

Chapter 5. Measuring business capabilities for innovation

Business capabilities include the knowledge, competencies and resources that a firm accumulates over time and draws upon in the pursuit of its objectives. Collecting data on business capabilities is of critical importance for the analysis of the drivers and impacts of innovation (why some firms innovate and others do not), the types of innovation activities performed by firms, and their impacts. Business capabilities of relevance to innovation include management capabilities, workforce skills, and technological capabilities. The discussion of technological capabilities covers technical expertise, design capabilities and digital competences.

5.1. Introduction

5.1. Business capabilities include the knowledge, competencies and resources that a firm accumulates over time and draws upon in the pursuit of its objectives. The skills and abilities of a firm's workforce are a particularly critical part of innovation-relevant capabilities. Collecting data on business capabilities is of critical importance for analyses of the effect of innovation on firm performance and why some firms seek to innovate and others do not (see Chapter 11).

5.2. Numerous business capabilities can potentially support innovation activities and the economic success of innovations. This chapter provides options for measurement for four types of capabilities that are relevant for research on the innovation performance of firms:

- the resources controlled by a firm (section 5.2)
- the general management capabilities of a firm, including capabilities related to managing innovation activities (section 5.3)
- the skills of the workforce and how a firm manages its human capital (section 5.4)
- the ability to develop and use technological tools and data resources, with the latter providing an increasingly important source of information for innovation (section 5.5).

5.3. Many of the concepts relating to business capabilities have changed over time as research improves our understanding of the process of innovation. Further improvements in understanding will require data collection to adopt new concepts and measurement approaches.

5.4. The discussion in this chapter of internal capabilities with the potential to affect innovation in firms complements Chapter 7, which addresses the effects of external factors on innovation. Some of these factors are linked, for instance the skills of a firm's workforce are constrained by the availability of skilled employees in the labour market. Chapter 6 covers the activities and capabilities of firms to draw on and use externally produced knowledge and consequently provides a bridge between this chapter and Chapter 7.

5.5. Both innovation-active and non-innovative firms can develop and use the business capabilities discussed in this chapter.

5.6. Section 5.2 describes the general resources of the firm which strongly influence its ability to engage in innovation activities. Section 5.3 examines the firm's management capabilities, in particular its competitive strategy and its organisational and managerial capabilities. Human resources and workforce skills of relevance to innovation are reviewed in section 5.4, followed by various technological capabilities (including design) in section 5.5. The chapter's recommendations for measurement are summarised in section 5.6.

5.2. General resources of the firm

5.7. The resources available to a firm have a strong influence on its ability to pursue its objectives by engaging in different types of activities, including innovation-related activities. Relevant resources for the firm include its own workforce, physical and intangible assets (comprising knowledge-based capital), accumulated experience in conducting business activities and available financial resources. Access to the resources of affiliated enterprises for firms that are part of an enterprise group and those of partners and collaborators can be equally relevant.

5.2.1. *Firm size*

5.8. Firm size is a commonly used predictor of innovation activities and a firms' propensity to innovate (Cohen and Klepper, 1996). The most common measures of firm size include the number of employed persons and the volume of turnover (or equivalent measures in sectors such as financial services for which this is a less relevant measure of output). Data on both employment and turnover should therefore be collected. Employment data can be collected in headcounts, but should be based whenever possible on full-time equivalents (FTE). Another measure of firm size is the value of assets owned, which is useful for productivity analysis.

5.2.2. *Business assets*

5.9. In business accounting, total assets consist of tangible fixed assets, intangible fixed assets, goodwill and current assets (e.g. cash, accounts receivable, inventories). The distinction between assets that imply liabilities on another party and those that do not helps separate financial from "real" assets. In the economics literature and throughout this manual (see also Chapters 2 and 4), the term asset is applied to those resources controlled by the firm that are expected to continue to be productive for more than a year. Data on assets can be obtained from financial statements and include the book value of tangible fixed assets (property, plant, and equipment) and the gross carrying amount of intangible assets (e.g. software, patents, franchises, trademarks and goodwill). Regulatory licenses to exploit resources (e.g. wireless spectrum, natural resources, etc.) can also be considered as business assets.

5.2.3. *Age*

5.10. A firm's age is another resource indicator because it captures a firm's overall accumulated experience over time. Older firms have usually accumulated a larger stock of knowledge than younger firms on how to implement change and obtain results from investments. Learning over time can affect both the ability to innovate and innovation outcomes (Huergo and Jaumandreu, 2004). Conversely, younger firms can be more agile in implementing change if they are less affected by organisational inertia and have lower adjustment and sunk costs.

5.11. The measurement of a firm's age involves several conceptual and practical challenges such as identifying the relevant date of birth of an enterprise (Eurostat/OECD, 2007). The definition of an enterprise birth does not include entries into the business population due to mergers, break-ups and other forms of business restructuring. It also excludes entries resulting solely from a change of activity.

5.12. The age of the firm should be measured whenever possible by the number of years that a firm (as an organisational unit) has been economically active. This provides a measure of the length of time that the firm has been effectively accumulating knowledge. This can differ from the number of years since a firm's legal establishment, since firms can adopt a legal form well after having started operations or may not be active for some time after being set up. In line with the definition used by Eurostat/OECD for business demographics, it is important for events other than births to be excluded, which can be difficult in practice if only basic administrative data are available.

5.13. It is therefore recommended to collect data on the year a firm started any type of business activity, including activities before the year of legal establishment. Information on how firms are established can also be of value because different methods of establishment (start-up by an individual, spin-off from a university or firm, family operation, etc.) can influence innovation activities and strategies.

5.2.4. *Financing and ownership*

5.14. A firm's internal financial sources are another major driver for innovation. More profitable firms and firms with a larger share of own capital can find it easier to invest in activities with uncertain outcomes, such as those relating to innovation. Useful measures of a firm's internal financial resources include the profit margin (earnings before taxes, or earnings before interest, taxes, depreciation and amortisation) and the equity ratio. Data on internal financial sources are also important when interpreting data on a firm's external financing and its access to financial markets (see subsection 7.4.3). These can also be measures of financial outcomes of innovation (see Chapter 8).

