Chapter 6. Business innovation and knowledge flows

Knowledge is one of the most strategically significant resources for firms. How it is accessed and deployed is particularly important for firms engaged in innovation activities. This chapter focuses on the measurement of knowledge flows and exchanges between firms and other actors in the innovation system. It describes the conceptual framework underpinning knowledge exchange, diffusion and open innovation. This framework is used as the basis for recommendations on how to measure inbound and outbound knowledge flows, internal and external sources of knowledge for innovation, innovation collaboration partners, as well as enablers and barriers to knowledge flows. Specific recommendations are provided on capturing knowledge-based linkages between firms and higher education and public research institutions.

6.1. Introduction

6.1. Knowledge is one of the most strategically significant resources for firms. How it is accessed and deployed is particularly important for firms directly or indirectly engaged in innovation activities (see subsection 2.2.2). Knowledge flows encompass the deliberate and accidental transmission of knowledge. Knowledge exchange (sometimes referred to in a narrower context as knowledge transfer) is the deliberate transmission of knowledge from one entity to another (OECD, 2013).

6.2. Interest in knowledge flows stems from the observation that knowledge is generated, distributed and used by multiple actors of an innovation system, such as firms, universities, public research institutions (PRIs), customers as users of product innovations, and individuals. Firms draw on external sources of knowledge for their innovation activities (Chesbrough. 2003; Dahlander and Gann, 2010). Information can also be exchanged, but it is not useful unless it is understood and turned into knowledge.

6.3. Firms can source knowledge within their organisational boundaries, as well as from outside including from their key customers, investors, known experts, and other groups that are potential new sources of knowledge (Enkel, 2010).

6.4. The factors that support knowledge flows and the formation of knowledge networks have changed due to new technology and business models. Digital information and communication technologies have substantially reduced the cost of copying, storing and distributing data and information, enabling pecuniary and non-pecuniary models for sourcing and exploiting knowledge. New methods and platforms for obtaining knowledge and other innovation inputs from diverse sources have emerged, such as crowdsourcing ideas and solutions to problems (e.g. through inducements such as prizes, awards, tournaments, hackathons – collaborative events where experts meet to develop specialised software solutions – etc.), crowdfunding, and the use of digital online platforms to obtain user comments and suggestions on goods and services. Intellectual property (IP) rights can be used to create knowledge markets that support knowledge flows while ensuring that knowledge creators can appropriate the benefits from their investments in developing new knowledge.

6.5. The measurement of knowledge flows between firms and other actors of the innovation system can contribute to a better understanding of their relative importance in the division of labour underpinning innovation activities (see subsection 3.2.2), differences in knowledge networks by industry, how these networks change over time, the effect of knowledge flows on innovation outcomes, and the methods that firms use to manage their knowledge capabilities. Data on knowledge flows can assist both policy analysts and business managers in identifying the opportunities and constraints affecting such flows, and the factors enabling firms to absorb external knowledge.

6.6. This chapter focuses on the measurement of knowledge flows and related exchanges between firms and other actors in the innovation system, as described in Chapter 2. Section 6.2 provides a conceptual framework and rationale for the measurement of knowledge flows and open innovation. The framework views innovation in the Business sector as a highly distributed process based on managed knowledge flows across organisational boundaries.

6.7. Section 6.3 proposes specific approaches for measuring knowledge flows in innovation surveys. In addition to surveys, mapping knowledge flows and the diffusion of innovations often requires the use of other data to identify the linkages between actors, outputs and outcomes. The proposals for data collection cover the role of other firms or organisations in the development and adoption of innovations by a firm (see Chapter 3), the external

orientation of a firm's business innovation activities (see Chapter 4), collaborative activities for innovation, the main sources of ideas and information for innovation, and the measurement of IP-based registration activities and transactions. Additional guidance is provided on how to measure the links between firms and higher education and PRIs, as well as on measures of the barriers and challenges for engaging in knowledge flows with external parties. Section 6.4 provides a brief summary of recommendations.

6.2. Knowledge flows and innovation: Key concepts and definitions

6.2.1. Diffusion of innovation

6.8. The concept of **innovation diffusion** encompasses both the process by which ideas underpinning product and business process innovations spread (innovation knowledge diffusion), and the adoption of such products, or business processes by other firms (innovation output diffusion). The adoption of a product or a business process can result in an innovation by the adopting firm if the products or business processes differ significantly from those previously offered by the firm (as defined in Chapter 3). In some cases, adoption can entirely replace or render obsolete previously used products and business processes.

6.9. Both the process and the outcomes of innovation diffusion are of policy and research interest because diffusion amplifies the economic and social impacts of ideas and technology, especially when there are synergies and complementarities in their use. Innovation diffusion can also create knowledge flows that lead to further innovations, for instance when learning from using an adopted business process results in significant improvements (Rosenberg, 1982; Hall, 2005). The expected speed and nature of innovation diffusion also shape the incentives to innovate.

