Summary of Knowledge Transfer Barriers and Possible Policy Responses

The extensive Table B.1.6 identifies a wide range of typical KT barriers and organises these into those that are primarily on the supply side, demand side, or in the linking mechanisms between demand and supply. It also notes the factors that frequently lay behind these specific barriers. The table also provides examples of the types of policy responses that governments and universities have introduced with the objective of reducing the barrier.

Table B.1.6: Major Knowledge Transfer Barriers and Possible Responses

Type of Barrier	Causes	Examples of Responses to Address the Barriers
Supply Side		
Lack of high-quality research relevant to industry	• No prior orientation to industry priorities	• Identify research that is high potential for new knowledge and application (Pasteur's Quadrant)

[79] Giuri, P., Munari, F., Scandura, A. and Toschi, L., 2019. The strategic orientation of universities in knowledge transfer activities. *Technological Forecasting and Social Change*, *138*, pp.261-278; Technopolis, 2021. Knowledge exchange and place: A review of literature. Technopolis; Good, M., Knockaert, M., Soppea, B. & Wright, M., 2019 The technology transfer ecosystem in academia. An organizational design perspective. Technovation Volumes 82–83: 35-50

[80] Clark, B. R., 1998. Creating Entrepreneurial Universities: Organizational Pathways of Transformation. Emerald Publishing Group; Guerrero, M., & Urbano, D., 2012. The development of an entrepreneurial university. *The Journal of Technology Transfer, 37*(1), 43–74; Etzkowitz, H., 2013. Anatomy of the entrepreneurial university. *Social Science Information, 52*(3): 486–511; Etzkowitz, H., Ranga, M., Benner, M., Guaranys, L., Maculan, A. M., & Kneller, R., 2008. Pathways to the entrepreneurial university: Towards a global convergence. *Science and Public Policy, 35*(9): 681–695.

[81] Research England: Knowledge Exchange Framework (kef.ac.uk); See also: Oxford Economics, 2017, The Economic Impact of Universities in 2014-15, Report for Universities UK. https://www.oxfordeconomics.com/recent-releases/the-economic-impacts-of-universities-in-2014-15

RTO lacks reputation to attract industry interest	• No prior effort to build industry links	• Participate in industry networking events • Develop links through informal interaction
Lack of key researchers prepared to contribute to KT Lack of incentives to register discoveries	• Lack of incentives to participate in KT	• Increase the level of benefit share with researchers • Include KT in performance assessments • Reduce the administrative burden of KT • Increase the benefits or participation in KT • Reduce the administrative burden of KT
RTO culture does not support KT	• Incentives focus on publications • Lack of trust in KTO • Concern over administrative burden	• RTO develop a strategic approach to KT, including the priorities for different KT channels and communicate the strategy clearly Include KT in performance assessments • KTO/support staff to take on the administrative tasks • Review, clarify and simplify procedures
Time consuming or inflexible administrative processes discourage researchers	• Policies and procedures based on excessive control and lack of trust	• KTO to take on the administrative tasks • Review, clarify and simplify procedures
Technology too embryonic to be marketable	• Lack of appreciation of the challenges of commercialisation • Lack of funding for the early high-risk stage of commercialisation	• Establish a form of Pre-Seed or Proof of Concept fund at the RTO- possibly in collaboration with an external (private or public) investor (for example, the Pre-Seed fund at the Australian National University). • Establish a national Proof of Concept funding program (i.e., separate from programs providing Seed funding for start-ups) that may also offer related services (for example: Finland's "New knowledge and business from research ideas"; Irelands Commercialisation Fund; New Zealand's Pre-Seed Accelerator Fund; Singapore's NRF Proof of Concept Funding). Many of these programs also provide advice to RTOs on commercialisation and/or actively promote

		RTO-industry links. Develop RTO strategies to increase innovation impacts
Lack of support for KT from senior managers	• KTOs are generally cost centres rather than sources of revenue and involvement in KT can divert researchers from research leading to publications.	• RTO develop a strategic approach to KT, including the priorities for different KT channels and communicate the strategy clearly
Lack of confidence in KTO	• KTO yet to develop strong capability • RTO's KT activities too small to justify a broad-based KTO	• Invest in KTO and train staff • Modify KTO structure to one with more decentralisation to build closer links with researchers
Lack of clear KT policies and procedures	• KT had not been a priority	• RTO develop a strategic approach to KT, including the priorities for different KT channels and communicate the strategy clearly • Review, clarify and simplify procedures • Ensure that the process of making decisions on patenting (or not) and KT channel are transparent.
Lack of clarity of IP ownership	• Unclear policies at the national or RTO level	• Review, clarify and codify laws and policies at the national or RTO level
Lack of clarity over RTOs legal ability to make decisions over IP commercialisation	• Excessive central control with lack of trust	• Develop delegation with accountability: Review, clarify and codify national laws to enable RTOs to manage their IP commercialisation and KT more generally – within the scope of national priorities
Lack of clarity over benefit sharing with researchers	• Underdeveloped policies and lack of awareness of the key importance of incentives for researchers.	• Review, clarify and codify national laws and RTO policies to ensure a high (at least 30%) level of incentive to researchers. • Define the basis of revenue (gross or net income)
Concerns that KT to SMEs will be too time and resource consuming	• Experience is that innovation-related collaboration with SMEs (and firms with low	• Form a separate technology consulting organisation.

	absorptive capacity more generally) is very time consuming.	• Seek government support for work with SMEs and enterprises with low capability • Clarify overall strategy regarding KT partners
Lack of prior informal links with industry	• No prior effort to build industry links	• Allow staff to spend some time in consulting to industry • Develop links through informal interaction • Allow staff to take leave to spend time working in companies • Form a separate technology consulting organisation • Maintain links with alumni • Participate in industry networking events
Lack of clear IP law to support patenting and a lack of trust with potential partners	• Where property rights are hard to enforce either because the IP law and its enforcement is not strong, or because many firms are opportunistic, licensing is a high-risk approach to commercialisation.	• Assess the scope for commercialisation through spin-offs
• **Linkage and Intermediaries**		
Lack of capabilities in KTO	• Underdevelopment of the culture, strategies, structures, skills, support mechanisms and policies required to establish knowledge transfer as important as research and teaching. • Lack of capability to bridge the RTO-I distance (geographical, cultural, social, organisational) • Lack of incentives for KTO staff	• Improve incentives and recruit professional and experienced KTO staff • Train KTO staff • Contract KTO services from more experienced KTOs • Government program to strengthen KTOs • Contract KTO services from more experienced KTOs • Develop national, regional or sectoral KTOs • Recruit an experienced advocate, possibly from industry

	• KTO with a low flow of IP and transactions will have difficulty covering overheads and maintaining a team with strong capability • Lack of capable KT champions	
Inflexible processes in KTO	• Control had been more important than effectiveness.	• Review, clarify and simplify procedures • Consider standard templates for negotiation
Lack of capability to market IP and capability	• Lack of staff with marketing knowledge	• Recruit staff with experience in the target industries or in marketing technology products or services.
Lack of information on potential knowledge supply and demand	• No prior effort to build industry links • Lack of regional or national databases, knowledge exchanges	• Establish a national or regional virtual marketplace • Coordinate and share information among KTO • Develop networks with local businesses • Participate in industry exhibitions
Lack of formal & informal links with enterprises	• No prior effort to build industry links	• Develop networks with local businesses • Participate in industry exhibitions • Recruit RTO staff from industry
Lack of support and infrastructure for spin-offs	• No prior demand to support entrepreneurial activity • Lack of scale • Lack of funds for Proof of Concept (PoC)	• Develop an incubator at the RTO or local city/region • Develop a PoC, Seed and/or VC fund • Develop an entrepreneur support program • Ensure researchers can take leave to work with a spin-out
Lack of collaborative research	• Lack of funds for collaboration with industry • Lack of industry interest in collaboration	• Regional or national competitive RTO-industry collaborative R&D and innovation fund.

	• Lack of researcher interest in collaboration	
• **Demand Side**		
Lack of absorptive capacity in industry	• Enterprises lack capabilities for R&D and innovation • Lack of confidence in ensuring a competitive advantage from KT from RTOs. • Preference for proven commercial technology • Lack of complementary assets (eg strong capability to market and improve technology in competitive markets.	• Long term strategy to build capabilities. RTO can contribute through consulting, contract research, training, movement of graduates.
Enterprises lack information on KT opportunities and on working with KTO	• Lack of prior demand for disembodied knowledge • No prior contact with RTOs • Lack of experience working with RTOs	• Establish a national or regional virtual marketplace • Coordinate and share information among KTO • Develop networks with local businesses • Participate in industry exhibitions
Expectation that negotiation with RTOs will be unrewarding	• Expectation that RTO will overvalue IP • Expectation that the KT negotiation process will be time and resource consuming	• RTO: review, clarify and simplify procedures and consider standard templates for negotiation
Expectation that the technology will need a lot of further development	• Preference for proven commercial technology • RTOs generally lack incentive, capability and resources to raise the TRL- this is a major disincentive for all but	• Requires regional or national programs to support PoC and RTO-industry collaboration.

	the most capable firms or clearly very high potential new IP	
Uncertainty over the strength of IP	• Lack of confidence in the strength of the patent	• Strengthen national IP laws and assessment procedures
High risk avoidance	• Lack of technological and managerial capability • Corporate culture developed in a context of high political, policy, regulatory or market uncertainty	• Develop links through informal contacts and collaboration.

Sources: Technopolis, 2015; Siegel, D.S., Veugelers, R. and Wright, M., 2007. Technology transfer offices and commercialization of university intellectual property: performance and policy implications. *Oxford review of economic policy*, *23*(4), pp.640-660.; Edler, J., Cunningham, P. and Gök, A. eds., 2016. *Handbook of innovation policy impact*. Edward Elgar Publishing.; Sandström, C., Wennberg, K., Wallin, M.W. and Zherlygina, Y., 2018. Public policy for academic entrepreneurship initiatives: A review and critical discussion. *The Journal of Technology Transfer*, *43*(5): 1232-1256.

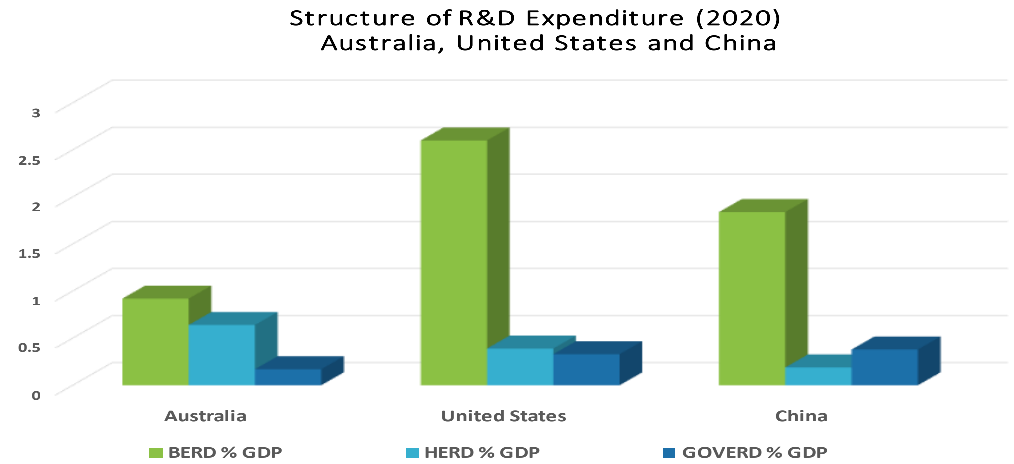
PART C

8 INTERNATIONAL CASE STUDIES

8.1 C.1: INTRODUCTION TO THE CASE STUDIES

The three case study countries have quite different innovation systems. The US is the major global funder of R&D in terms of expenditure and also has a relatively high intensity (R&D/GDP) of investment in R&D. Its total R&D expenditure (GERD) is dominated by expenditure by business (BERD). In contrast, in Australia overall R&D intensity of substantially lower and the major reason for that is the relatively low level of business R&D intensity (BERD/GERD). In the Australian innovation system, universities have a relatively major role – which points to the importance that governments attach to effective knowledge transfer. In China, business is the dominant R&D performer and universities a relatively more limited role in overall R&D. Government R&D organisations have a larger role in R&D performance in China than in the US and particularly in Australia. Figure C.1.1.

Figures C.1.1: Basic Structure of the Innovation Systems of Case Study Countries.



Figures C.1.2 to C.1.4 provide additional indicators of comparative innovation-related performance in most of the case study countries in order to develop a broader perspective. Notable is the relatively very high level of business funding of university R&D in China and the relatively high level of venture capital investment in the US.

Figure C.1.2: Structure of R&D Expenditure in Selected Countries, 2020 (% of GDP)

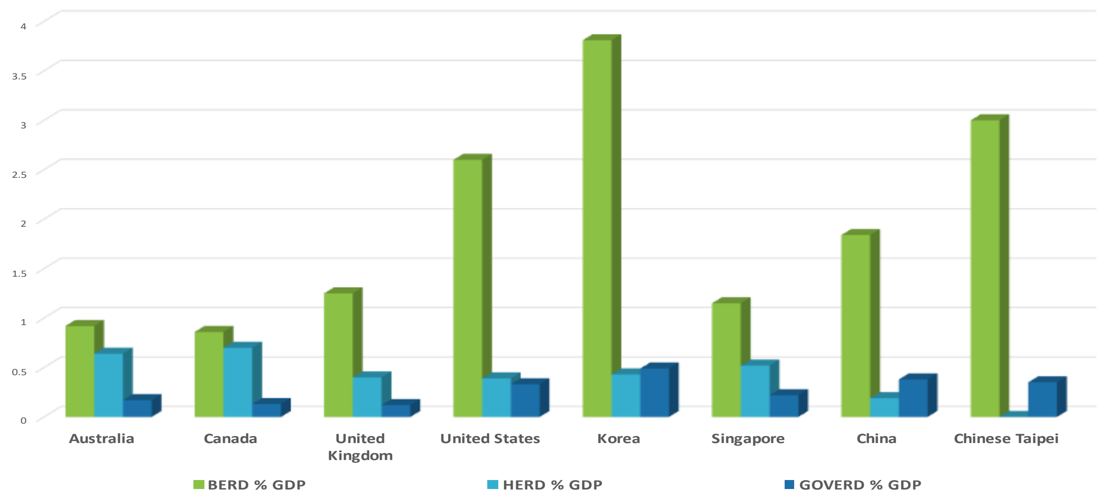


Figure C.1.3: Share of University R&D financed by industry (%)- Selected Countries, 2020