5.15. A firm's ownership status can also affect access to resources. Firms that are part of an enterprise group could have access to resources that substantially exceed the firm's own resources. Data can be collected on the following (some of this information can be obtained from business registers):

- if the firm is a stand-alone enterprise or part of an enterprise group
- if the firm is part of a multinational group (firms of the enterprise group are located in different countries) or a national group (all firms of the enterprise group are located in the same country)
- the country of the head office of the firm's ultimate owner (the firm that has the controlling stake in the firm)
- if the firm is publicly listed on the stock exchange and, if so, information on the concentration of ownership.

5.16. At a minimum, it is recommended to identify if a firm is a stand-alone firm or part of an enterprise group, and if the latter, if the enterprise group is a multinational or national group. In addition, more information on the enterprise group can be collected, e.g. the country of the group's headquarters and the size of the entire group.

5.3. Management capabilities

5.17. Management capabilities can influence a firm's ability to undertake innovation activities, introduce innovations and generate innovation outcomes. While the management literature has identified a large variety of management practices and capabilities that can potentially affect innovation performance, this section focuses on two key areas: a firm's competitive strategy and the organisational and managerial capabilities used to implement this strategy.

5.3.1. *Business strategy*

5.18. A business strategy includes the formulation of goals and the identification of policies to reach these goals. Strategic goals cover the intended outcomes over the mid- and long-term (excluding the goal of profitability, which is shared by all firms). Strategic policies or plans include how a firm creates a competitive advantage or a "unique selling proposition". Common strategic choices include:

- competing on price or quality
- market leadership or followership (proactively shaping the market or reacting to competition)

- approach to risk (involvement in high-risk and high-reward activities versus a preference for low-risk activities)
- degree of openness (seeking out new collaboration partners versus establishing close and stable ties with key partners)
- transformation (searching for new business models versus continuous improvements to the existing business model)
- a focus on a single product market versus serving multiple markets simultaneously.

5.19. The geographical distribution of sales activities (e.g. local, national or international markets) is an important dimension of a firm's competitive strategy, as is the degree of vertical integration. Finally, competitive strategies are more likely to influence a firm's operations, including innovation activities, if they are formalised and communicated within the firm.

5.20. A firm's business strategy influences key economic outcomes, such as its growth (in terms of sales, employment or capital stock), profit margin or return on capital, and market share. Data on general business competitive strategies, objectives for innovation and outcomes (see Chapter 8) are of value to research on the relative success of different strategies with respect to observed performance.

5.21. Data collection can obtain information on the existence of different strategic plans, how these plans are communicated to employees (for instance if there is a written strategic plan), and systems to monitor progress towards achieving such plans. In addition, information on which business functions are covered by a strategic plan (e.g. finance, marketing and customer relations, logistics) and which activities (e.g. innovation, workforce development, health and safety, corporate social responsibility) can help identify the linkages between strategies and innovation.

5.22. One major choice made by firms that will influence innovation activities is whether to primarily compete on price or quality. Quality-focused firms should be more likely to develop new-to-market product innovations, whereas price-focused firms should put greater emphasis on highly efficient processes. To capture these strategic orientations, it is recommended to collect data on the overall relative importance of cost and quality for a firm's competitive strategy including:

- the extent to which firms focus on the price of their products (cost competitiveness)
- the extent to which firms focus on quality features (e.g. functionality, durability, flexibility of use, etc.).

5.23. Other relevant information includes the importance to firms of focussing on improving existing products, introducing entirely new products, or aligning products to the specific requirements of individual customers. Another dimension of quality-related competitive strategies includes the significance of branding activities to differentiate a firm's products from those of its competitors.

5.24. One strategic choice is whether a firm serves a single product market or multiple markets simultaneously, since a higher level of diversification can drive innovation activity. Firms that serve multiple markets are more likely to have greater opportunities and needs for innovations than those that serve a single product market. To capture this type of diversification, surveys can collect data on the number of product lines in which the firm is active and the respective revenue shares. This information can be used to construct diversification or concentration indexes similar to the Herfindahl index. Alternatively, surveys can ask respondents if their firm targets specific product markets or applications

within a product market. For this purpose, the number of different customers served, or the share of the main three or five customers in total sales, can provide valuable information. Data collection on a firm's product strategy should be linked with data on the level of competition in the firm's product market (see subsection 7.4.2).

5.25. Because it is possible for firms to adopt different strategies in different markets, the questions on strategic orientations should either be broken down by market or refer specifically to all of a firm's markets.

5.26. The geographical markets targeted by a firm provide additional information on a firm's strategy because they relate to the variety of user demands and competitive and regulatory environments that affect the extent and orientation of innovation activities. A simple way to collect this information is to ask if a firm sells products in specific geographical regions. The share of sales to customers located abroad (export share) is another useful measure. It is recommended to collect data on whether or not a firm serves markets outside its domestic country, and if so, the share of sales from exports.

5.27. Another dimension of a firm's competitive strategy is the "make or buy" decision, particularly for product components (and relevant production and logistic processes) that are of greatest value to users, and consequently critical to a firm's market position. The degree of vertical integration (share of in-house production) can offer clues on the breadth of a firm's innovation activities. However, data on the share of purchased materials and services in gross production are insufficient because they fail to capture vertical integration for key components. Consequently, survey questions need to collect information from self-assessments, such as the extent of vertical integration for critical and non-critical components. This type of data should be linked with data on the role of suppliers in the firm's production and innovation activities (see subsection 7.4.3).

5.3.2. *Organisational and managerial capabilities*

5.28. Organisational and managerial capabilities include all of a firm's internal abilities, capacities, and competences that can be used to mobilise, command and exploit resources in order to meet the firm's strategic goals. These capabilities typically relate to managing people; intangible, physical and financial capital; and knowledge. Capabilities concern both internal processes and external relations. Managerial capabilities are a specific subset of organisational capabilities that relate to the ability of managers to organise change.

