The Measurement of Scientific, Technological and Innovation Activities

Oslo Manual 2018

GUIDELINES FOR COLLECTING, REPORTING AND USING DATA ON INNOVATION

OECD eurostat

4th Edition

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Foreword

Addressing the current and emerging economic, social and environmental challenges requires novel ideas, innovative approaches and greater levels of multilateral co-operation. Innovation and digitalisation are playing an increasingly important role in virtually all sectors and in the daily lives of citizens around the world. As such, policy makers are placing the “innovation imperative” at the centre of their policy agendas.

The design, development and implementation of policies, however, is fraught with difficulty – and even more so when international co-ordination is required. Innovation has often been regarded as ‘too fuzzy’ a concept to be measured and accounted for. The OECD *Frascati Manual* opened the way for measuring one key dimension of science, technology and innovation so that, nowadays, investment in research and development – R&D – is systematically encouraged and monitored around the world. However, policymaking today is still largely focused on what is easier to measure. There is, therefore, an urgent need to capture how ideas are developed and how they can become the tools that transform organisations, local markets, countries, the global economy and the very fabric of society.

In 1991, the city of Oslo witnessed the first agreement within the global community of practitioners in the OECD Working Party of National Experts on Science and Technology Indicators on how to conceptualise and measure business innovation. These guidelines became known as the *Oslo Manual*, which was published and put to the test with the support of the European Union. The fast adoption and diffusion of the manual’s proposals, both within and beyond the OECD and the EU, are a clear indication of the value of this initiative; in fact, innovation surveys covering more than 80 countries have been carried out thus far.

Moreover, the OECD and Eurostat have jointly led further revisions of the manual to extend the scope and increase the robustness of the data collected according to the Oslo guidelines. These revisions have been based on the experience gained from collecting data on innovation in OECD member and partner countries.

This fourth edition of the *Oslo Manual* takes account of major trends such as, the pervasive role of global value chains; the emergence of new information technologies and how they influence new business models; the growing importance of knowledge-based capital; as well as the progress made in understanding innovation processes and their economic impact. Its guidance seeks to contribute to measuring the process of digital transformation and thus supports the goals of the OECD’s Going Digital initiative.

The manual is a truly international resource benefitting from inputs by UNESCO, the World Bank and a number of regional development banks, who, like the OECD, are strongly committed to developing an evidence base to support investments in innovation and promote economic and social development. The 2018 edition is relevant for economies worldwide, regardless of their levels of economic development, and supports the assessment of the Sustainable Development Goals (SDGs). The manual rises to the challenges of being globally relevant – as set out by the G20 at its 2016 summit in

Hangzhou (China); and continuing to improve measurement systems to better capture the key features of science, technology and innovation – as stated in the Declaration of Science and Innovation Ministers Meeting in Daejeon (Korea) in 2015.

For the first time, the *Oslo Manual* provides a common framework for measuring innovation in a more inclusive manner across the economy, in government, in non-profit organisations and in households. This provides a path for realising many of the proposals put forward at the OECD Blue Sky Forum held in Ghent (Belgium) in 2016. For example, the inclusion of a new chapter in the manual focuses on the use of innovation data for constructing indicators and conducting analysis and evaluation.

The *Oslo Manual* has earned a pre-eminent place in the family of continuously evolving instruments devoted to the definition, collection, analysis and use of data related to science, technology and innovation. As a statistical manual, it represents a meeting point between users' needs for practical concepts, definitions and evidence on innovation, and the expert consensus on what can be robustly measured. Conceived as an open, voluntary standard, the *Oslo Manual* seeks to inspire dialogue, encourage new data collection efforts and experimentation.

As highlighted by the OECD Innovation Strategy, better measurement of innovation and its impact on economic growth, sustainability and inclusiveness is key to fulfilling the promise of better co-ordinated innovation policies in the digital era. The OECD has long argued for a whole-of-government approach to innovation policy and has stressed the importance of understanding the complex array of factors that influence innovation and the way it impacts our societies, anticipating and addressing their unintended outcomes. The *Oslo Manual* represents an extremely valuable additional tool for a wide range of innovation experts and policy practitioners worldwide.

Angel Gurría

OECD Secretary-General

Acknowledgements

This joint publication of the OECD and Eurostat is the outcome of a collective effort of all national delegates and representatives from international organisations participating in the OECD Working Party of National Experts on Science and Technology Indicators (NESTI).

Several people invested considerable time and effort to help steer the revision process on behalf of the entire NESTI group. The present fourth edition came together thanks to the leadership and dedication of the members of the Oslo Manual revision steering group (OMSG). Chaired by the NESTI Chair Svein Olav Nås (Research Council, Norway), the OMSG was set up by OECD and Eurostat to steer the revision process from inception to publication. A diverse group of experts comprising Ales Capek (Eurostat), Alessandra Colecchia (OECD), Tomohiro Ijichi (NISTEP and Seijo University, Japan), John Jankowski (NSF/NCSES, United States), Carsten Olsson (Eurostat), Christian Rammer (ZEW, Germany), Monica Salazar (Inter-American Development Bank) and Martin Schaaper (ITU, formerly UNESCO Institute for Statistics) stepped up to the challenges set out in the revision's terms of reference. The OMSG deliberated frequently, using (and sometimes abusing) the opportunities provided by online remote communication across different time zones, to provide a collegial and effective interface between the working party and the drafting team. This allowed the work to progress in between meetings and fulfil the NESTI vision and agreements.

Anthony Arundel (University of Maastricht and consultant to the OECD secretariat), Fernando Galindo-Rueda (OECD) and Christian Rammer (ZEW) prepared, on request from the OMSG, a series of chapter outlines and drafts for discussion and review. These drafts represented the backbone of the present manual. Anthony Arundel took responsibility for editing the entire manual, ensuring consistency and the timely delivery of the manual for discussion and approval by delegates. Vladimir López-Bassols (consultant to the OECD secretariat) supported the OECD in the final copy and style editing of the manuscript and the preparation of the glossary of terms. Fred Gault (UNU-MERIT, TUT-IERI and consultant to the OECD secretariat) provided additional editorial support and assisted the NESTI Chair in outreach and liaison activities with other international organisations such as the International Organization for Standardization (ISO).

The revision work undertaken by NESTI was facilitated by the S&T indicators unit in the Economic Analysis and Statistics (EAS) Division of the OECD Directorate for Science, Technology and Innovation (STI), led by Fernando Galindo-Rueda with support from Michela Bello and Daniel Ker. On the part of the Eurostat STI Working Group (STI WG) Secretariat, Giulio Perani and Gregor Kyi within Unit G4 Innovation and Digitalisation at Eurostat's Business and Trade Statistics Directorate played an instrumental role getting the revision off the ground and defining its final scope. Carsten Olsson, as the Unit G4 head, co-chaired the OMSG in the initial phase of the project. His successor, Ales Capek, facilitated the final signature of the co-publication agreement between the OECD and Eurostat. Formal oversight within the OECD was provided by Alessandra Colecchia as

Head of the EAS division. STI Director Andrew Wyckoff and Deputy Director Dirk Pilat provided guidance and comments on the drafts.

This edition would not have been possible without the financial and human resources provided by the following organisations: the United States' National Science Foundation/National Center for Science and Engineering Statistics, the German Federal Ministry for Research and Education, the Research Council of Norway, Eurostat, and the European Commission. These organisations supported work directly related to the revision as well as preparatory, exploratory and methodological work in the years preceding the revision.

Participants in four revision workshops (Oslo, December 2016; Ghent, September 2016; a NESTI meeting in Paris, March 2017; and a NESTI meeting in Madrid, December 2017) provided valuable insights to the discussions and contributed discussion documents and presentations. Additionally, webinars were carried out in June 2016 and October 2017. The December 2017 NESTI meeting was kindly hosted by the Spanish Foundation for Science and Technology (FECYT), during which the manual was agreed to in principle by delegates.

Workshops organised by the US National Academies of Science and Engineering in Washington DC (through a grant from NSF/NCSES), ZEW in Mannheim, RICYT in San José (Costa Rica), and the OECD Blue Sky Forum in Ghent, provided excellent opportunities to float ideas and proposals with members of the external academic and policy users community.

We would also like to gratefully acknowledge the input from individual and institutional submissions to the online stakeholder consultation process and the chairpersons and delegates of the OECD Committee for Scientific and Technological Policy (CSTP) and Committee for Statistics and Statistical Policy (CSSP), as well as their national teams, for the feedback provided up until declassification approval.

This work would not have been possible without the additional input of the NESTI Bureau and that of several other OECD and Eurostat colleagues, including IT, publications, communication and administrative support staff. They all contributed to the final printed and online (http://oe.cd/oslomanual) versions of this Manual.

Special gratitude is owed to the experts who initially conceived this manual and worked on it for nearly 30 years to enhance its relevance and quality, overcoming several challenges along the way. It is hoped that they will see this edition as a substantive and worthwhile "innovation" as it is implemented worldwide and inspires new measurement and analysis. The NESTI and STI WG communities, in partnership with experts from all over the world, will strive to make the Oslo Manual guidelines accessible and useful in the coming months and years.

Cover image

The cover image of this manual is part of a photographic reproduction of a fresco mural painting by Mexican artist Rufino Tamayo. He was commissioned in 1957 by the International Committee of Art Advisors of UNESCO to contribute to the artistic decoration of Room II upon the completion of the Fontenoy building at UNESCO Headquarters in Paris. The fresco was executed in situ and completed in 1958.

The subject portrayed, “Prometheus bringing the fire to mankind”, comes from the ancient Greek mythology and has been recurrent theme in the arts for centuries. The titan Prometheus disobeys the gods giving the human race the gift of fire and the skill of metalwork, an action for which both he and humankind are punished, albeit not fatally, ultimately being freed byanother heroic character, Heracles.

As noted in the UNESCO Works of Art Collection website, “Tamayo’s fresco seems to be an exaltation of the red colour through its different tones: the carmines and the vermilions bring the fire to life”.

We would like to express our gratitude to María Eugenia Bermúdez Flores de Ferrer, representative of the heirs of Rufino Tamayo’s legacy, the “Fundación Olga y Rufino Tamayo”, and Ms. Tania Fernández de Toledo, Chief of Section at UNESCO, for kindly allowing us to reproduce this image that so well symbolises the essence of this publication and the meaning of innovation.

TAMAYO, Rufino (1899-1991)

PROMETHEUS BRINGING FIRE TO MANKIND, 1958

Fresco, signed lower right 'Tamayo 9-58', 500 x 450 cm

http://www.unesco.org/artcollection/

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Abbreviations and acronyms

AI	Artificial intelligence
ANZSIC	Australian and New Zealand Standard Industrial Classification
APSC	Australian Public Service Commission
CAD	Computer-aided design
CAPI	Computer-assisted personal interviewing
CATI	Computer-assisted telephone interviewing
CDM	Crépon, Duguet and Mairesse
CIS	Community Innovation Survey (European Commission)
CPC	Central Product Classification (United Nations)
EC	European Commission
EIS	*European Innovation Scoreboard*
ESS	European Statistical System
EU	European Union
EUIPO	European Union Intellectual Property Office
Eurostat	European Commission's Directorate-General for Statistics
FTE	Full-time equivalent
G20	Group of Twenty
GDP	Gross domestic product
HEI	Higher education institution
ICT	Information and communication technology
ILO	International Labour Organization
INSEE	Institut national de la statistique et des études économiques (France)
IP	Intellectual property
IPP	Intellectual property product
IPRs	Intellectual property rights
ISCED	International Standard Classification of Education
ISIC	International Standard Industrial Classification of All Economic Activities
ISO	International Organization for Standardization

IT	Information technology
KAU	Kind-of-activity unit
KBC	Knowledge-based capital
MMD	Micro-moments database
MNE	Multinational enterprise
NACE	Statistical classification of economic activities in the European Community
NAICS	North American Industry Classification System
NEPAD	New Partnership for Africa’s Development
NESTI	Working Party of National Experts on Science and Technology Indicators
NPI	Non-profit institution
NPISHs	Non-profit institutions serving households
NSO	National statistical organisation
NSS	National statistical system
NTF	New-to-firm
NTM	New-to-market
OECD	Organisation for Economic Co-operation and Development
OM	*Oslo Manual*
PCT	Patent Cooperation Treaty (World Intellectual Property Organization)
PIAAC	Programme for the International Assessment of Adult Competencies
PRI	Public research institution
RICYT	Ibero-American/Inter-American Network for Science and Technology Indicators
R&D	Research and experimental development
RHG	Response homogeneity group
SIBS	Survey of Innovation and Business Strategy (Canada)
SMEs	Small and medium-sized enterprises
SNA	System of National Accounts (United Nations)
STI	Science, technology and innovation
TQM	Total Quality Management
TRIPS	Trade-Related Aspects of Intellectual Property Rights
UIS	UNESCO Institute for Statistics
UN	United Nations
UPOV	International Union for the Protection of New Varieties of Plants
WIPO	World Intellectual Property Organization
WTO	World Trade Organization

Executive summary

What is the *Oslo Manual*?

The *Oslo Manual* provides guidelines for collecting and interpreting data data on innovation. It seeks to facilitate international comparability, and provides a platform for research and experimentation on innovation measurement. Its guidelines are principally intended to support national statistical offices and other producers of innovation data in designing, collecting, and publishing measures of innovation to meet a range of research and policy needs. In addition, the guidelines are also designed to be of direct value to users of information on innovation.

These guidelines should be viewed as a combination of formal statistical standards, advice on best practices, as well as proposals for extending the measurement of innovation into new domains through the use of existing and new tools.

At present, a large number of countries and international organisations recognise the importance of innovation measurement and have developed capabilities to collect such data. This manual supports this co-ordinated effort in pursuit of robust, internationally comparable data, indicators and analysis.

Why a manual for measuring innovation?

Innovation is central to improvements in living standards and can affect individuals, institutions, entire economic sectors, and countries in multiple ways. Sound measurement of innovation and the use of innovation data in research can help policy makers to better understand economic and social changes, assess the contribution (positive or negative) of innovation to social and economic goals, and monitor and evaluate the effectiveness and efficiency of their policies.

The purpose of this manual is to guide innovation data collection and reporting efforts through a common vocabulary, agreed principles and practical conventions. These can enhance the comparability of statistical outputs and support the progressive development of a global statistical information infrastructure on innovation that is relevant and useful for researchers and decision makers alike.

Jointly published by the OECD and Eurostat, the *Oslo Manual* is a key component of the series of measurement manuals produced by OECD under the title "*The Measurement of Scientific, Technological and Innovation Activities*". As part of this family of manuals, it addresses the need to reflect how innovation systems operate beyond a description of the efforts made to invest in new knowledge (captured in the OECD *Frascati Manual* on resources dedicated to R&D), or the numbers and characteristics of patented inventions (as covered in the OECD *Patent Statistics Manual*).

The *Oslo Manual* plays a key role in demonstrating and communicating the multidimensional and often hidden nature of innovation. However, there are several outstanding research and policy questions that call for extended and more robust data.

What is innovation?

A key tenet of the *Oslo Manual* is that innovation can and should be measured. The requirement for measurability is an essential criterion for selecting the concepts, definitions and classifications in this manual. This feature sets this manual apart from other documents that conceptualise and define innovation.

Key components of the concept of innovation include the role of knowledge as a basis for innovation, novelty and utility, and value creation or preservation as the presumed goal of innovation. The requirement for implementation differentiates innovation from other concepts such as invention, as an innovation must be implemented, i.e. put into use or made available for others to use.

The term 'innovation' can signify both an activity and the outcome of the activity. This manual provides definitions for both. The general definition of an innovation is as follows:

> *An* ***innovation*** *is a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process).*

This definition uses the generic term "unit" to describe the actor responsible for innovations. It refers to any institutional unit in any sector, including households and their individual members.