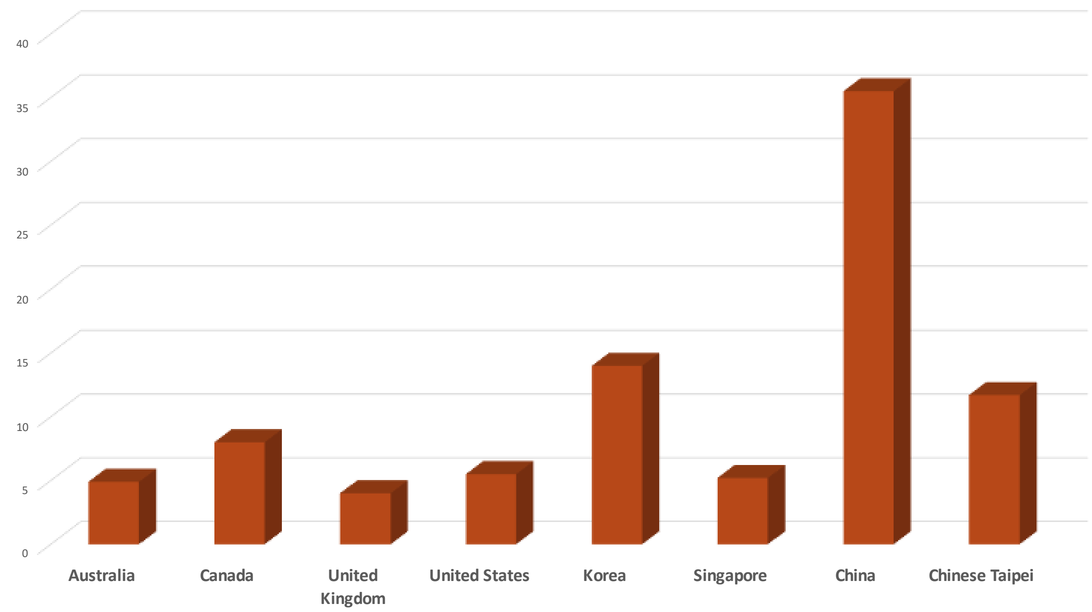
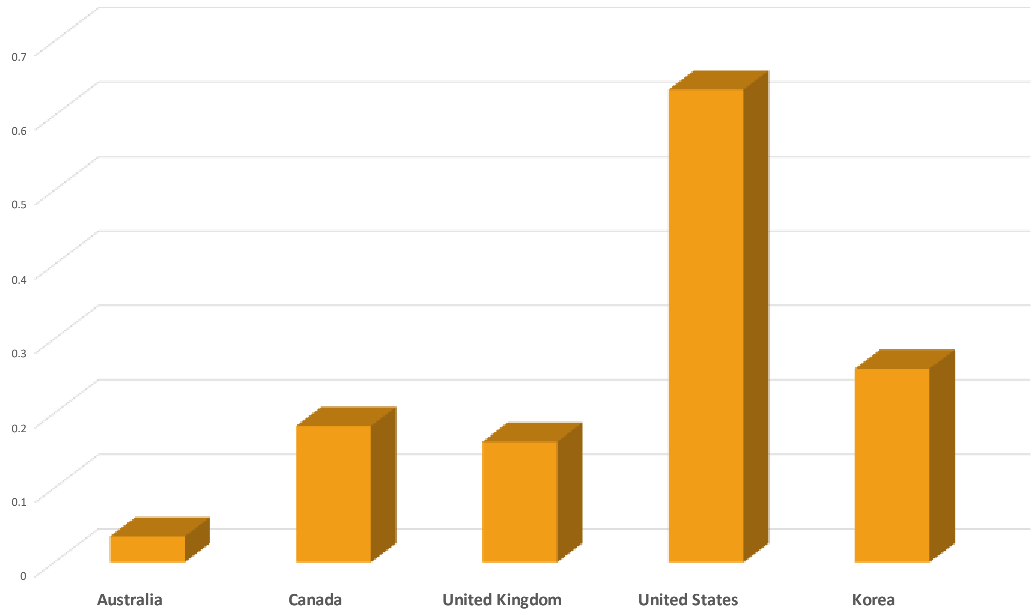


Figure C.1.4: Venture Capital Investment (% GDP)- Selected Countries



Figures C.1.5 and C.1.6 provide information on some indicators of knowledge transfer performance for Australia, the US, the UK and Canada. Figure C.1.5 shows the trends in the income to universities from licenses, options and assignments (LOAs) over 2004-2016. During this period many initiatives were introduced in these countries to improve the levels of knowledge transfer. However, there is no indication that the income to universities from formal knowledge transfer arrangements improved over this period relative to R&D expenditure. It is important to note that in almost all cases the income from LOAs was equivalent to 1 to 5% of R&D expenditure.

Figure C.1.6 focuses on one of the other widely used indicators of knowledge transfer performance – the generation of start-up companies relative to R&D expenditure. Performance in the UK and Australia declined over this period while in the US and Canada it improved to some extent. Overall the rate of spin-off formation over this period was an average of about one spin-off per US$100m of R&D.

In each of the case studies the development of knowledge transfer performance and policy is characterised in terms of major phases. This characterisation of phases aims to capture the key changes in that period. In reality the developments in policy tend to be evolutionary rather than revolutionary and trends may extend over a number of phases.

Figure C.1.5: Trends in Commercialisation Performance: Income from LOAs

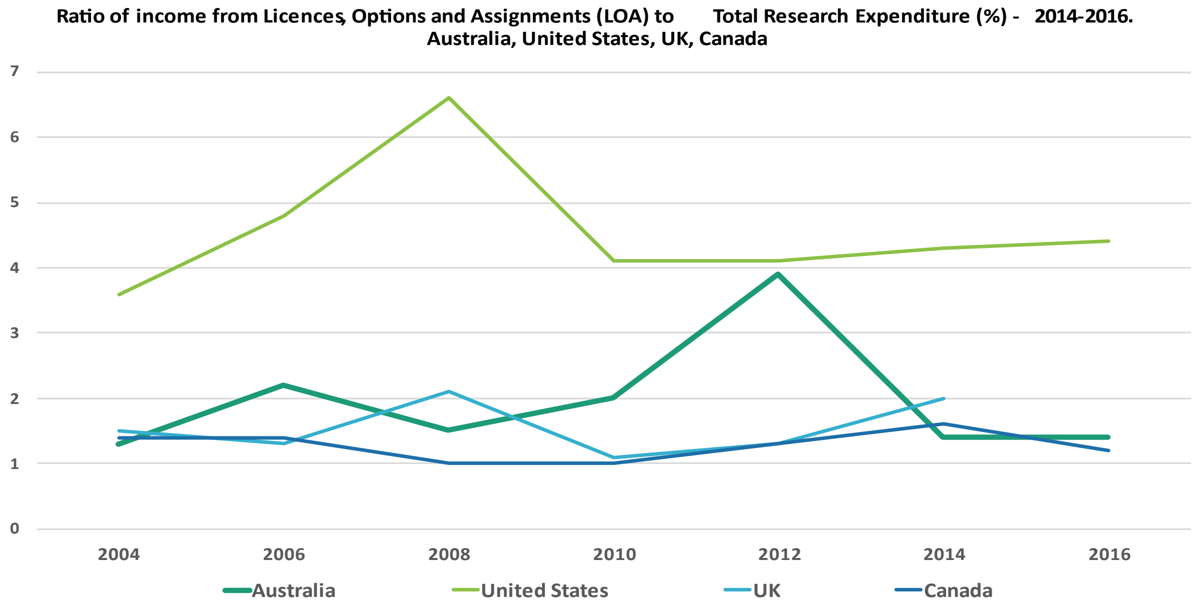
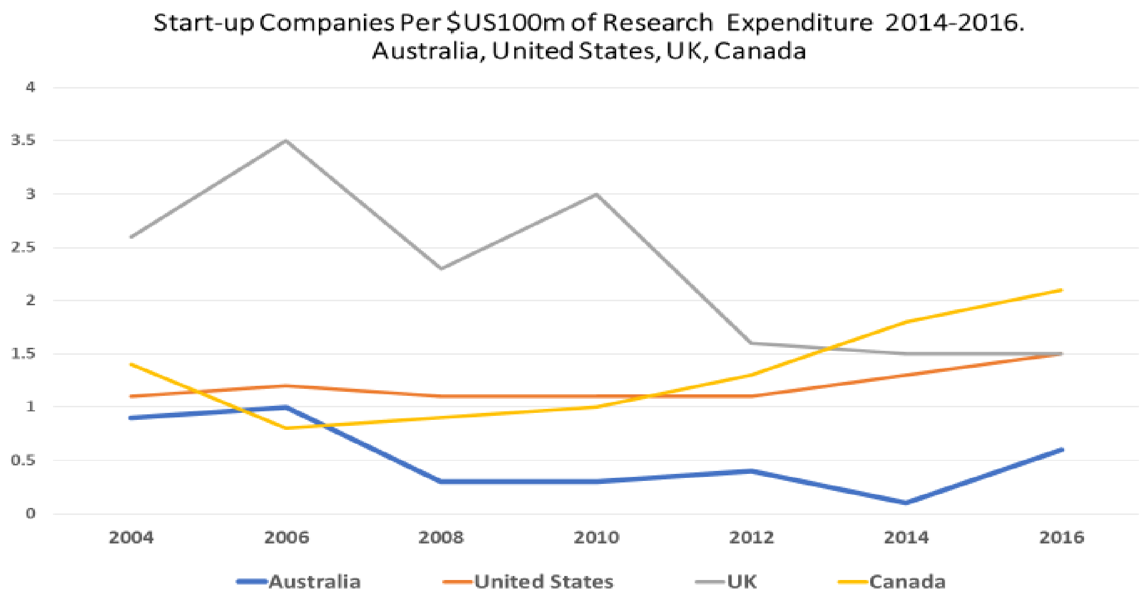


Figure C.1.6: Trends in Commercialisation Performance: Start-up companies



Source: The National Survey of Research Commercialisation. https://www.industry.gov.au/data-and-publications/national-survey-of-research-commercialisation

8.1.1 Phases in the Development of Knowledge Transfer Perspectives, Strategies and Policies

The development of commercialisation practice and policy can be seen as evolving through four phases. Over this evolution, technology transfer was increasingly recognised as being a component of overall knowledge transfer and as a part of (and hence shaped by) the complex relationships and knowledge flows within innovation systems. The perspectives that characterised each phase framed, for that phase, the approaches both to management, at the level of universities and research organisations, and to policy, at the level of regional or national governments. Each phase was also characterised by innovations in policy and in institutions. However, rather than new perspectives leading to the displacement of the policies and institutions of the previous phase, the development has been more one of new policies and institutions (and indicators) being added those of the previous phase, leading to a more complex knowledge transfer system.

The characteristics of the four phases are

- **Phase 1: The patent-licence pipeline**

  This phase begins with the Bayh-Dole Act by the US Congress, which confirmed university ownership of IP developed through government funding of university research, along with university responsibility for active approaches to the commercialisation of that IP. As many other countries introduced similar policies this led to a strong growth in the level of patenting and licensing by universities. The key institutional innovation of this phase was the Technology Transfer Office (TTO), which were developed by many universities as a key intermediary between the university and industry. This phase developed in the 1980s and 1990s in the US and Europe and many other developed economies.

- **Phase 2: Deepening research collaboration and increasing governance**

  Expectations that the clarification of IP ownership and the development of TTOs would transform technology commercialisation and lead to much more extensive linkages between industry and universities were generally not realised. While the level of licensing increased and there were many outstanding individual cases of licensing that generated multimillion US dollar income for some universities, most universities made little or no profit from licensing. Similarly, many firms found the experience of licensing from universities unrewarding. As a result, there was a growing awareness of the barriers to effective knowledge transfer. At the university level this led to an increasing professionalisation of TTOs requiring a higher level of investment. At the policy level a major response was the development of programs to encourage greater university-industry collaboration particularly through subsidies for collaborative applied research[82]. A complementary policy response was a stronger steering of research funding toward (what were considered to be) industry priorities. A major institutional innovation was the formation of collaborative (or joint or cooperative) research centres, often located in new facilities in or near universities. Another institutional innovation was the formation of 'science parks', designed to encourage closer research-industry collaboration, and perhaps including a number of joint research centres.

  While the first phase focussed on managing knowledge transfer from what was seen as the end of the 'pipeline', this phase began to address the later stage of the 'pipeline'. In most OECD economies, this phase developed most strongly in the 1990s and early 2000s.

- **Phase 3: Spin-offs and start-ups**

  From the mid-1990s systemic changes in the innovation systems in most OECD economies became increasingly significant and changed the context for university-industry interaction. The most important of these changes was the increasing level of technology-related entrepreneurial opportunity due to emergence of major new technologies such as ICT and biotechnology. In some emerging technology areas research findings and research capability in universities could be readily applied to commercial value creation – and these were often areas where industry was yet to develop strong capabilities. The potential of new venture creation based on new technological and market opportunity stimulated a strong surge in entrepreneurship enabled by the development of the venture capital industry – an important institutional innovation, also enabled by regulatory changes in capital markets.

[82] Boardman, P. C.,2009. Government centrality to university–industry interactions: University research centers and the industry involvement of academic researchers. *Research Policy*, *38*(10): 1505–1516.

The evolution of the venture capital industry and of entrepreneurial activity stimulated the formation of complementary institutional innovations, including new venture incubators, business angel networks and a wide variety of entrepreneurship development programs. This evolution was most strongly expressed in the United States, where the exemplar that has inspired countless initiatives around the world was Silicon Valley.

Hence, new venture pathways became an (often attractive) alternative to licensing. In those cases where an industry that might licence the technology did not exist, it was the only route to commercialisation. While the growth of entrepreneurial opportunity changed options for the commercialisation at the 'end of the pipeline', it also undoubtedly changed the allocation of resources into research. Over time, increasing entrepreneurial activity also significantly changed the capabilities required in TTOs and also the range of important external relationships.

- **Phase 4: Beyond the pipeline – rethinking the developmental university in innovation systems**

  From the 1990s the systems perspective began to influence innovation policy in OECD economies. One consequence of that perspective was a renewed awareness, a reminding, of the many channels through which knowledge acquired, maintained and generated by universities flows into and is applied throughout an economy. From the 1990s, and particularly in the 2000s, there was an increasing awareness of the geography of innovation and entrepreneurship - i.e., of the importance of networks of interaction, of complementarities, and of shared 'culture', among organisations within a region. It was clear that in many regions universities played vital roles that extend far beyond the transfer of technology through licensing and spin-offs[83]. These changing perspectives have led to a rethinking of what talent and knowledge universities produce and disseminate and how they engage as a partner with enterprises and other organisations in contributing to growth, sustainability and equality. The 'third mission' is the expectation that universities will make more direct economic and social contributions, in addition to their traditional roles in teaching and research[84]. These newer perspectives are also expressed in conceptual frameworks such as the 'entrepreneurial university' - regarding which there is now a very extensive literature[85].

In most OECD economies policies and strategies at the university and government levels evolved through these phases. This involved ongoing debates and extensive studies and reviews. It has also involved a long (and continuing) learning process by all participants, universities, governments, industry, TTOs, incubators, VC investors etc.

Industrialising countries that are focused more on building than adapting their research and innovation systems have generally not experienced these phases of evolution. Such countries can (and should) draw on international experience, recognise the role of the 'third mission', and assess the relevance of such frameworks as the 'entrepreneurial university'. However, it is important to also take into account that the design and implementation of strategies and initiatives to develop

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[83] For example: Lauvås, T., & Steinmo, M., 2021. The role of proximity dimensions and mutual commitment in shaping the performance of university-industry research centres. *Innovation: Organization and Management*, *23*(2), 182–208.