6.10. Based on concepts presented earlier in this manual, firms are active in innovation diffusion when they:

- Adopt products or business processes with no or very little additional modification, as long as the adopted product or business process differs significantly from what the firm previously offered or used. These innovations are *only* new to the firm.
- Draw upon the ideas, experiences, products or business processes of other firms or actors to develop a product or business process that differs from what was originally offered or used by the source firm.
- Enable other parties to make use of their innovations or relevant knowledge, for example, by providing another firm with IP rights or the tacit knowledge required to use the innovation or knowledge in a practical application.

6.2.2. Knowledge flows

6.11. All firms are engaged in knowledge interactions with other actors. A knowledge network consists of the knowledge-based interactions or linkages shared by a group of firms and possibly other actors. It includes knowledge elements, repositories and agents that search for, transmit and create knowledge. These are interconnected by relationships that enable, shape or constrain the acquisition, transfer and creation of knowledge (Phelps, Heidl and Wadhwa, 2012). Knowledge networks contain two main components: the **type** of knowledge and the **actors** that receive, supply or exchange knowledge.

Type of knowledge

6.12. Knowledge can be "captured" by or embodied into "objects" such as databases, software routines, patents, publications, public presentations and know-how. Knowledge can be classified by the following criteria:

- The extent to which knowledge is codified or tacit and therefore the ease with which it can be transferred to other parties and rendered directly usable (Polanyi, 1958; von Hippel, 1988). This has implications for rivalry in the use of knowledge. When codified and inexpensive to copy, the amount of knowledge available for use does not diminish with the intensity of use by other firms or individuals. Codified knowledge can be transferred through articles, books, formulas, models, materials, databases, and IP rights such as patents. In contrast, tacit knowledge may only be available in the minds of people who use it (Breschi and Lissoni, 2001). This applies if the holder of the knowledge does not codify it or make it available through presentations or verbal discussions.
- Excludability, i.e. the ability to prevent other parties from using knowledge. Partial excludability is a characteristic of tacit knowledge and knowledge that requires considerable expertise to understand. Excludability in the application of knowledge can be created through the assignment and enforcement of IP rights, but also by other means such as secrecy, agreements or social norms.
- The extent to which knowledge already exists or has a prospective nature, i.e. whether knowledge is yet to be developed. Agreements to jointly produce new knowledge, for example through collaboration, will typically entail a pledge for active participation in the production of new knowledge and the exchange of existing knowledge required to achieve that goal.

6.13. Different types of knowledge can be complementary, creating a motivation for knowledge flows and in some cases for pooling the IP rights to complementary knowledge.

Actors engaged in knowledge flows

6.14. All organisations, agents or individuals can be involved in knowledge flows. The various entities and individuals with whom a firm interacts can be classified using several criteria:

- The economic activity (e.g. industry) of the actors in knowledge flows since the type of knowledge exchanged, competitive pressures to obtain or create new knowledge, and excludability all vary by industry.
- The institutional affiliation of the actor (see section 5.2). For instance if the actor is a PRI, a stand-alone firm, a firm that is part of a domestic or a multinational group. Institutional affiliation influences the ownership and control over knowledge and its uses, the predominant sources of funding for creating knowledge, and the sources of knowledge available to the actor.
- Supplier or user of knowledge: actors can use, supply, or search for knowledge, or act as both suppliers and users of knowledge.
- Capability attributes: these determine the absorptive capacity of individuals and organisations to apply knowledge obtained from other entities, including entities that are affiliated with the firm via ownership and independent entities such as universities or other firms (see section 5.3).

- Relatedness or distance between entities such as ownership ties, geographic distance, past knowledge flows and common network membership. The use of criteria based on the existence of formal ties (e.g. being part of a common supply chain) or similarities between actors is often required in order to identify the relevant measure of "distance" for testing or predicting the likelihood that knowledge flows will take place.

Types of knowledge flows

6.15. Knowledge flows can occur without an explicit agreement between both parties (the producer and recipient of the knowledge), for instance when a firm reverse engineers a competitor's innovation, or when its personnel obtain knowledge through reading publications. Alternatively, knowledge flows can occur intentionally through formal linkages between two or more parties. Examples include linkages through ownership or participation in a collaborative venture. Intentional knowledge flows can also occur informally through discussions at trade fairs or conferences. In some cases regulation can require the public disclosure of information. Examples include requirements to provide data on product characteristics in some markets or the requirement to fully describe an invention in a patent application.

6.16. Unintentional knowledge flows can result in unwanted transmission of information to competitors. Some types of flows can be illegal, such as knowledge obtained through industrial espionage. Firms cannot prevent knowledge contained in patents from flowing to competitors, but they can obtain damages for the misuse of knowledge protected by IP rights.