5.29. Change management capabilities are closely related to an organisation's innovation capability. They include:

- responsiveness (the ability to identify relevant external challenges)
- learning (the ability to learn from experience)
- alignment (the ability to integrate different processes to achieve strategic goals)
- creativity (the ability to generate and use new knowledge and new solutions).

5.30. Surveys can collect data on the relevance of these capabilities for a firm's business operations, using a Likert scale, or alternatively on the level of managerial abilities for each of these four capabilities. In both cases, data collection will need to rely on the subjective assessment of respondents.

5.31. A further concept of relevance to innovation is a firm's "dynamic managerial capabilities" which refers to the ability of managers to organise an effective response to internal and external challenges (see Helfat and Martin, 2015; Helfat et al., 2007). Dynamic managerial capabilities include three main dimensions:

- managerial **cognition**: knowledge structures that influence managers' biases and heuristics when, for example, anticipating market changes or understanding the implications of different choices
- managerial **social capital**: goodwill derived from relationships that managers have with others and can use to obtain resources and information
- managerial **human capital**: learned skills and knowledge that individuals develop through their prior experience, training, and education.

5.32. Data collection on dynamic managerial capabilities can rely on items that have been developed in a series of management studies (see Helfat and Martin [2015] for a review).

5.33. Another organisational capability that is closely related to innovation is the adoption of Total Quality Management (TQM), part of the ISO 9000 family of standards. It includes all efforts to install and maintain continuous improvement in a firm's ability to produce and deliver high-quality goods or services. Data collection can identify if a firm has ISO certification for TQM, when this certification was obtained, and if the firm follows other quality management approaches, such as continuous improvement processes or lean manufacturing. The former is a management approach to continuously identify potential shortcomings in an organisation's processes and develop ways to overcome them. Lean manufacturing focuses on production activities that create value, while avoiding all other activities.

5.34. Management is responsible for defining performance goals. The use of key performance indicators across different operational areas indicates how systematically a firm defines and monitors operational objectives (see Bloom and Van Reenen, 2010). Surveys can ask respondents about the following methods for tracking performance (e.g. Australian Bureau of Statistics, 2016):

- whether firms have key performance indicators in place
- which performance areas and business functions are measured through performance indicators (e.g. financial, operational, quality, innovation, human resources, environment, health and safety)
- how frequently performance is monitored
- if performance results are used to determine the remuneration of managers or employees, e.g. through a bonus system or promotions
- the consequences if performance results are not met.

5.3.3. *Characteristics of the business owner and top management*

5.35. Organisational and managerial capabilities are usually only relevant to larger organisations that split operations across different departments or business functions. Many of these concepts are therefore not relevant to small firms, including firms in the informal sector, which lack multiple departments or functions. For these firms it can be more appropriate to collect data on the characteristics of the owner-manager responsible for the firm's strategies and activities. In the case of larger and more complex enterprises, especially those with highly distributed ownership, data collection efforts can combine information on organisational capabilities and data on the characteristics of top management.

5.36. Relevant data for collection includes the owner or manager's highest educational qualification, entrepreneurial experience, and professional career. All three of these characteristics can influence the owner's level of human capital and types of expertise. The

owners' entrepreneurial experience and professional career are measures of their managerial skills obtained through business practice. Relevant data include the years of professional experience or the number of different firms a person owned before becoming the owner of the current firm.

5.37. Demographic data on the age, sex or gender identity, place of birth, and sociocultural background of the owner can also be of value (US Census Bureau, 2018), although the type of demographic data that can be collected will depend on legislation about the collection and use of personal data. Data on personal characteristics can be of value for research on the effects of government policies to support innovation and other business activities among specific population groups.

5.38. A special form of firm ownership relevant to the analysis of management capabilities is the family-owned business. A firm is family-owned if members of the same family hold 50 % or more of the firm's shares. Family ownership can affect innovation if family-owned firms have different preferences than other firms for strategic goals such as profitability and growth, and more importantly the time frame to achieve these goals. In addition, differences in management experience and risk-taking between family owners and managers could affect a firm's innovation activities.

5.39. If data collection can identify family-owned firms, the following additional variables are relevant to research on the effect of family ownership on strategic goals and innovation (see Bloom and Van Reenen, 2007):

- the number of generations the firm has been family-owned
- if the firm is managed only by family members, jointly by family members and external managers, or only by external managers
- the share of managing directors that are family members
- if the owners plan to transfer the firm to the next family generation.

5.40. Other characteristics related to ownership that can be relevant to a firm's capability to innovate include the legal type of ownership, whether the firm is listed on a stock market, or whether other firms hold minority shares in it.

5.41. In some countries, it may be possible to link innovation survey data to other sources of data on the characteristics of business owners.

5.3.4. *Innovation management capabilities*

5.42. Innovation management covers all activities to initiate, develop, and achieve results from innovation. The relevant capabilities are closely linked to general organisational and managerial capabilities and include:

- identifying, generating, assessing and pursuing ideas for innovation
- organising innovation activities within the firm (i.e. aligning different innovation activities)
- allocating resources to innovation activities
- managing innovation activities conducted in collaboration with external partners
- integrating external knowledge and other external inputs into a firm's innovation activities

- monitoring the results of innovation activities and learning from experience
- exploiting and managing innovations and other knowledge that has been generated as part of a firm's innovation activities, including protecting knowledge and innovation assets.

5.43. A major innovation management capability is to stimulate, collect and evaluate novel ideas produced within the firm. Data collection can identify the use or importance of the following methods:

- knowledge management systems
- idea management platforms
- employee suggestion schemes
- financial and non-financial incentives (awards, promotion) for employees to propose innovative ideas
- delegating decision-making to innovation project managers and innovation staff
- involving employee representatives in innovation decisions
- actions to identify, promote and motivate key individuals and groups to drive innovation.

5.44. The organisation of innovation activities within the firm includes the development or modification of an innovation strategy, the establishment or reorganisation of units within a firm with a responsibility for innovation (for example a research and experimental development [R&D] department or a design lab), and human resource practices to encourage innovation throughout the firm.