[84] Compagnucci, L. and Spigarelli, F.,2020. The Third Mission of the university: A systematic literature review on potentials and constraints. Technological Forecasting & Social Change 161 120284; Knudsen, M.P., Frederiksen, M.H. and Goduscheit, R.C., 2021. New forms of engagement in third mission activities: A multi-level university-centric approach. *Innovation*, *23*(2), pp.209-240. The development of the 'third mission' presents universities with substantial strategic, governance and managerial challenges, see, for example: Broström, A., Buenstorf, G. and McKelvey, M., 2021. The knowledge economy, innovation and the new challenges to universities: introduction to the special issue. *Innovation*, *23*(2), pp.145-162.

[85] For example: Etzkowitz, H., Webster, A., Gebhardt, C., & Terra, B. R. C., 2000. The future of the university and the university of the future: Evolution of ivory tower to entrepreneurial paradigm. *Research Policy*, *29*(2), 313–330; Etzkowitz, H., 2004. The evolution of the entrepreneurial university. *International Journal of Technology and Globalisation*, *1*(1), pp.64-77; OECD., 2012. ***A guiding framework for entrepreneurial universities***. http://www.oecd.org/site/cfecpr/EC-OECD%20Entrepreneurial%20Universities%20Framework.pdf.

the wider roles of universities will also involve a process of learning by all participants. For this reason, strategies and initiatives should include explicit measures to support learning, supported by appropriate evaluations.

8.2 C.2: KNOWLEDGE TRANSFER IN THE UNITED STATES

As the US government is both a major source of funding for R&D, and a major performer of R&D, its technology transfer policies have a major bearing on the overall benefits of R&D. As competitive challenges increase, the effectiveness of knowledge transfer has become critically important.

Phases	**Phases**	**Before 1981**
Before 1981	Broadcast	Growth of R&D investment
1981-1995	Patent and License Pipeline	Growth of Licensing from Universities and Federal Laboratories
1995-2010	Growing collaboration	Developing Mechanisms for Research-Industry Collaboration
2005-	Strengthening Knowledge Ecosystems	Increasing Emphasis on Entrepreneurship and Local Innovation Systems

8.2.1 Stage 1: Prior to 1981 and the Bayh-Dole Act

The essential role of research and the application of that research in World War 2 led to strong increase in government funding of research that continued through the 1950s. However, outside the context of wartime emergency relationships knowledge transfer reverted to the traditional modes: knowledge put into the public domain through academic publications; and in the case of rural industries, dissemination through extension services. Many different government agencies funded research in universities and government research laboratories but ownership of any intellectual property generated was either retained by the government agency or remained ambiguous - there was no uniformity across the many agencies and even the authority for the agencies to hold patents or to license technology was either not clear or limited to non-exclusive licenses. The rate of licensing of the patents retained by the government funding agency was very low – 1% for NASA in 1978 – whereas as the licensing rate for those cases where the researcher was awarded patent rights was 10 to 20 times higher. It became clear that the retention of patent ownership by the funding agency contradicted the essence of the patent system, in which the right to exclude was essential for the incentive to commercialise – as, in this context, what is available to all is of interest to no one. Moves within the Federal government to review the ownership of IP from federally funded research and its commercialisation, began in the early 1960s and continued through the 1970s. However, the policies across Federal research funding agencies remained divergent, generally restrictive and not attractive to potential industry partners. Many government funding agencies strongly resisted moves to have ownership of IP move to the research organisation[86].

Initially when some universities began to encourage patenting and commercialisation of staff discoveries there was strong resistance from many academics who considered that these considerations would divert researchers from basic discovery research[87].

[86] Bremer, H.W. , 1998. University Technology Transfer Evolution and Revolution. Paper for the 50th Anniversary of the Council of Governmental Relations; Lacy, J.V., Brown, B.C. and Rubin, M.R., 1991. Technology transfer laws governing federally funded research and development. *Pepp. Law. Review.*,*19*, p.1.

[87] Recent studies have found no evidence that the greater focus on commercialisation has had a negative impact on basic research, for example: Grimaldi, R., Kenney, M., Siegel, D.S. and Wright, M., 2011. 30 years after Bayh–Dole: Reassessing academic entrepreneurship. *Research policy*, *40*(8): 1045-1057.

8.2.2 Stage 2: 1981-c.1995 - Growth of Licensing from Universities and Federal Laboratories

The Bayh-Dole Act of 1981 was the culmination of many years of work to clarify and strengthen the policies that support technology transfer. The Act confirmed that the ownership of IP from federally-funded research would be with the university, research organisation or company carrying out the research, that researchers had a responsibility to disclose their inventions to the Technology Transfer Office (TTO), and that the owner of the IP could enter into an exclusive licence with a company commercialising the technology. The passing of the Act by Congress was followed with directives to clarify the policy and to ensure that federal agencies implemented the changes. The essential change in Phase 2 is the confirmation of ownership of intellectual property (patents, copyrights, etc). The US Constitution provides a powerful foundation in that the Fifth Amendment states:

"*No person shall be deprived of life, liberty or property, without due process of law; nor shall private property be taken for public use without just compensation*."

The Constitution also explicitly recognised, in order "..to promote the progress of Science and the useful arts....the exclusive right [of inventors] to their .. discoveries."

The Stevenson-Wydler Act of 1980, and particularly the changes to that Act in the Federal Technology Transfer Act (FTTA) of 1986, encouraged technology transfer from federal research laboratories (there are over 700 federal labs), recognising the essential role of business in commercialisation. FTTA provided internal financial incentives to employee inventors, along with greater support for technology transfer.

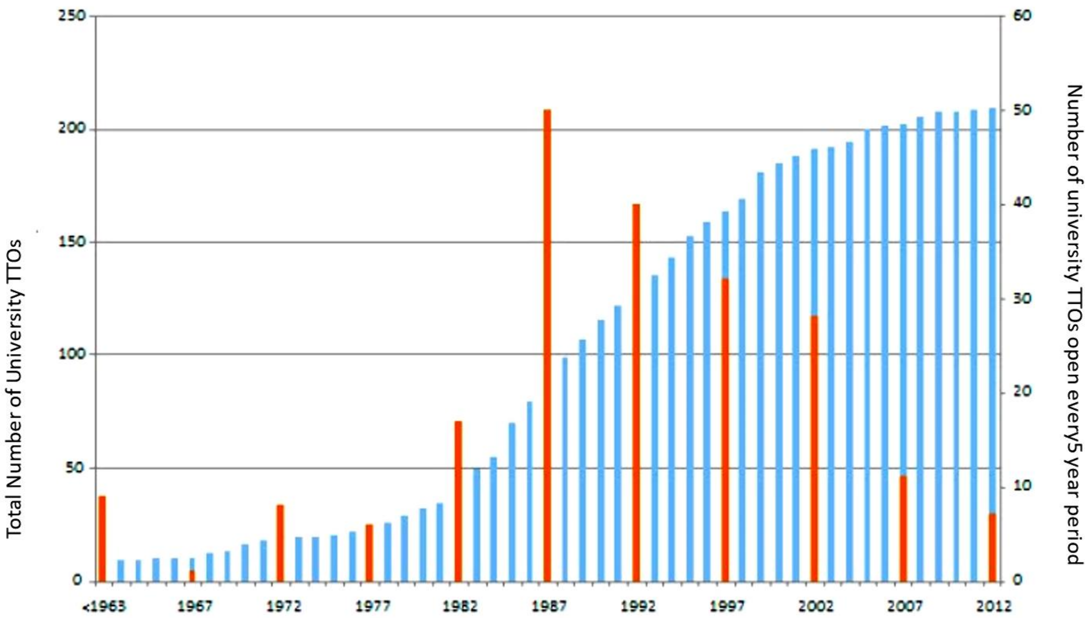
Growth in the level of patenting and licensing by US universities and government research laboratories was increasing prior to 1980 but grew more quickly after the Bayh-Dole Act and the FTTA. More generally, these changes led to a greater recognition of the importance of IP and the potential of technology transfer[88]. The Association of University Technology Managers reports that from 1991 to 2004, university revenues from licensing IP have increased over 533%, from US$220 million to US$1.385 billion (AUTM, 2004)[89]. One of the central developments of this stage was the growth of TTOs in most universities, and their gradual professionalisation[90].

Figure C.2.1: Growth of US University TTOs – 1963-2012

[88] Some analysts question the significance of the Bayh-Dole Act in transforming the system of knowledge transfer, arguing that there were also important changes on the demand side, for example: Mowery, D.C., 2011. Learning from one another? International policy "emulation" and university–industry technology transfer. *Industrial and Corporate Change*, *20*(6): 1827-1853.

[89] Phan, P.H. and Siegel, D.S., 2006. The effectiveness of university technology transfer. *Foundations and Trends in Entrepreneurship*, *2*(2): 77-144

[90] Through the later 1980s and in the 1990s, many universities in Europe developed approaches similar to those of the US.



An important policy initiative of this phase was the Small Business Innovation Research (SBIR) program (begun in 1982) that provided funding to SMEs that were developing technologies to meet new federal government procurement requirements - but also to market the SBIR technology in the private sector which, in turn, helps stimulate the economy. The Small Business Technology Transfer (STTR) program of 1992 provides federal funds for cooperative R&D projects involving small companies and researchers at universities, federally funded research and development centres, or non-profit research institutions.

A particular challenge in this phase (but actually one that continues) was the role of the Federal Laboratories in knowledge transfer. These changes have widened the level of autonomy of labs in dealing with IP. The Stevenson-Wydler Act of 1980 made technology transfer a part of federal lab's mission and created mechanisms to facilitate transfer. The 1983 Presidential Memorandum on Government Patent Policy authorised government agencies to license government technology to firms. The Trademark Clarification Act of 1984 and the Federal Technology Transfer Act of 1986 removed identified barriers to knowledge transfer and improved incentives. The Federal Technology Transfer Act of 1986 required scientists and engineers to consider technology transfer to be a professional responsibility and that would be included in performance evaluations. The Cooperative Research and Development Agreement (CRADA) reinforced the role of CRADAs established in the Federal Technology Transfer Act of 1986, enabling most federal labs to enter into CRADAs and to negotiate licensing arrangements and to exchange personnel, services and equipment with other organisations, including firms. The National Competitiveness Technology Transfer Act of 1989 further extended the use of CRADAs and the Technology Transfer Commercialization Act of 2000 broadened the licensing authority of labs making CRADAs more attractive to private industry. In forming CRADAs the labs have been careful to select industry partners with the capabilities and commitment to sustain effective research collaboration[91]. Public Law 104-113 of 1996, amended the Stevenson-Wydler Technology Innovation Act to provide additional incentives for enterprises to commercialise technology from federal labs, essentially by ensuring rights to license technologies developed through collaboration.

[91] Franza, R.M. & Grant, K.P. (2006) Improving Federal to Private Sector Technology Transfer, Research-Technology Management, 49(3): 36-40

The federal labs formed the Federal Laboratory Consortium (FLC) which consists of over 600 member laboratories and research centers from 16 federal departments and agencies. A major purpose of the FLC is to assist in matching these federal resources to the needs of private sector as well as state and local government partners. Matching is done through the FLC's Laboratory Locator Network which helps users identify and access federal R&D laboratories and centers by matching requests for technology, expertise, and facilities with the appropriate federal laboratory capabilities[92].

8.2.3 Stage 3: 1995-2010-Developing Mechanisms for Research-Industry Collaboration

The Association of University Technology Managers (AUTM), on the basis of annual surveys from 1996 to 2010 and economic input–output models, claim that the impact of university licensing to the U.S. economy during that period was in excess of US$162.1 billion and that jobs created over the same period range from 7000 to 23,000 per year[93].

There were several significant initiatives to promote greater RTO-industry collaboration:

- The National Science Foundation's Engineering Research Centres and University-Industry Co-operative Research Centre, Science and Technology Centers and Industry-University Cooperative Research Centers
- The U.S. Commerce Department's Advanced Technology Program (ATP)
- Many States provided support for science parks (to attract industry to work with universities) and incubators.

8.2.4 Stage 4: 2005-2020-Increasing Emphasis on Entrepreneurship and Local Innovation Systems

A major development in this phase was a growing orientation toward commercialisation through startups, in addition to licensing to established firms. The example of Stanford University's sale in 2005 of Google stock earning US$336 million gained a great deal of attention from universities. Along with this interest there was also a focus on the potential local area impacts of universities, based on the perception that universities had a seminal role in the development of Silicon Valley and other high-technology regions. Many universities developed entrepreneurship programs, business plan competitions, incubators and accelerators, and some established seed funds in order to address the challenges of early-stage funding[94].

The National Science Foundation (NSF) established the Innovation Corps (I-Corps) program in 2011 to boost the application of NSF research. The initiative was influenced by the awareness that researchers were often not effective entrepreneurs. Under I-Corp teams of would-be entrepreneurs

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[92] Erlich, J. & Gutterman, A. A, 2003. Practical View of Strategies for Improving Federal Technology Transfer. Journal of Technology Transfer, 28: 215–226,

[93] Roessner, J.D., Bond, J., Okubo, S., Planting, M., 2013. The economic impact of licensed commercialized inventions originating in university research. Research Policy42 (1), 23–34.

[94] Barr, S., Baker, T., Markham, S., Kingon, A., 2009. Bridging the valley of death: lessons learned from 14 years of commercialization of technology education. Academy of Management Learning and Education 8 (3), 370–388; Wright, M., Piva, E., Mosey, S., Lockett, A., 2009. Business schools and academic entrepreneurship. Journal of Technology Transfer 34 (6), 560–587.; Wright, M., Vohora, A., Lockett, A., 2004. The formation of high-tech university spinouts: the role of joint ventures and venture capital investors. The Journal of Technology Transfer 29 (3–4): 287–310.

(such as students of the researcher), the researchers, and mentors experienced in technology transfer would undertake a six-week new venture development training program[95].

Although most universities in the US established KTOs, in smaller universities and also larger universities without major biomedical faculties these have struggled to be effective. Many lack the expertise to evaluate disclosures and assess alternative commercialisation strategies, and to negotiate with venture capital investors over equity sharing decisions for spin-offs[96].

The concern with the commercialisation performance of federal labs continued. A particular concern was that US universities generate ten times as much income from licences and form six times as many start-ups per US$100m as do the Federal labs. In 2014 total federal R&D investment was $130.8 billion[2]while the total annual income generated from licensing was only $194 million - a monetary return on R&D investment of only 0.15 percent

Table C.1.1: Relative Commercialisation Performance of US Universities and Federal Labs

US FY 2015	Universities	Federal Labs
Intellectual Property Activity - Invention Disclosures /USD100m Research Expenditure	38.0	10.50
Patents Issued Per US$100m Research Expenditure	10.0	4.74
Licensing Activity- LOAs Executed per US$100m Research (No.)	11.9	2.3
Ratio of LOA Income to Total Research Expenditure (%)	3.8	0.33
Start-up Company Activity - Start-ups formed/ US$100m R&D (No.)	1.5	0.26

In 2016 the federal government in launching the Lab-to-Market initiative[97], focused on improving the commercialisation rates of federal labs, noted that there are several systemic challenges to effective transfer of technology, knowledge, and capabilities from federal R&D[98]*:*

- inconsistent practices across federal agencies
- difficulty in negotiating IP provisions
- too much emphasis on technology push
- inability to copyright digital products produced by government operated labs
- challenges in protecting trade secrets when federal labs work with private companies;
- requirements that force federal employees to leave government service to launch companies
- difficulty attracting and retaining high-quality talent.