6.17. It is important to distinguish between *ex post* intentional knowledge flows based on existing knowledge and *ex ante* knowledge flows supporting the creation of new knowledge. The latter imply a greater degree of uncertainty about outcomes and require an explicit or implicit agreement on the production and distribution of future knowledge and its value.

Table 6.1. Typology and examples of mechanisms for intentional knowledge flows

Existing knowledge	Prospective knowledge
Disembodied, intellectual property rights (IPR)-based mechanisms	Sourcing knowledge solutions
Confidentiality and non-disclosure agreements	Consultancy services
IP licensing (exclusive, non-exclusive)	Research services
Pooling agreements for IP (may also involve commitments about future rights)	Crowdsourcing prizes for research outcomes
Sale or assignment of IP rights	
Inclusion of IP in franchise agreements	
Know-how contracts (transfer in tangible form through technical data)	
Embedded knowledge transactions	Co-development of new knowledge
Transfer of rights to IP and other knowledge-based capital through mergers and acquisitions	Co-development programmes
Acquisition of equipment; turnkey project agreements (delivery of facility with incorporated technology ready to use)	Research joint ventures
Material and data transfer/use agreements	Research/commercialisation alliances
	Temporary secondments to share or exchange personnel
	Network membership agreements (depending on the nature of exchanges within the network)

Source: OECD (2013), "Knowledge networks and markets", https://doi.org/10.1787/5k44wzw9q5zv-en.

6.18. Table 6.1 lists mechanisms for intentional knowledge flows for *ex post* (existing knowledge) and *ex ante* (prospective knowledge) conditions. Transactions involving existing

knowledge are divided into disembodied, IP rights-based mechanisms and those where knowledge is embedded in transactions concerning other goods and services. The latter includes the transfer of knowledge through the acquisition of other firms or capital equipment. Transactions for the creation of prospective knowledge can also be divided into agreements where a firm contracts a supplier to provide customised knowledge, and agreements where both parties contribute to the joint development of a knowledge product.

6.19. An agreement to provide knowledge to another actor can be based on different forms of compensation, such as deferred financial compensation, provision of other services in return, exchange for other forms of knowledge, or co-ownership of IP rights. Actors can also seek nonmonetary rewards, such as an improved reputation, or they may be able to bundle "free" knowledge with other proprietary services. Knowledge can also be provided with no expectation of compensation, as when knowledge is made freely available, or when knowledge is shared among affiliated firms.

6.2.3. Open innovation

6.20. The importance of inbound and outbound knowledge flows for improving the efficiency of innovation activities of firms has been recognised for many decades (Kline and Rosenberg, 1986; Teece, 1986) and discussed in previous editions of this manual. Questions on inbound and outbound flows of technical knowledge were included in the first European Community Innovation Survey (CIS) in 1992/93. The concept of open innovation (Chesbrough, 2003) stresses the advantages to firms of "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively". The "open innovation" paradigm has increased awareness of the distributed nature of knowledge production and usage across actors and the importance of accessing knowledge from specialised networks and markets (Arora, Fosfuri and Gambardella, 2001).

6.21. Although the term "open" lends itself to several different interpretations in the science and innovation context (see Box 6.1), open innovation is a useful umbrella concept for generalising existing and prospective forms of knowledge flows across the boundaries of innovation-active firms.

6.22. The open innovation perspective defines inbound and outbound knowledge as follows:

- **Inbound** (or inward) knowledge flows occur when a firm acquires and absorbs externally sourced knowledge in its innovation activities. This encompasses knowledge acquisition and sourcing activities, some of which are described in Chapter 4.
- **Outbound** (or outward) knowledge exchanges occur when a firm intentionally enables other firms or organisations to use, combine, or further develop its knowledge or ideas for their own innovation activities. An example is when a firm licenses its technology, patents or prototypes to another firm.

6.23. Companies that combine outbound and inbound knowledge flows have been described as "ambidextrous" (Cosh and Zhang, 2011). These companies engage in coupled or joint processes that can involve the search for new sources of knowledge and the recombination of knowledge from inside and outside the company. Innovation collaboration is an example of a coupled process where all partners participate in both inbound and outbound knowledge flows. Data on the use of inbound and outbound knowledge flows can be used to identify the position of firms in innovation networks.

6.24. Outbound open innovation activities have seldom been measured, especially within the domain of official statistics. Outbound strategies are used by firms that earn revenues by selling or licensing their knowledge or inventions to other firms and by knowledge service firms that provide research and experimental development (R&D) or related services under contract to third parties. A firm can also follow an outbound strategy whereby it gives other firms or customers the right to use its innovations at no cost. This can benefit the firm if its innovation is used in a standard that increases the firm's market or if the adoption of its innovations by others creates market dominance that can be used to sell other services.