This definition is further developed and operationalised to provides the basis for the practical guidelines in this manual for the business sector. Although the concept of innovation is inherently subjective, its application is rendered fairly objective and comparable by applying common reference points for novelty and utility, requiring a significant difference to be appreciated. This facilitates the collection and reporting of comparable data on innovation and related activities for firms in different countries and industries and for firms of different sizes and structures, ranging from small single-product firms to large multinational firms that produce a wide range of goods or services.

> ***Innovation activities*** *include all developmental, financial and commercial activities undertaken by a firm that are intended to result in an innovation for the firm.*

> *A* ***business innovation*** *is a new or improved product or business process (or combination thereof) that differs significantly from the firm's previous products or business processes and that has been introduced on the market or brought into use by the firm.*

Compared to the previous edition, a major change for the definition of business innovation in this manual has been the reduction, informed by cognitive testing work, in the complexity of the previous list-based definition of four types of innovations (product, process, organisational and marketing), to two main types: product innovations and business process innovations. The revised definition also reduces the ambiguity of the requirement for a "significant" change by comparing both new and improved innovations to the firm's existing products or business processes. The basic definitions of a product and business process innovation are as follows:

> *A **product innovation** is a new or improved good or service that differs significantly from the firm's previous goods or services and that has been introduced on the market.*

> *A **business process innovation** is a new or improved business process for one or more business functions that differs significantly from the firm's previous business processes and that has* been brought into *use by the firm.*

Business process innovations concern six different functions of a firm, as identified in the business management literature. Two functions relate to a firm's core activity of producing and delivering products for sale, while the other functions concern supporting operations. The taxonomy of business functions proposed in this manual maps reasonably well onto the previous edition's categories of process, marketing and organisational innovations.

Why and how was the manual revised?

Measurement requires an understanding of what needs to be measured and awareness of what can be reliably measured. In response to strong policy demand for empirical evidence on innovation, the *Oslo Manual* addresses both requirements and supports further experimentation to improve and extend innovation data. Increasing societal awareness of innovation-related phenomena has also expanded interest in new targets for measurement. Yet despite these advances, there are still major gaps in the evidence and questions about the role of innovation and what policies can do to influence it. One of the main objectives of this fourth edition of the *Oslo Manual* is to address some of these gaps and outstanding questions.

This edition of the *Oslo Manual* is based on the experience gained from collecting innovation statistics in both OECD and non-member countries since the early 1990s. It is a result of the collective work of the Working Party of national Experts on Science and Technology Indicators (NESTI) and Eurostat's Community Innovation Survey IS Task Force, involving more than 120 experts from nearly 45 countries and international organisations. The revision took place over a three year period and was supported by an expert consultation at its outset and a number of workshops involving key stakeholders throughout the revision. The OECD established a liaison with the International Organization for Standardization's (ISO) technical committee on Innovation Management in order to facilitate greater alignment between definitions.

This and previous revisions to the *Oslo Manual* reflect continual evolution in expert consensus on what can and should be measured. This evolution is due to ongoing changes in economic and social factors, the nature of innovation and how it occurs, as well as the accumulation of measurement experiments and the sharing of experiences among experts.

What are the main novelties of this edition?

This new edition contains a number of major novelties, compared to the previous 2005 edition, to enhance the relevance of the manual as a source of conceptual and practical guidance for the provision of data, indicators and quantitative analyses on innovation. This manual:

- Provides a conceptual framework and a general definition of innovation that is applicable to all sectors in the economy (Business, Government, Non-profit institutions serving households and Households). These are necessary for developing future guidelines for measuring innovation in sectors other than business and eventually building up an economy- and society-wide statistical view of innovation, as recommended in the 2016 OECD Blue Sky Forum.
- Updates and streamlines core definitions and taxonomies to facilitate reporting and interpretation across the entire business sector, including service sector firms specialised in providing knowledge-based services.
- Supports the measurement of investment in intangible assets by making a link between intangibles (also described as knowledge-based capital) and the generation of different types of knowledge for innovation, providing explicit measurement recommendations.
- Provides guidance on measuring internal and external factors influencing business innovation, integrating previous ad hoc guidance on measuring innovation in developing countries, as well as addressing the need to measure the incidence and effect of diverse government policies on innovation.
- Promotes the collection of a broader set of data relevant to both non-innovative and innovation-active firms to help analyse the drivers and enablers of innovation.
- While the baseline definition of innovation in this manual does not require it to be a success, recommendations are provided for measuring attributes of the outcomes of innovation. This aims to facilitate a better understanding of the diverse range of innovations and their impacts on the firm and the market and the broader social context in which it operates.
- Provides extended methodological guidelines for the entire innovation data lifecycle, from survey design and testing to data dissemination and curation. Compared to previous editions of the manual, there is considerably more guidance on methods for assessing question items and the implications of using different survey methods. The importance of the length of the observation period is discussed, highlighting the importance of seeking greater international convergence in survey practices.
- Extends guidance on the linkage of surveys with other sources, such as administrative records, and proposes complementary methods for obtaining evidence on a firm's focal (i.e. most important) innovation. Integrating an object-based approach can deliver significant improvements in survey data quality.
- Supports users of innovation data with a new chapter explaining the use of statistical data on innovation to construct indicators and for analysis. It presents a blueprint for the production of statistical indicators of innovation by thematic areas, drawing on the recommendations in previous chapters. It also describes methods for analysing innovation data, with a major focus on the analysis of innovation impacts and the empirical evaluation of innovation policies.
- Provides a glossary of key terms for ease of reference and to facilitate translation efforts to different languages.

In addition, this manual contributes to a better understanding of digitalisation and its links with innovation by providing guidance on the role of digitised information from both a product and business process innovation perspective. It also achieves this goal by recognising data development activities, along with software, as a potential innovation activity; highlighting data management competences as a key potential innovation capability for measurement, as well as recommending the measurement of external factors such as the role of digital platforms in the markets in which the firm operates.

The analysis of globalisation and how it shapes innovation is supported by guidance on capturing knowledge flows with the rest of the world and the role of multinational enterprises (MNEs) and mapping the position of a firm's business processes within value chains. International coordination is called for when interpreting data on the role of MNEs.

The *Oslo Manual*'s recommendations for data collection are limited to the Business enterprise sector (including public – i.e. government controlled – enterprises) and focus principally on statistical survey methods for representative samples of units within the business population. However, the recommendations also cover complementary data sources and collection methods, including administrative sources and big data, pointing to an integrated use of sources and methods to address user needs.

How are the guidelines intended to be used?

The manual is a statistical resource that contains guidelines for applying concepts, definitions, classifications, taxonomies and statistical methods for collecting innovation statistics about the Business sector. The manual makes recommendations and identifies possible approaches for experimentation. Within the OECD context, the recommendations are not mandatory, but member countries are nonetheless expected to adopt the recommendations to the best of their ability. This is required in order to produce internationally comparable data that can constitute a global public information good on innovation.

The manual allows for a significant degree of discretion on how different countries or groups of countries carry out their data collection activities. As measurement results are sensitive to the choice of survey methods, it is difficult to obtain international comparability without uniformity in data collection and reporting practices. Although uniformity is not feasible in an OECD or global setting, greater convergence in methods should be possible and aimed for. To this end, the OECD works with other international organisations and networks that support statistical capability development and the sharing of experiences on collecting innovation data.

Although not designed with this purpose in mind, the manual can provide a reference for policy or regulatory uses, for instance linking policies to specific innovation activities and outcomes described in the manual. In addition, the adoption of its concepts and definitions by innovation managers and practitioners will facilitate data collection.

Where to find additional relevant resources?

As a statistical standard, the *Oslo Manual* is freely available on line in multiple formats. Additional online annex material is expected to be developed and evolve to complement guidance in the manual's printed edition, following the example of the 2015 edition of the *Frascati Manual*. Relevant resources, including links to updated classifications and statistics on innovation published by the OECD, Eurostat and other international and national bodies, can be found at http://oe.cd/oslomanual.

Part I. Introduction to the measurement of innovation

Chapter 1. Introduction to innovation statistics and the *Oslo Manual*

Innovation is central to improvements in living standards and can affect individuals, institutions, entire economic sectors, and countries in multiple ways. Sound measurement of innovation and the use of innovation data in research can help policy makers better understand economic and social changes, assess the contribution of innovation to social and economic goals, and monitor and evaluate the effectiveness and efficiency of their policies. Since 1992, the Oslo Manual *has been the international standard of reference for conceptualising and measuring innovation. It has since been revised on three occasions to account for growing levels of adoption and address evolving user needs. The manual provides the basis for a common language to discuss innovation, the factors supporting innovation, and innovation outcomes. This chapter sets out the rationale for measuring innovation and summarises the objectives pursued by this edition of the manual. The chapter outlines the contents of the manual and highlights the main definitions and other major novelties introduced in this edition. The chapter concludes with an overview of the main implementation challenges amidst a context of digital transformation of our economies and societies.*

1.1. Objectives and background of the *Oslo Manual*

1.1.1. The origins of the Oslo Manual

1.1. Innovation is central to improvements in living standards and can affect individuals, institutions, entire economic sectors, and countries in multiple ways. Policy can contribute directly and indirectly to setting the direction of innovation and shaping how its effects are distributed. Sound measurement of innovation and the use of innovation data in research can help policy makers better understand economic and social changes, assess the contribution (positive or negative) of innovation to social and economic goals, and monitor and evaluate the effectiveness and efficiency of their policies (OECD, 2010).

1.2. Measurement requires an understanding of what needs to be measured and awareness of what can be reliably measured. In response to strong policy demand for empirical evidence on innovation, the *Oslo Manual* addresses both requirements, and supports further experimentation to improve and extend innovation data. The manual identifies best practices for data collection on innovation, facilitates international comparability, and provides a platform for research on innovation measurement. The manual plays a key role in communicating that innovation often does not require research and experimental development (R&D) and that innovation also involves the diffusion of existing technologies and practices across an economy.

1.3. The first edition of the *Oslo Manual* was issued in 1992 (OECD, 1992) and covered innovation in manufacturing industries. "Oslo" in the title of the manual is a reference to the city where the guidelines were first approved by the OECD Working Party of National Experts on Science and Technology Indicators (NESTI). Innovation surveys based on the 1992 edition included the European Community Innovation Survey (CIS) and comparable surveys in Australia and Canada. These surveys showed that it was possible to develop and collect data on complex and differentiated innovation phenomena.

1.4. The second edition (OECD/Eurostat/EU, 1997) updated the concepts, definitions and methodology to incorporate accumulated survey experience as well as greater understanding of the innovation process. This edition included guidelines for measuring innovation in several service industries in addition to manufacturing. It expanded the guidance for developing internationally comparable innovation indicators for OECD countries and discussed analytical and policy problems that could be addressed using innovation data and indicators.

1.5. Both the first and second editions limited innovation to new or significantly improved "technological" products and processes. This reflected a focus on the technical development of new products and new production techniques and their diffusion to other firms. The measurement of "non-technological" innovation, however, was discussed in an annex to the second edition.

1.6. The third edition (OECD/Eurostat, 2005) built on a large amount of data and experience gained from the rapid adoption of innovation surveys worldwide, including in economies at very different levels of economic development. The third edition expanded the innovation measurement framework: it gave greater emphasis to the role of linkages with other firms and institutions in the innovation process, recognised the major importance of innovation in traditionally less R&D-intensive industries, and modified the definitions of innovation and innovation activities to accommodate innovation in market-based service industries. The identification of product and process innovation with technological change was abandoned in order to include service innovations that significantly improved user experiences without necessarily having a technological component. The definition of innovation was extended to include two additional and complementary types: organisational and marketing innovation. The third edition also included an annex on measuring innovation in developing countries, reflecting widespread interest in this topic.

1.7. The revisions to the *Oslo Manual* over time reflect continual evolution in expert consensus on what can and should be measured. This evolution is due to ongoing changes in economic and social factors, such as the nature of innovation and how it occurs, as well as the accumulation of measurement experiments and the sharing of experiences among experts interested in measuring innovation. Increasing societal awareness of innovation-related phenomena has also expanded interest in new targets for measurement. Yet despite these advances, there are still major gaps in evidence and questions about the role of innovation and what policies can do to influence it. One of the main objectives of this fourth edition of the *Oslo Manual* is to address some of these gaps and outstanding questions.

1.1.2. Main objectives of the fourth edition

1.8. Published 13 years after the release of the manual's third edition, this fourth edition seeks to strengthen its relevance as a source of conceptual and practical guidance for the provision of data, indicators and quantitative analyses on innovation. The role of the *Oslo Manual* as a key guideline for policy analysis and discussion was highlighted in the Group of Twenty (G20) Innovation Action Plan (G20, 2016) endorsed by G20 Leaders in Hangzhou, the People's Republic of China, in September 2016. The summit demonstrated high-level interest by the governments of the world's largest economies in good innovation measurement to assist policy, as well as reaffirming the OECD's role in supporting this objective.

1.9. The 2016 OECD Blue Sky III Forum (http://oe.cd/blue-sky) stressed the need to extend the measurement of innovation to the broader economy and society. With this in mind, NESTI proposed that this fourth edition also become a platform for future experimentation and guidance by discussing key innovation concepts in a broader sense and by providing a general definition of innovation, as requested by many stakeholders. Consequently, despite the *Oslo Manual*'s focus on measuring innovation in the Business sector, the fourth edition includes a framework for measuring innovation in all sectors using a common definition. This explains why the title of the fourth edition does not refer explicitly to business innovation.

1.10. At the outset of the revision process, participants agreed that the fourth edition of the *Oslo Manual* should incorporate the following substantial extensions and improvements:

- Include general definitions and concepts of innovation applicable to all four economic sectors (Business, Government, Non-profits serving households, and Households). These are necessary for developing future guidelines for measuring innovation in sectors other than the Business sector.
- Ensure that the recommendations are relevant to both developed and developing countries so that the manual provides effective global guidance.
- Ensure consistency with the 2015 edition of the *Frascati Manual* for measuring R&D (OECD, 2015) and major statistical frameworks and guidelines, including the System of National Accounts (SNA) (see EC et al., 2009).
- Address the ongoing digitalisation of the economy and society, as identified in the OECD project "Going Digital" (www.oecd.org/sti/goingdigital.htm). The manual covers digital perspectives in several chapters and provides guidance on measuring innovation in digital products, platforms, and data capabilities.

- Fully reflect changing models of innovation, including those relating to open innovation, global value chains and global innovation networks.
- Apply the evidence and experience accumulated over the past decade to address long-standing challenges (subjectivity and international comparability, interpretation of the novelty and improvement requirements for innovation, quantitative measurement of innovation inputs and outputs, coverage of non-R&D-based innovation, etc.).
- Promote the collection of a broader set of data of relevance to both non-innovative and innovation-active firms, for instance on investments in knowledge-based capital (KBC) and on the internal and external conditions in which firms operate and decide to undertake innovation-relevant practices. This is required for analyses of the drivers and enablers of innovation.
- Provide in-depth discussion of survey methodology, plus the implications of data collection methodologies on data quality, timeliness, and international comparability.
- Discuss how statistical data on innovation can be used to support research, management, and policy, including indicator development and how to assess the effectiveness of policies to support innovation.

1.1.3. Scope and approach of the fourth edition

1.11. With the exception of the introductory chapter, this fourth edition of the *Oslo Manual* focuses on innovation in the Business enterprise sector, including, in many cases, government-owned enterprises. The approach of the fourth edition is as follows:

- Collect innovation data using statistically representative samples of firms in the Business sector. Although new data sources are available, such as from the Internet, many of them do not share the desirable features of representative samples from the population of interest. Consequently, the manual recommends the use of representative surveys as the preferred method for data collection. Where feasible, these can be complemented with additional representative surveys or by linking surveys to administrative data.
- Highlight how responses to survey questions are influenced by survey methods and questionnaire design. In particular, it is advised not to combine an innovation survey with an R&D survey.
- Primarily collect data using a subject-based approach that captures all of a firm's innovation activities. This can be complemented with additional information on the firm's most important innovation (or the most important innovation activity, or change for non-innovative firms), also known as an object-based approach.