One of the initiatives introduced following the Lab-to-Market review is knowledge transfer competitions among researchers in federal labs The goals of this competition are:

- to surface or stimulate the development of easy-to-use tools that support entrepreneurship
- to highlight successful examples of innovation ecosystems and resources that support the development of an innovation ecosystem, and

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[95] Bozeman, B., Rimes, H. and Youtie, J., 2015. The evolving state-of-the-art in technology transfer research: Revisiting the contingent effectiveness model. *Research Policy*, *44*(1): 34-49.

[96] Mowery, D.C., 2011. Learning from one another? International policy "emulation" and university–industry technology transfer. *Industrial and Corporate Change*, *20*(6): 1827-1853.

[97] https://www.nist.gov/tpo/lab-market

[98] NIST's Request for Information; https://www2.deloitte.com/us/en/pages/public-sector/articles/federal-technology-transfer-innovation-economy.html

- to enhance the connection and integration of Federal resources that support innovation ecosystems.

However, the assessment of the challenges for improving the US knowledge transfer system continue and are greatly influenced by the concern that China is developing capabilities to innovate at the world frontier and take leadership in key technologies. The policy assessment is now looking at the overall knowledge ecosystem, both the supply and the demand side, and at programs that take on more risk over a longer time horizon and sustain engagement from research through to application – which is what the US DARPA program does in Defence-related technologies.

8.3 Observations

- **Channels of Interaction of Federal Labs.** The focus on the licensing income of the federal labs misses the range of knowledge transfer through other channels. A survey in the 1990s found that CRDAs and licenses were the predominant forms of interaction but represented about 31% of the total types of contact between companies and the labs, with licensing amounting to only 5%. Among the other types of were technical assistance (23%), personal exchanges between scientists at the companies and the labs, including lab scientists working at the companies (13%), cooperative research and development outside of a CRDA structure (15%), and the use of laboratory equipment[99].
- **Developing a Knowledge Transfer Culture.** There is a recognition that the culture of federal labs has been an impediment to knowledge transfer. Studies find that senior management as an essential role providing an environment and culture that promotes knowledge transfer, often manifest in establishing and resourcing a professional knowledge transfer unit[100]. The FTTA requires that ''Each laboratory director shall ensure that efforts to transfer technology are considered positively in laboratory job descriptions, employee promotion policies, and in evaluation of the job performance of scientists and engineers in the laboratory''[101].
- **Personal Networks and the Initiation of Collaboration.** When companies sought to develop links with universities and federal labs they focused on individual researchers, taking into account their research capability in the specific area of interest, previous personal contacts. The companies sought access to specialised and unique knowledge for the development of new products and services and for solving problems – the goal of obtaining a license was less important. The most common initiators of collaboration were company R&D managers and R&D researchers, rather than lab managers or researchers – starting new industry partnerships had not been seen as a major part of the mission of the lab researchers or managers. The study authors note:
  "..*most of the contact between the labs and then companies has been based on informal interactions between scientists and engineers, and there may well be real questions as to whether lab-industry partnership can be successfully forged through formalistic programs*[102].

[99] Erlich, J. & Gutterman, A. A., 2003 Practical View of Strategies for Improving Federal Technology Transfer. Journal of Technology Transfer, 28, 215–226,

[100] Richard M. Franza & Kevin P. Grant (2006) Improving Federal to Private Sector Technology Transfer, Research-Technology Management, 49:3, 36-40 P.38.

[101] Erlich, J. & Gutterman, 2003 p218

[102] Erlich, J. & Gutterman, 2003, p225

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Link, Albert N., Donald S. Siegel, and David D. Van Fleet (2011). "Public Science and Public Innovation: Assessing the Relationship between Patenting at U.S. National Laboratories and the Bayh-Dole Act," *Research Policy,* 40: 1094-1099.

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8.5 C.3: KNOWLEDGE TRANSFER IN AUSTRALIA

8.5.1 Introduction

Universities play a relatively large role, and government research organisations a relatively lower role, in the research system. These characteristics have led to knowledge transfer being both an important policy priority and a continuing challenge for all participants.

8.5.2 Main Trends in Commercialisation Capabilities, Policy and Performance

The challenge and the importance of effective knowledge transfer has been a focus of many studies over the past 30 years (see Box 1), but, at least over the 2004-2016 period, no significant improvements in some of the key indicators of commercialisation outcomes[103], see Section 3 Introduction to Case Studies. The overall characteristics of policy for knowledge transfer in Australia over the past 40 years are:

Increasing emphasis on knowledge transfer from RTOs

Governments have increasingly emphasised the expectation that RTOs will contribute more significantly to knowledge transfer, innovation and economic growth. This has led to a great deal of policy development aiming to stimulate and support RTO-industry interaction. Policies have focused on:

- The demand side by encouraging industry to interact with RTOs, eg by lowering the cost of engagement through vouchers.
- The supply side, by requiring the major government PRO (CSIRO) to increase 'external income' from customers.
- **An increasing emphasis on sustained RTO-industry collaboration.**
  A shift from the pipeline model of licensing of new patented knowledge to a greater role for collaboration between RTOs and industry.
- **Increasing emphasis on the scope for entrepreneurship**
  All RTOs have increased their support for entrepreneurship by staff and students. Most have also become more supportive of spin-outs as a mechanism for commercialisation.

Box 1: Reports to Government on Commercialisation Challenges and Performance – 1999-2021

- Coordination Committee on Science and Technology (CCST), 1999. Interactions between Universities and Industry. Australian Government.
- Johnston, R. Matthews, M and Dodgson, M. 2000. Enabling the Virtuous Cycle: Identifying & Removing Barriers to Entrepreneurial Activity by Health and Medical Researchers in the Higher Education Sector, 2000
- Chief Scientist and PMSEIC, 2000. Investing in Knowledge for the 21st Century.
- PMSEIC, 2001. Commercialisation of Public Sector Research,
- Howard Partners 2001. Mapping the Nature and Extent of Business-University Interaction in Australia: A Study for the Australian Research Council, 2001

[103] While not an unambiguous indicator of the commercialisation of Australian research venture capital investment in Australia grew strongly over the 2016-2021 period (venture-capital-dashboard.pdf (industry.gov.au)).

- Johnston, R., Howard, J. and Grigg, S. 2003. Best Practice Processes for University Research Commercialisation. Department of Education.
- Phillips KCA, 2006. Knowledge Transfer and Australian Universities and Publicly Funded Research Agencies. Report to the Department of Education, Science and Training
- Howard Partners, 2007. The role of intermediaries in support of innovation. Howard Partners.
- Minister for Innovation Industry Science and Research, 2009. Powering Ideas: an Innovation Agenda for the 21st Century, [Set out aims to double the level of collaboration between RTOs and business, and raise the value of innovation from this collaboration.]
- Department of Innovation Industry Science and Research, 2011. Focusing Australia's Publicly Funded Research Review: Maximising the Innovation Dividend, 2011. [proposed measures to raise the level of RTO-industry collaboration.]
- Office of the Chief Scientist, 2015. Boosting High-Impact Entrepreneurship in Australia, 2015
- Innovation and Science Australia (2016) Performance Review of the Australian Innovation, Science and Research System 2016. Commonwealth of Australia. Canberra [Concluded that there are few direct mechanisms to support knowledge transfer and interaction between researchers and businesses is limited. Barriers to collaboration include information and skill gaps and regulatory issues.]
- Department of Industry, Energy, Science and Resources, 2014. Boosting the Commercial Returns from Research, DIESR, Canberra. [Set out plans to improve RTO-industry collaboration, develop an intellectual property (IP) Toolkit, and improve access to information about collaboration opportunities and outcomes.]
- Department of Education, Science and Employment. Research Commercialisation Consultation Paper. 2021. [Identified ongoing barriers to commercialisation and RTO-industry collaboration.]
- Innovation and Science Australia (ISA), the statutory board established to advise government, released their ISA's strategic plan for the innovation system: Australia 2030: Prosperity through Innovation (2017)

This assessment characterises four stages in the evolution of the knowledge transfer system, a pattern very similar to that in the US and many other OECD economies:

1. Passive Diffusion Before 1985
2. Development of the Technology Transfer Model and Licensing Pipeline 1985-1995
3. Strengthening Capabilities and Relationships 1995 – 2010
4. Developing Knowledge Ecosystems 2010-

8.5.3 Passive Diffusion – Prior to 1985

Over this period there were few new policies are strategies at the RTO or national level to promote knowledge transfer, but awareness of the importance for knowledge transfer was growing. The Birch Review into the CSIRO (1977) recommended a stronger emphasis on the implementation of research results.

In this period informal channels of knowledge transfer have been substantially more important than formal channels – with some exceptions. However, Australia has long had a strong system of extension to transfer new knowledge to farmers.

8.5.4 Development of the Technology Transfer Model and Licensing Pipeline- 1985-1995

This phase was characterised by optimism over the scope for transformation of the knowledge transfer system and saw the development of KTOs in universities and PROs and a focus on the role of licensing and later also spin-offs. International and local experience suggested that an active approach to patenting and licensing inventions could generate revenue for research organisations and promote innovation in industry.

Government policy changes in the late 1980s, required all PROs to earn 30% of their income from external sources other than direct appropriations from government- this requirement was removed in 2002. Legislation governing CSIRO was changed in 1986 to amend its governance with a new Board and independent Chair, permit the organisation to become more commercial, to retain earnings from commercial activities, to create spin-offs and to provide support services to industry on a commercial basis. CSIRO created SIROTECH, its TTO. Patenting and spin-off formation increased rapidly. Senior managers with experience in industry were recruited.

In the 1980s major changes in the overall regime of industry and STI policy increased the emphasis on international competitiveness. Industry policy emphasised the role of technology and innovation capability. Incentives for R&D were introduced for firms and a what became a increasing number of initiatives were introduced to promote RTO-industry collaboration, these included:

- The Australian Research Council's Linkage Program which funded university research which was jointly funded with industry
- The Cooperative Research Centres (CRC) Program, 1990, to support user-driven, multi-year collaborative research programs
- The Rural Research Council were corporatised to ensure that their research was more user-driven.

New policy initiatives sought to encourage investment in the early high-risk stage of commercialisation: for example, the Pooled Development Funds (1992) to encourage Venture Capital investment.

8.5.5 Strengthening Capabilities and Relationships -1995 – 2010

Evaluations of government innovation programs and other research had led to recognition of the limitations of the commercialisation pipeline model and increasing emphasis on a broader interface with industry. These studies found that:

- few businesses in Australia are research-intensive and seek to collaborate with RTOs and to commercialise university IP. Although firms are increasingly relying on external sources of knowledge for their innovations, they are considerably more likely to view customers and suppliers as direct sources of ideas rather than universities and research organisations.
- there is no useful 'market for ideas' and it is very difficult for business to find out what useful knowledge RTOs may have and for RTOs to find out what knowledge business is seeking.
- the culture of universities provided incentives for excellence in research but little incentive for engagement in commercialisation or engagement with industry.

- the early stages (Proof of Concept and Scale-Up) of many technology commercialisation processes typically involve high levels of uncertainty risk. These are strong disincentives for investment, whether by an existing firm licensing IP or a start-up licensing the technology and seeking venture investment.
- commercialisation performance of RTOs (as indicated by licensing and spin-offs) increased and overall reached a level similar to that of the average level of RTOs in the US and comparable countries, but significantly behind the leading performers[104].
- barriers to industry-university collaboration include a lack of financial, time or workforce resources needed to collaborate, regulatory and intellectual property barriers, information asymmetry where businesses and universities are unaware of what they can offer each other, a lack of workforce skills to engage with sectors, and others.
- university patenting and licensing, though rapidly increasing, remains a very small contributor to the overall stock of patents
- university licensing income is a very small fraction of income from sponsored research (between 1 and 2 percent for Australian universities in 2000) and only a very small fraction of university patents make money
- Patenting is a relatively minor pathway for the flow of knowledge from universities to the private sector, outside the biomedical and ICT sectors.

Performance and Key Policy Changes Over this Period

The Cooperative Research Centres (CRC) program was a major initiative to collaboration between RTOs and industry that was ambitious, long-term and strategic. Over the period from 1990 to 2003 the program has funded 145 centres, each with funding over at least five years. The total investment in research over this period was equivalent to almost A$4.5 billion (combining financial and resource contributions) of which at least 25% came from the government. The program is generally considered to have been successful, although more in generating research than, apart from significant successes, in knowledge transfer[105].

The commercialisation activities of RTOs increased and by 2007 there were almost 500 specialist technology transfer staff in Australian RTO[106]s. RTOs became increasingly interested in active approaches to promote commercialisation including through supporting commercialisation through new venture formation, including by RTOs taking equity in new ventures. For CSIRO, the level of patenting declined as the level of collaboration with industry increased. By 2000 CSIRO had over 130 specialist commercialisation staff. Over the 20 years from the mid-1980s income from royalties had risen from about A$1m to A$30m.

There were further initiatives to encourage investment in the early stages of commercialisation: for example, the Commercialising Emerging Technologies Program (1999) and R&D Start programs that provided funds to businesses commercialising technologies.

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[104] Allen Consulting Group. (2004). *Building effective systems for the commercialisation of university research*. Melbourne: Australian Vice-Chancellors' Committee and the Business Council of Australia.

[105] Howard Partners 2003 Evaluation of the Cooperative Research Centres Programme. Department of Education, Science and Training

[106] Upstill, G., Elsum, I. and Spurling, T. (2010) Transferring technology from public research institutions to Australian industry: An evolutionary perspective Australian and New Zealand Academy of Management Conference. 2010.

Over this period surveys[107] and reviews of various government programs[108] identified several major barriers to effective commercialisation:

- The structure of Australian industry is characterised a high proportion of SMEs and relatively high levels of foreign ownership and concentration in many sectors. R&D intensity is generally relatively low. This has strong implications for the demand for new knowledge from RTOs and also for the types of relationships with RTOs that different types of firm seek.
- For many companies with a low appetite for innovation-related risk, the cultural differences with research organisations, a lack of capabilities required for early-stage commercialisation and the challenges of managing sometimes complex IP and contractual issues, are strong disincentives to collaboration with RTOs.
- By the late 1990s the growth of high tech (IT and biotech) startups globally was raising awareness of the significance of new ventures, and of the venture capital mode of investment, for commercialising new technologies. A report to the Prime Minister's Science, Engineering and Innovation Council in 2001 proposed policy initiatives to greatly increase the rate of spin-offs from RTOs.
- A 2008 review of the CRC Program recommended a greater emphasis on the application of new knowledge by users rather than a focus on commercialisation by the CRC itself (O'Kane, 2008)
- Commercialisation is constrained by a lack of funding for knowledge transfer, including a lack of gap funding for proof of concept[109].
- Industry motivation to collaborate with RTOs is reduced by the cultural gap between RTOs and industry, a lack of skills within RTOs, overvaluation of IP and slow-moving University approval processes due to a lack of support by senior management.