Box 6.1. Uses of the "open" concept in science and innovation

Open innovation denotes the flow of innovation-relevant knowledge across the boundaries of individual organisations. This includes proprietary-based business models that use licensing, collaborations, joint ventures, etc. to produce and share knowledge. This notion of "openness" does not necessarily imply that knowledge is free of charge (i.e. "gratis") or exempt from use restrictions (i.e. "libre"). Pricing and use restrictions are often key conditions for access to knowledge.

The term "open source" is often applied to innovations that are jointly developed by different contributors. Although open source outputs such as software code can be included in products that are sold, royalty fees are seldom paid to contributors and there are usually no significant restrictions on how these outputs are used. Follow-on additions to open source outputs may also need to be provided on an "open source" basis.

"Open science" describes a movement to promote greater transparency in scientific methodology and data, the availability and reusability of data, tools and materials by researchers; and the availability to researchers and the general public of research results (particularly when publicly funded).

"Open access" typically describes the ability to access content (e.g. documents) or data on line, free of charge and with minimal copyright and licensing restrictions. This term is also applied to the business models of firms that secure revenue through bundling services with information that is provided on a free and unconstrained basis. An alternative access model is when firms charge for posting information on an open access site, as with open access journals.

A key implication for survey practitioners of these different uses of the notion of "open" is the need to avoid the unqualified use of this term in survey questions. Instead, the main attributes of interest should be fully described.

Sources: OECD (2013), "Knowledge networks and markets", https://doi.org/10.1787/5k44wzw9q5zv-en; OECD (2015a), "Making open science a reality", https://doi.org/10.1787/5jrs2f963zs1-en.

Co-operation, collaboration and co-innovation

6.25. Although these three concepts are often used interchangeably, they can have different meanings. For the purposes of this manual, they are defined as follows:

6.26. **Co-operation** occurs when two or more participants agree to take responsibility for a task or series of tasks and information is shared between the parties to facilitate the agreement. An innovation-active firm co-operates with another firm if it procures ideas or inputs from the other firm by providing it with a detailed specification of its needs.

6.27. **Collaboration** requires co-ordinated activity across different parties to address a jointly defined problem, with all partners contributing. Collaboration requires the explicit definition of common objectives and it may include agreement over the distribution of inputs, risks and potential benefits. Collaboration can create new knowledge, but it does not need to result in an innovation. Each partner in a collaboration agreement can use the resulting knowledge for different purposes.

6.28. **Co-innovation**, or "coupled open innovation", occurs when collaboration between two or more partners results in an innovation (Chesbrough and Bogers, 2014). An important implication for innovation measurement is that summing the number of innovations reported by firms in a population could result in an overestimate, with the size of the overestimate dependent on the prevalence of co-innovation.

6.29. Alliances, consortia, joint ventures and other forms of partnerships are all mechanisms for knowledge flows that can be used in innovation activities, although each of these can be used for other purposes. In alliances and consortia firms participate with other organisations in a common activity or pool their resources to achieve a common goal. Participants retain their separate legal status, with the consortium's control over each participant generally limited to activities involving the joint endeavour, particularly the division of profits. A consortium is formed by contract, which delineates the rights and obligations of each member. Joint ventures arise when two or more companies invest funds (equity) into creating a third, jointly owned company, into which they may also transfer access to some of their own resources, such as IP.

6.3. Collecting data on knowledge flows and their relationship to innovation

6.30. Knowledge management is the co-ordination of all activities by an organisation to direct, control, capture, use, and share knowledge within and outside its boundaries. The management of internal and external knowledge flows is discussed in Chapter 5.

6.3.1. General issues

6.31. The complexity of knowledge flows creates practical challenges for measurement. Firms can establish knowledge-based linkages with multiple actors in different locations and seek different types of knowledge objects at different phases in the innovation and diffusion process. They can enter into a variety of knowledge exchange agreements. In addition, changes to the boundaries of the firm through mergers, acquisitions and disposals can affect the structure of internal and external knowledge flows. Such complexity can also reduce the ability of the subject-based approach to innovation measurement to provide sufficient detail to trace changes in knowledge sources over time. Research in this area could benefit from the object-based approach discussed in Chapter 10.

6.32. Some of the limitations of survey data on knowledge flows can be addressed by linking survey data to other sources, such as data on the co-invention or co-ownership of intellectual assets and co-publications. Administrative transaction data linking buyers and sellers can also be used to map some types of knowledge-based interactions.

6.33. The recommendations in this section cover the measurement of internal knowledge flows (within an enterprise and with affiliated firms linked through ownership) and external knowledge flows with unaffiliated firms or organisations. Knowledge flows among the affiliates of multinational enterprises is a special case of high research and policy interest that requires specific attention.