1.12. While anchored in accumulated experience, this fourth edition provides ample discussion and suggestions to support necessary experimentation in the measurement of business innovation. It also highlights instances where advanced digital tools can be used for data collection and analysis, both to provide new types of data that can result in additional insights and to reduce respondent burden in surveys.

1.13. This manual is designed as a freely accessible open standard that provides guidance on what innovation statistics should be collected, how they should be compiled and how they can be used. Adherence to the guidelines will improve the uniformity and comparability of innovation data collected by a large number of organisations. Although not designed with this purpose in mind, the manual can provide a reference for policy or regulatory uses, for instance linking policies to specific innovation activities and outcomes described in the manual. In addition, the adoption of its concepts and definitions by innovation managers and practitioners would facilitate data collection.

1.1.4. The Oslo Manual *and other statistical standards*

STI measurement standards

1.14. The OECD produces a series of measurement manuals under the title "The Measurement of Scientific, Technological and Innovation Activities". Each manual presents internationally agreed methodological guidelines and proposals for the collection, reporting, and use of data and indicators on science, technology and innovation (STI). The OECD commenced its activities on setting STI statistical standards with the *Frascati Manual*, first published in 1963. While relatively recent compared to other manuals, the *Oslo Manual* is a central component of the OECD family of statistical guidelines on the measurement of STI.

1.15. Over time, additional manuals have been added, such as the OECD Patent Statistics Manual (OECD, 2009a). Manuals in this series are periodically revised to take into account new challenges and developments. The scope of the series will also continue to expand in line with developments in the field.

Links to general statistical standards and statistics

1.16. The *Oslo Manual* makes extensive use of and pursues full alignment with United Nations' statistical classifications. These include the SNA 2008 (EC et al., 2009) and the International Standard Industrial Classification of All Economic Activities (ISIC) (UN, 2008).

1.17. External classifications are regularly updated by the relevant organisations in charge. The references in this manual to other statistical documents are for the editions at the time of this manual's publication (printed edition and electronic file). An updated set of references is maintained on line as an annex.

1.18. This manual follows the recommendations in the SNA 2008 to treat expenditures on R&D, as well as on other forms of knowledge, as investments in capital assets, rather than as an expense. This affects how gross domestic product (GDP) is measured and how growth accounting exercises interpret the contribution of innovation-related activities to economic growth.

1.19. While the SNA does not currently recognise many types of innovation activities as capital formation (other than R&D and software), the development of satellite innovation accounts is part of the measurement agenda in many countries that is also converging with an interest in satellite accounts that map the extent of digital economic activities. Further progress on integrating innovation data in economic statistics will require sustained efforts to improve the measurement of innovation activities and their costs and benefits to businesses, as well as documenting the lifespan of innovations in order to contribute to the measurement of obsolescence and depreciation.

1.20. Furthermore, the SNA is used to define the Business enterprise sector (the primary scope of this manual, see Chapter 2) and to define other sectors where innovation has been measured by researchers and statisticians.

Links to other standards

1.21. In parallel with work to produce the fourth edition of the *Oslo Manual*, the OECD established a relationship with the International Organization for Standardization's (ISO) technical committee on Innovation Management, responsible for developing standards for the innovation management ISO 50500 series. The exchange between the two expert groups of the OECD and ISO covered different perspectives on the definitions of innovation and innovation management, with the OECD requiring definitions suitable for innovation measurement and the ISO requiring definitions for standardisation. The discussions led to an alignment of the definitions, taking into account the different objectives of the *Oslo Manual* and of the ISO standards.

1.2. Structure and contents of the *Oslo Manual 2018*

1.22. The 2018 edition of the *Oslo Manual* comprises three Parts that provide a general presentation of innovation measurement (Part I), a framework and guidelines for measuring business innovation (Part II), and practical guidance on methodologies for collecting and using innovation data (Part III).

1.2.1. Introduction to the measurement of innovation (Part I)

Concepts for measuring innovation (Chapter 2)

1.23. Chapter 2 explains the purpose of the manual and what makes innovation distinctive from other related phenomena such as invention or R&D. It sets out the basic concepts of innovation, including in sectors other than the Business enterprise sector.

1.24. The chapter uses internationally accepted statistical frameworks to identify the boundaries of the Business enterprise sector (the focus of this manual) and other sectors of an economy. However, actors in other sectors also play a role in the innovation system and can contribute to innovation in the Business enterprise sector. The chapter identifies connecting elements that link sectors to allow for future guidance to refer to the same underlying phenomenon. The requirement for measurability is an essential criterion for selecting the concepts, definitions and classifications in this manual. This feature sets the manual apart from other documents that conceptualise and define innovation.

1.25. The chapter concludes with a general definition of innovation that is relevant to all sectors and discusses the potential measurement of innovation in other sectors of an economy. The general definition of an innovation for all types of units is as follows:

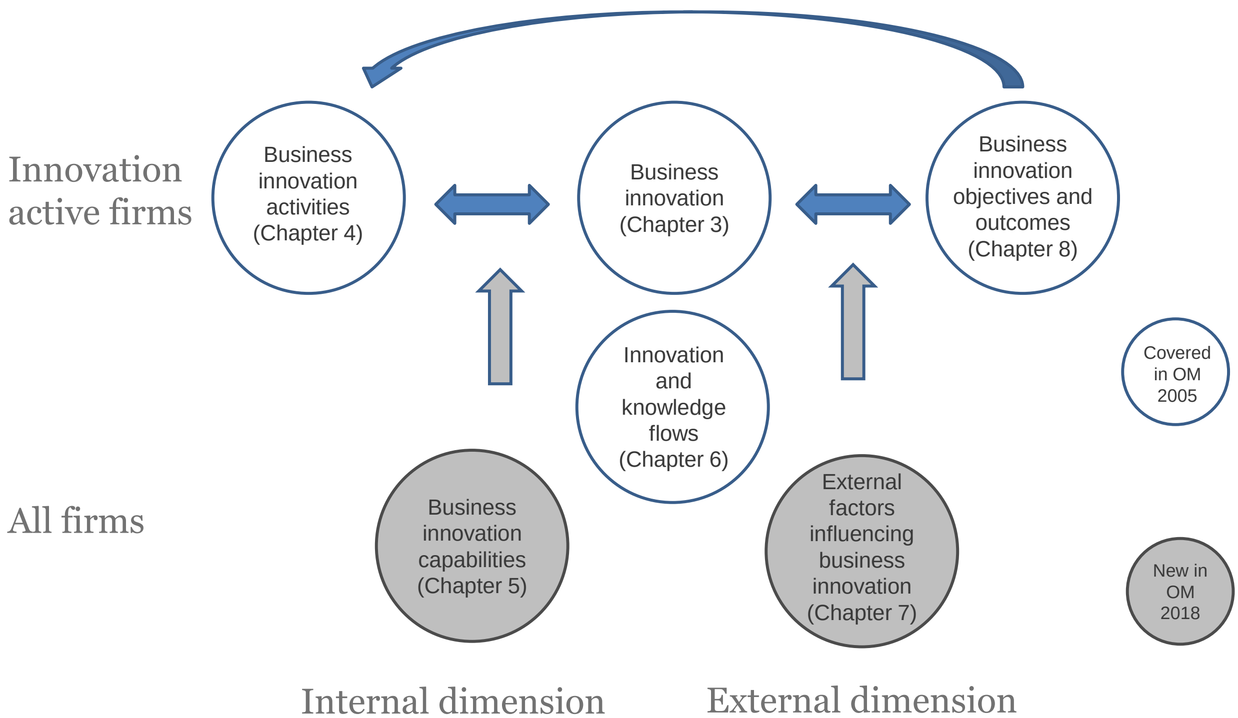
> *An* ***innovation*** *is a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process).*

1.26. The general definition uses the generic term "unit" to describe the actor responsible for innovations. It refers to any institutional unit in any sector, including households and their individual members. The definition is appropriate for measuring innovation developed by individuals, a key goal identified at the 2016 Blue Sky Forum.

1.2.2. Framework and guidelines for measuring business innovation (Part II)

1.27. Part II of the *Oslo Manual* describes the innovation process in firms and the relationship between firms, their competitive environment, and the innovation system in which they are embedded. Compared to the third edition, this edition contains an extensive discussion of the external environment of firms. This complements chapters on the definition of innovation, the measurement of innovation activities, internal capabilities, knowledge-based linkages for innovation, and innovation outcomes. Figure 1.1 provides a schematic representation of the relationship between the chapters in Part II of this manual.

Figure 1.1. General representation of the relationship between chapters in Part II



1.28. This manual emphasises the value of collecting data on all firms, regardless of their innovation activities and outcomes, as this can help improve understanding of the key drivers and potential implications of innovation.

Concepts and definitions for measuring business innovation (Chapter 3)

1.29. Chapter 3 provides a set of definitions to guide statistical surveys of innovation within the Business sector. The definitions in this chapter facilitate the collection and reporting of comparable data on innovation and related activities for firms in different countries and industries and for firms of different sizes and structures, ranging from small single-product firms to large multinational firms that produce a wide range of goods or services.

1.30. The chapter resolves the duality of "innovation" as a *process* and as an *outcome* by providing separate definitions for both concepts:

> ***Innovation activities*** *include all developmental, financial and commercial activities undertaken by a firm that are intended to result in an innovation for the firm.*
>
> *A **business innovation** is a new or improved product or business process (or combination thereof) that differs significantly from the firm's previous products or business processes and that has been introduced on the market or brought into use by the firm.*

1.31. Compared to the third edition, a major consideration in revising the definition of business innovation was the decision, based on cognitive testing work, to reduce the complexity of the previous list-based definition, comprising four types of innovations (product, process, organisational and marketing), to two main types: product innovations and business process innovations. The revised definition also reduces the ambiguity of the requirement for a "significant" change by comparing both new and improved innovations to the firm's existing products or business processes. The chapter provides detailed explanations of the definition of business innovation and provides guidance on what does not constitute an innovation. The basic definitions of a product and business process innovation are as follows:

> *A **product innovation** is a new or improved good or service that differs significantly from the firm's previous goods or services and that has been introduced on the market.*

> *A **business process innovation** is a new or improved business process for one or more business functions that differs significantly from the firm's previous business processes and that has been brought into use by the firm.*

1.32. Business process innovations concern six different functions of a firm, as identified in the business management literature. Two functions relate to a firm's core activity of producing and delivering products for sale, while the others concern supporting operations. The six main business functions have a reasonable match with the third edition's categories of process, marketing and organisational innovations.

1.33. The definitions for innovation and innovation activity lead to guidance on how firms can be characterised:

> *An **innovative firm** reports one or more innovations within the observation period. This applies equally to a firm that is individually or jointly responsible for an innovation.*

> *An **innovation-active firm** is engaged at some time during the observation period in one or more activities to develop or implement new or improved products or business processes for an intended use. Both innovative and non-innovative firms can be innovation-active during an observation period.*

1.34. In common usage the term "innovative" can refer to a potential ability or propensity to innovate in the future, creativity, a type of product or process, etc. In contrast, the term "innovative" is only used in this manual for a specific meaning: to identify whether a firm has an innovation over a given time period. The meaning of this adjective is restricted to a single purpose to avoid misunderstanding. Adaptations of this manual to different languages should replicate the precision in definitions. This also applies to innovation indicators, which should be given labels or headings that do not mislead users.

1.35. A non-innovative firm is innovation-active if it had one or more ongoing, suspended, abandoned or completed innovation activities that did not result in an innovation during the observation period. A number of activities, such as an experiment or co-creation exercise, can be completed without resulting in an innovation within the observation period.

Business innovation activities (Chapter 4)

1.36. Chapter 4 provides a framework for measuring business innovation activities. The chapter identifies eight types of activities that firms can undertake in pursuit of innovation, although many of these largely knowledge-based activities can also be carried out for other, more general purposes:

- R&D activities
- engineering, design and other creative work activities
- marketing and brand equity activities
- intellectual property (IP) related activities
- employee training activities
- software development and database activities
- activities relating to the acquisition or lease of tangible assets
- innovation management activities.

1.37. The chapter recommends collecting data on whether or not firms conduct each of these activities and whether they do so in pursuit of innovation. Similarly, data collection on expenditures for these activities should first determine all expenditures on each activity, for any purpose, followed by a question, for innovation-active firms only, on expenditures specifically for innovation. Data for all firms on each activity can provide useful information on the role of investment in KBC (intangible investment) on the propensity to innovate and economic performance. It is also useful to determine if activities are conducted in-house or procured from external sources.

1.38. The chapter proposes that questions on expenditures for innovation should make a distinction between R&D expenditures, for which records exist in most firms, and expenditures for other innovation activities. Expenditures can also be collected for personnel costs and for other major accounting categories. The measurement of expenditures on innovation activities other than R&D is an ongoing challenge. The chapter proposes several alternative approaches to innovation activity measurement. Experiments with these methods should lead to improvements in the accuracy of collected data.

Business innovation capabilities (Chapter 5)

1.39. Chapter 5 is a new chapter that was not included in previous editions of the *Oslo Manual*. Business capabilities include the knowledge, competencies and resources that a firm accumulates over time and draws upon in pursuit of its objectives. Collecting data on business capabilities is of critical importance for analyses of the effect of innovation on firm performance and why some firms engage in innovation activities and others do not.

1.40. Numerous business capabilities can potentially support innovation activities, the development of product or business process innovations, and the economic impact of these innovations. The chapter provides measurement options for four types of capabilities that are relevant for research on the innovation performance of all firms:

- the resources controlled by a firm
- the general management capabilities of a firm
- the skills of the workforce and how a firm manages its human resources
- the ability to design, develop and adopt technological tools and data resources, with the latter providing an increasingly important source of information for innovation.

Business innovation and knowledge flows (Chapter 6)

1.41. Chapter 6 focuses on the measurement of inward and outward information and knowledge flows and linkages between firms and other actors in the innovation system and extends the third edition's coverage of these topics. The chapter provides an introduction to theories of knowledge flows and open innovation that describe innovation in the Business sector as a distributed process based on managed knowledge flows across organisational boundaries.

1.42. The chapter builds on previous experience with capturing knowledge flows in innovation surveys. Mapping knowledge flows and the diffusion of innovations would benefit from the use of non-survey data sources to identify the linkages between actors, outputs and outcomes. The chapter recommendations cover data collection on the role of other firms or organisations in the development and adoption of innovations by a firm (extending Chapter 3), collaborative activities for innovation, the main sources of ideas and information for innovation, and the role of IP in knowledge flows. Additional guidance is provided on measuring the linkages between firms, universities, and public research organisations and the barriers and challenges for engaging in knowledge exchanges with external parties.

External factors influencing business innovation (Chapter 7)

1.43. Chapter 7 is new to the fourth edition of the manual and complements Chapters 5 and 6 by promoting the measurement of the firm's external environment as well as the associated challenges and opportunities that managers need to consider when making strategic choices, including for innovation. These factors include customers, competitors and suppliers; labour markets, legal, regulatory, competitive and economic conditions, and the supply of technological and other types of knowledge of value to innovation.

1.44. The chapter identifies the main elements of the external environment and provides priorities for data collection. Markets are a leading contextual factor that is often shaped by the firm's own decisions. The chapter also provides guidance on measuring the direct and indirect effects of public policy on innovation activities, social and environmental factors, and external factors that can hinder innovation.