Taking such issues into account, a report[110] from a Prime Minister's Science Engineering and Innovation Council Working Group recommended:

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[107] Harman, G. 2010. Australian university research commercialisation: perceptions of technology transfer specialists and science and technology academics. *Journal of Higher Education Policy and Management* 32(1), 2010, 69–83

[108] Phillips KPA. (2006). *Knowledge transfer and Australian universities and publicly funded research agencies*. Canberra: Department of Education, Science and Training; Productivity Commission. (2007). *Public support for science and innovation: Productivity Commission, Research Report*. Canberra: Commonwealth of Australia; Yencken, J., & Ralston, L. (2005). *Evaluation of incentives for commercialisation of research in Australian universities: A survey of selected Australian universities*. Canberra: Department of Education, Science and Training; Howard Partners. (2003). *Evaluation of the Cooperative Research Centres Programme*. Canberra: Department of Education, Science and Training; Business, Industry and Higher Education Collaboration Council [BIHECC]. (2008). *Advice to the Australian government in response to the Deloitte Insight Economics recommendations*. Canberra: BIHECC Secretariat; Deloitte Insight Economics. (2007). *Business case for knowledge transfer*. Canberra: Deloitte Insight Economics. Department of Education; Allen Consulting Group. (2004). *Building effective systems for the commercialisation of university research*. Melbourne: Australian Vice-Chancellors' Committee and the Business Council of Australia; Allen Consulting Group. (2006). *The economic impact of cooperative research centres in Australia – Delivering benefits to Australia*. Canberra: Cooperative Research Centres Association; Australian Research Council. (2000). *Research in the national interest: Commercialising university research in Australia*. Canberra: Australian Research Council.

[109] The government's response to the review of Australian Higher Education (Bradley Review), 2008) (Department of Education, Employment and Workplace Relations, 2008.) rejected the proposals for funding for universities' Third Stream' activities. In the UK the Lambert Review had argued that funding for Third Stream activity was essential to provide certainty for planning and to address the administrative burden involved. (Lambert, 2003). The 2013 Witty review, Encouraging a British Invention Revolution, similarly stressed the importance of 'Third Stream' and the case for funding to support that role (Witty, 2013).

[110] Commercialisation of Public Sector Research, PMSEIC, 2001

- Information Exchange—facilitate information linking intellectual property (IP) to market opportunity, and help industry and researchers find a ‘common language’, for example, through a regular ‘trade fair of ideas’
- Confidence to Commercialise—give researchers and their business partners the skills to commercialise, by raising researchers’ awareness of commercial reality, educating industry about the potential returns from investing at the pre-seed stage, and providing both with the tools to better manage the risks.
- Incentives for Success—provide appropriate incentives to encourage researchers to consider the commercialisation potential of their work and remove obstacles such as the taxation treatment of share options, media and political beat up for perceived failure; and
- International Development—establish profitable international developments to optimise the benefits of global collaboration, and showcase Australia’s innovation potential to the world, while increasing local awareness and appreciation of research, innovation and commercialisation.

Reviews of medical research (Wills, 1998) and of the Defence Science and Technology Organisation (Trenberth, 2003) also recommended policy and organisational changes to improve knowledge transfer.

8.5.6 Developing Knowledge Ecosystems – 2010-

From the early 2000s the innovation systems perspective began to influence innovation policy. This perspective supported the shift from the commercialisation of public sector research to a view of the distinctive and diverse roles of RTOs in the innovation system. From this perspective a comprehensive policy for knowledge transfer recognises the many channels of knowledge transfer and the role of knowledge exchange.

The experience of the limited success in the previous phase brough a wider recognition that the longer-term goals of a university are also served by developing entrepreneurial capability in staff and students and in contributing to the infrastructure for innovation and entrepreneurship, through eg, venture capital funds, incubators, science parks etc.

In 2015 the government announced a new initiative (National Innovation and Science Agenda (NISA)) for science, research and innovation to which the government committed A$1.1 billion for 24 different measures over 4 years. The measures focused on support for entrepreneurship and industry-research collaboration.

Consultations indicated that, even in 2021 after years of policy reform, that IP-related issues were widely seen as barriers to effective commercialisation of research outcomes: “difficulties in negotiating IP terms and agreements [due to a] lack of money, time and expertise on both sides and lack of understanding of each other's needs and objectives.“[111] A review of the performance of the innovation system[112] in 2016 found that collaboration between researchers and businesses continues to be limited.

[111] Higher Education Research Commercialisation IP Framework: Consultation Framework. 2021. Department of Education, Skills and Employment https://www.dese.gov.au/higher-education-reviews-and-consultations/resources/higher-education-research-commercialisation-intellectual-property-framework. p3.

112 Innovation and Science Australia (2016) Performance Review of the Australian Innovation, Science and Research System 2016. Commonwealth of Australia. Canberra

Performance and Key Policy Changes Over this Period

Surveys indicated that Australian public-sector research organisations generate patents at 20% and start-ups at 25-30% of the rate of US universities per R&D $.

There were several significant initiative aiming to encourage collaborative research and knowledge transfer:

- Industry Growth Centres (2015) -six growth centres were established in priority sectors (food and agribusiness; advanced manufacturing; oil and gas; mining equipment, technology and services; medical technology and pharmaceuticals; and cyber security). Each Growth Centre is intended to be 'industry led' and aims to raise productivity, competitiveness and innovative capacity and involves collaboration with RTO.

- Industrial Transformation Research Program funds research hubs aligned with the growth centres, and research training centres, and supports Higher Degree by Research students and postdoctoral researchers in placements in industry.

- Biomedical Translation Fund provides at least A$500 million (50-50 Government and private sector) for investment in the commercialisation of biomedical discoveries. Licensed fund managers can draw down funds over seven years.

- Entrepreneurs' Programme including: Accelerating Commercialisation, to help SMEs, entrepreneurs and researchers to commercialise novel products, processes and services; Business Management to provide advice on strategy; Innovation Connections, to help businesses identify barriers to business growth; and Incubator Support, to provide funding support for new incubators and accelerators and existing incubators.

- Trailblazer Universities Program involve almost A$250m to support selected universities to boost R&D and knowledge transfer with industry partners over five years. The Trailblazer Universities Program responds to feedback, which highlighted the importance of strengthening capability at the RTO level, developing more effective IP arrangements and providing greater incentives for academics and institutions to translate and commercialise research. In parallel with this initiative, the Department of Education, Skills and Employment will develop Higher Education Research Commercialisation IP Framework, which will become mandatory for all government funded research in RTOs. The framework is a set of templates intended to be used to provide a basis for negotiation and agreements[113].

In 2021 a review of the performance of knowledge commercialisation from Australian universities reached the conclusion that many barriers remained, many related to IP management – Table C.3.1.1.

Table C.3.1: IP-related constraints to successful commercialisation and collaboration[114]

Constraint	Description
IP rights and access	IP rights and access were raised extensively in the University Research Commercialisation Scheme consultation process and are discussed in detail below.

[113] https://www.dese.gov.au/hercip/framework-resources

[114] Higher Education Research Commercialisation IP Framework: Consultation Framework. 2021. Department of Education, Skills and Employment. https://www.dese.gov.au/higher-education-reviews-and-consultations/resources/higher-education-research-commercialisation-intellectual-property-framework. p5-6

IP valuation and royalties	Businesses think universities overvalue their technology, research and IP, and universities think businesses undervalue the technology and the university's pre-existing IP. This means committing to an upfront royalty payment may be difficult.
Confidentiality before publication	If not appropriately managed, publication requirements of a university can conflict with confidentiality requirements of businesses in securing IP rights. There are specific challenges for PhD students working on projects under deeds of confidentiality.
Contractual confidentiality obligations	Conversations about confidentiality must be at an early stage of project design to establish if the project will fit with university and business policies on publication of research results. This is critical if research outputs need to be held as trade secrets or by government for security considerations.
Warranties and liabilities	There can be differences between what each party considers reasonable in terms of warranties about performance of IP that they should provide, and what warranties they expect in return. There can be concerns about who carries liability, scope of indemnity, and capping liability, as well as whether a party is able to cover the agreed indemnity.
Cost	Significant costs to both universities and businesses can be incurred for lawyers and patent attorneys. This can be a deal breaker for SMEs. There are also opportunity costs of diverting staff, loss of timeliness, principal researcher funding drying up, and strategic costs (one party 'swearing off' the other for future collaboration).
Timeliness	Significant problems arise when negotiations are drawn out and cycle times are not specified or adhered to. There are also long lead times in complex research projects, particularly in basic or discovery research projects.
Materiality	Efforts to arrive at a comprehensive contract can be seen as time-wasting and harm trust between parties. Parties can differ in their basis for making decisions on materiality, from a risk management-based approach with contingency planning, to a worst-case-scenario approach.
Research performance incentives	Measuring research success by academic journal publication, which is required for researcher and university rankings and grant funding, is widely perceived as a constraint on commercialisation activity. Despite this, many businesses welcome academic publication as a measure of leading-edge research.
Communication	There are difficulties due to a lack of effective communication channels and procedures (nominated personnel, timeliness, frequency of contact and establishing relationships for potential licensing or collaboration). This compounds the other constraints.
Asymmetry between parties	A common perception is that some universities are in a poor bargaining position. Businesses can also feel out of their depth in navigating the system and finding people with relevant knowledge.

Concerned with these issues and recognising the slow improvement in RTO-industry collaboration, the association of university RTOs and other organisations committed to improving innovation in Australia, Knowledge Commercialisation Australia (KCA), recommended to government three priority initiatives for improving knowledge transfer[115]:

- Establish of system wide third-stream funding for supporting the development of additional commercialisation capacity and development and delivery of worldwide recognised training and support for developing best practice in commercialisation.

[115] Knowledge Commercialisation Australia, 2021 Submission to the University Research Commercialisation Taskforce. KCA.

- Provide funds for Pre-Seed and Proof of Concept funding by establishing a devolved proof of concept funding scheme to enable rapid, local decision making for advancing opportunities to the point at which they can be commercialised.
- To align senior management with university research commercialisation activities by developing a Research Commercialisation Concordat to be adopted by university leadership, similar to the UK's Knowledge Exchange Concordat, outlining a series of principles supporting research commercialisation.

8.6 Observations

Revenue Generation Vs Knowledge Transfer., Many RTOs had sought to maximise their income from knowledge transfer through protection of IP and rigorous negotiations with potential licensees. This can raise the transaction costs for the potential licensees and lead to a decline their willingness to license RTO IP and hence a decline in the overall level of knowledge transfer from RTOs to industry. The key lesson from experience is that knowledge transfer should generate national benefit – through problem solving, economic development – as the key goal, rather than income to an RTO or private profit. The later can only be means to an end. By 2004 gross university income from licensing was A$38.4m, but commercialisation costs (staff, legal advice, etc) was A$29.4 million. For many universities, commercialisation costs exceeded income. In the same year universities' income from research contracts and consultancies was A$631m – i.e., 16 times the income from IP-related commercialisation[116].

Capabilities in RTOs. Where the performance of a university of PRO is judged through the excellence of their research (as indicated by, in particular, publications and citations), the key capabilities are those relevant to research at the frontier of knowledge. However, where knowledge transfer and knowledge application are important dimensions of performance, a wider range of capabilities are required. Many companies who might seek to access and apply knowledge from RTOs, have limited capabilities to apply that knowledge for problem solving and innovation – i.e., limited absorptive capacity. If RTOs aim to be effective agents of not only knowledge generation but also of knowledge transfer and application, then they need to develop relevant capabilities. Perhaps the most generic but most important of these is communication capabilities. The capabilities to apply knowledge will often be multidisciplinary, rather than the narrow and highly discipline-focused approach of many research organisations[117]. This is one of the reasons why multidisciplinary research centres have been established and why much knowledge transfer (and exchange) is through collaborative and contract research where there is close engagement between users and RTO staff. Knowledge transfer usually requires close interaction between the RTO researchers and the business users of the knowledge.

Structure and Capabilities of TTOs. Many universities and PROs established TTOs in the 1980s, often staffed by people with legal backgrounds. By 1990 at least seven of the larger universities had established TTOs. In some cases, smaller universities established TTOs that were managed by other more experienced universities. Some Scandinavian countries had experimented with TTOs that serviced several universities or that focused on one or a few industrial sectors. However, by the mid-1990s, many universities and PROs had moved away from central TTOs servicing a university or PRO,

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[116] Department of Education, Science and Training [DEST]. (2007). National survey of research commercialisation years 2003 and 2004. Canberra: DEST.

[117] Howard, J., 2005, May. The emerging business of knowledge transfer: From diffusion to engagement in the delivery of economic outcomes from publicly funded research. In *Triple Helix 5 Conference, 'The capitalization of knowledge', Turin* (pp. 18-21).

toward a distributed arrangement, with TTO branches in faculties and research divisions as partners with researchers, rather than central separate intermediaries.

Innovation Processes and Pathways. Innovation is increasingly a distributed process, involving a range of actors, possibly in different industries and countries. RTOs might be involved in many different roles, possibly over long time periods as a new product or process is developed, adapted and improved[118]. Most industrial innovation does not involve RTOs in any direct roles. The 'linear model' role, where research leads to a patent which is then licensed by a company, which then commercialises the technology with little or no involvement by the RTO, is relevant largely only in the bio-medical sector. In many cases RTO researchers provide elements of (old or new) knowledge, which along with knowledge developed within firms, contribute to an innovation. Hence, there is no single model for the commercialisation of new knowledge and for role of RTOs in innovation more generally.

[118] Thompson, L.J., Gilding, M., Spurling, T.H., Simpson, G. and Elsum, I.R., 2011. The paradox of public science and global business: CSIRO, commercialisation and the national system of innovation in Australia. *Innovation*, *13*(3), pp.327-340.

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8.8 C.4: KNOWLEDGE TRANSFER IN CHINA

8.8.1 Context

R&D expenditure in China has grown rapidly over the past 20 years and now exceeds 2.4% of GDP or about US$400 billion – the highest level after the US. The share of GERD accounted for by the business sector has also grown steadily - it was 76% by 2015. The number of patent applications (to the national patent office, SIPO) increased 25-fold from 2000 to 2016 – about 20% of patent applications have been from universities and PROs[119].

"The Chinese university system is one of the world's largest academic research performers and technology transfer is one of the system's central roles."[120] Since about 1990, funding of university research has grown strongly, at an annual compound growth rate of over 15%. This has led to a rapid growth in publications, and, after policy changes, also in also in patenting, but the growth in the quality of publications and patents has been slower.

The development of policies and programs to promote commercialisation, and the performance in commercialisation can be seen in three phases – Table C.4.1.1

Table C.4.1.1: Phases of Knowledge Transfer Policies in China

Phases	Focus	Lessons
1: 1985-1995	Finding a way forward	
2. 1995-2015	Implementing reforms and Driving growth in R&D	Universities and PROs lacked adequate incentives to pursue knowledge transfer
3. 2015-	Increasing innovation impacts	Lack of demand from Chinese firms due to a lack of absorptive capacity limits knowledge transfer. Lack capable KTO offices in many research organisations limits knowledge transfer.

8.8.2 Prior to 1985

Before 1985 the legacy of the Soviet style approach, with high central control and vertical rather than horizontal linkages, separated education, research and production and meant that there were no incentives for RTO-industry links. The initial frameworks for IP law and the promotion of S&T were established- Table C.4.2.2.