6.34. Both non-innovative and innovation-active firms can regularly scan their environment for potentially useful knowledge for innovation and can also provide innovation-relevant knowledge to other firms. It is recommended to collect data on these activities in order to prevent under-reporting of both inbound and outbound knowledge flows, as well as for use in research on the propensity to engage in innovation. Additional details on knowledge flows are only likely to be relevant for innovation-active firms.

6.3.2. Data on knowledge flows from innovation activities

6.35. Chapter 4 recommends collecting qualitative data on the use of external providers for seven types of innovation activities. The data for external providers are measures of knowledge flows from an external source to the firm, for instance for the provision of design, training or R&D services that either contain knowledge embedded in the service or provide the firm with new knowledge for use in developing innovations. Data on the division of innovation efforts and responsibilities

6.36. The division of labour in innovation activities (see subsection 3.2.2) allows firms to acquire knowledge, necessary capabilities and complementary assets for their innovation activities from other firms or organisations.

Inbound knowledge for innovation

6.37. As illustrated in Table 6.2, surveys can collect information on the relative contributions to innovation of internal and external sources, ranging from innovations that replicate what is already in use by other firms or organisations to innovations that are entirely developed in-house. The model question in Table 6.2 distinguishes between explicit "imitation" innovations (item a), innovations that require some internal innovation activities (item b), innovations that require considerable external input (item c), or external input as part of collaboration with other firms or organisations (item d). The final category (item e) consists of innovations that are mainly developed in-house. Innovations that draw on both internal and external knowledge (items b, c and d) do not necessarily contain more or fewer novel characteristics than innovations developed mainly in-house (item e). Instead, they may signal a higher degree of specialisation.

Table 6.2. Measuring the contribution of inbound knowledge flows to innovation

	Were any of your firm's product innovations/business process innovations
a)	Replicating products/business process already available from/to other firms or organisations, with no or very few additional changes by your firm
b)	Developed by your firm by adapting or modifying products/business processes available from/to other firms or organisations, including reverse engineering
c)	Developed by drawing substantially on ideas, concepts and knowledge sourced or acquired from other firms or organisations, directly or via intermediaries
d)	Developed as part of a collaborative agreement with other firms or organisations, with all parties contributing ideas or expertise
e)	Mainly developed by your firm on its own, from the idea to implementation

6.38. For data collection, the number of options in Table 6.2 can be altered, depending on research and policy interests. For example, items (b) and (c) could be combined, or item (e) could be disaggregated to identify the role of external sources in the implementation phase only.

6.39. Cognitive testing suggests that it is difficult to elicit precise responses on the role of other actors in innovation, particularly at different phases of the innovation process (Galindo-Rueda and Van Cruysen, 2016). This is partly because respondents interpret the

concept of "developing innovations" as applying to the entire innovation process, including implementation. This differs from an R&D-based interpretation of development as applying only to the development of ideas, concepts or designs, as with the definition of "experimental development" in the OECD's *Frascati Manual 2015* (OECD, 2015b) – see also the section on R&D in Chapter 4. To avoid differences in interpretation, questions on the role of internal and external sources should specify which items include development and implementation activities.

6.40. The options presented in Table 6.2 differentiate among a rich variety of inbound knowledge sourcing strategies. They enable research to identify, for example, if service innovations are more or less likely to require external inputs than goods innovations, and differences in knowledge sourcing strategies between business process innovations and product innovations.

6.41. Since a firm can have multiple product or business process innovations, questions on inbound knowledge flows should permit respondents to select more than one option in Table 6.2. It is also possible to ask respondents to identify the most commonly used option listed in the table. Alternatively, the object-based approach described in Chapter 10 can be used to identify the method used for the firm's most economically valuable innovation.

6.42. Data collected on inbound knowledge flows can be used to qualify other data on whether or not the respondent's firm has new-to-firm (NTF) or new-to-market (NTM) innovations. Innovations that meet the criteria for items (b) or (c) are more likely to be NTM innovations, while those that meet the criteria for option (a) are more likely to be NTF innovations. However, innovations that meet the criteria for item (a) can also be NTM innovations, for instance if the firm's market is a local region. It is recommended to collect data on a firm's market (see subsection 5.3.1) in addition to the data in Table 6.2, in order to identify how NTM innovations are developed.

6.43. Respondents might understate the role of other firms or organisations in their firm's innovations, particularly when the original concept is acquired externally, but the development work took place in-house. To reduce such under-reporting, item (e) on innovations that are mainly developed in-house should be placed after the other options.

Sources of inbound knowledge

6.44. It is recommended to collect data on the different sources of inbound knowledge and the geographic location of the source. The institutional classification in the *Frascati Manual 2015* (OECD, 2015b: Chapter 3) is recommended for innovation data for international comparison purposes, as shown in Table 6.3.