Objectives and outcomes of business innovation (Chapter 8)

1.45. Chapter 8 reviews different approaches to measuring innovation objectives and outcomes. It discusses a number of qualitative measures of the variety of innovation objectives and outcomes pursued by firms. This is followed by an evaluation of quantitative measures of innovation outcomes for product and business process innovations. This chapter also discusses limitations in the measurement of outcomes that are further developed in Chapter 11.

1.2.3. Methods for collecting, analysing and reporting statistics on business innovation (Part III)

Methods for collecting data on business innovation (Chapter 9)

1.46. Chapter 9 provides guidance on the methodologies for collecting data on business innovation. The chapter focuses on the use of surveys, discussing the different steps for producing data, from setting objectives and priorities with stakeholders to data release and microdata storage. Compared to previous editions of the manual, there is considerably more guidance on methods for assessing question items and the implications of using different survey methods. The importance of the length of the observation period is highlighted and discussed.

1.47. Survey questions need to be carefully formulated to be correctly understood by potential respondents. All respondents must interpret questions as intended by the concepts and definitions in this manual. Many concepts and definitions cannot be used verbatim in a question, but require careful adaptation. Key terms often need to be adapted to match the language used by potential respondents in different cultural, regional and national contexts. In some cases, more than one question item may be needed to obtain data that matches a definition or a concept (see Chapter 3). The chapter also covers several practical issues that were included in the third edition's Annex on "Innovation Surveys in Developing Countries".

Object-based approaches for measuring and analysing business innovation (Chapter 10)

1.48. Chapter 10 is a new chapter that discusses the use, in innovation surveys, of the object approach to innovation – namely collecting data on a single, "focal" innovation (the object of study). This method can complement data collected through the subject approach, which covers all of a firm's innovation activities. The main purpose of the object approach is to support analytical and research uses, as well as helping data producers assess statistical quality (e.g. potential over or under-reporting of innovation). Under some conditions, the object approach can also be used to construct indicators.

Using innovation data: statistical indicators and analysis (Chapter 11)

1.49. Chapter 11 is a new chapter that addresses the use of statistical data to construct indicators and for multivariate analyses. These are key outputs of data collection that can describe and shed insights into business innovation phenomena. This final chapter provides guidance not only to those producing indicators in an official capacity, but also to other interested users of innovation data, including academics, policy analysts or managers. Other users could draw on the manual to guide their own data collection, analysis, and construction of innovation indicators.

1.50. The first half of the chapter discusses the concept of indicators, major available resources, and methodologies for constructing statistical indicators of innovation, both from a micro and a macro perspective. It also discusses approaches for summarising aggregate information on innovation into dashboards, scoreboards and composite indexes. It presents a blueprint for the production of statistical indicators of innovation by thematic areas, drawing on the recommendations in previous chapters.

1.51. The second half of the chapter describes methods for analysing innovation data, with a major focus on the analysis of innovation impacts and the empirical evaluation of innovation policies. This includes an introduction to the distributed, multi-country analysis of innovation microdata as featured in OECD (2009b).

1.2.4. Cross-cutting issues covered within this manual

1.2.5. Digitalisation and innovation

1.52. Digitalisation entails the application of digital technologies to a wide range of existing tasks and enables new tasks to be performed. Digitalisation has the potential to transform business processes, the economy and society in general. Although this manual only provides a few concrete examples of digitalisation processes, due to their rapid obsolescence and replacement, it introduces several new elements that can contribute to a better understanding of digitalisation, both as an innovation process in its own right and as a key factor driving innovation. Examples include:

- Recognition of the role of information from both a product and business process innovation perspective (Chapter 3). The definition of product innovation comprises intellectual products that exhibit features of both goods and services, as is often the case for digitised information. This is of particular importance for industries that specialise in developing and selling information content. The definition of business process innovation adopts a business function typology that separates innovations within the firm's information and communication function. Innovation in data-based business models is also discussed.
- Recognition of data development activities, along with software, as a potential innovation activity (Chapter 4). Data accumulation by companies can entail significant direct or indirect costs, for example when a firm gives away for free, or at a discounted price, the use of goods or services that generate a stream of information of value for advertising existing products. In addition, the information could also be used to improve business decision processes that result in product or business process innovations.
- Data management competences are highlighted as key potential innovation capabilities that innovation surveys should capture, directly or indirectly, in order to assess the factors influencing innovation and related outcomes within firms (Chapter 5). This chapter provides a basis for analysing the interrelationships between data-based competences and other competences such as skills, general management and design. The chapter also promotes the measurement of advanced technology development and use, in close co-ordination with surveys on information and communication technology use in firms.
- The analysis of knowledge flows related to innovation (Chapter 6) is relevant to digitalisation, with decentralised collaboration models supported by digitised knowledge.
- Digitalisation is also relevant to the discussion on external factors influencing innovation (Chapter 7), such as the nature of a firm's markets and the extent to which a firm uses digital platforms. Consumer and societal perspectives such as trust are also relevant to digitalisation.

1.53. Digitalisation is also a key driver of measurement opportunities. Digital sources and tools can be used:

- To collect information on innovation outside the Business sector, even though these digital sources and tools were not originally developed for statistical purposes (Chapter 2).
- In identifier technology in combination with available sources to reduce respondent burden, such as identifying a most important business partner (supplier or customer) or innovation collaborator, thus avoiding complex matrix-based questions (Chapter 6).
- To obtain statistical data on innovation and business characteristics and to reduce respondent burden (Chapter 9).

- To implement leaner and more secure electronic methods for collecting survey data from respondents, minimising potential sources of bias and facilitating the collection of inputs from different divisions within a firm (Chapter 9).
- To collect qualitative information from respondents on their most important innovations or changes (Chapter 10) and apply semantic analysis tools in a semi- or entirely automated fashion to determine if the description is consistent with the responses obtained on key items, such as whether innovation has been under- or over-reported.
- To analyse and visualise data on innovation (Chapter 11).

1.2.6. Globalisation and innovation

1.54. This manual provides a number of tools aimed at supporting the analysis of globalisation and its relationship with innovation. As in the previous edition, the measurement of knowledge flows aims to make a distinction between domestic flows and those with the rest of the world (Chapter 6). The importance of identifying the role of multinational enterprises (MNEs) is for the first time highlighted for measuring innovation capabilities (Chapter 5), characterising knowledge flows with other parts of the business group (Chapter 6) as well as describing the position of the firm in the value chain (Chapter 7) through questions on the location of business functions. Furthermore, the methodological discussion in Chapter 9. also addresses some of the specificities associated with collecting data from MNEs.

1.3. Implementing the guidance in this manual

1.3.1. Nature of the guidance in this manual

1.55. The purpose of this manual is to guide innovation data collection and reporting efforts through a common vocabulary, agreed principles and practical conventions. These can enhance the comparability of statistical outputs and support the progressive development of a global statistical information infrastructure on innovation that is relevant and useful for researchers and decision makers alike.

1.56. The manual is a statistical resource that contains guidelines for applying concepts, definitions, classifications, taxonomies and statistical methods for collecting innovation statistics about the Business sector. The manual makes recommendations and identifies possible approaches for experimentation. Within the OECD context, the recommendations are not mandatory, but member countries are nonetheless expected to conform to recommendations to the best of their ability. This is required in order to produce internationally comparable data that can provide a global public information good on innovation.

1.57. The manual allows for a significant degree of discretion on how different countries or groups of countries undertake their surveys. As measurement results are sensitive to the choice of survey methods, it is difficult to obtain international comparability without uniformity in data collection and reporting practices. Although uniformity is not feasible in an OECD or global setting, greater convergence in methods should be possible and aimed for. To this end, the OECD works with other international organisations and networks that support statistical capability development and the sharing of experiences on collecting innovation data.

Glossary of terms and online annex material

1.58. Definitions represent one of this manual's major contributions. As an additional resource, a glossary is included for the first time in this edition of the *Oslo Manual*, following the example of the latest edition of the *Frascati Manual* (OECD, 2015). The glossary of terms facilitates translation efforts to different languages as well as reference checks.

1.59. Online annex material is expected to be developed and evolve to complement guidance in the printed edition of the *Oslo Manual*, following the example of the latest edition of the *Frascati Manual*. Relevant resources, including links to updated classifications, can be found at http://oe.cd/oslomanual.

1.3.2. Transition and implementation

1.60. The revision of this manual entails a number of changes that require implementation and adaptation over a transition period for both the producers and users of innovation statistics. Implementing recommendations for surveys can take time. Throughout a transition period, the wording used in survey forms, databases and reports needs to be tested and adapted to the local context in which it is used. Cognitive testing with potential respondents and consultation with key stakeholders is strongly recommended.

1.61. The continuity with previous innovation data is of great importance and has been an overarching consideration throughout the fourth edition. Changes in practices have been introduced that will or might imply breaks or discontinuities in data series. Therefore, it is important for practitioners to identify possible breaks in series and to work collectively to build bridges between previous and new data, especially on the incidence of generic types of innovation for which an approximate correspondence has been established in Chapter 3. This will facilitate the enhanced maintenance and use of innovation data on a time series basis.

1.62. Burdens on data producers and respondents should also be considered. There is no expectation that all recommendations for new questions will be introduced at once. The manual provides suggestions for assigning priority to different questions. Some questions can also be rotated on a two, four or six-year cycle in order to minimise respondent burden. Other questions can be included in surveys as experiments to collect evidence on key knowledge gaps outside the traditional core set of questions.

1.63. Experience shows that unilateral country-level experimentation may fail to yield the expected results due to a lack of historical information or international benchmarking opportunities. It is therefore useful to engage in multilateral collaboration efforts across national statistical organisations and agencies in charge of innovation surveys to co-ordinate the content and timing of experimental questions. This will contribute to a more valuable set of statistical resources for users in the years to come.

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Chapter 2. Concepts for measuring innovation

This chapter provides the context and key foundations for innovation measurement underpinning this manual. It describes major perspectives and theories of innovation, user needs for innovation data, a framework for innovation measurement, and different approaches to measuring innovation. Although this manual focuses on the measurement of innovation in the Business enterprise sector, this chapter provides a general definition of innovation that applies to all sectors and discusses the measurement of innovation in both the Business enterprise sector and in other sectors.

2.1. Introduction

2.1. This chapter provides the context for innovation measurement, and outlines its rationale and possibilities. It describes the concepts that underlie major perspectives and theories of innovation, user needs for innovation data, the elements of a framework, and different approaches for innovation measurement. A general definition of innovation that is suitable for all sectors is developed and presented in the final section of the chapter

2.2. Innovation is more than a new idea or an invention. An innovation requires *implementation*, either by being put into active use or by being made available for use by other parties, firms, individuals or organisations. The economic and social impacts of inventions and ideas depend on the diffusion and uptake of related innovations. Furthermore, innovation is a dynamic and pervasive activity that occurs in all sectors of an economy; it is not the sole prerogative of the Business enterprise sector. Other types of organisations, as well as individuals, frequently make changes to products or processes and produce, collect, and distribute new knowledge of relevance to innovation.

2.3. These dynamic and complex activities and relationships represent significant, but not insurmountable, challenges for measurement. Precise definitions of innovation and innovation activities are required to measure innovation and its subsequent economic outcomes. This manual draws upon the academic and management literature, and recent experience with innovation measurement in multiple countries, to update relevant definitions and measurement guidelines.

2.4. Data about innovation are relevant to managers and stakeholders of private and public organisations, academics and policy users. Policy analysts and governments around the world seek to promote innovation because it is a key driver of productivity, economic growth and well-being. In addition, policies require an empirically grounded understanding of how innovation works in order to support economic and social changes that can address domestic and global challenges. These challenges include changing demographics, the need for food and housing security, climate change and other environmental issues, and many other obstacles to well-being.

2.5. Innovation occurs in all of the four broad sectors of an economy, as defined by the United Nations' (UN) System of National Accounts (SNA): Business enterprises (referred to within the SNA as the corporate sector), General government, Households, and Non-profit institutions serving households (NPISHs) (EC et al., 2009). Although the concepts discussed in this chapter are broadly applicable to all four sectors, the focus of this edition of the *Oslo Manual* (as with previous editions) is the Business enterprise sector and its linkages within and outside this sector. However, this chapter also provides relevant information for readers interested in measuring innovation in the other three SNA sectors.

2.6. The structure of this chapter is as follows. Section 2.2 discusses key innovation concepts that set innovation apart from other related phenomena. This is followed by section 2.3, which discusses user needs for innovation data; and section 2.4, identifying the subject and phenomena that characterise the possible scope of innovation measurement. The formulation of a general measurement framework for innovation is completed by section 2.5, which deals with general strategies for measuring innovation and sets out the basis for the measurement choices that this manual applies to the Business enterprise sector. Section 2.6 provides a general definition of innovation and short descriptions of the context for innovation in the government, NPISH and Household sectors. No guidelines for measuring innovation outside of the Business enterprise sector are provided, in the expectation that other guidance, consistent with this manual, will be developed in the future for other SNA sectors.

2.2. The concept of innovation

2.2.1. Conceptual foundations

2.7. The conceptual foundations for innovation measurement are primarily derived from the management and economics disciplines (Smith, 2006). Management perspectives on innovation cover how innovation can change a firm's position in the market and how to generate ideas for innovation. Economic perspectives examine why organisations innovate, the forces that drive innovation, the factors that hinder it, and the macroeconomic effects of innovation on an industry, market or economy. Schumpeter's (1934) theories on how firms search for new opportunities and competitive advantage over current or potential competitors are a major influence in this regard. Schumpeter introduced the concept of "creative destruction" to describe the disruption of existing economic activity by innovations that create new ways of producing goods or services or entirely new industries. The economic growth literature has used this paradigm to investigate the drivers of long-term economic growth.

2.8. Diffusion theory (Rogers, 1962) examines the processes by which innovations are communicated and adopted over time among the participants in a social system. Evolutionary theories (Nelson and Winter, 1982) view innovation as a path-dependent process (Dosi, 1982) whereby innovations are developed through interactions between various actors and then tested on the market. These interactions and market tests determine, to a large extent, which products are developed and which ones are successful, thereby influencing the future path of economic development. The work by Simon (1982, 1969) into decision-making and problem-solving has influenced the literature on innovation and the emergence of design thinking methods that harness creativity to solve complex problems (Verganti, 2009) for innovations in both private and public sector organisations.

2.9. Theories of innovation such as Kline and Rosenberg's (1986) chain-link model and innovation systems theory (Freeman, 1987; Lundvall, 1992; Nelson [ed.], 1993; OECD, 1997) stress that innovation is not a linear, sequential process, but involves many interactions and feedbacks in knowledge creation and use. In addition, innovation is based on a learning process that draws on multiple inputs and requires ongoing problem-solving.

2.10. The systems perspective of innovation calls for multidisciplinary and interdisciplinary approaches to examine the interdependencies among actors, the uncertainty of outcomes, as well as the path-dependent and evolutionary features of systems that are complex and non-linear in their responses to policy intervention. Innovation systems include organisations from the Business enterprise sector and the three other SNA sectors. Innovation systems can be delineated by industry, technology, or geography and are often interrelated, with local systems linked to national and global systems. Measurement usually collects data at the firm level, with the resulting data then aggregated to provide results at the national or industry level. Innovation measurement that covers multiple countries is of high potential value, but requires considerable co-ordination efforts.

2.11. Systems perspectives are used for developing innovation policies to co-ordinate system transformations that serve broad societal objectives (OECD, 2016). An example of a system transformation is a regime shift to decarbonise transportation systems (Kemp, Schot and Hoogma, 1998). This would require co-ordination among producers and consumers to ensure that each complementary component of a complex network is in place, particularly when some of the key actors may not exist (such as a dense network of electric vehicle charging stations). Systemic changes can be the outcome and the channel by which new technologies are adopted, for example the application of artificial intelligence across a broad range of uses.

2.12. An evaluation of innovation theories points to four dimensions of innovation that can guide measurement: knowledge, novelty, implementation, and value creation. Each is discussed below.