5.45. Innovation management requires assigning responsibility for innovation within the firm. Respondents can be asked if responsibility is assigned to a separate department, to specific individuals (innovation managers), distributed across multiple business functions, or combined with general management. Innovation activities can be organised within clearly defined projects (see subsection 4.5.2) to achieve a particular objective, or organised as non-structured processes. Firms can use more than one method to assign responsibility or organise their innovation activities.

5.46. Knowledge management supports internal and external knowledge sources and flows. Data collection on knowledge management practices within the firm can cover practices or mechanisms to support three knowledge activities: knowledge capture, the codification of knowledge (which will assist internal knowledge flows), and activities to promote knowledge sharing within the firm. Some management practices and mechanisms can be relevant to more than one of these activities.

5.47. Support for co-operation and mutual learning within the firm is a critical part of knowledge management because innovation typically involves different functional areas within a firm and requires communication between different people, groups and departments. Data can be collected on the use of the following methods to support the internal exchange of innovation-related knowledge and experience:

- innovation circles and team work in innovation projects
- stimulating informal contacts between employees
- joint development of innovation strategies across functional areas

- exchanging innovation ideas openly across the firm
- mutual support across functional areas to address problems in innovation projects
- regular meetings of heads of functional areas to discuss innovation issues
- mechanisms for iterative and interactive project development and delivery
- temporary involvement in innovation projects of personnel from different functional areas.

5.48. Knowledge flows with external sources (see Chapter 6) can require supporting systems, institutions and procedures to enable social relationships and networks for identifying and collecting knowledge from external sources. Firms need to search and evaluate potential knowledge partners, sources and their offerings; agree on the terms of knowledge purchases where necessary, and resolve potential disputes (OECD, 2013). Data collection can obtain information on the enablers of knowledge flows by identifying the internal practices and channels used by firms to obtain external knowledge or the use of external service providers such as knowledge brokers for this purpose.

5.49. Good innovation management must allocate scarce resources as effectively and efficiently as possible. Management methods to meet this objective include:

- organisation of innovation activities into dedicated projects with defined objectives, a budget, time schedule, and manager
- systematic evaluation and prioritisation of innovation ideas
- use of quantitative methods to assess likely returns from innovation ideas
- choice of methods to allocate resources to innovation activities, e.g. stepwise depending on progress made (e.g. stage-gate processes) or all-at-once
- offering incentives for stopping or revising unsuccessful innovation activities
- stopping innovation activities before completion if they do not meet certain objectives.

5.50. The collection of data on the number of innovation projects that have been successfully completed and those that have been stopped before completion, as proposed in subsection 4.5.2, can provide additional relevant information on resource allocation to innovation activities (see Klingebiel and Rammer, 2014).

5.51. Innovation management practices that demonstrate a commitment to innovation can contribute to the establishment and maintenance of an innovation culture, defined as the behaviours, values and beliefs with regard to innovation that are shared by a firm's personnel. The characteristics of a supportive innovation culture can include open-mindedness, willingness to change, diversity, collaboration, and learning from failure. Data can be collected on the following practices for building a supportive culture:

- communicating the importance of innovation, including the innovation vision and strategy
- allowing time and resources for innovation activities and providing supporting tools and methods
- recognising innovators and innovation results
- training employees on how to engage in innovation
- assessing innovation performance using dedicated innovation indicators.

5.52. Identifying and evaluating external knowledge (see Chapter 6) is a key element of innovation management for developing absorptive capacity (Cohen and Levinthal, 1990). Managers can support the sourcing of external knowledge through:

- regular, systematic communication with customers, suppliers and other organisations along a firm's value chain to identify opportunities and needs for innovation
- regular, systematic screening of the firm's knowledge environment (e.g. through patent searches, attending trade fairs, reading trade or scientific journals, or web searches)
- entering into alliances, joint ventures or strategic co-operation with other organisations in order to access external knowledge
- support for innovation contests or crowdsourcing to provide ideas for solving innovation problems.

5.53. The first two methods in the above list are relevant to all firms regardless of their innovation status.

5.54. Firms can benefit from the results of their innovation activities through innovations and other methods of exploiting the knowledge assets produced by these activities. These other methods include:

- protecting intellectual assets generated by innovation activities through formal and informal mechanisms
- licensing-out knowledge to external organisations
- transferring knowledge to external partners
- exploring alternative applications for their knowledge.

5.55. Assessing innovation results and learning from past innovation can help maximise the returns from innovation activities. Learning and assessment is supported by the development and use by firms of indicators to monitor and evaluate innovation inputs, outputs and performance. Activities to document innovation activities or projects, for example in databases, can enable learning from experience and support future innovation activities or projects.

5.3.5. Intellectual property management and appropriation

5.56. The World Intellectual Property Organization defines intellectual property (IP) as creations of the mind, comprising inventions; literary and artistic works; and symbols, names and images used in commerce (WIPO, 2004). The management of IP and associated IP rights includes strategic decisions for the application and registration processes as well as the types of IP rights use. Data collection can cover both the use of specific types of IP and the importance of different types of IP and other strategies for capturing economic value from innovations (appropriation).

5.57. Table 5.1 provides an overview of different IP rights, what they protect, application requirements, and the relevant jurisdiction for obtaining a right. The act of application or registration represents disclosure, initially to the managing authority and subsequently to the public. As a result, IP registration is an indicator of outbound knowledge flows.