6.45. As depicted in Table 6.3, the headline Frascati institutional sectors can be broken down according to policy and research needs.

- It is advisable to separate between affiliated and non-affiliated business sources of knowledge.
- It is also important to separate between households and their members acting on that capacity, and other private non-profit organisations.
- Research institutes, defined on the basis of their main economic activity, constitute a group of high policy interest. Research institutes can be found in all Frascati sectors (see subsection 2.4.1). Measurement recommendations can be found below in subsection 6.3.4.

Table 6.3. Sources of inbound knowledge flows for innovation

	Domestic		Rest of the world
	Local/regional	Elsewhere in same country	Abroad
a) Business enterprises			
Affiliated enterprises			
Other, unrelated enterprises[1]			
b) Government			
Government research institutes			
Other government departments and agencies			
c) Higher education			
d) Private non-profit			
Private non-profit research institutes			
Other private non-profit organisations			
Households/individuals			

1. Includes other commercial (public or private) research institutes. A separate subcategory may be created for data collecting purposes.
Source: Adapted from OECD (2015b), *Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development*, http://oe.cd/frascati.

6.46. The geographic location of the source can be further subdivided, for instance "domestic" can be divided into local sources and sources "elsewhere in the same country". Sources in the "Rest of the world" can be subdivided into major areas such as the European Union, free trade areas, continents, etc.

Outbound knowledge flows

6.47. Very few data collection exercises have obtained data on outbound knowledge flows, although the first CIS included questions on the outbound transfer of technology through licensing IP, consulting or R&D services, equipment sales, communication with other firms, and employee mobility. The drawback to data collection on outbound knowledge flows is that respondents may not know if their firm's knowledge was used in another firm's innovation, with the exception of instances where explicit agreements for knowledge exchange have been signed, e.g. to receive running royalties for the licensing of IP. Categories used in past surveys such as "employee mobility" and "communication with other firms" are imprecise and may or may not be directly associated with the transfer of knowledge from the focal firm to another firm. Examples of direct mechanisms for outbound knowledge flows are given in Table 6.4.

6.48. Questions on outbound knowledge flows are, in principle, relevant for all firms, regardless of their innovation status.

6.49. Item (a) in Table 6.4 is relevant for professional and specialist knowledge service providers in all domains, including R&D, software, engineering, design, and creative services. Items (b) and (c) in Table 6.4 capture the activities of firms in all sectors that choose to extract value from their knowledge by either licensing or through free provision to other parties. These questions can help capture these strategies and related knowledge flows.

Table 6.4. Measuring direct mechanisms for outbound knowledge flows

a)	Contribute to the development of products or business processes by other firms or organisations (e.g. through R&D or consultancy contracts, etc.).
b)	License-out IP rights, alone or bundled with a product, to other firms or organisations (include licensing at no cost, such as part of a cross-licensing agreement).
c)	Receive running royalties from licensing IP rights.
d)	Private disclosure of knowledge of potential use for the product or business process innovations of other firms or organisations, including know-how agreements.
e)	Public disclosure of knowledge of potential use for the product or business process innovations of other firms or organisations, including the release of information for standards.

6.50. Information on outbound knowledge flows can assist the interpretation of reported product innovations for firms in the professional and creative service industries. Respondents from these firms might view the knowledge provided to a client as a product innovation in some circumstances.

6.51. A question on outbound knowledge flows can be complemented by questions on the types of recipient organisation using the categories in Table 6.3 (including households). Data on the revenue earned from outbound knowledge flows in the reference year can be collected to assist research on the system-wide division of innovation efforts.

Collaboration for innovation and co-innovation

6.52. Innovations can be developed through collaboration or co-innovation. Due to the importance of these methods of innovating within an open innovation paradigm, it is recommended to collect data on the types of collaboration or co-innovation partners, using a modified version of the schema given in Table 6.3 which disaggregates unaffiliated business enterprises into suppliers, customers, etc., and asks about the location of collaboration partners (Table 6.5). If feasible, separate data on co-innovation and collaboration can be collected, but it is not recommended to collect data on co-operation. Since collaboration can produce intermediary knowledge or standards that are not used in an innovation, questions on collaboration are relevant to all firms that are innovation-active during the observation period.

Table 6.5. Types of collaboration partners for innovation

	Domestic		Rest of the world
	Local/regional	Elsewhere in same country	Abroad
a) Business enterprises (affiliated and unaffiliated)			
Suppliers (equipment, materials, services)			
Specialised knowledge services providers and commercial (private or public) research institutes			
Customers (equipment, materials, services)			
Competitors/investors/other businesses			
b) Government			
Government research institutes			
Other government departments and agencies			
c) Higher education			
d) Private non-profit			
Private non-profit research institutes			
Other private non-profit organisations			
Households/individuals			

6.53. The questions outlined in Table 6.5 collect qualitative information on spatial collaboration partners. An additional question can ask which type of collaboration partner provided the most valuable contribution to the firm's innovation activities during the observation period (see also Chapter 10).