2.2.2. Knowledge

2.13. Innovations derive from knowledge-based activities that involve the practical application of existing or newly developed information and knowledge. Information consists of organised data and can be reproduced and transferred across organisations at low cost. Knowledge refers to an understanding of information and the ability to use information for different purposes. Knowledge is obtained through cognitive effort and consequently new knowledge is difficult to transfer because it requires learning on the part of the recipient. Both information and knowledge can be sourced or created within or outside a relevant organisation.

2.14. Research and experimental development (R&D), described in detail in the OECD's *Frascati Manual* (OECD, 2015a), is one of a range of activities that can generate innovations, or through which useful knowledge for innovation can be acquired (see Chapter 4). Other methods of gaining potentially useful knowledge include market research, engineering activities to assess the efficiency of processes, or analysing data from the users of digital goods or services. Innovation-relevant information can be gathered without a specific application in mind, for instance to help develop and evaluate options for future actions.

2.15. Knowledge has specific attributes that are relevant to and influence its measurement (Arrow, 1962). Knowledge is non-rival because its use by one organisation or person does not diminish the amount potentially available for use by others. The scope for spillovers that create new knowledge provides a policy motivation for ensuring that knowledge is widely available. However, the resources required to assimilate and effectively use knowledge can be rival (for instance if there is a limited supply of skilled and proficient people or other scarce complementary resources), as well as the ability to realise value from knowledge. Depending on the context, knowledge can be more or less valuable to a given actor if other parties hold it or are able to use it.

2.16. A number of practices that are supported by economic and social institutions can make knowledge an excludable good, including the use of secrecy or other intellectual property (IP) protection methods. These practices affect the incentives and ability to source and transform new knowledge into innovations. Technological, market and regulatory changes can also influence incentives. For example, the growing ability to digitise, organise and access information at a nil or marginal cost has increased the stock of knowledge that can be made potentially available, and created advantages from being able to exclude other users (Cameron and Bazelon, 2013).

2.2.3. Novelty with respect to potential uses

2.17. Knowledge can be used to develop new ideas, models, methods or prototypes that can form the basis of innovations. These can be sourced externally or developed within an organisation. The novelty of an innovation is related to its potential uses, as determined by the characteristics of a product or process compared to alternatives, and by the previous experiences of its provider and intended users.

2.18. Some characteristics can be objectively measured, such as energy efficiency, speed, material strength, fault rates, and other physical attributes, while subjective characteristics such as user satisfaction, usability, flexibility, responsiveness to changing conditions and emotional affinity can be more challenging to measure. Novelty can be difficult to ascertain for subjective characteristics, although the boundary between what can and cannot be measured has shrunk as organisations develop methods to gauge experiential and emotional responses. Furthermore, novelty can be intrinsically subjective because users can assign different priorities to specific attributes, for example one group of users could give higher priority to the ease of use of a mobile phone, while a second group could prioritise its technical performance.

2.2.4. Implementation and actual use

2.19. In order for a new idea, model, method or prototype to be considered an innovation, it needs to be implemented. Implementation requires organisations to make systematic efforts to ensure that the innovation is accessible to potential users, either for the organisation's own processes and procedures, or to external users for its products. The requirement for implementation is a defining characteristic of innovation that distinguishes it from inventions, prototypes, new ideas, etc.

2.20. At a minimum, innovations must contain characteristics that were not previously made available by the relevant organisation to its users. These features may or may not be new to the economy, society, or a particular market. An innovation can be based on products and processes that were already in use in other contexts, for instance in other geographical or product markets. In this case the innovation represents an example of diffusion. Innovation diffusion can generate substantial economic and social value and is consequently of policy importance. This manual defines innovation to include diffusion processes (see Chapter 3), while providing guidelines for identifying different levels of novelty, including new-to-world innovations.

2.21. Lastly, implementation is not the final step for an innovative organisation. Follow-on activities to review innovations after their implementation can result in minor improvements or radically new innovations, e.g. through a fundamental redesign or major improvements. Some of these follow-on efforts could potentially result in innovations in their own right. Post-implementation reviews can also lead to the abandonment of innovations.

2.2.5. Value creation

2.22. Viewed as an economic activity, innovation requires resources that could be used for other purposes. The existence of opportunity costs implies the likely intention to pursue some form of value creation (or value preservation) by the actors responsible for an innovation activity. Value is therefore an implicit goal of innovation, but cannot be guaranteed on an *ex ante* basis because innovation outcomes are uncertain and heterogeneous.

2.23. Value-related measures are thus important for understanding the impacts of innovation, although there is no single measure of economic or social value in established statistical frameworks such as the SNA. Statistical measures of gross value added capture the production surplus over and above the cost of intermediate inputs (excluding employee compensation or the cost of meeting financing obligations). Financial measures such as net worth capture the value of all assets owned by an institutional unit or sector, minus the value of all outstanding liabilities. These measures can be extended to account for outputs and assets that escape formal accounting conventions and for which market prices cannot provide reliable indicators of economic value.

2.24. Although it is not possible to make broad generalisations about the drivers of organisational behaviour, decisions to innovate can be presumed, *a priori*, to have an implicit motive to directly or indirectly benefit the innovative organisation, community or individual. In the Business enterprise sector, benefits often involve profitability. In normally functioning markets, customers have the freedom to decide whether to acquire a new product on the basis of its price and characteristics. Therefore, the markets for products and finance fulfil a selection function for innovations by guiding the processes of resource allocation in the Business enterprise sector. This is replaced by different mechanisms in the other SNA sectors.

2.25. The realisation of the value of an innovation is uncertain and can only be fully assessed sometime after its implementation. The value of an innovation can also evolve over time and provide different types of benefits to different stakeholders. Complementary measures and analytical strategies can be used to trace innovation outcomes after a suitable length of time. The importance of outcome measures depends on the intended uses of innovation data. They are particularly necessary for the study of government policy initiatives to promote innovation that delivers socially desirable outcomes such as inclusion, sustainability, jobs, or economic growth.

2.3. User needs and relevance of statistical evidence on innovation

2.26. User needs drive the construction of a system for measuring and reporting innovation and the subsequent production of innovation data, statistics, indicators, and in-depth analyses of innovation activities. There is widespread interest in understanding what drives firms, communities and individuals to innovate and the factors that influence their innovation activities. The relevance of innovation data for understanding innovation processes and drivers can vary across countries, industries and institutional settings. The usefulness of innovation data also depends on the ability to connect them with other types of data.

2.27. There are three main current or potential users of innovation data: academics, managers, and policy makers or policy analysts. The data needs of all three types of users are similar, with an interest in: (i) obtaining comparable data across industries, regions and time; (ii) keeping up with changes in the nature of innovation, such as open innovation or the use of design thinking principles; (iii) enabling analyses of innovation impacts on innovative organisations, other parties, and regional or national economies; (iv) providing data on the factors that enable or hinder innovation; and (v) linking innovation data to other relevant data, such as administrative registers or data on individual users of innovations.

2.3.1. Research academics

2.28. Academics use innovation data to improve society's understanding of innovation and its socio-economic effects, and to test the predictions and implications of a broad range of models on the role of innovation in economic development, organisational change, firm dynamics and social transformation. Academics have a strong interest in research that can provide predictive and causal interpretations of innovation outcomes, which requires longitudinal data on innovation linked to data for variables such as value added, employment, productivity and user/stakeholder satisfaction. Robust causal inference studies are an important input to policy development, as they overcome the limitations of cross-sectional studies that can only identify correlated phenomena.

2.29. Experience gained from using innovation data for research can point to desirable changes in the measurement framework for collecting innovation data and the types of data that are required to improve analysis (Gault, 2018). Academic researchers conducted many of the initial studies to measure innovation and consequently had a strong influence on the first edition of the *Oslo Manual* (Arundel and Smith, 2013). Academics also use the *Oslo Manual* guidelines to develop specialised or "one-off" surveys that test new questions for evaluating theories or hypotheses about innovation and innovation policies. Some of these approaches or questions have been adapted for general data collection.

2.3.2. Business managers

2.30. Managers can also benefit from statistical evidence on innovation. Although micro-level innovation data collected on a confidential basis cannot be publicly released, managers can use aggregated results for their industry to benchmark their organisation's innovation activities and outcomes. It is also worth noting that the act of collecting data on innovation in an organisation can indirectly influence managerial decisions by raising awareness of potential innovation activities and resources. This could induce search, learning and other actions leading to innovation among targeted survey respondents (Gault, 2013). The interests and incentives of innovation managers, as main providers of data on innovation, should be placed at the centre of data collection efforts in order to ensure high-quality data.

2.3.3. Innovation and other public policy makers

2.31. The core target user of innovation data is the policy community, consisting of policy analysts and policy makers. An important function of innovation data is to provide an informed basis for public policy decisions through benchmarking indicators and research using innovation data. Public policy interest in innovation is extensively reflected in the literature (OECD, 2015b, 2010a) and is relevant to all industries and SNA sectors (OECD, 2015c). Consequently, coherent policies across multiple government portfolios are required to marshal the transformational power of innovation in order to achieve key policy objectives.

2.32. The scope for establishing international benchmarking comparisons is of relevance to this manual's methodological guidelines, which are intended for use in different economies and to support mutual economic co-operation and development in a multilateral setting. However, not all indicators that are useful for benchmarking or analysis within a single country are suitable for benchmarking across countries, due to linguistic, cultural and contextual differences.

2.33. In order to determine if a set of data and indicators is well-suited to inform public policy, the goals of public policy need to be identified to ensure that the measurement framework matches policy needs. While policy interests influence the types of data that are needed, policy can also influence the extent and quality of collected data through support for funding new data collection or data linkage to existing sources.

2.34. The user base for innovation statistics is evolving over time as statistical data on innovation prove to be more or less relevant for informing decisions, or as new data become available. Innovation data are relevant to a wide array of policy areas, including general macroeconomic management, public services and industry, taxation, and environmental policies. Innovation data can be particularly informative for the study of structural policies because of the high degree of persistence of many innovation-related behaviours. This means that some types of innovation data do not need to be collected on a frequent basis, although the value of timely data will increase in the presence of rapid structural change or at times of economic or financial crises.

2.35. A potential area for future development from a user perspective is the scope for improving the relevance of innovation data to other statistical frameworks. For example, innovation statistics are of relevance to productivity statistics and the measurement of output gaps, trade and foreign investment, deflators, and other economic statistics. Greater recognition of the value of innovation statistics would help integrate innovation measurement in the broader framework of national statistics, where the precedent of satellite accounts on R&D (mainstreamed into the core accounts since the SNA 2008) may one day be followed by innovation satellite accounts.

2.4. Elements of an innovation measurement framework

2.36. An innovation measurement framework covers a defined scope, such as an SNA sector of interest, a jurisdiction or geographic a rea where data will be collected, a set of relevant phenomena of interest for understanding innovation, and measurement strategies. The latter are discussed separately in section 2.5.

2.37. The phenomena of interest must be measurable, which requires instruments that can reliably capture intended concepts (Griliches, 1986). For example, survey respondents must be able to understand a question as intended and provide valid responses (meeting one among various validity criteria). The definitions of innovation in Chapter 3 meet basic validity requirements as a result of extensive cognitive testing with potential respondents. This distinguishes them from other definitions in the literature that have not been rigorously assessed for measurability.

2.38. In addition, valid statistical data must be representative of the target population. This contrasts with other data collection methods based on case studies or other non-representative samples, although these methods can provide very useful information for specific purposes. Further discussion of data quality requirements is provided in Chapters 9 and 11 for business innovation measurement.

2.4.1. Scope of innovation measurement: SNA sectors and jurisdictions

2.39. As much as possible, the scope of measurement should be consistent with general statistical frameworks. The SNA (EC et al., 2009) provides a globally adopted, generic framework for measuring the economic activities of production, consumption, and accumulation and the associated concepts of income and wealth. The SNA framework is useful for the collection of innovation statistics because it permits the integration of innovation data with other statistical sources that are consistent with the SNA. Furthermore, guidance for measuring innovation in all SNA sectors should follow SNA terminology to ensure consistency.

2.40. The fundamental unit for analysis in the SNA is the *institutional* unit, which has legal responsibility for its actions and consequently can own assets, incur liabilities and engage in the full range of economic transactions. In practice, institutional units can be controlled by other units, as in the case of a domestic subsidiary of an international corporation. This can place limits on the autonomy of decision-making.

The jurisdiction for data collection

2.41. This manual adopts the SNA's jurisdictional perspective as a reference framework for compiling innovation statistics. The main jurisdiction for data collection on innovation is a country or economy, but innovation data can also be provided at the level of sub-divisions such as regions, states, provinces, municipalities, etc. The "rest of the world" consists of all non-resident organisations that enter into innovation-related relationships or transactions with resident (domestic) units located in a specific country. For some purposes, it can be convenient to describe the rest of the world as if it were a sector.

2.42. The globalisation of economic activities represents a challenge for measuring jurisdiction-based activities because actors outside the reference country can make decisions on innovation. For example, a head office located in a different jurisdiction could be responsible for such decisions, or a domestic innovation could depend on innovation activities conducted by organisations in other countries. Some of the contributions of non-resident actors can be captured by collecting data on the linkages between non-resident organisations and domestic institutional units. As in other statistical areas, collaboration across different jurisdictions can be necessary to obtain a complete picture of innovation activities that span national boundaries.

SNA sectors and this manual's focus on business enterprises

2.43. Institutional units are classified in the SNA into four sectors on the basis of their principal functions, behaviours and objectives:

- The SNA **Corporations sector** consists of corporations that are principally engaged in the production of market goods and services. This manual adopts the convention of referring to this sector as the Business enterprise sector, in line with the terminology adopted in the OECD's *Frascati Manual* (OECD, 2015a).
- **General government** consists of institutional units that, in addition to meeting their political and regulatory responsibilities, redistribute income and wealth and produce services and goods for individual or collective consumption, mainly on a non-market basis. The General government sector also includes non-profit institutions controlled by the government.
- **NPISHs** are legal entities that are principally engaged in the production of non-market services for households or the community at large and whose main resource is from voluntary contributions. If controlled by government, they are part of the General government sector. If controlled by firms, they are assigned to the Business enterprise sector.
- **Households** are institutional units consisting of one or more individuals. In the SNA, individuals must belong to only one household. The principal functions of households are to supply labour, to undertake final consumption and, as entrepreneurs, to produce market goods and services.

2.44. An institutional unit can be assigned to only one SNA sector. The total economy consists of all institutional units resident in the economic territory of a country. As previously mentioned, the main focus of this manual is the Business enterprise sector, although innovation data can also be collected for institutional units and individuals employed in other SNA sectors, as discussed in section 2.6 below.

2.45. The Business enterprise sector includes a type of government-controlled unit known as public business enterprises.

2.46. The "public sector" is a broader concept than the General government sector, with the former including all institutions controlled by government, including public business enterprises. The latter should not be confused with publicly listed (and traded) corporations.

2.47. The borderline between business enterprises and households presents a number of challenges when dealing with the entrepreneurial activities of households, which consist of unincorporated enterprises that remain within the Household sector, except under specific conditions. These can be particularly relevant for the study of innovation and can be also hard to separate from the Business enterprise sector.

2.48. Self-employed persons work for themselves, often through establishing an unincorporated enterprise that is not legally separate from its owner. The self-employed include the sole or joint owners of unincorporated enterprises in which they work, contributing family members, and members of producer co-operatives. Examples of unincorporated enterprises include small farms or communal construction.

2.49. Under some conditions, self-employed and unincorporated enterprises (with or without employees) can be part of the "informal sector" or the "informal economy". The informal sector can play a very significant economic role, not only in low- and middle-income countries, but also in high-income countries.