Table 5.1. Types of intellectual property protection for data collection

Type of IP right	Protection	Application requirements	Jurisdictions ¹
Patents (utility)	Exclusive rights for patentable inventions A utility model is a subclass with lower requirements	Application filing, granting by authority (post examination), possible invalidation	National; the Patent Cooperation Treaty (PCT) permits a single international patent application
Trademarks	Exclusive rights to a sign that identifies the commercial source of a product	Application, examination and registration	National; international for countries party to the Madrid Agreement
Industrial design rights	Exclusive right for the aesthetic elements of an object	Application, examination and registration (national variations)	National; international for countries party to the Hague Agreement
Copyright and related rights	Copyright grants authors, artists and other creators protection for literary and artistic works, including literary works, computer programs, databases, films, music, choreography, visual arts, architecture, maps and technical drawings	Copyright obtained automatically, but some countries offer optional registration that facilitates dispute settlements	National; international countries party to the Berne Convention
Plant breeder's rights	Exclusive rights to new plant varieties	Application, examination and registration	National; international for countries party to the International Union for the Protection of New Varieties of Plants (UPOV) convention
Geographical indications	Right to use a sign on goods indicating geographical origin and qualities or reputation due to the place of origin	Accreditation for use of existing indications. National and regional procedures for new ones	National and international rights vary by country or region
Trade secrecy	Unauthorised use of manufacturing, industrial or commercial secrets by persons other than the holder is regarded as an unfair business practice	No registration, but the firm must undertake reasonable steps to protect secrets	National in accordance with articles 35-38 of the World Trade Organization (WTO) Trade-related Aspects of Intellectual Property Rights (TRIPS) agreement
Layouts of integrated circuits	Exclusive rights to the layout of semiconductor products	Application and registration required in some countries	National in accordance with article 39 of the WTO TRIPS agreement

1. There may also be regional arrangements and jurisdictions, for example within the European Union. The nomenclature used for the different types also varies by jurisdiction.

Source: OECD, based on WIPO (2004), "What is intellectual property?", www.wipo.int/edocs/pubdocs/en/intproperty/450/wipo_pub_450.pdf.

5.58. In a number of jurisdictions, trade secrets are considered formal intellectual property rights (IPRs) that apply to technical information such as production methods, chemical formulas, blueprints or prototypes that may or may not be patentable, as well as commercial secrets including sales and distribution methods, contract forms, business schedules, details of price agreements, consumer profiles, advertising strategies and lists of suppliers or clients.

5.59. Data collection should obtain information on whether a firm has applied for or has been granted registration of IP rights, a measure of potential use of IP. This may not require explicit survey questions as registers are public records that can be in principle linked to survey data. Information on the use of secrecy for protecting IP can also be collected through questions such as:

- if the firm required any other parties to sign confidentiality agreements
- if the firm required any employees to sign non-compete agreements
- if the firm has taken other active steps to maintain secrecy.

5.60. Testing shows that questions on IP rights can be sensitive for firms and should therefore be carefully designed to avoid non-response. Data on the importance of each type of IP right or strategy can be collected at the same time as data on the use of each type of IP. As there are multiple reasons for using IP, including for protection against copying, use in cross-licensing, to sell, etc.; importance should be defined in a way that captures the importance of each method for appropriating the value of innovations. To place IP in context, questions on appropriation should also ask about the importance of:

- technical complexity of goods or services in preventing imitation by competitors
- use of lead time advantages (rapid introduction of product or business processes) to stay ahead of competitors
- establishing and maintaining good relationships with other firms in a value chain.

5.4. Workforce skills and human resource management

5.61. People are the most important resource for innovation as they are the source of creativity and new ideas. The design, development and implementation of innovations require a variety of skills and the co-operation of different individuals. Data on the skill levels of a firm's workforce and on how a firm organises its human resources (including how it attracts and retains talent) are therefore critical for understanding innovation activities and innovation outcomes. Data on workforce skills and human resource management are also important for analysing the role of labour markets, education, and human resources for innovation (see subsection 7.4.3).

5.4.1. Workforce qualifications, occupational structure and competences

5.62. A key indicator for workforce skills is the composition of the workforce by levels of educational attainment. A simple but informative measure is the share of employed persons with tertiary education. It is recommended to collect this information from all firms, regardless of their innovation status. Tertiary education should be defined using the respective International Standard Classification of Education (ISCED) levels (levels 5 to 8 in the ISCED 2011 classification; see UNESCO/UIS, 2012). In addition, it is useful to obtain the share of employed persons with tertiary education by field of education and training according to the ISCED-F 2013 classification (UNESCO/UIS, 2015), with a focus on:

- natural sciences, mathematics and statistics
- engineering (including manufacturing and construction)
- health and medicine
- information and communication technology (ICT)
- media and design.

5.63. If business records allow, more detailed breakdowns can separate between different ISCED attainment levels and fields of education and training. Detailed breakdowns are particularly useful for analysing combinations of skills within a firm and their links to innovation.

5.64. In addition to tertiary education, the workforce composition by occupational status is another important dimension contributing to innovation capability. Occupations are characterised by a combination of attributes relating to tasks, work activities, knowledge requirements, technology and broader skills, and personal abilities and values. For international comparability, occupational categories should use the International Labour Organization's (ILO) International Standard Classification of Occupations (ISCO-08; see ILO, 2012), which includes ten major occupational groups (although not all groups may be required for data collection). Alternatively, a national classification system that is comparable to the ILO classification can be used.

5.65. In addition to data on the qualifications and occupational status of the workforce, the share of the workforce with completed vocational training is another useful indicator. Indicators of workforce experience and tenure within the firm can also provide relevant information for research on the incidence and impacts of innovation. Data on workforce qualifications and occupations can be obtained through surveying managers or, where possible, through linkage to other sources that contain relevant data.

5.66. The diversity of a firm's workforce can influence innovation performance. As innovation activities usually involve communication and interaction among employees, diversity can both stimulate and hamper the exchange of knowledge (see Østergaard, Timmermans and Kristinsson, 2011). Relevant dimensions of employee diversity include age, gender, nationality, and sociocultural background. Collecting detailed data on more than a few dimensions of employee diversity through innovation surveys is generally unfeasible. Research on the effect of diversity on innovation often requires linked employer-employee surveys or the ability to link firm-level data with employee-level data. Collecting workforce-level information from firms requires business respondents to have access to detailed information on personnel.