Table C.4.2.2: Major Legislation Related to Knowledge Transfer Prior to 1985

Time	Main legislation	Goal
1949	Common Program of the Chinese People's Political Consultative Conference	Basic definition of the role of science in development of Chinese society
1951	Instructions on Strengthening the Contact between the Chinese Academy	Scientists should engage in research with benefits to society

[119] Baoming Chen, Can Huang, Chunyan Peng, Minglei Ding, Ning Huang, Xia Liu, And Juan Yang, (2021) China. In Arundel, et al (Eds) Harnessing Public Research for Innovation in the 21st Century- an International Assessment of Knowledge Transfer Policies, Cambridge University Press.; Wu, W. 2017. 'Research and innovation in Chinese universities'. In Krishna (Ed) 2017 Universities in the National Innovation Systems. Experiences from the Asia-Pacific. Routledge - Taylor and Francis

[120] Chen, A., Patton, D. and Kenney, M., 2016. University technology transfer in China: A literature review and taxonomy. *The Journal of technology transfer*, *41*(5), p.891

	of Sciences and Industry, Agriculture, Health, Education and National Defence	
1975	Constitution of the People's Republic of China	Research should be combined with productive labour
1978	National Science and Technology Development Plan Outline from 1978–1985	S&T should play an increasingly large role in production and research should be combined with production and application
1984	Patent Law of the People's Republic of China	Granted inventors the right to patent inventions

Source: Chen, Patton and Kenney, 2016

8.8.3 Phase 1: 1985-1995

China had joined the World Intellectual Property Organisation in 1980 and in 1985 established a Patent Office and signed the Paris Convention for the Protection of Industrial Property. As the development of China's IP system dates from only that time, a long process of legal development, understanding and capability development has been required. The patent law has been amended three times since 1985. The patent law affirms that inventions created by researchers, as part of their work, are the property of the employing organisation, but the researcher has a right to some benefit from his/her invention.

The 1985 Decision on Reforming the Science and Technology System required many PROs funded by central or provincial governments to collaborate more closely with enterprises and seek funding through those relationships. As the overall level of R&D funding remained very limited through the 1980s and early 1990s, the potential for IP generation in RTOs and R&D activity in enterprises was also limited. The 1993 National Outline for Educational Reform and Development addressed some of these limitations by focusing national investment on a group of elite universities- Table C.4.2.

An important initiative in the wider innovation system development in this period was the Torch Program, established in 1991, which promoted the growth of science and industry parks.

Table C.4.2: Major Legislation Related to Knowledge Transfer Prior to 1985- 1995

Time	Main legislation	Goal
1985	State Council's Interim Provisions on Technology Transfer	Encouraged a market for state-funded technology
1986	High-technology Research and Development Plan Outline (namely the 863 Program)	Program funded to stimulate the development of defence-oriented technologies
1987	Opinions on Science and Technology Reform in Universities	University education and research should contribute to production and URIs and firms should cooperate
1987	Technology Contract Law of People's Republic of China	Guaranteed technology contracting parties' lawful rights and interests and maintain order in technology markets
1988	China Torch Program	High-technology development plan that eased regulations, provided support for facilities to attract foreign companies, and encouraged the establishment of indigenous firms in special zones throughout China, many of which were located close to URIs. This facilitated the development of USPs

1993	Scientific and Technological Progress Law of the People's Republic of China	Called the Chinese "Bayh-Dole Act" and granted universities the rights to commercialize government-funded technologies and IP

Source: Chen, Patton and Kenney, 2016

8.8.4 Phase 2: 1995-2015

This phase has seen the launch of many ambitious initiatives to raise China's research and technological performance. The 1995 Strategy of Invigorating China through Science and Education, and the 1998 Law of Higher Education, underpinned a sustained increases in investment in universities and also established 'social service' as a key role of universities. The policies were reinforced by the 2006 National Plan for Medium and Long-Term S&T Development, which stressed the importance of universities and PROs contributing to innovation, including through technology transfer.

In the late 1990s, policy making for innovation and knowledge transfer began to be influenced by the knowledge economy and NIS concepts, and the Academy of Science was tasked with developing pilot projects for NIS development. From the early 2000s, MNCs began to play more active role in the Chinese NIS[121]. The Law on Promoting the Transformation of Scientific and Technological Achievements (PTSTA), promulgated in 1996, required universities and PROs to establish knowledge transfer offices and form links with external agencies for that purpose. However, the law did not confirm clear ownership rights and required universities and PROs to seek government approval for licensing IP. It also required research organisations to pay to the Ministry of Finance any revenue earned from knowledge transfer. However, despite the PTSTA the number and total value of knowledge transfer agreements by universities increased little over 2008-2014.

In 2002, universities were granted full rights of ownership and commercialization for inventions derived from government funded research. *The Measures for Intellectual Property Made under Government Funding* provided rules for IP ownership and licensing, inventor compensation, and firm creation. An important part of the legal foundation for managing IP in universities and PROs was consolidated by the 2007 Science and Technology Progress Law. The law confirms that IP developed by a university or PRO through public funding will be the property of the university or PRO. The 2007 National Technology Transfer Promotion Action Program sought to promote an enterprise-centric innovation system.

Over the period from 1986 to the early 2000s the linkages among PRIs, universities, and industries were also relatively weak – most firms had little capacity, and most state-owned firms had no incentive, to innovate[122]. However, the context began to change, as from 2004 to 2013, R&D expenditure in universities and research institutions grew at compound annual growth rates of around 20%. But over this period, as industry investment in R&D grew, HERD declined as a proportion of GERD.

In this phase the Public Research Organisations (PROs) usually had a larger role in overall R&D expenditure than universities (which accounted for less than 10% of GERD between 1997 and 2013) and a more direct role in innovation[123]. However, there were few links between universities and PROs, which spend 90% of their funds internally.

[121] Xue, L. Li, D. & Yu, Z., 2017 China's National and Regional Innovation Systems. Chapter 2.1 in Yip, G.S. and McKern, B., 2016. *China's next strategic advantage: From imitation to innovation*. MIT Press

[122] ibid

[123] Wu, W. 2017. 'Research and innovation in Chinese universities'. In Krishna (Ed) 2017 Universities in the National Innovation Systems. Experiences from the Asia-Pacific. Routledge - Taylor and Francis

Table C.4.3: Main university technology transfer-related laws and regulations enacted from 1995–2015.

Time	Main legislation	Goal
1996	Law on Promoting the Transformation of S&T Achievements	Meant to promote, guide, and standardize state-funded IP technology transfer at URIs
1998	Law meant to create world-class Universities (985 Project)	Provided massive funding to selected universities so that they can become world class
1999	Regulations on Promoting Scientific and Technological Achievement Transformation	Encouraged S&T personnel to invent new technologies and transfer them to develop high-tech industries; enabled easier movement of researchers between research and business.
1999	Regulations on Universities' Intellectual Property Protection and Management	Gave university IP rights and encouraged them to contribute to S&T industrialization
1999	Decisions on Enhancing Technological Innovation, Developing High Technology, and Realizing Industrialization	Encouraged and supported universities to establish USPs and improved their IP management systems
1999	"211 Project" Construction Planning	Funded construction at approximately 100 universities in a variety of key subjects
2002	Opinions on Giving Full Play to the Role of Universities' Scientific and Technological Innovation	Further encourage university S&T innovation and promote the combination of science and education in order to improve NIS
2003	Enterprises' State Assets Transfer Interim Measures Order No. 3	Meant to regulate and standardize technology transfers to firms of state assets under SASAC
2007	National Technology Transfer Promotion Action Program	Meant to build an innovation system of industry–university–institute to promote the transformation of S&T into productivity
2007	National People's Congress (NPC, the Legislature) Revised the Science and Technology Progress Law	Meant to enhance technology transfer and encourage local government support for research cooperation between industry and universities
2008	National Intellectual Property Strategy Outline	Meant to increase China's IP creation, utilization, protection, and management ability
2010	National Patent Development Strategy (2011–2020)	Declared 2020 goal to become a country with high levels of patent creation, utilization, and protection
2012	Opinions on Deepening the Reform of Scientific and Technological System and Speeding up the Construction of National Innovation System	Supported enterprises and URIs in working with each other by setting up an R&D platform and innovation strategy alliance
2015	Opinions on Deepening the Reform of Systems and Mechanisms and Speeding up the Implementation of Innovation-driven Development Strategy	Plan to gradually separate URIs and their subsidiary enterprises (UOEs) and they should no longer create UOEs. Also, to strengthen IP management.

2015	Law of Promoting Scientific and Technological Achievements transformation of the People's Republic of China (2015 Revision)	Meant to standardize and speed-up the transformation of S&T achievements into economic benefits

Source: Chen, Patton and Kenney, 2016; Wu, 2017.

The first group of Chinese TTOs were termed "National Technology Transfer Centers" and in 2001 the first ones were established at six elite universities. Initiatives by the Ministry of Education in 2002 encouraged the development of university affiliated enterprises and many universities did establish such enterprises – however, more for selling services to raise revenue than to commercialise technology[124]. Later the MOE began to see patenting and income from technology transfer as criteria for assessing the performance of universities and their leaders.

In the 2000s there has been a high level of activity in promoting research-industry interaction with many initiatives by governments and universities, new incubators and S&T Parks, and many private sector start-ups. For example, in 2016, China hosted 17 specialized national co-working spaces, around 4,200 normal co-working spaces, 3,600 S&T enterprise incubators, and 400 enterprise accelerators. There is also an acceptance that many policy and commercial ventures will not be successful[125].

Over this period the number of university-based science parks reached 115 by 2014. While some universities had established science parks in the early 1980s, only in 1999 did the central government approve the formation of university science parks, after which their number grew.

Policies also sought to encourage research-industry links to support innovation through strategic alliances. Over 50 such alliances, often led by RTOs were established in 2010. Industrial technology development projects funded under the National Science and Technology Plan must include enterprises in the research planning and performance, although only about a half of the projects are led by enterprises. The continued growth of S&T Parks has also stimulated closer RTO-industry collaboration, not least through human resource movements. Several technology markets, including the Zhejiang Online Technology Market in the Zhejiang Province, became established in this phase and began to attract participants. For example, by 2013 the Zhejiang Online Technology Market was reported to have almost 95,000 members[126].

During this phase some provincial governments became active in promoting knowledge transfer, experimenting with different policies. Some of this experience influenced national policy

The level of patenting by universities grew rapidly after patenting became a metric through which the performance of universities would be judged. The level of patenting by universities grew 100-fold from 1999 to 2013, and the level of patents granted grew at almost this rate.[127]. The quality of many of those patents is less evident. But by 2014 only about 15% of universities had licensed a patent.

A relatively high proportion of R&D in Chinese universities is funded by industry[128]. From this perspective contract research may be the major channel for knowledge transfer - from 2000 to 2004 universities income from technology contracts were 10 times the income from licensing and twice the revenue from spin-offs[129]. One focus of a significant proportion of research contracts is the adaptation of foreign technology, often by reverse engineering. The revenue that universities and R&D institutions earned from patent ownership declined markedly over this phase, the income from

[124] Wu, 2017
[125] Xue, L. Li, D. & Yu, Z., 2017 China's National and Regional Innovation Systems. Chapter 2.1 in Yip, G.S. and McKern, B., 2016. *China's next strategic advantage: From imitation to innovation*. MIT Press
[126] Chen et al 2021, p312
[127] Chen, Patton &Kenney, 2016
[128] Chen, Patton &Kenney, 2016, and Wu, 2017 state that industry funds 35% of university research.
[129] Chen, Patton &Kenney, 2016

contract research increased by almost 50% between 2010 and 2016 and the income from 'technology transfer' (not defined) declined.[130]. However, over 2000-2014, as a share of R&D revenue, the income from research contracts accounted for a declining share - from 22% in 2000 to 5% in 2014. Over the same period the percentage of university R&D revenue from patent licensing and sales also declined - from 2.3% to 0.9%.

Collaboration through some form of contract research, and also hiring of graduates, contributes to building relationships that can lead to licensing and closer collaboration. However, overall, the role of universities in direct knowledge transfer declined, despite the growth of the high-tech sector in China. Even the share of patents granted to universities that were then licensed or sold declined from 19.3 % in 2000 to 2.7% in 2014[131]. Over this period the growth of university research-based spin-offs also seemed to decline in number and significance. The evidence indicates that the policies that increased incentives for patenting by universities and led to a growth in patent numbers also led to a decline the rate of commercialisation of those patents. It also led to an approach to maximising the number of patents by increasing the focus of each patent application. It seems that the reason for this is that the incentives reduced interest in applied research, including 'Proof of Concept' work, essential to develop the commercial potential of inventions derived from basic research[132].

In this phase many barriers limited knowledge transfer[133]:

- Incentives that rewarded scholarly outputs above commercialisation contributions- particularly in elite universities
- Weak links, and poor communications, between universities and enterprises
- Lack of support for developing technologies through 'proof of concept'
- Lack of technology transfer skills
- Lack of absorptive capacity in enterprises
- Enterprises seeking rapid results and low risks prefer to avoid the risks of unproven technologies, by relying on imported technologies

Phase 3: After 2015[134] -Addressing Barriers through the 2015 PTSTA

The 2015 amendments to the 1996 PTSTS policy had removed ambiguities regarding the legality of universities and PROs engaging in knowledge transfer and also provided incentives for knowledge transfer. It allowed research organisations to deal with IP themselves and also allowed them to retain earnings from IP licensing or sale. On the other side of the coin, the law also made knowledge transfer a legal responsibility of universities and PROs and it required them to develop capabilities, processes and organisational capacities to support knowledge transfer and to report on their performance.

Industry funding of university research also grew strongly in the 2000s, as an increasing number of firms developed absorptive capacity and began to see universities as potential sources of expertise

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[130] Yi, G., Krishna, V.V., Zhang, X. and Jiang, Y., 2021. *Chinese universities in the national innovation system: Academic entrepreneurship and ecosystem*. Routledge India.
[131] Chen et al 2021.
[132] Gong, H. and Peng, S., 2018. Effects of patent policy on innovation outputs and commercialization: evidence from universities in China. *Scientometrics*, *117*(2), pp.687-703.
[133] Chen et al, 2021; Wu, 2017.
[134] There are very few systematic and independent reviews of knowledge transfer performance in China since 2015. There are long lists of R&D centres, incubators, demonstration centres, technology parks, etc, but next to no assessments of their effectiveness.

and technology. For example, by 2016, Huawei had formed cooperative relationships with over 40 universities. Income from patent licencing increased for the large elite universities, which accounted for the great majority of such income. For example, by 2016, Tsinghua's income from patent licencing was higher than that of Stanford or MIT. However, very few patents taken out by universities are subsequently licenced; in 2017 the rate of patent licensing from universities was equivalent to less than 3% of the rate of patenting by universities. The regulations over university IP ownership and commercialisation were still considered to be ambiguous by some universities. Issues of revenue distribution, clarity of the legality of patent licencing and transfer[135] and the consideration of KT activities in academics' performance assessment continue to affect the motivation for researchers to engage in TT. However, in 2015 the State Council issued an updated Technology Transfer Law which raised the expected share for the inventor's share from 15% to 70% of total royalties. Lack of capabilities in KTOs, particularly around issues of evaluation and marketing, continue to affect TT performance in most universities[136].

The Program on Promoting Scientific and Technological Achievements, Transfer and Transformation of 2016 set out requirements for the implementation of the 2015 amendments to the PTSTA. It initiated mechanisms to consolidate information on research outcomes and on problems for which industry was seeking support. It also began steps to establish a national technology market through a trading platform. The network of Innovation Relay Centres provided an open platform of information on opportunities for knowledge transfer used by RTOs and enterprises. By 2016 RTOs accounted for about 10% of the annual value of knowledge transfer contracts – i.e., most contracts were between enterprises. Furthermore, much of the interaction between RTOs and enterprises was through contract research and consulting- rather than licensing. From this perspective it is not surprising that the majority of knowledge transfer agreements between the RTO and enterprises do not involve patented knowledge.