6.3.3. Sources of ideas or information for innovation

6.54. It is recommended that surveys collect data on the importance of a broad variety of sources of ideas and information for innovation. Table 6.6 provides a list of relevant sources.

Table 6.6. Measurement of sources of ideas and information for innovation

Generic source	Examples and possible breakdowns	Degree of use /importance
Internal resources[1]		
	Marketing department	
	Production/logistics/delivery departments	
	Design department	
	R&D department	
	Databases	
	Employees (including managers) hired in the previous six months	
Other affiliated business enterprises[2]		
Unaffiliated business enterprises		
	Suppliers (equipment, materials, services)	
	Knowledge service providers and commercial (private or public) research institutes	
	Customers (equipment, materials, services)	
	Competitors/investors/others	
Government		
	Government research institutes	
	Government suppliers and customers	
	Government regulations, standards	
	Government websites, searchable repositories/databases, including IPR registers	
Higher education institutions		
	Departments, teams, faculty	
	Graduate students	
Private non-profit institutions and individuals		
	Private non-profit research institutes	
	Other private non-profit organisations	
	Individuals/households as customers or users	
	Individuals as volunteers[3]	
	Individuals paid by firms to contribute to business activities[3]	
Other sources[4]		
	Scientific and trade publications	
	Conferences	
	Trade fairs and exhibitions	
	Business websites, searchable repositories or databases	
	Commercial/trade standards	

1. Disaggregation by several key business functions is provided as an option. If these options are used, a "not relevant" response option is required for firms that do not have an R&D department, design department, etc.
2. Similar disaggregation as for internal resources can be used for affiliated enterprises.
3. Including crowdsourced inputs, participation in co-creation activities, focus groups, etc.
4. Sources not specifically attributable to a particular actor or group of actors.

6.55. The list is broader than that for collaboration partners because it also includes inanimate data sources such as publications that are not attributable to a specific actor, as well as internal sources within the firm. An alternative is to ask if any of the firm's innovations would not have been possible in the absence of knowledge obtained from one or more of the sources listed in the table (Mansfield, 1995).

6.3.4. Interactions with higher education and public research institutions

6.56. Data collection can use dedicated modules or questionnaires to capture information of high policy relevance on a variety of knowledge-based relationships with specific actors in the innovation system. Of particular policy interest are channels for knowledge-based interactions linking firms with higher education institutions (HEIs) and PRIs.

6.57. HEIs can be found in any of the three System of National Accounts (SNA) institutional sectors (Business, Government and Non-profit institutions serving households [NPISH]) and can be public or private. As a special case, HEIs are separately identified as a main sector in the Frascati Manual, including HEI-based research institutes.

6.58. Although there is no formal definition of a PRI (sometimes also referred to as a public research *organisation*), it must meet two criteria: (i) it performs R&D as a primary economic activity (research); and (ii) it is controlled by government (formal definition of public sector). This excludes private non-profit research institutes.

Table 6.7. Measuring channels for knowledge-based interactions between firms and HEIs/PRIs

Main types	Possible knowledge-based interaction channels
Ownership linkages	The firm is fully or partly owned by a HEI/PRI
	The firm is fully or partly owned by individuals who work for a HEI/PRI
	The firm originated within a HEI/PRI and is currently independent from it
Sources of knowledge	The firm's employees participate in conferences and networks organised by HEI/PRIs
	The firm uses information or data repositories maintained by HEI/PRIs
	The firm regularly obtains knowledge from HEI/PRIs
	The firm obtains knowledge from patents owned by HEI/PRIs
Transactions	The firm commissions ad hoc R&D services from HEI/PRIs
	The firm commissions other technical or intellectual services from HEI/PRIs
	The firm secures specialised education and training from HEI/PRIs
	The firm buys specialised goods from HEI/PRIs such as materials, specimens, etc.
	The firm uses HEI/PRI infrastructure, such as laboratory facilities or equipment
	The firm licenses or otherwise obtains IP rights from HEI/PRIs
	The firm delivers specialist equipment or products for use by HEI/PRIs
	The firm has assigned IP rights to HEI/PRIs
Collaboration	The firm has engaged in collaborative research agreements with HEI/PRIs
	The firm has funded Chairs, scholarships, or research by HEI/PRIs
	The firm has used HEI/PRI facilities such as equipment
People-based interactions	Some of the firm's employees have a position at a HEI/PRI
	The firm appoints HEI/PRI staff to advisory or board roles
	The firm hosts HEI/PRI staff or students through secondments or internships
	Some of the firm's employees are hosted by a HEI/PRI through secondments or internships
	Some of the firm's employees undertake academic courses at HEI/PRIs
	The firm conducts idea competitions for students at HEI/PRIs

6.59. PRIs can be found in the SNA corporate, NPISH and Government sectors. PRIs in the corporate sector are public enterprises and are within the scope of business innovation surveys, along with private, market-oriented research institutes. PRIs in the Government sector may have varying degrees of connection with government departments and agencies. PRIs in the NPISH sector do not sell their products at economically meaningful prices and are not controlled by either units in the Government or Business sector, although they may draw a substantive part of their revenue from such sources.