5.67. In addition to formal qualifications, a wide range of skills and competences can play an important role in innovation. An example of a survey that captures skills among the adult population is the OECD Programme for the International Assessment of Adult Competencies (PIAAC). There are different possible models for capturing various facets of skills. For instance, the O*NET occupational content model (incorporating tasks, skills, knowledge requirements, and values) identifies the following workforce characteristics of potential relevance to innovation (O*NET, 2018):

- enduring attributes of workforce members that influence performance, such as:
 - cognitive abilities, in particular idea generation and reasoning abilities of the workforce
 - adaptability and flexibility towards change.
- workforce capacities that facilitate performance of activities that occur across different jobs such as:
 - social skills, to work with people to achieve goals
 - complex problem-solving skills, to solve novel, ill-defined problems in complex, real-world settings
 - technical skills, to design, set up, operate, and correct malfunctions involving machines or technological systems
 - systems skills, to understand, monitor, and improve sociotechnical systems
- work values and styles, such as those related to entrepreneurialism, teamwork, creativity and autonomy.

5.68. Relevant data on skills and competences include measures of the presence of these skills in a workforce or the importance of these skills to a firm's business strategy.

5.4.2. *Human resource management*

5.69. Human resource management practices can influence the ability of a firm to profit from the creative potential and skills of its workforce. Many of these practices can benefit both innovation and other goals. Human resource management practices that can benefit innovation activities include:

- employee recruitment policies that seek creative skills
- training and skills development (see subsection 4.2.5)
- appraisals and incentives for employee performance in suggesting ideas for innovation (see subsection 5.3.4 above) or in developing innovations
- promotion and career development opportunities.

5.70. Other human resource management policies can indirectly improve innovation outcomes by increasing employee satisfaction and loyalty, such as flexibility in working hours and places (flexi time, home office, sabbatical) and social initiatives (family-friendly policies). Firms can be asked about the presence of these policies and the share of employees that benefit from these schemes.

5.5. Technological capabilities

5.71. The novelty or improved characteristics of an innovation are often due to the use of new or modified technology. At the same time, the accumulated innovation activities of one or more actors can advance knowledge within specific technological domains, creating new markets and opportunities for innovation. The ability of a firm to take advantage of these opportunities will depend on its technological capabilities within relevant domains.

5.72. In its broadest sense, "technology" is defined as the state of knowledge on how to convert resources into outputs (OECD, 2018). This includes the practical use and application to business processes or products of technical methods, systems, devices, skills and practices. Technological knowledge can be applied to transform the functional or experiential characteristics of goods, services and business processes. Technological capabilities include knowledge about these technologies and how to use them, including the ability to advance technologies beyond the state of the art. The latter is typically associated with R&D activities, although it is possible for new techniques to be developed in the absence of systematic R&D efforts.

5.73. Three types of technological capabilities are of particular interest to potential users of innovation data: technical expertise, design capabilities, and capabilities for the use of digital technologies and data analytics.

5.74. **Technical expertise** consists of a firm's knowledge of and ability to use technology. This knowledge is derived from the skills and qualifications of its employees, including its engineering and technical workforce, accumulated experience in using the technology, the use of capital goods containing the technology, and control over the relevant IP.

5.75. **Design capabilities** are difficult to define in a way that is consistently understood by all types of firms across different countries. For the purposes of this manual, design is defined (following the *Frascati Manual*) as an innovation activity "aimed at planning and

designing procedures, technical specifications and other user and functional characteristics for new products and business processes” (OECD, 2015a: § 2.62).

5.76. Capabilities related to **digital technologies and data analytics** are part of a firm's technical expertise. These are specifically singled out because of the enabling, general-purpose nature of digital technologies and data analytics.

5.5.1. *Technical expertise*

5.77. Surveys can collect generic information on a firm's degree of technical expertise by asking respondents if their firm engaged in the following activities:

- acquiring technology embodied in objects (machinery, equipment, software) from other firms or organisations
- acquiring IP rights that give ownership, exclusion rights or rights to use technical knowledge (see subsection 6.3.6)
- modifying or adapting existing technology to the firm's specific needs
- developing new technology in-house.

5.78. A similar question structure for inbound knowledge flows is used in Table 6.2.

5.79. An alternative method for obtaining generic data on technical expertise is to ask respondents if their firm conducts in-house R&D, and if so, if R&D is performed continuously (permanent staff for R&D) or only occasionally (when needed). It is recommended that surveys collect data on continuous or occasional in-house R&D activities as a basic proxy indicator of technical expertise (see subsection 4.3.2).

Expertise with emerging and enabling technologies

5.80. There is considerable policy interest in the ability of firms to use or develop emerging and enabling technologies, particularly those with applications across multiple industries. In the past, areas of policy interest included the use of biotechnology, advanced manufacturing methods, nanotechnology and ICTs and applications. More recent areas of interest are quantum computing, artificial intelligence (AI) and robotics, as well as Internet-based applications such as cloud services and big data analytics.

5.81. Expertise with emerging technologies can be measured through an open question or through a checklist of specified technologies.

5.82. In the first method, respondents are given an open question and asked to specify new technologies that are important for their firm, and describe their level of expertise with each technology. The results can be compared to an existing list of technologies of interest or used to construct a data-driven taxonomy. The principal disadvantage of this method is that it might elicit responses covering many established technologies of limited interest to policy.

5.83. In the second method, respondents are given a predefined checklist of technologies and asked if they use each one. Questions on use can distinguish between the ability to use a technology in the firm's operations and the ability to further develop or modify the technology. This method has been used in surveys on the use of advanced manufacturing and services technologies, including surveys on the use of biotechnology, nanotechnology, and other enabling and emerging technologies such as robotics, photonics, AI and machine learning (Statistics Canada, 2016). It is also used in dedicated surveys of ICT usage that focus on the uptake of ICT technologies in business processes (OECD 2015b).

5.84. The second method needs to provide:

- Completeness by covering all emerging technologies that may be relevant to the target business population. The optimal list of relevant technologies is likely to differ between services and manufacturing firms and also within specific service or manufacturing industries.
- Clarity and accuracy such that respondents can recognise the listed technologies and can accurately identify those used by their firm. This requires a “don’t know” option because many technologies are likely to be unfamiliar to a high percentage of respondents.
- Relevance to data users, which requires capturing emerging technologies while excluding technologies that have been widely adopted. This means that a list of emerging technologies needs to be continually updated.

5.85. The disadvantage of the second method is that many emerging technologies are only relevant to a limited number of industries and consequently only a very small percentage of firms are likely to be active in developing or using the technology.