Table C.4.4: Main university technology transfer-related laws and regulations enacted 2015.

Time	Main legislation	Goal
2015	Opinions on Deepening the Reform of Systems and Mechanisms and Speeding up the Implementation of Innovation-driven Development Strategy	Plan to gradually separate URIs and their subsidiary enterprises (UOEs) and they should no longer create UOEs. Also, to strengthen IP management.
2015	Law of Promoting Scientific and Technological Achievements transformation of the People's Republic of China (2015 Revision)	Meant to standardize and speed-up the transformation of S&T achievements into economic benefits

Source: Chen, Patton and Kenney, 2016

By 2016 there were 7,315 'R&D institutions' established in Chinese universities, of which only 15% were established jointly with firms. By 2017 about a half of the universities had established a TTO and there were more than 1,000 technology transfer local market platforms, it is generally considered that technology markets and other bridging mechanisms remain immature. By 2019, there had been 169 national high-tech parks in China of which 17 parks were in Jiangsu province, the largest number in a province.

According to Li, Yin and She (2017) the Ministry of Education does not support an increasing emphasis on technology transfer, seeing this as a diversion from the core mission of universities and

[135] In some cases the IP remains formally state-owned.

[136] Li, J. Yin, X. and She, S. China's Science-Based Innovation and Technology Transfer in The Global Context. Chapter 4.2 in Yip, G.S. and McKern, B., 2016. *China's next strategic advantage: From imitation to innovation*. MIT Press; Huang, C & Sharif, N. 2016. Intellectual Property Rights Protection. Chapter 4.5 in Yip, G.S. and McKern, B., 2016. *China's next strategic advantage: From imitation to innovation*. MIT Press.

argued against new laws promoting commercialisation. The changing roles of universities have led to tensions between the science and education ministries and difficult challenges for most universities.

"*Thus, the challenge of [university technology transfer] is not only to increase the inventor's share of the royalty but also to allow universities more freedom to deal with the UTT and invest more resources in the organizational capability of the TTO*."[137]

Addressing one of the barriers that became evident, the government supported programs for training knowledge transfer personnel. Provincial governments in China are active in developing policies and undertaking investments for regional economic development and many provincial governments introduced measures to support the implementation of the 2015 PTSTA and provided additional funding for knowledge transfer and greater financial incentives for researchers participating in knowledge transfer[138]. In addition to national high-tech parks, there are provincial and municipal high-tech parks. Each prefecture-level city in China has a high-tech park.

Wider innovation policy initiatives that have developed RTO-industry links for innovation include the 2016 National Innovation Centres/Platforms program for industrial technologies seen as strategic priorities. By this phase foreign multinational firms had become a significant component of the Chinese innovation system. By 2015, foreign-owned firms had established over 2000 R&D laboratories, of some form, in China. Many of these involved collaboration with Chinese RTOs[139]. For example, in 2013 Tsinghua University established five new joint research centers with MNCs Samsung, Daimler, Intel and Microsoft.

The amendments to the PTSTA policies were both a challenge and an opportunity for universities and PROs and they responded through[140]:

- **Increasing rewards and compensation for inventors and knowledge transfer contributors.** The 2015 amendments state that at least 50% of the 'net profit' from knowledge transfer should go to the inventors and others who contributed to the transfer, including knowledge transfer officers. Some RTOs now give up to 70 % of 'net profits' to the inventors and related contributors. A continuing problem is defining 'net profit'.
- **Setting up knowledge transfer organizations.** There is a National Technology Transfer Center and a National Technology Transfer Demonstration Institution, as well as many provincial level knowledge transfer organisations. KTOs in PROs generally collaborate with one or more of these provincial or national organisations.
- **Implementing performance evaluation systems.** The performance of KTO staff in many RTOs is evaluated and high performers have greater opportunities for promotion.
- **Marketing of information on scientific and technological achievements.** Increasing industry awareness of the knowledge assets and the research capabilities of RTOs is an ongoing challenge. Most large RTOs participate in exhibitions organised by governments or others, to make links and exchange information with enterprises and investors and to disseminate information on the assets and capabilities.
- **Permission for academics to take a leave of absence to start a business.** The new law required RTOs to develop management systems that allow academics to take leave and to keep their faculty position for up to three years when taking leave to create a new venture.

[137] Xue, L. Li, D. & Yu, Z., 2017 China's National and Regional Innovation Systems. Chapter 2.1 in Yip, G.S. and McKern, B., 2016. *China's next strategic advantage: From imitation to innovation*. MIT Press. p.322

[138] Liu, Y., Tan, L. and Cheng, Y.J., 2016. University patent licensing and its contribution to China's National Innovation System. In *Economic impacts of intellectual property-conditioned government incentives* (pp. 259-277). Springer, Singapore.

[139] Holmes Jr, R.M., Li, H., Hitt, M.A., DeGhetto, K. and Sutton, T., 2016. The effects of location and MNC attributes on MNCs' establishment of foreign R&D centers: Evidence from China. *Long Range Planning*, *49*(5), pp.594-613; Wang, J., Liang, Z. and Xue, L., 2014. Multinational R&D in China: Differentiation and integration of global R&D networks. *Int. J. Technol. Manag.*, *65*(1/2/3/4), pp.96-124.

[140] Based on Chen et al, 2021

- **Policies on spinoffs.** Many RTOs introduced measures to encourage students in universities and professionals and technicians in RTOs to start businesses.
- **Strengthening cooperation between universities, public research institutes and local industry.** Knowledge transfer via university–industry collaboration has also been encouraged. This has often taken the form of a joint research institute that providing technology services to business in the region. To encourage such initiatives provincial governments often provide land, funds, and buildings.

Table C.4.5: National Innovation Demonstration Zones

Date	Title	Location	University
2009	Zhongguancun Science Park	Beijing	Tsinghua University
2009	Wuhan East Lake	Wuhan, Hubei province	Wuhan University
2011	Shanghai Zhangjiang	Shanghai	Shanghai Jiao Tong University
2014	South Jiangsu	4 prefecture-level cities	Nanjing University
2015	Tianjin	Tianjin	Tianjin University
2015	Pearl River Delta	9 prefecture-level cities,	Sun Yat-sen University
2016	Shandong Peninsula	6 prefecture-level cities	Shandong University
2016	Shenyang-Dalian	Shenyang and Dalian	Harbin Institute of Technology

Source: Yi, G., Krishna, V.V., Zhang, X. and Jiang, Y., 2021. Chinese universities in the national innovation system: Academic entrepreneurship and ecosystem. Routledge India.

Despite these many policy changes, it is clear that significant barriers to knowledge transfer remain:

- Most Chinese firms lack absorptive capacity and hence are reluctant to base innovation on technology licensed from and RTO[141]. As a consequence, at least in the second phase of the development of commercialisation by RTOs, perhaps 50% of licences for RTO IP were with foreign firms.

- The limited funding which is available for commercialisation based on a patent does not extend beyond a few years. Unless an enterprise is prepared to license and then develop a technology that has a low level of readiness[142], the patent is likely to lapse.

- Some ambiguities remain in the regulations for knowledge transfer, one of which is a lack of clarification for how 'net profit' should be ascertained, when there are usually many types of cost involved in the knowledge transfer.

8.8.5 Related Issues

Spatial concentration. Much commercialisation activity is concentrated in regions where there a many R&D intensive firms and also large R&D intensive universities – most government funding of universities focused on the elite universities. This concentration is further driven by the role of science parks that encourage the co-location of universities, government research centres and R&D intensive firms or corporate R&D centres. Neither research excellence, knowledge transfer intensity,

[141] Brehm, S. and N. Lundin, (2012. "University-industry linkages and absorptive capacity: An empirical analysis of China's manufacturing industry." Economics of Innovation and New Technology, 21(8): 837–52; Lau, A.K. and Lo, W., 2015. Regional innovation system, absorptive capacity and innovation performance: An empirical study. *Technological Forecasting and Social Change*, *92*, pp.99-114

[142] Towery, N., Machek, E. & Thomas, A., 2017. *Technology Readiness Level Guidebook* (No. FHWA-HRT-17-047).

nor the returns from licensing and entrepreneurship, are evenly distributed – in fact all are highly skewed.

Regional Governments. The administration of some universities was delegated to regional governments in the early 2000s. Provincial governments have been active supporters of commercialisation in China, through funding, for example, R&D and commercialisation, providing land and buildings for RTO-industry joint R&D centres and through supporting knowledge exchange markets. This support reflects the recognition that to many of the benefits of RTO research are captured locally through startups, licensing, technical assistance to local firms, supply of trained professionals to local firms and creation of an innovation ecosystem that attracts new investment through the location of new firms[143].

Complementary infrastructure. National and provincial science parks have also often facilitated RTO-enterprise collaboration and hence knowledge transfer. The first national science park was in Beijing in 1988 and by 2018 there were almost 170 national-level science parks. Science parks often also included incubators and a high proportion of China's R&D intensive firms, and MNC research centres[144], are located in science parks[145]. However, some policy researchers question the extent to which the R&D conducted through collaboration with MNCs is near the global frontier, rather than largely for modification for the Chinese market[146].

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[143] Johnson, W.H. and Liu, Q., 2011. Patenting and the role of technology markets in regional innovation in China: An empirical analysis. *The Journal of High Technology Management Research*, *22*(1), pp.14-25; Jongwanich, J., A. Kohpaiboon, and C. H. Yang, 2014. "Science park, triple helix, and regional innovative capacity: Province-level evidence from China." Journal of the Asia Pacific Economy, 19(2): 333–52; Kafouros, M., C.Q. Wang, P. Piperopoulos, and M.S. Zhang.,2015. "Academic collaborations and firm innovation performance in China: The role of region-specific institutions." Research Policy, 44(3): 803–17; Kenney, M., & Mowery, D. C. (Eds.)., 2014. Public universities and regional growth: Insights from the University of California. Stanford, CA: Stanford University Press

[144] Todo, Y., W. Y. Zhang, and L.A. Zhou (2011). "Intra-industry knowledge spillovers from foreign direct investment in research and development: Evidence from China's 'Silicon Valley'." Review of Development Economics, 15(3): 569–85.

[145] Motohashi, K., 2013. The role of the science park in innovation performance of start-up firms: An empirical analysis of Tsinghua Science Park in Beijing. *Asia Pacific Business Review*, *19*(4), pp.578-599. Hobbs, K.G., Link, A.N. and Scott, J.T., 2017. Science and technology parks: an annotated and analytical literature review. *The Journal of Technology Transfer*, *42*(4), pp.957-976.

[146] Wu, 2017

8.9 C.5: KNOWLEDGE TRANSFER IN TAIWAN

8.9.1 Context

Taiwanese industry is largely composed of SMEs with some larger industrial groups that have emerged over the last 20 years. It does not have the large Chaebols that play a major role in Korea, nor the large foreign firms and state-owned firms that have major roles in China.

GERD increased from about US$11 billion in 2008 to over US$20 billion by 2000, rising from about 2.7% of GDP to over 3.3%, over this period. The number of universities increased from 53 in 2000 to over 100 by 2010. The industry and S&T policy has clear priorities for research and industrial investment with targeting facilitated through research and investment subsidies. Taiwan's higher education focuses on STEM areas in order to support high-tech industries. Typically, over 70% of PhD students and about 50% of undergraduates are from engineering and applied science[147].

Taiwan has a strong patenting performance, particularly in IT. However, Taiwan's patents are focused on process technology and draw to a relatively very low level on academic research. For example, in 2002 Taiwan's patents in the US cite academic research only 0.21 times per patent- a very low level compared with other countries: US (4.46), UK (3.2), Japan (0.99), South Korea (0.76).

Unlike Japan and Korea in which large industry groups have played a central role, Taiwan has relied on technology startups in a more decentralised innovation systems and a competitive market. However, U.S.-educated and trained Taiwanese engineers and entrepreneurs led the formation of many IT startups, several of which (including Taiwan Semiconductor Manufacturing Company) have become leading firms. Links with Silicon Valley firms and universities have continued and contributed to technological dynamism[148]. The government-funded Industry Technology Research Institute (ITRI) played a major role in the acquisition and diffusion of foreign technology and in particular has established several companies that have become prominent firms in the global IT market. ITRI had assisted SMEs with product- and process-oriented knowledge through technical services, consultancy, licensing and workforce training. Science parks have been significant parts of the innovation system in Taiwan. In 2020 the turnover of firms in the three major science parks was about US$100 billion.

Information Technology (IT) became the leading sector in Taiwan as IT output grew from about US$100m in 1980 to over US$5billion by 1990 and continued to grow at over 20% annually through the 1990s, reaching over US$21 billion by 2000 and over US$250 billion by 2021. Taiwan's exports have been dominated by IT (almost 50% in 2017) of which semiconductors account for the majority. However, more recently, much of the manufacturing of personal computing and mobile phone components has shifted to China. This has led to a renewed focus in Taiwan on generating talent and encouraging new startups- although major new clusters have not yet emerged[149].

8.9.2 Knowledge Transfer from Universities in the 1990s

Prior to the early 1980s universities were not permitted to collaborate with industry. Nevertheless, two organisations founded in the 1970s with private funding did actively support cooperation (through technical services, specialised training and contract research) with industry: Taiwan

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[147] Wu & Hu, 2017

[148] Saxenian, 2001. These US trained engineers also influenced industry and innovation policy.

[149] Feigenbaum, 2020.

University's Tjing-Ling Industrial Research Institute (TLIRI) and Tze-Chiang Foundation of Science and Technology (TCFST)[150].

Government policies to promote university-industry interaction began in the 1990s with the provision of grants and support for the creation of incubators. In the late 1990s the Department of Small & Medium sized Enterprises (DSME) of the Ministry of Economic Affairs began helping set up more than 30 incubators - almost all focused on specific technology areas.

However, the major policy change was the Science and Technology Basic Law of 1999, which clarified the right of universities to commercialise technology created through public funding. However, a range of other laws that govern universities and academics (as government employees) have had strong inhibiting impacts.

Although the government subsidised the process of patenting and provided incentives to researchers to patent, smaller TTOs lacked the professional staff to assist researchers and hence operated more as administrative units[151]. The government subsidies for patenting also led to TTOs facing mounting patent maintenance costs – in almost all cases for patents that found no commercial application.

The focus of university-industry interaction in this period was the transfer of know-how and not licensing of patents. Cases of successful collaboration with SMEs typically involved lead researchers who had prior industrial experience, and the gradual strengthening of SME absorptive capacity[152]. Over 1997 to 2001 industry funding accounted for about 3% of the overall funding for university R&D. A small proportion of university patents were ever licensed[153].

8.9.3 Knowledge Transfer from Universities in the 2000s

In 2000 the government developed *Guidelines for Ownership and Utilization of S&T Research and Development Results*, which set-out the requirement to pay 20% of any licensing income to the relevant government funding agency, 40% to the university and 40% to the inventors. In 2002, with the aim of encouraging researchers to be involved in patenting, the National Science Council (NSC) promulgated *the Principles of Management and Promotion of Academia R&D Result*s. Initially the NSC committed to reimbursing 70% of the cost of patent application and maintenance, a level of subsidy that was later reduced [154].