6.60. In some cases, in addition to government-controlled research institutions, national surveys may find it useful to extend their coverage of links with PRIs to private research institutes that are highly reliant on direct or indirect government funding for their R&D activities.

6.61. Table 6.7 provides a proposed list of channels that firms can use to exchange knowledge with HEIs and PRIs. This may facilitate the collection of separate data for each type of institution, which often play different roles in an innovation system. Questions on knowledge channels can be followed by questions on the geographic location and proximity of those HEIs and PRIs with which the firm interacts.

6.3.5. IP rights and knowledge flows

6.62. Firms can use IP rights to facilitate inward and outward knowledge flows and knowledge exchange. Non-innovative firms can also use IP rights in this way, for instance if they have IP that predates the observation period and therefore should be included in data collection on the use of IP rights. Relevant uses of IP rights are presented in Table 6.8.

Table 6.8. Potential questions on the use of IP rights for knowledge flows

Inward knowledge flows (the counterpart to some of these examples can capture outward knowledge flows)
Made use of open source or other freely available IP
Received IP from other unaffiliated parties, with the IP embedded in goods or services or part of technical assistance or know-how
Acquired a controlling stake or financial interest in another firm that included access to existing or future IP
Licensed IP on an exclusive or non-exclusive basis from unaffiliated parties, without the IP being embedded in goods or services (includes IP obtained during the creation of a spin-out or spin-off)
Additional forms of knowledge exchange
Participated in cross-licensing agreements, with or without financial payments
Contributed IP to a new or existing pool for IP

6.3.6. Barriers and undesirable consequences of knowledge flows

6.63. Innovation barriers due to policy, regulation and labour market conditions are covered in section 7.6 as part of the assessment of external influences on business innovation. Two types of challenges are specific to knowledge flows (see Table 6.9). The first includes factors that constrain the firm from interacting with other parties in producing or exchanging knowledge. The second includes undesirable consequences from other organisations accessing or using knowledge produced by the firm. The latter include breaches of the firm's IP rights as well as legal strategies that competitors can use to exploit the firm's knowledge.

Table 6.9. Measuring barriers and unintended outcomes of knowledge interactions

Challenges	Possible items
A. Barriers	
Factors that constrain a firm from interacting with other parties in the production or exchange of knowledge	• Loss of control over valuable knowledge • High co-ordination costs • Loss of control over strategy • Difficulty finding the right partner • Difficulty establishing trust • Concerns about triggering antitrust policy enforcement • Concerns about employees leaking valuable information or know-how • Concerns about potential costs of dispute settlements • Lack of sufficient time or financial resources
B. Unintended outcomes	
Undesirable or unintended outcomes experienced when others use the firm's knowledge	• Counterfeiting of the firm's products • Infringement of the firm's IP (including copyright) • Breach of confidentiality • Internet security breach • Being sued for IP infringement • Sued other parties for IP infringement • Your IP "designed around" by a competitor • Competitor reverse engineered your firm's products

6.4. Summary of recommendations

6.64. This chapter identifies several characteristics of knowledge flows of value to policy and other research purposes. Recommendations of questions for general data collection for all firms are given below. Other types of data covered in this chapter are suitable for specialised data collection exercises.

6.65. Key questions for data collection include:

- contribution of inbound knowledge flows to innovation (Table 6.2)
- collaboration partners for innovation by location (Table 6.5)
- sources of ideas and information for innovation, but excluding details on internal resources (Table 6.6)
- barriers to knowledge interactions (Table 6.9, part A).

6.66. Supplementary questions for general data collection (given space or resources) include:

- sources of inbound knowledge flows for innovation by location (Table 6.3)
- outbound knowledge flows (Table 6.4)
- channels for knowledge-based interactions between firms and HEIs/PRIs (Table 6.7)
- use of IPRs for knowledge flows (Table 6.8).

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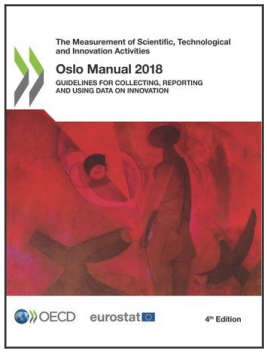

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