5.86. It is not recommended to include a checklist for the use or development of emerging technologies in the core section of a general innovation survey because these questions will take up considerable questionnaire space while obtaining little information for a large majority of firms. Technology checklists aimed for use in representative business surveys, for example as ad hoc modules in innovation surveys, should focus on more widely diffused technologies with a broad range of applications.

5.87. A feasible alternative for online innovation surveys is to target questions on the use of emerging technologies, or technologies with specialised applications to firms that are likely to use them. For instance, questions on the use of biotechnology could be sent only to firms in industries known to use biotechnology, while questions on the use of AI could be sent only to firms in information technology (IT)-intensive industries.

5.88. Another method of identifying technical expertise in emerging technologies is to analyse publicly available patent application data, which contain information on the technological fields of relevance to the invention as well as unstructured information on the nature of the claims (OECD, 2009). Patent data can be merged with other firm data, using information in the patent application on the name and address of inventors and assignees. A limitation with patent data is that it misses firms that only apply existing technologies to their operations, without engaging in technological development that leads to a patentable invention. In addition, not all technological development activities result in patentable inventions and firms do not seek patent protection for all of their inventions.

5.5.2. Design capabilities

5.89. Design capabilities can be subdivided into three categories that are defined both by their skill sets and purpose:

1. engineering design, including technical specifications, tooling up and prototype construction
2. product design that determines the shape, colour or pattern of objects, the interface between software and users, or the user experience of services
3. design thinking, which is a systematic methodology for approaching the design of a good, service or system.

5.90. Engineering design and product design often overlap, but the former can be part of R&D, while the latter focuses on the user experience and is often conducted within a design department, design lab, or outsourced to a design consultancy.

5.91. A firm's design capabilities can be measured by identifying personnel with design-relevant responsibilities (occupations) or skills. These occupations or skills are relevant to both engineering and product design and are expected to score highly across some of the following dimensions:

- knowledge and skills of design techniques, tools, and principles used in computer-aided design, technical drawings, the construction of models, and rendering
- the practical application of engineering science and technology (e.g. applying principles, techniques, procedures, and equipment to the design and production of goods and services)
- problem-solving and critical thinking skills that use evidence, logic and reasoning to identify the strengths and weaknesses of alternative solutions, conclusions or approaches to problems
- ability to come up with novel or creative solutions for a given topic or situation, or to develop creative ways to solve a problem
- skills for evaluating the feasibility of design ideas, based on factors such as customer usability, appearance, safety, function, serviceability, budget, production costs/methods, and market characteristics and trends
- skills in conferring with customers and with engineering, marketing, production, or sales personnel.

5.92. Collecting data on the presence of a design department can fail to capture design capabilities in small firms or service sector firms that do not perform design activities as a separate, distinct activity, since these firms can combine design activities with other business functions. Workforce design capabilities can be identified by asking respondents about the presence and importance of the design-relevant skills listed above. The importance of formal qualifications and accreditation may vary according to the application area of design (e.g. within engineering) and practical experience levels.

5.93. Similar to the use of patents to measure technical expertise, publicly available data on design registrations can be used to identify some design activities. Design rights protect the shape, colour or pattern of objects. Hence they cover only one aspect of design use in a firm, with a focus on tangible goods. National as well as international intellectual property organisations such as the European Union Intellectual Property Office (EUIPO) offer IPRs for designs. Data on registered designs can be linked to other firm-level data, provided that the name and address of firms are available for other data sources. Designs can also be protected by means other than registered design rights, such as copyrights, or patents when the design incorporates functional performance features.

Design thinking

5.94. Design thinking is a systematic methodology for the design process that uses design methods to identify needs, define problems, generate ideas, develop prototypes and test solutions. It can be used for the design of systems, goods, and services (Brown, 2008).

5.95. The use of design thinking often does not meet the novelty and uncertainty requirements of R&D. However, collecting data on design thinking is of value to policy

because the methodology can support the innovation activities of both service and manufacturing firms, resulting in improvements to competitiveness and economic outcomes.

5.96. Measuring design thinking is difficult because there are several methodologies with similar aims and because design methods can be used without adopting a systematic design thinking methodology. Respondents can be asked if their firm uses specific methods that are commonly used as part of design thinking activities such as:

- divergent idea generation or brainstorming
- techniques to develop an understanding of the customer experience, particularly ethnographic field research methods (observing how people use a product in real-world environments, developing an empathetic understanding of what users want in a product, etc.)
- co-design or co-creation (involvement of potential users in generating design concepts)
- prototyping and testing.

5.97. In addition to ethnographic methods for understanding user experiences, firms can use other methods to obtain information from actual or potential users of goods and services. This information can initiate or supplement design activities, for instance by identifying opportunities and problems in relation to new or existing goods or services. Data collection can ask about the following methods for obtaining information from users:

- feedback from sales or marketing personnel
- evaluation of user initiated reports of their experiences with a product (social media, online reviews and comments, etc.)
- structured data collection (feedback forms, dedicated user surveys, focus groups).

5.98. Examples of questions on user-engagement capabilities and practices can be found in the innovation surveys implemented by Statistics Denmark and Statistics Finland (Kuusisto, Niemi and Gault, 2014).

5.99. The importance of design capabilities to a firm's business strategy can be identified through questions that position a firm on a "Design Ladder", a concept developed by the Danish Design Centre (Galindo-Rueda and Millot, 2015; Galindo-Rueda and Van Cruysen, 2016). It is recommended to collect this data, using the following four categories:

- no design activity at all
- design is used to develop the aesthetic form or style of goods and services, but design activities are not conducted on a systematic basis
- design thinking methods are integrated into the product development process
- design is a key strategic element of the firm's business model.

5.100. The use of questions on design capabilities should be preceded by a description of product design and design thinking (see above) because of national and linguistic differences in how respondents understand the concept of design.

5.5.3. *Capabilities related to digital technologies and data analytics*

5.101. Digital technologies comprise electronic tools, systems, devices and resources that generate, store, process, exchange or use digital data. **Digitisation** is the conversion of an

analogue signal conveying information (e.g. sound, image, printed text) to binary bits. **Digitalisation** is the application or increase in use of digital technologies by an organisation, industry, country, etc., for example transforming existing tasks or enables new ones. This concept thus refers to how digitisation affect the economy or society.