The National Science Council was granted a budget of around US$1 million in 2001 to set up a program to encourage the establishment of Technology Licensing Centers in the universities. Seven institutions were chosen to establish initial Technology Transfer Centres for the first stage and subsequently 30 technology research centres have been established in 22 public and private technology universities since 2002. These are administrated by six regional industry and academia cooperation councils funded by the Ministry of Education [155].

Most university-industry cooperation is subsidised by the government and is promoted by the National Science Council, Ministry of Education and Ministry of Economic Affairs – often with conflicting processes and policies[156]. The programs of the National Science Council included:

[150] Wu, 2000

[151] Lin et al 2012.

[152] Chang & Hsu, 2002

[153] Chang et al, 2006

[154] Chang, Chen, Hua and Yang, 2005

[155] Wu & Hu, 2017

[156] Liu, 2009

- University-Industry Cooperation Research Program, introduced in 1991 to promote collaboration in pilot technology research
- Program to Upgrade Industrial Technology and Enhance Human Resources was introduced in 2002 to support applied R&D for SMEs
- Digital Content University-Industry Cooperation Program, introduced in 2004 to support the development of digital content and related skills.
- Grants for establishment of technology transfer centers has since 2001 supported the formation of technology transfer centres in universities, as noted above.

Ministry of Economic Affairs (MOEA) programs included:

- The Technology Development Program for Academia, aimed to develop new technologies and industries drawing on basic research through the support for industrial technology development centres with long term strategies.
- The Innovation Incubators program was initiated in 1996 with the objective of encouraging innovative SMEs to move into university-based incubators. At the end of 2005, there were 91 incubators of which 69 were set up by universities. There were also a further 82 incubators sponsored by the MOEA.

The Ministry of Education has formed three programs:

- Regional university-industry cooperation centers initiative of 2002, which focused on six universities, aiming to develop cooperation among universities, government and industry for application-oriented R&D.
- To support cooperation between technology universities/colleges and industrial parks the Ministry of Education provides grants to enable universities to provide support to firms in industrial parks. In 2005 the program provided NT$84 million to sponsor 225 cooperation projects.
- The MOE has provided support for technology development centers in selected research-focused universities since 2003.

Two Examples of the Development of University- Industry Interaction

National Tsing Hua University

National Tsing Hua University, which is located, along with ITRI, beside the very successful IT-focused Hsinchu Science-Based Industrial Park, is the nation's premier research university and has frequently won the national Technology Transfer Centre Merit Award. The Research and Development Office of the National Tsing Hua University manages several specialised research institutes at the university, the technology licensing and patents application processes and the portfolio of spin-off entrepreneurial ventures. An Office of Technology Service and Licensing (OTSL) was created in 1998 to manage patenting, licensing and commercialisation. For five years from 2001, the development of the OTSL was supported by a grant of about US$0.2m from the National Science Council. However, income from contract research is typically five times that of income from licensing. Overall research funding from industry provides only about 4% of the university's research funding. In 1998 an Innovation Incubator was formed at the university with funding from the Small and Medium Enterprise Administration. Its capacity to support startups has grown over time. By 2013 over 100 companies had graduated from the incubator, about half from faculty, students and alumni[157]. The experience of Tsing Hua University has been that the priority of most firms (particularly large firms) is the recruitment of qualified graduates rather than the acquisition of technology.

Chung Yuan Christian University

[157] Hsu et al, 2015.

Chung Yuan Christian University established an innovation and incubation centre in 1997, a patent licensing centre in 2003, and an Industry-Academia Operation Headquarters in 2009. The university has also established a number of specialised industrial technology research centres, including the Centre for Membrane Technology and the Centre for Intelligent Manufacturing. The centres have continued to be dependent on government funding, rather than income from industry. However in the field of Electronic Engineering the level of corporate funding has grown consistently since the early 2000s[158]. In the case of the Centre for Membrane Technology, after 18 years of operation it remained largely dependent on government funding as industry funded only 18% of the research and income from licensing provided an additional 1%. According to Whah (2019), "*the Centre did generate one small spin-off but its formation was very difficult with little support from the university and its inflexible regulations – which discouraged other researchers from forming spin-offs or remaining in the university*."

There have been very few cases of licensing of patented technology through these centres and most of the interaction with industry has been through contract research and technical services/consulting, often with participation by Masters and PhD students. As a consequence, and perhaps most importantly, the 'research' centres have produced many PhD and Masters graduates with experience in applied research in areas of high interest to industry and as a result raising the capability of enterprises. In addition, many successful alumni have provided significant donations and opportunities for R&D collaboration with the university[159] [Similarly, the National Taiwan University raised US$ 20million from its alumni to establish a seed fund to commercialize innovations generated by the university[160].]

According to Wu and Hu (2017) the number of university 'technology transfer agreements' grew strongly in the early 2000s. Over the same period income from licensing also grew to US$4.6 million in 2005 and the capital raised by ventures in university-based incubators reached US$200 million by 2005. However, the limited available evidence suggests that this growth did not continue.

In 2003 a survey of 122 Taiwanese universities aimed to assess the responses to the changes in IP ownership introduced with the Science and Technology Basic Law of 1999. The survey found that more than half of the universities had established TTOs and/or incubators, most after 1999. However, the primary mechanism of interaction with industry was through education and training programs, which were far more frequent that the next mechanism, contract research. The experience of the universities was that informal, short-term and inexpensive training programs were attractive to SMEs with limited R&D budgets. The survey found that the major barriers to greater interaction were the conflicting organisational objectives of industry and universities, researcher's attitudes to commercial objectives and lack of understanding of industry needs[161].

By 2004 two thirds of GERD was funded by industry but only five percent of university R&D expenditure was funded by industry. Incentives to form TTOs and to patent continued to spur the growth of patenting but licensing income to TTOs did not increase. A case study of the National Cheng Kung University found that the analysis of experience "..*from 2001 to 2007 show[s] that, like most HEIs, not a single case arose because the enterprise wanted to carry out patent licensing with the HEIs. For the enterprises, the only purpose in technology transfer was to discover the 'know-how' of R&D. Patent licensing play a minor role in the process of technology transfer*."[162]

In conjunction with the policies of 2006, a review of the many laws and regulations that regulated universities began. Universities had been civil service organisations and faculty public servants – with all the regulations and restrictions that entails. The subsequent revisions included allowing enterprises initiated by universities, increasing university autonomy with regard to personnel management and budgets, permit university-industry personnel exchanges and deregulate the

[158] Whah, et al, 2019

[159] Whah, et al, 2019

[160] Hsu, et al, 2015

[161] Chang, Chen, Hua and Yang, 2005

[162] Lin et al, 2012, p.185.

sale/licensing of IP and other assets. Other initiatives began to address the problem of the different R&D and commercialisation regulations under the different ministries: Health, Agriculture, Education, etc, and to have the National Science Council develop a coordination mechanism across programs. Work also began in around 2006 to create a technology transaction market place/platform and patent auction system, along with a 'technology valuation system'[163] .

The many reforms introduced by the 2008 Inter-Ministerial Project did improve licensing rates at the National Cheng Kung University. Over 2008-2009 the level of licensing and the income from licensing did improve from the levels over 2004-2007, but the changes were not transformative[164]. Regulatory changes in 2008 enabled the university to pay competitive salaries for TTO staff and as a result to recruit senior staff with industry experience. This contributed to further improvements in licensing. But at least by 2012 these improvements were not sustained. This was due to an inability to retain senior TTO staff with industry experience and also to a lack of industry demand for licensing university IP[165].

In 2008 an inter-ministerial project (National Science Council, Ministry of Education and Ministry of Economic Affairs) was introduced (the Project for Enhancing University-Industry Collaboration Performance toward Higher Education Institutions) aimed at improving linkages. The initiative had ambitious goals, which included:

- Strengthening IP management and marketing capabilities and improve information provided to potential partners
- Improving the integration of support organisations and management systems funded by the different government agencies
- Building a culture in universities that encourages staff and student participation in industry collaboration
- Strengthening the professional capabilities of TTOs.

However, a study in 2016 which surveyed 26 participants in university-industry technology transfer found that major roadblocks remained. The key barriers were the lack of mutual understanding about expectations and working practices, and the rules and regulations imposed by universities or government funding agencies. For researchers, the lack of time outside of teaching and research was seen as a major barrier, while for TTO staff, the lack of recognition of technology transfer objectives by university management was also a major barrier[166]. The limited experience of TTO staff, who are employed under contract, appears to have remained a significant problem for effectiveness[167].

Table C.5.1: Policies Aiming to Develop Entrepreneurial Universities: 1990-2007[168]

Major policies	Details
Large Industry-University Cooperation Program (1991)	Aimed to upgrade the technological capabilities of large companies- but had limited impacts.

[163] Liu, et al, 2009

[164] Lin et al, 2012.

[165] Lin et al, 2012

[166]Shen, 2016.

[167] Hsu, et al, 2015.

[168] Based on Hu et al. 2016.

Science and Technology Basic Law (1999)	• Allow research institutions and industry to fully or partially claim and commercialize the titles of IP derived from government-funded research. • The government income from the share of technology transfer and commercialization of research institution is pooled to National S&T Development Fund.
Encouragement of Industrial Innovation and R&D (2001)	• Higher education institutions and Academia Sinica are able to retain 80% of income derived from technology transfer and commercialization. • Assisting higher education institutions to establish technology transfer or licensing offices.
Small Industry-University Cooperation Program (2002)	Aims to promote SMEs and startups- which are seen as the key actors in the innovation system
Management & Promotion of Academia R&D Results (2002)	• Subsiding patent application and maintenance fees for higher education institutions until 2005. • Reinforcing IP management and technology transfer training programs.
Development Plan for World Class Universities and Research Centers of Excellence (2006)	• Number of industry–academia co-operations and intellectual property rights, including those for patents, technology licensing, and technical reports become major evaluation criteria. • To set up 10 elite (or Asian top-tier) universities or fields of research within 5 years, and at least one university to ascend to the world class within 10 years. • Funding for the world class universities would be between NT$35 and NT$60 billion (about US$1.2–1.9 billion), depending on the number of selected universities.
Encouragement for Industry-Academia Collaboration Performance (2007)	• Aiming at helping the establishment of organizational structure and manpower recruitment and nutrition for the implementation of universities' industrial collaborations. • Reward funding for outstanding performance of industry–academia collaboration when the derived revenue is reached NT$50 million (about US$1.5 million) or exceeds 10% of total from the NSC. • Reward funding is NT$20 million per year (maximum) for each candidate.

8.9.4 Increasing Emphasis on New Venture Formation

In 2009, the Ministry of Education established the Entrepreneurship Services Program which was re-labelled the U-start Plan in 2010 and renamed the 'U-start Plan for Innovation and Entrepreneurship' in 2018. U-Start aims to promote an innovation and entrepreneurship culture in universities and provide opportunities for startups. It supports an entrepreneurship angel fund plan which works with the incubation and innovation resources of colleges and universities to support student entrepreneurial teams. At least two thirds of the teams (which must be three or more) must be students who graduated from a college or university in the last five years or current students (undergraduates and post-graduates) and working with a university-based incubator. Teams that pass the evaluation of the first stage of the Plan can receive US$11,000 in subsidies. Start-up teams will also receive guidance and assistance from the incubation unit for at least six months. During the second stage, teams passing the evaluation with distinction will be granted startup awards of US$8,000 to US$32,000.

In 2011 MOST launched the Germination Program (with the participation of the NSC and the support of Academia Sinica) which is aimed at identifying and promoting the development and commercialization of Taiwan's cutting-edge technologies. The program's ultimate goal is to foster investment-worthy startups with high commercial potential and based on research outcomes. Under the program Germination Function Units were established to identify and evaluate original technologies[169].

8.9.5 Key Findings

There has been extensive policy innovation aiming to enable universities to be more flexible in the management of, and to provide some incentives and support for, knowledge transfer, but change in the knowledge transfer system has been slow.

The structure of Taiwanese industry creates particular challenges for technology transfer through licensing and collaborative research. The relatively small number of leading firms are highly specialised and R&D-intensive. The primary interest of larger firms in linking with universities has been the recruitment of graduates, particularly from the leading public universities[170]. The large population of SMEs have little interest in commercialising novel and inherently commercially risky technologies from universities.

Training and technical services/consulting are more important channels for knowledge transfer than are licensing and collaborative R&D. According to Wu and Hu, 2017, many universities established Business Incubation Centres, and integrated a range of industry support activities to offer a more comprehensive range of management, engineering, consulting, training and IT support services. These so-called Business Incubation Centres work with the Technology Licensing Offices, providing a single point of contact and to also supporting collaborative R&D. Hence technical services and forms of cooperative 'research'- rather than technology licensing and start-ups - are the main channels of knowledge transfer from universities in Taiwan. Wu and Hu comment that: "*This can be attributed to the fact that 96 per cent of Taiwan's industry is composed of SMEs, as well as to the nature of catch-up latecomer economies in which the process of innovation focusses on the provision of technical services as the most critical requirement*"[171].

Although the many university research centres have found that interaction with industry is much more likely to involve training and technical assistance/consulting than collaborative R&D or licensing, the participation of graduate students in industry projects contributes to the generation of graduates with more relevant skill and knowledge.

As in many other countries, from the late 1990s there has been an increasing emphasis on the role of startups and the potential of university facilities, graduates, staff and students, as well as new knowledge generated in universities, to contribute to startups with the potential to grow to become significant new actors in the innovation system.

A range of persistent barriers have limited knowledge transfer and research commercialisation[172]:

- Industry concern about the confidentiality of their information when cooperating with universities, leading to a reluctance to collaborate

[169] Lee, Lin, Hsi, and Lim, 2016

[170] Hu and Mathews 2009;

[171] Wu & Hu, 2017, p236

[172] Draws on Liu et al, 2009.

- Different organisational objectives of universities and enterprises
- Poor coordination among government agencies leading to regulatory complexity
- Research portfolios not oriented to industry demands for new knowledge- a result of a high dependence on public funding and lack of awareness of industry priorities
- Restrictions of the capacity of researchers to serve in private enterprises, due to their status as government employees
- Complex administrative processes and uncertainties over the valuation of IP discourage SMEs to consider licensing from universities.

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9 Terms of Reference

The Subcontractor will provide expert advisory services to the National Agency for Technology Entrepreneurship and Commercialization Development (**NATEC**) to support series of planned workshops, that will be co-organized by NATEC and the National Assembly's Legal Committee with participation of representatives from Ministries and agencies which are engaged with the Intellectual Property Law, Law on Management and Use of Public Property, Law on Science and Technology, Law on Technology Transfer, Enterprise Law and Investment Law. These workshops will serve both as a consultation platform and policy advocacy for transfer of ownership of state-funded research results to universities and research institutes with a view to boost science commercialisation and meet the society's development needs. NATEC would like to have support from Aus4Innovation both in terms of financial funding and technical expertise to this process.

Required Services include:

i i) desk-based reviews and interviews on different approaches and lessons from commercialising publicly funded research in Australia, China and US;

ii ii) at least two missions to Vietnam to engage in workshops and meetings with NATEC and other key stakeholders; and

iii) providing advice through virtual communication to help inform and guide NATEC in:

a. understanding how others have incentivised universities and research organisations to commercialise research; and

b. creating and enabling research ecosystem and policy environment.