2.50. According to the SNA, the following factors can influence inclusion in the informal sector:

- Registration practices, which differ across countries and activity characteristics. Generally, registered unincorporated enterprises are part of the Business enterprise sector.
- Legal incorporation: units for which a full set of accounts, including a balance sheet, are available or can be drawn up are part of the Business enterprise sector.
- Size in terms of employment or turnover, with very small units more likely to be included in the informal sector.
- Activities such as services for own consumption, which may occasionally be offered to third parties.
- Activities not according to or authorised by law.
- Terms of employment at the boundary of service provision, as in the "gig economy" (individuals working as independent contractors or freelancers instead of as full- or part-time employees).

2.51. For a wide number of statistical purposes, individuals, rather than the households to which they belong, can be the more appropriate measurement targets.

2.52. Institutional units with similar principal economic activities are grouped into industries according to the UN International Standard Industrial Classification of All Economic Activities Revision 4 (ISIC Rev.4) (see UN, 2008), or compatible regional classifications (e.g. NACE within Europe, NAICS in North America, and ANZSIC in Australia and New Zealand).

2.53. Policy interest in measuring innovation often calls for evidence on institutional units engaged in specific economic activities that do not match with SNA institutional sectors. In particular, the *Frascati Manual* (OECD, 2015a) assigns a special "headline sector" status to units active in providing higher education services, regardless of which SNA sector they belong to. Similarly, many countries also pay special attention and grant special status to many research institutes specialising in the provision of R&D services. Both are called out specifically within this manual's Chapter 6 in the context of capturing knowledge-based linkages with business enterprises.

2.54. This manual's coverage of economic activities in the Business enterprise sector expanded from manufacturing industries in the first edition, to manufacturing and selected service industries in the second edition. The current edition provides guidance for all industries in the Business enterprise sector (see Chapter 9).

2.4.2. Innovation phenomena for measurement

The object of innovations

2.55. Innovations and innovation activities are the central object of analysis in an innovation measurement framework. Chapter 3 describes the characteristics of product and process innovations from the perspective of business enterprises. Products and processes are generic concepts that are also applicable to the other three SNA sectors.

2.56. The SNA defines a product as a good or service that results from production activities. Products can be exchanged and used as inputs into the production of other goods and services, for final consumption, or for investment.

2.57. **Goods** are objects for which current or potential demand exists and for which ownership rights can be established. Ownership permits goods (and rights to such goods) to be transferred from one owner to another through market transactions.

2.58. **Services** are the result of a production activity that changes the conditions of users or facilitates the exchange of products, including financial assets. They cannot be traded separately from their production. By the time their production is completed, they must have been provided to their users. As indicated in the SNA, changes in the condition of users include:

- Changes in the condition of the *user's goods*: the producer works directly on goods owned by the user by transporting, cleaning, repairing or otherwise transforming them. Users include other firms, for example a firm can provide materials to another firm to be transformed into a product that the original firm then sells.
- Changes in the *physical* condition of a person: the producer transports a person or provides accommodation, medical or surgical treatments, changes the appearance of their hair, etc.
- Changes in the *psychological* condition of a person: the producer provides education, information, advice, entertainment, experience or similar services, potentially but not necessarily in a "face-to-face" manner. These services may be digitally delivered.

2.59. The boundary between a good and a service can be difficult to identify and is subject to constant change. The provision of goods can shift to service-based models and vice versa. Furthermore, some products can combine features of both goods and services, for example, knowledge-capturing products that concern the provision, storage, safekeeping, communication and dissemination of information that users can copy, share and access repeatedly have features of both goods and services (see Chapter 3). Digital technologies have contributed to an increase in the variety of information and knowledge-based products available, as well as the ways in which production (understood in a general sense) and consumption takes place in all SNA sectors.

2.60. **Production processes** (or production activities) are defined in the SNA as all activities, under the control of an institutional unit, that use inputs of labour, capital, goods and services to produce outputs of goods and services. These activities are the focus of innovation analysis.

2.61. The SNA classifies production activities by the types of goods or services produced as outputs, the types of inputs used or consumed, the techniques or models of production employed, and how the outputs are used. By including goods and services, the concept of production is broader than manufacturing. All SNA sectors have distinctive approaches to production.

2.62. Beyond production, measurement can identify innovations in redistribution, consumption and other activities. These can be relevant to the study of innovation at the household or systemic level, as major system transformations require not only production shifts, but also the development of new consumption habits for recycling, sustainability, etc.

Activities leading to and following from innovations

2.63. Institutional units can undertake a series of actions with the intention to develop or adopt innovations. This can require dedicated resources and engagement in specific activities, including policies, processes and procedures.

2.64. Chapter 4 identifies innovation activities that are used by firms to develop innovations. These activities can be characterised by the knowledge they draw upon and generate, or the stage in the innovation process when they are used. They include R&D, engineering, design and other creative activities; marketing and brand equity activities, IP-related activities, employee training activities, software development and database activities, activities related to the acquisition or lease of tangible assets, and innovation management activities.

2.65. Engagement in these activities can strengthen organisational or individual capabilities for innovation, although most of these activities can be conducted without an explicit innovation objective. For example, R&D, as formally defined, is neither a sufficient nor necessary condition for either innovation activity or innovation to occur.

2.66. Innovation activities can be organised around explicit innovation projects. ISO 10006 defines a project as a "unique process consisting of a set of co-ordinated and controlled activities with start and finish dates, undertaken to achieve an objective conforming to specific requirements, including constraints of time, cost and resources" (ISO, 2017). The concept of an innovation project, while useful for understanding how innovation takes place, is unlikely to be applied in the same way across all types of organisations or institutional units. Some organisations, especially large firms, will have a broad portfolio of innovation projects at different stages of maturity, while start-ups could devote all of their resources to a single innovation without viewing it as a project. This limits the usefulness of innovation projects as a construct for measurement.

Transactions and assets of relevance to innovation

2.67. Innovation data users are interested in the magnitude of efforts devoted to innovation activities. In-house expenditures on these activities can be difficult for managers to estimate if the activity is not undertaken within a formal division of the organisation or under narrowly defined cost codes. In comparison, market purchases of goods or services to support innovation activities can often be identified from company accounts. Chapter 4 discusses methods for estimating expenditures on developing or acquiring knowledge used in business innovation activities, including methods for estimating the internal costs of these activities.

2.68. Innovation activities can produce knowledge-based assets. The SNA defines an asset as a store of value that represents a benefit or series of benefits accruing to the economic owner by holding or using the asset over a period of time. Both financial and non-financial assets are relevant to innovation. Fixed assets are the result of production activities and are used repeatedly or continuously in production processes for more than one year. The SNA treatment of knowledge assets (formally defined as intellectual property products) has evolved over time, with the addition of R&D in 2008. Other types of knowledge assets that the SNA recognises as generated through production and of relevance to innovation include investment in computer software and databases, and entertainment, literary and artistic items.

2.69. Knowledge assets can be used by their owners in production or sold on the market if use of the knowledge is restricted through legal or other protection mechanisms. The ability to exclude users provides an incentive to invest in innovation, as recognised in theories of innovation and economic growth (Aghion and Howitt, 1992; Romer, 1990).

2.70. Units in all sectors can develop or acquire knowledge assets (Corrado, Jäger and Jona-Lasinio [eds.], 2016). Because development requires some degree of specialisation, many units, including firms, acquire knowledge assets of value to innovation without engaging in their production.

2.71. The study of innovation can extend beyond products and processes. In the SNA, the production activities and ownership of assets generates income for institutional units. Units can use their disposable income for the consumption of individual or collective goods to satisfy household needs or wants. Collective consumption services are provided simultaneously to all members or groups of the community. Changes in consumption patterns over time are a potential object of innovation analysis, especially if the focus is on institutional units with final consumption as a defining attribute, as is the case for the Government and Household sectors.

Knowledge flows

2.72. Knowledge for use in innovation can be exchanged through market transactions and through non-market means. Relevant channels include knowledge carried in the minds of individuals across different organisational boundaries. Individuals can work temporarily in different organisations without a change in employer, for instance when an employee is seconded to work in an academic institution as part of a collaboration project. Data on the types of networks used, linkages between organisations, and the role of different actors in knowledge creation and diffusion is useful for research on the division of innovation labour across organisations and the creation of innovation value chains. It is difficult, however, to fully trace innovation-relevant linkages due to complex feedback loops and because respondents may not be aware of relevant linkages that extend beyond an immediate partner organisation.

2.73. Innovations can emerge through linkages between actors within or across different sectors and through a wide range of mechanisms (co-operation, alliances, joint ventures), or as an interactive process involving open innovation or user-producer interactions (OECD, 2013). The conceptualisation and measurement of linkages for innovation in the Business enterprise sector, including the open innovation paradigm, are covered in Chapter 6.

Innovation policies, laws and regulations

2.74. Understanding the effects of innovation policies on the innovation activities of organisations, especially firms, is of major interest to the policy community. Innovation policies are intended, as a primary or secondary objective, to influence the extent and nature of innovation in an economy. The implementation of innovation policies and practices can be complex and influenced not only by the intention of enabling legislation, but also by their actual use at different organisational and jurisdictional levels. Innovation policies require co-ordination and institutional arrangements that extend beyond science and research ministries to a whole-of-government approach (OECD, 2010a). Typologies of innovation policies, of value for measuring the use of innovation programs by firms, are in continuous development. Chapter 7 discusses methods for assessing the relevance of different policies and policy instruments for the innovation activities of firms.

Innovation outcomes

2.75. At the level of a society, the ultimate impacts of innovation are the satisfaction of current or future human needs at either the individual or collective level. For a firm, the expectation of outcomes such as an increase in market share, sales, or profits acts as an incentive for innovation. Measuring the extent to which innovation results in social or private outcomes is difficult, but remains a high priority. Furthermore, innovation does not necessarily result in desirable outcomes for all parties.

2.76. Productivity, profits, jobs, and social and environmental impacts are examples of outcomes of interest to users of innovation data. Innovation outcomes can be widely distributed over time, organisations and individuals. Innovation impacts can be measured directly (e.g. self-reported impacts), or indirectly through the analysis of data on innovation activities, data on outputs (such as different types of innovations) and data on internal or external outcomes (such as profits). Chapter 8 discusses the measurement of outcomes from innovation in the Business enterprise sector.

2.5. General strategies for measuring innovation

2.77. The choice of which methods to use to measure innovation depends on the quality of the data collected and its intended use. A measurement strategy for innovation must address several issues, such as the choice of a subject or object approach, the collection of qualitative and quantitative data, data sources, and responsibility for data collection.

2.78. The structure of a measurement strategy can vary over time as user needs and the types of data that can be collected evolve in response to new opportunities or challenges. In addition, different measurement approaches can complement each other. The value to users of innovation data can often be improved by combining several approaches to measurement and by creating opportunities for data linkage and follow-on analysis.

2.5.1. Subject- versus object-based approaches

2.79. In selecting the unit of analysis, a measurement framework can focus on the phenomena of interest (the object approach) or on the actors that are responsible for the phenomena (the subject approach). It is also possible to combine both approaches: for instance a survey questionnaire can include general questions about strategies and innovation practices (subject), followed by detailed questions focused on a single innovation (object).

2.80. The most common use of the object-based approach is to collect data on specific innovations, for example innovations reported in trade journals, crowdfunding platforms or, in a survey context, the most important innovation for a given organisation. Other options are to collect data on specific innovation projects or innovation-related transactions or linkages. Object-based approaches can provide a high level of granularity and detail, but can suffer from self-selection or non-representative samples, as when cases are selected from trade journals.

2.81. The subject approach is commonly used in innovation surveys to collect data on the innovation activities, outputs and outcomes of the respondent's organisation. Subject-based surveys can benefit from the statistical infrastructure of business registers and other available information at the firm level, including the industry of activity and the number of employees.

This permits the drawing of representative samples, analyses at the level of the organisation, and the presentation of results by industry or by region. Another advantage of subject-based surveys is that they can collect data on organisations with no innovations or innovation activities in the reference period, whereas these organisations would not be captured through object-based approaches based on self-reported innovations or innovation activities.

2.82. Subject- and object-based approaches can converge if it is possible to collect separate data for every innovation introduced by a firm. This is only likely to be feasible for small organisations with only one or two innovations within the observation period. The combined use of subject and object approaches in business innovation surveys is discussed in Chapter 10.

2.5.2. Qualitative and quantitative data

2.83. Academic and policy users prefer quantitative data for most research purposes. However, survey respondents find it difficult and demanding to report quantitative, interval data for innovation activities or outcomes, such as expenditures, personnel, income generated by innovations, the number and length of collaborations, the number of IP registrations or applications, etc. In addition, many innovation concepts are difficult to quantify, in part because the records and management systems of firms do not align with innovation concepts, or because the concepts only apply to specific contexts.

2.84. Qualitative measures for innovation activities that cannot be collected on an interval level can be obtained and codified by using questions that ask for nominal or ordinal data, such as the importance of different information sources or categories for the frequency with which these sources are accessed. This type of qualitative data can be used in econometric analysis and to construct indicators.

2.85. There is considerable scope for using unstructured qualitative data to construct statistics. Examples include self-reported descriptions of an organisation's most important innovation, or descriptions of innovation strategies in company or organisational reports. These can be codified manually or through machine-based algorithms that use natural language processing techniques. Chapter 9 discusses the collection of qualitative and quantitative data on innovation.

2.5.3. Sources of innovation data

Census and sample statistical surveys

2.86. Innovation surveys collect data by sending a questionnaire to all firms in a target population that meet predefined inclusion criteria (a census) or to a random sample of the target population. As a census is expensive, representative samples of the population are commonly used. Sample results can be extrapolated to the entire population and differences between subgroups can be tested using statistical inference techniques. However, non-response can reduce the reliability and validity of the results if the respondents are not representative of the entire population and if the size of this effect cannot be accurately measured.

2.87. Surveys are well-suited for eliciting information that is not available from other sources, provided that respondents have the ability and incentive to report truthfully and accurately. Surveys of organisations face challenges that are not found in surveys where an individual is the subject of interest, as in social surveys. In surveys of complex organisations, designated respondents might be faced with questions they are unable to answer. For instance, an R&D manager could be unaware of the innovation activities of a logistics division or not know the amount spent on the purchase of equipment innovations for production. Accurate answers may only be possible if different people answer different sections of the questionnaire. In contrast, this problem is considerably less likely to occur in small organisations.

Administrative and commercially generated data

2.88. Data created for administrative purposes or in the course of commercial activities provide a potentially valuable source of information on a range of innovation phenomena.

2.89. Company filings and published reports can provide detailed information on innovation activities and outcomes, although not always in a structured and comparable fashion. Administrative data can provide detailed information on specific elements of the innovation process, such as applications for different types of IP rights (patents, design registrations, etc.), or on possible outcomes of innovation, such as value added and profits.

2.90. The increasing digitalisation of economic and social activities provides new and complementary sources of innovation data. Examples include:

- Barcode data signalling product launches and product recalls.
- Data from electronic platforms where individuals or organisations post proposals for innovation projects in order to secure funding and feedback (e.g. Kickstarter). These can provide a measure of user needs and wants.
- Media reports for product launches, joint ventures, collaborations, product reviews, etc.
- Meta-databases such as the Open Knowledge Foundation's Open Product Data.

2.91. Internet platforms provide new sources of innovation data derived from diffusion and feedback processes. This is a promising area of future research, although such data must be evaluated for quality and representativeness.

2.5.4. Responsibility for primary source data collection

2.92. This manual's guidelines are designed for organisations with expertise in data collection (particularly national statistical organisations [NSOs]), but they can also be useful for other organisations that collect innovation data on a continuous or one-off basis. Other organisations include government agencies, academic and research organisations, international organisations, market research organisations and consultancies.