5.102. Digitalisation provides a wealth of innovation opportunities for firms (OECD, 2017). Capabilities to manage digital technologies, to generate, access, link, process and analyse data, including the use of AI, and to exploit new ICT-enabled applications can be crucial for harnessing these innovation opportunities. The digital skills of the workforce are particularly relevant in this context.

5.103. A starting point for capturing the digital capabilities of firms is to collect data on the use of different digital technologies, including computer infrastructure (server technologies), AI, Internet-connected devices, automation, mobile communication technologies, cloud computing, the use of digital technologies for collaboration, communication and value exchange (e.g. through social media), and digital technologies for planning and management (e.g. enterprise resource planning, customer relationship management) or distributed ledgers (blockchain).

5.104. Data collection should also obtain data on a firm's capabilities for using digital technologies. Measures include the existence of a separate IT department, the size of the firm's annual IT budget (both for hardware and software), the prevalence of digital skills among the workforce (e.g. software programming skills, database skills, computer engineering skills), the sales generated from e-commerce, and if a firm has an IT strategy or a digital strategy. It is also worthwhile to obtain data on the importance or centrality of digital capabilities to a firm's general strategy and leadership.

5.105. A common feature of digital technologies is their potential to connect various business activities and business functions, forming an integrated system with structured data exchanges among different functions and units. Data on the digital integration of different business functions (production/delivery of services, logistics, marketing/sales, product development, administration) and digital connections with suppliers and customers can provide valuable information on the state of digital capabilities and usage in a firm.

5.106. An increasingly critical capability in the digital age is the use of pervasive, large data sources and tools for business intelligence purposes. Digital technologies allow firms to generate and store huge amounts of data (often in real time) on a range of business operations, both within the firm and related to suppliers and users. These data are an increasingly important source for the development of business strategies, business models, products and business processes. Measures of these capabilities can be obtained through questions on the use of data analytic methods and tools, either in-house or through acquiring data analytics services externally: database management systems, data mining tools, machine learning, data modelling, predictive analytics, user behaviour analysis, and real time data analysis.

5.107. Digital-based innovations include product or business process innovations that contain ICTs, as well as innovations that rely to a significant degree on ICTs for their development or implementation. Qualitative studies find that digital-based innovations are widespread, with respondents noting their use in a very high share of innovations in all industries (OECD, 2015b). For this reason, there is little value in identifying innovations that contain or were developed through the use of digital technologies. Instead, data collection should obtain information on the digital competences of firms as a key component of their innovation capabilities.

5.108. Digital competence is a multi-faceted construct that captures the ability of a firm to benefit from digitalisation and address associated challenges. Some relevant dimensions of digital competence include indicators of:

- digital integration within and across different business functions
- access to and ability to use data analytics to design, develop, commercialise and improve products, including data about the users of the firm's products and their interactions with such products
- access to networks and the use of appropriate solutions and architectures (hardware and software)
- effective management of privacy and cybersecurity risks
- adoption of appropriate business models for digital environments, such as e-commerce, participative platforms, etc.

5.109. These indicators can refer to managerial and general workforce skills, infrastructures and practices within the firm.

5.110. Digital platforms are a distinguishing feature of the digital age. Platforms integrate producers and users at various stages of the value chain. They often form an ecosystem in which new products are developed and sold, and data generated and exchanged. Data on the participation of firms in digital platforms and the position of firms in these platforms (whether or not a firm owns the platform or controls who may enter, the information shared on the platform, etc.) can provide information on the firm's potential to leverage the business opportunities of digital technologies. Digital platform activities are also discussed in subsection 7.4.4.

5.111. Dedicated ICT surveys (OECD, 2015b) are the main instrument for collecting data on ICT use by firms. The most cost-effective option that also reduces response burden is to link data on digital capabilities and usage from ICT surveys with data from innovation surveys. If no dedicated ICT surveys are conducted in a country, or if data linkage is not possible, innovation surveys can opt to directly collect data on the use of digital technologies. The challenge is to identify a relevant list of current and emerging technologies, while excluding technologies that are used by almost all firms at the time of the survey (see subsection 5.5.1).

5.6. Summary of recommendations

5.112. This chapter covers a large number of business capabilities of relevance to innovation. Recommended data collection for general innovation surveys are divided into key and supplementary indicators. Key indicators should be collected whenever possible, while supplementary ones should only be collected if relevant to data users and if resources permit. Of note, some of these indicators are either available in administrative sources (such as IP registers) or collected in ICT or other surveys, and may be obtained through data linkage at the level of the firm. Data on other capabilities discussed in this chapter could be collected through ad hoc modules in innovation surveys, specialised surveys, pilot studies, or using experimental methods from unconventional sources.

5.113. Key indicators for general data collection include:

- number of employed persons (full-time equivalents) (subsection 5.2.1)
- total turnover (subsection 5.2.1)

- firm age by year the firm began business activities (subsection 5.2.3)
 - firm ownership status (stand-alone, part of a national group, part of a multinational group) (subsection 5.2.4)
 - geographical distribution of sales (local, national, international markets) (subsection 5.3.1)
 - export share of sales (subsection 5.3.1)
 - importance of cost versus quality for the firm's competitive strategy (subsection 5.3.1)
 - share of employed persons with a tertiary education (subsection 5.4.1)
 - level of design capability (subsection 5.5.2).
- 5.114. Supplementary indicators for general data collection (given space or resources):
- family-owned firm status (subsection 5.2.4)
 - number of product lines (subsection 5.3.1)
 - innovation management: responsibility for innovation within the firm (subsection 5.3.4)
 - innovation management: methods to support internal knowledge exchange (subsection 5.3.4)
 - number of employed persons by major field of education (subsection 5.4.2)
 - technical expertise in emerging technologies (subsection 5.5.1)
 - digital competences (may be collected through dedicated ICT surveys) (subsection 5.5.3).

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