National statistical organisations

2.93. NSOs and comparable agencies have the resources, expertise and jurisdictional authority to conduct representative innovation surveys. Comparable agencies include research institutes with delegated data collection responsibilities and quality assurance mechanisms. Many NSOs and comparable agencies can use legislation to compel respondents to answer innovation surveys and can link other administrative information to innovation data. The expertise, independence and reputation of NSOs, plus routines to ensure confidentiality, increase the trust and confidence of survey respondents, thereby helping secure high response rates and high-quality data from representative samples. However, NSOs can face legal or resource constraints that limit the number of questions that can be asked, the ability to link administrative and innovation data, or the use of in-depth innovation surveys that focus on specific topics or parts of the relevant population.

Other organisations

2.94. Academics and research organisations are regular and frequent users of innovation data collected by NSOs or other comparable agencies. Furthermore, they often self-organise as consortia to conduct one-off or regular surveys of innovation or related topics. Examples include inventor surveys (Giuri et al., 2007), the Division of Innovative Labour survey (Arora, Cohen and Walsh, 2016), and the World Management Survey consortium (http://worldmanagementsurvey.org).

2.95. Several international organisations have conducted surveys for countries or on topics that were not covered by national innovation surveys. For example, several Eurobarometer surveys, funded by the European Commission, provided in-depth coverage of innovation-related topics such as the effect of public procurement on the innovation activities of firms. Other organisations that have conducted innovation surveys include the World Bank and the European Bank for Reconstruction and Development. A major motivation for international organisations is to obtain microdata on innovation for multiple countries.

2.96. Market research organisations and consultants can also conduct innovation surveys on behalf of other organisations, including government agencies, foundations, trade bodies, media companies, etc.

2.5.5. Summary of the measurement approach in this manual

2.97. The *Oslo Manual* provides guidelines for the statistical measurement of innovation with the following data collection features:

- A target population of business enterprises, which has been progressively extended from manufacturing industries in the first edition to the entire Business enterprise sector in this manual. The *Oslo Manual*'s guidelines are not expressly designed to measure innovation in other SNA sectors, but research shows that many of the concepts can be applied to them (Gault, 2018).
- A subject approach focused on the innovation activities of a firm. However, this manual provides recommendations for the collection of data on specific innovation objects, such as the most important innovation or innovation project (see Chapter 10).
- Compatibility with censuses or surveys that are representative of the target population and linkable to other data sources (see Chapters 9 and 11).
- Guidelines designed for use by NSOs or delegated agencies that conduct innovation surveys under some degree of public authority. As an open standard, the guidelines can also be used by international organisations, research institutes, academics, and any other groups with an interest in measuring innovation.
- A focus on serving policy user needs through providing guidance for the construction of indicators and for analysis (see Chapter 11).

2.98. Although not all measurement strategies are sufficiently mature for inclusion in this manual, the intention is to encourage the development of complementary approaches as well as research on questions that are not covered in this manual. Further research and experimentation are necessary to respond to changes in user demand and to improve existing research practices.

2.6. Measuring innovation beyond the Business sector

2.99. Innovation activities occur in all four SNA sectors. Consequently there is a need for a general definition of innovation that is applicable to all institutional units or entities, while retaining consistency with the definition in Chapter 3 for business enterprises. The general definition of an innovation for all types of units is as follows:

> *An **innovation** is a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process).*

2.100. Processes include policies that provide an overall strategy that drives a unit's activities, activities that transform inputs into outputs, and procedures that govern the detailed steps for activities to transform inputs into outputs.

2.101. Newly established entities such as firms or organisations do not have previous products or processes for comparison. In this case the comparison group for defining an innovation is what is available in the relevant market. Therefore, a product or process of a newly established entity is an innovation if it differs significantly from products available in the relevant market or processes that are currently in use by other entities in the relevant market.

2.102. Specific innovations can involve the participation of multiple actors across sectoral boundaries. These units can be linked through various methods, such as funding mechanisms, hiring of human resources, or informal contacts.

2.6.1. Innovation in the General government sector

2.103. Government units are established by political processes with legislative, judicial or executive authority and occur at the national, regional and local administrative levels. Public corporations are part of the Business sector. The key difference between a government unit and a public corporation is that the former do not charge economically significant prices for their goods or services. In order to analyse the full engagement of government in innovation in an economy, it can be useful to collect and report data at the level of the entire public sector, which includes all general government units and all public corporations.

2.104. The range of goods and services provided by government, and the prices charged, are based on political and social considerations rather than on profit-maximisation or related business objectives. This influences the types of product innovations developed by institutional units within the Government sector and made available to households, non-profits or business enterprises. Many process innovations in the Government sector draw on or are similar to innovations in the Business enterprise sector, but public service innovations often pursue redistributive or consumption-related goals that are unique to government. Common characteristics of innovation in the Government sector include the frequent use of collaboration, including with organisations in other SNA sectors, and the co-production of innovations.

2.105. The presence or absence of a market is frequently cited as the major difference between the Business and Government sectors (Bloch and Bugge, 2013; Gault, 2012; Lægreid, Roness and Verhoest, 2011). The absence of a market alters both the incentives for innovation and the methods for measuring innovation outcomes compared to the business sector. Without data on the cost or price paid for government services, outcome measurement has relied on subjective, self-reported measures, such as an increase in efficiency or improved user satisfaction (Bloch and Bugge, 2013). It is also difficult to provide aggregated economic outcome measures (financial measures of cost savings or benefits) or external validity measures for outcomes. High-quality outcome measures are generally only available for specific innovations. Examples include the cost and benefits of new treatments or protocols in hospitals or new educational methods in schools.

2.106. The study of innovation within government and the public sector more broadly has attracted a growing body of empirical research, motivated in part by the increasing demand for benchmarking the efficiency and quality of public services as well as identifying the factors that contribute to desirable innovation outputs and outcomes. Many of these studies have adapted the guidelines in the previous edition of this manual to develop surveys of innovation in public administration organisations (APSC, 2011; Arundel and Huber, 2013; Bloch and Bugge, 2013; OECD, 2015c), but more recent surveys have added questions that are explicitly designed for the Government sector. This shift was driven by the need to collect data to support public sector innovation policy (Arundel, Bloch and Ferguson, 2016). Other research has used various methodologies to examine innovation in education, health and social care services (Windrum and Koch [eds.], 2008; Osborne and Brown [eds.], 2013). The OECD has supported extensive testing of questions on public sector innovation and interim guidelines for measurement OECD (2015c).

2.6.2. Innovation and non-profit institutions

2.107. Non-profit institutions (NPIs) produce or distribute goods or services, but do not generate income or profit for the units that control or finance them. NPIs that are not part of the Government or Business enterprise sectors are classified as NPISHs. They are often non-governmental social institutions. The assignment of an NPI to the NPISH sector can change, due to an increase in the role of government or business representatives in decision-making or funding. NPISHs can also spin out businesses or exert control over business enterprises in order to serve social objectives.

2.108. Many NPISHs seek to implement "social innovations", defined by their objectives to improve the welfare of individuals or communities (Mulgan, Joseph and Norman 2013; Young Foundation, 2012). The same issues for measuring innovation outcomes in the General government sector apply to the NPISH sector.

2.6.3. Innovation, households and individuals

2.109. People drive the innovation process at many levels and consequently policies often encourage individuals and collective groups in all SNA sectors to engage in innovation (OECD, 2010a). Households, including individuals and unincorporated enterprises, play a critical role for innovation from both a supply and demand perspective.

2.110. Individuals are the ultimate providers of human and financial resources for production activities including innovation processes. As employees, individuals contribute directly to innovations attributed to their employers and can be engaged in reporting innovation data. Members of one or more households can be involved in innovations for which they are solely responsible as individuals. This can occur outside of regular employment, or through their work on a self-employed basis in unincorporated enterprises for which they are the sole or joint owner.

2.111. Self-employed individuals, in the Household or Business sector, can have considerable involvement in innovations, although their status can also be highly transient because a promising idea can quickly lead to incorporation, potentially resulting in a transition from the Household to the Business sector. Individuals can also benefit from policy interventions such as direct funding or tax support for innovation that can lead to incorporation or other forms of registration.

2.112. Historically, individuals have played a leading role in the development of new ideas and subsequent solutions. With the rise in research specialisation and the growth of the industrial corporation, households and individuals came to be viewed as passive consumers of innovations incorporated in purchased goods and services, rather than developers of innovations (von Hippel, 2017, 2005; von Hippel, Ogawa and de Jong, 2011). While individuals lack the organisational support to develop innovations requiring considerable investment, empirical research indicates that there is a non-negligible proportion of individuals who develop concepts and ideas into early prototypes or models, which they either make available to others or pursue further by themselves.

2.113. Technological developments such as the Internet, 3-D printing and crowdfunding platforms can potentially support the innovation activities of individuals, although technical and commercial success is likely to result in a transition from the Household to the Business sector. Individuals can also finance the innovation activities of other members of the Household sector or start-ups, for instance through crowdfunding platforms. In many of these cases, individual funders can receive the product before it is widely marketed, becoming lead users.

2.114. Understanding and managing the impact of innovation on individuals in their roles as employees (OECD, 2014; OECD, 2010b), asset owners, and consumers is a policy priority. Measurement could provide policy-relevant data on a range of topics, such as the effect of innovation on skills obsolescence, the willingness of individuals to trade personal data for access to free apps and networks, and factors that support trust and empower consumers to make well-informed purchasing decisions that benefit their interests. Data on the use of innovations by final consumers is also of value to business managers and policy makers. Individuals can contribute useful data for the design of new products and processes, for example behavioural data through their digital online footprint and the use of connected devices, as well as through feedback and review mechanisms. These examples point to the value of innovation measurement in the Household sector.

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Part II. Framework and guidelines for measuring business innovation

Chapter 3. Concepts and definitions for measuring business innovation

This chapter provides a set of definitions to guide statistical surveys of innovation within the Business sector, including a taxonomy for different types of innovation. The definitions within this chapter also help characterise business enterprises in relation to their innovations and their activities in pursuit of innovation. The aim of this chapter's definitions and complementary guidance is to facilitate the collection and reporting of comparable data on innovation and related activities for firms in different countries and industries and for firms of different sizes and structures, ranging from small single-product firms to large multinational firms responsible for a wide range of products (goods or services). The chapter concludes with recommendations on the use of definitions in surveys.

3.1. Introduction

3.1. Based on the concepts presented in Chapter 2, this chapter provides a set of definitions to guide statistical surveys of innovation within the Business sector. As innovation is a pervasive, heterogeneous and multi-faceted phenomenon, clear and concise definitions for innovation and related concepts are required for accurate measurement and interpretation of business innovation activities and to establish a common standard that serves the needs of the producers and users of innovation statistics.

3.2. The definitions given in this chapter facilitate the collection and reporting of comparable data on innovation and related activities for firms in different countries and industries and for firms of different sizes and structures, ranging from small single-product firms to large multinational firms that produce a wide range of products, including services.

3.3. Section 3.2 contains the main definitions for measuring innovation in the Business enterprise sector. Section 3.3 develops various taxonomies of business innovation including by type, and by novelty and impacts. Changes that are not innovations are described in section 3.4. Section 3.5 categorises firms according to their innovation status. Section 3.6 concludes with recommendations on the use of definitions in surveys.

3.2. Innovation in the Business enterprise sector

3.2.1. Definition of innovation activities and innovation

3.4. As discussed in Chapter 2, the term "innovation" can be used in different contexts to refer to either a **process** or an **outcome**. To avoid confusion, this manual uses the term "innovation activities" to refer to the process while the term "innovation" is limited to outcomes.

3.5. The basic definition of (business) innovation activities is as follows:

> ***Innovation activities*** *include all developmental, financial and commercial activities undertaken by a firm that are intended to result in an innovation for the firm.*

3.6. Innovation activities can result in an innovation (defined below), be ongoing, postponed or abandoned. Follow-on activities as defined in subsection 4.5.3 are generally outside the scope of innovation activity.

3.7. The organisation of innovation activities varies greatly between firms. Some firms manage their innovation activities through well-defined innovation projects or programmes with dedicated budgets, for which an innovation represents an intermediate or final milestone. Other firms primarily integrate their innovation activities into regular business operations and work to make continuous improvements to their products and business processes, while other firms primarily engage in innovation activities on an ad hoc basis. All methods of organising innovation activities are within the scope of the definitions and recommendations in this chapter. Additional details on the definition, categorisation and measurement of innovation activities are provided in Chapter 4.

3.8. This chapter focuses on the concept of innovation and provides summary definitions for innovation and for different types of innovation. Each definition is followed by additional details on the interpretation of the definition.

3.9. The basic definition of a business innovation is as follows:

> *A* ***business innovation*** *is a new or improved product or business process (or combination thereof) that differs significantly from the firm's previous products or business processes and that has been introduced on the market or brought into use by the firm.*

3.10. As introduced in Chapter 2, a **product** is a good or service (or combination thereof). **Business processes** include all core activities by the firm to produce products and all ancillary or supporting activities.

3.11. A product is introduced when it is made available for use by its intended users. A business process is introduced when it is brought into actual use in the firm's operations. The act of introduction is defined as **implementation** and is the point in time when a significantly different product or business process is first made available for use. Firms will often make further adjustments to an innovation after its implementation (see Chapter 4), for instance to the characteristics of a new service. Some of these can be sufficiently different to count as an additional innovation.

3.12. The minimum requirement for an innovation is that the product or business process must have one or more characteristics that are significantly different from those contained in the products or business processes previously offered by or used by the firm. These characteristics must be relevant to the firm or to external users. For example, the firm may expect the new or improved characteristics of a product (or business process) to increase utility for users or to enhance its own competitive position in the market. Relevant characteristics are described below for product innovations and business process innovations.

3.13. An innovation can also result from a series of minor improvements made during the observation period, provided that the sum of these minor improvements results in a significant difference in the final product or business process.

3.14. The requirement for significantly different characteristics applies to product and business process innovations that a firm develops itself and innovations first developed by other firms, organisations or individuals, with little or no additional modification. Therefore, the definition of innovation also includes **diffusion**.

3.15. The adoption of a new or improved product or business process by a firm that is part of an enterprise group is an innovation, even if the new or improved product or business process has previously been introduced on the market or brought into use by other firms within the same enterprise group. For instance, the adoption, by a subsidiary firm, of a new business process that was developed and brought into use by the parent firm is an innovation for the subsidiary firm. However, the adoption of a new or improved product or business process that was already in use in a different section or division of the same firm is not an innovation.

3.16. The concept of a "significant" difference excludes minor changes or enhancements. However, the boundary between a change that is an innovation and one that is not an innovation is unavoidably subjective because it is relative to each firm's context, capabilities and requirements. For example, an improvement to an online service could represent a minor change for a large firm in a research and experimental development (R&D)-intensive industry but be a significant difference for a small firm in a less R&D-intensive industry.

3.17. The definition does not require an innovation to be a commercial, financial or strategic success at the time of measurement. A product innovation can fail commercially or a business process innovation may require more time to meet its objectives.

3.18. The definition of an innovation does not require it to have a positive value for society, or a positive benefit for the firm. In the former case, an innovation can lead to a significant boost in the financial performance of the firm while providing fewer benefits to consumers than other offerings from the same firm or its competitors. An innovation can also result in safety, health or environmental problems. Conversely, an innovation does not necessarily improve the market position or financial performance of the firm when their users benefit from it. For example, an innovation can improve the utility for users without increasing a firm's sales, market share or net earnings.

3.2.2. Division of innovation effort and responsibilities

3.19. The division of labour that underpins economic specialisation also applies to innovation activities, as a majority of firms are unlikely to possess all of the necessary capabilities and property rights to develop an innovation. Many innovations are based on purchasing, imitating or modifying products, business process equipment, or business methods that are already in use by other firms or organisations. Consequently many firms do not develop all of the concepts, prototypes or designs that underpin their innovations and multiple firms can derive similar innovations from a single concept or technology. Nor do firms implement all of the concepts or prototypes they develop, for example when a firm only licenses an invention to other firms. These relationships and how they result in different types of innovations are discussed in detail in Chapter 6.

3.20. Innovations that have been developed in full or in part elsewhere, or in partnership with third parties are not necessarily less valuable; they may only signal a higher degree of specialisation. Data collection should encourage respondents to report all innovations, including those that were not primarily developed by their own firm.

3.3. Taxonomies of innovation

3.21. Innovation changes the characteristics of one or more products or business processes and consequently common usage describes innovation in terms of its purpose or object. For example, managers may refer to their firm's service innovations or to a delivery system innovation. Information on the object of an innovation is useful for assessing the purpose of the innovation, its general characteristics, its potential impacts on the firm, and the types of innovation activities that are relevant to its development and implementation.

3.3.1. Innovation types by object: Product and business process innovations

3.22. There are two major types of innovation by object: innovations that change the firm's products (product innovations), and innovations that change the firm's business processes (business process innovations).

3.23. Product innovations are divided into two main types, while business process innovations are divided into six broad types (see below). A single innovation can involve combinations of different types of product and business process innovations. Consequently, the typology of innovation types by object is not a classification of mutually exclusive categories. Furthermore, a firm can introduce more than one type of innovation over the observation period for data collection. It is therefore recommended to collect information on multiple types of innovations on the assumption that the responses can refer either to different innovations or to innovations that combine two or more innovation types.

Product innovation

3.24. The term "product" is defined in the System of National Accounts and encompasses both goods and services. Products are the economic output of production activities. They can be exchanged and used as inputs in the production of other goods and services, as final consumption by households or governments, or for investment, as in the case of financial products (EC et al., 2009).

> *A **product innovation** is a new or improved good or service that differs significantly from the firm's previous goods or services and that has been introduced on the market.*

3.25. Product innovations must provide significant improvements to one or more characteristics or performance specifications. This includes the addition of new functions, or improvements to existing functions or user utility. Relevant functional characteristics include quality, technical specifications, reliability, durability, economic efficiency during use, affordability, convenience, usability, and user friendliness. Product innovations do not need to improve all functions or performance specifications. An improvement to or addition of a new function can also be combined with a loss of other functions or a decline in some performance specifications.

3.26. Relevant characteristics can include financial attributes such as affordability and financial convenience. Examples of innovations with financial characteristics that provide benefits to users include dynamic toll pricing to ease traffic congestion, the introduction of a new product line that uses less expensive materials and is consequently offered at lower cost, and a service for automatic payment of a taxi ride after the ride has taken place.

3.27. An additional characteristic of both goods and services that can influence usability or utility is product design. New designs or improved design features can influence the appearance or "look" of a product and consequently enhance the user's utility, for instance through a substantial design change that creates a positive emotional response. However, minor design changes are unlikely to lead to goods or services that differ significantly from previous ones (see below).

3.28. A product innovation must be made available to potential users, but this does not require the innovation to generate sales. Limiting product innovations to those with sales would exclude product innovations that fail to meet established or expected demand or where sales require a longer observation period to materialise. In addition, this would exclude digital products that are offered at no cost to users, with revenue obtained from advertising, monetising user information, or through other methods.

3.29. Product innovations can use new knowledge or technologies, or be based on new uses or combinations of existing knowledge or technologies.

Types of products

3.30. Product innovations can involve two generic types of products: goods and services. These product types have been introduced in Chapter 2 and are defined below drawing on the System of National Accounts (SNA) (EC et al., 2009).

- **Goods** include tangible objects and some knowledge-capturing products (see below) over which ownership rights can be established and whose ownership can be transferred through market transactions.
- **Services** are intangible activities that are produced and consumed simultaneously and that change the conditions (e.g. physical, psychological, etc.) of users. The engagement of users through their time, availability, attention, transmission of information, or effort is often a necessary condition that leads to the co-production of services by users and the firm. The attributes or experience of a service can therefore depend on the input of users. Services can also include some knowledge-capturing products (see below).

3.31. As noted in Chapter 2, the dividing line between goods and services can sometimes be difficult to establish and some products can have characteristics of both. A company can sell goods to its customers or rent their use as a service, as is often the case for durable consumer goods and for assets for business production. Firms can also bundle ancillary services such as service contracts or insurance with their goods.

3.32. Knowledge-capturing products (as identified in the SNA) can have the characteristics of either a good or service and concern the provision, storage, safekeeping, communication and dissemination of digital information that users can access repeatedly. These products can be stored on physical objects and infrastructure, such as electronic media or the Cloud. An example is when access to digital products such as music, films and books is provided on demand to consumers for a fee. Knowledge-capturing products are similar to a good if consumers can share or sell them to others after purchase, but they are similar to a service if the consumer's rights are limited by a license that restricts sharing or selling. Digital technologies, through reducing the cost of copying and exchanging information to a negligible amount, have contributed to the proliferation of knowledge-capturing products.

3.33. At a minimum, it is recommended to collect data on both goods and services. Surveys should specifically refer to services to ensure that the questions are relevant to respondents from service sector firms. Where possible, data should be collected on knowledge-capturing products, especially those of a digital nature, to support research on the prevalence of these products and the factors that influence their development.

Business process innovation

3.34. All business functions can be the object of innovation activity. The term business process includes the core business function of producing goods and services and supporting functions such as distribution and logistics, marketing, sales and after-sales services; information and communication technology (ICT) services to the firm, administrative and management functions, engineering and related technical services to the firm, and product and business process development. Business processes can be considered as services for which the firm itself is the customer. Business processes can be delivered in-house or procured from external sources.

> *A **business process innovation** is a new or improved business process for one or more business functions that differs significantly from the firm's previous business processes and that has been brought into use in the firm.*

3.35. The relevant characteristics of an improved business function are related to those for an improved product, in particular services that can be delivered to business customers. Examples include greater efficacy, resource efficiency, reliability and resilience, affordability, convenience and usability for those involved in the business process, either external or internal to the firm.

3.36. Both new and improved business processes can be motivated by goals to implement business strategies, reduce costs, improve product quality or working conditions, or to meet regulatory requirements. A business process innovation can involve improvements to one or more aspects of a single business function or to combinations of different business functions. They can involve the adoption by the firm of new or improved business services that are delivered by external contractors, for instance accounting or human resources systems.

3.37. Business process innovations are implemented when they are brought into use by the firm in its internal or outward-facing operations. The implementation of a business process innovation can require several steps, from initial development, pilot testing in a single business function, to implementation across all relevant business functions. Implementation occurs when the business process is used on an ongoing basis in the firm's operations. This can occur shortly after pilot testing.

3.38. Digital technologies and practices are pervasive across business processes. They are used to codify processes and procedures, add functions to existing processes and enable the sale of processes as services. The implementation of business process innovations is therefore often tied to the adoption and modification of digital technologies.

Types of business processes

3.39. Business process innovations concern the different functions of a firm. Management research has produced several lists of business functions that differ by the definition of core functions (activities that produce income) and supporting business functions, and by how different activities are grouped (Brown, 2008). Business functions have proved useful for the study of global value chains, for example in Canada's Survey of Innovation and Business Strategy (SIBS) and the European Survey on International Sourcing of Business Functions (see Chapter 7).

Table 3.1. Functional categories for identifying the type of business process innovations

	Short term	Details and subcategories
1.	Production of goods or services	Activities that transform inputs into goods or services, including engineering and related technical testing, analysis and certification activities to support production.
2.	Distribution and logistics	This function includes: a) transportation and service delivery b) warehousing c) order processing.
3.	Marketing and sales	This function includes: a) marketing methods including advertising (product promotion and placement, packaging of products), direct marketing (telemarketing), exhibitions and fairs, market research and other activities to develop new markets b) pricing strategies and methods c) sales and after-sales activities, including help desks other customer support and customer relationship activities.
4.	Information and communication systems	The maintenance and provision of information and communication systems, including: a) hardware and software b) data processing and database c) maintenance and repair d) web-hosting and other computer-related information activities. These functions can be provided in a separate division or in divisions responsible for other functions.
5.	Administration and management	This function includes: a) strategic and general business management (cross-functional decision-making), including organising work responsibilities b) corporate governance (legal, planning and public relations) c) accounting, bookkeeping, auditing, payments and other financial or insurance activities d) human resources management (training and education, staff recruitment, workplace organisation, provision of temporary personnel, payroll management, health and medical support) e) procurement f) managing external relationships with suppliers, alliances, etc.
6.	Product and business process development	Activities to scope, identify, develop, or adapt products or a firm's business processes. This function can be undertaken in a systematic fashion or on an ad hoc basis, and be conducted within the firm or obtained from external sources. Responsibility for these activities can lie within a separate division or in divisions responsible for other functions, e.g. production of goods or services.

Source: Adapted from Brown (2008), "Business processes and business functions: A new way of looking at employment", www.bls.gov/mlr/2008/12/art3full.pdf and Eurostat (2018), *Glossary of Statistical Terms*, http://ec.europa.eu/eurostat/statistics-explained/index.php/Glossary:Business_functions.

3.40. Table 3.1 provides a list of six main business functions – based on the relevant management and statistical literature – that may be the object of innovation. The function "production of goods and services" constitutes the core function of a firm, whereas the other five functions comprise ancillary activities to support production and bring products to the market. Firms can develop business process innovations that target one or more functions. For example, the implementation of an online ordering system could represent an innovation in to the distribution and logistics business functions. The short descriptions of each business function, followed by the detailed description, are recommended for use in data collection. The list is sufficiently brief for use in surveys and provides moderate comparability with the definitions of process, organisational, and marketing innovations in the third edition of the *Oslo Manual*. More detailed applications of this taxonomy can improve comparability with the results of innovation surveys that followed the third edition of this manual. The new categories also cover areas that were not identified in the third edition, such as changes in financing (item 5c) and changes in functions dedicated to product or process development (item 6).

3.41. The latter captures business process innovations in the business function dedicated to the development of products and other business processes of the firm. There was no equivalent type of business process in earlier editions of this manual. Examples of innovations in this function include the use of new gene editing technologies to develop either existing or new plant varieties or pharmaceuticals and the application of data mining analysis to large databases to identify potential market development opportunities. Other examples for an innovation in this category include the adoption of new methodologies such as design thinking, co-creation, rapid prototyping or high-throughput screening. An innovation of this type may just seek to introduce incremental modifications that do not qualify as innovations – e.g. to be able to cater to different customers' needs – or may seek to bring about product or business process innovations. However, there is no guarantee that such innovations will ultimately materialise.

3.42. For data collection, some functions can be combined into a single item or disaggregated. For example, functions 1 and 6 could be combined into a single function that includes both production activities and the development of products and business processes. Functions 3 and 5 could be further disaggregated to facilitate comparison with the definitions of organisational and marketing innovation in the third edition of the manual (see next section for details).

Comparison of innovation types with the previous edition of the Oslo Manual

3.43. Table 3.2 compares the types of product and business process innovations used in this manual with the definitions used in the third edition of the *Oslo Manual*.

3.44. Two types of marketing innovation that are included in the third edition of the *Oslo Manual* (adoption of methods for product placement and product promotion or pricing) are not listed in the short description of the six business functions in Table 3.1, but these are included in the detailed descriptions. In addition, this manual assigns innovations involving the design of products under product innovation, whereas the third edition included these under marketing innovation. The change is due to the close relationship between design activities and the development of product characteristics for both goods and services. However, changes in the design of packaging remain under marketing.

3.45. There is a good match between the fourth edition and the third edition's definitions for two types of business process innovations, namely the production of goods and services and for distribution and logistics. The third edition's subcategory of ancillary services is divided in this edition between information and communication systems on the one hand and administration and management on the other, with the latter including activities that are listed in the third edition under organisational innovation.

Table 3.2. Comparing types of innovation in the current and previous *Oslo Manual* editions

Fourth edition, 2018 (*OM4*) compared to third edition, 2005 (*OM3*)

OM3	*OM3* subcomponents	*OM4*[1]	Differences
Product	Goods Services	Goods Services Goods and services include knowledge-capturing products, and combinations thereof. Includes the design characteristics of goods and services.	Inclusion of product design characteristics, which were included under marketing innovation in OM3.
Process	Production Delivery and logistics Ancillary services, including purchasing, accounting and ICT services	Production Distribution and logistics Information and communication systems	Ancillary services in *OM3* moved to administration and management.
Organisational	Business practices Workplace organisation (distribution of responsibilities) External relations	Administration and management	Organisational innovations in *OM3* are under administration and management subcategories a, b and f in this edition of the manual. Ancillary services in administration and management (subcategories c, d, and e) were included under process innovation in *OM3*.
Marketing	Design of products Product placement and packaging Product promotion Pricing	Marketing, sales and after-sales support	Marketing innovations in *OM3* are included under subcategories a and b in this manual. Innovations in sales, after-sales services, and other customer support functions were not included in *OM3*. Innovations related to product design are included under product innovation in this manual.
N/A	N/A	Product and business process development	Not explicitly considered in *OM3* , most likely reported as Process innovation.

1. Additional granularity is possible by disaggregating the detailed descriptions in Table 3.1.

3.46. Empirical research has shown that business managers can find it difficult to differentiate between organisational and process innovations. Organisational innovations in this manual are therefore subsumed under one type of business process (administration and management) that includes activities that can involve what previously was described as organisational innovation, such as strategic management (business practices and external relations in the third edition) and human resource management (workplace organisation in the third edition).

3.47. The third edition of the manual supported the construction of a category of "product or process innovators only" that excluded firms that were only organisational or marketing innovators. This category can be approximated using this manual's category of product innovation plus three business process categories: (i) production of goods or services; (ii) distribution and logistics; and (iii) information and communication systems. The approximation is not perfect because of differences between the third and current edition in the classification of different types of product design, purchasing and accounting services.

3.48. Previous innovation surveys that followed the third edition of this manual collected data on multiple types of innovation. For example, the European Community Innovation Survey (CIS) collected data on two types of product innovations, three types of process innovations, four types of organisational innovations and four types of marketing innovations. This data can be reanalysed to approximate the innovation categories in Table 3.1, thus minimising the impact of a break in series. However, there are several exceptions where surveys based on the third edition cannot replicate the categories of this manual, due to a lack of coverage of several administrative and management functions (e.g. corporate governance), financing, after-sales services, and the business function of product and business process development.

Combinations of several innovation types by object

3.49. Many innovations are bundled, presenting characteristics that span more than one type (O'Brien et al., 2015; Frenz and Lambert, 2012; OECD, 2013). This is due to the complementarity between different types of innovations. Some possible combinations of innovation types are as follows:

- A business process innovation can significantly improve the quality of a product, resulting in a joint business process and product innovation.
- A product innovation can require a supporting business process innovation. This is particularly common for service innovations. For example, a new online function for selling information products is both a business process innovation (requiring ICT and web development) and a service innovation for potential users. If it creates a new sales channel for the first time, it can also be a marketing innovation.
- Product and business process innovation can be closely intertwined, especially when the process is not distinguishable from the product. This applies particularly to services for which production, delivery and consumption occur simultaneously.
- Changes by the firm to non-economic outputs of production processes, such as carbon or NO_x emissions from energy generation, are due to innovations in business processes, but firms can choose to include emission changes in the product description if there is market demand. In this example, low emission energy can be a business process innovation and a product innovation.

3.50. The object approach discussed in Chapter 10 can help obtain information on the incidence of different types of bundled innovations.

Business model innovations

3.51. A business model includes all core business processes such as the production, logistical, marketing and co-operative arrangements in use as well as the main products that a firm sells, currently or in the future, to achieve its strategic goals and objectives. A firm can use a single business model or several business models at the same time, for instance for different product lines or markets. The innovation management literature notes that successful business models combine a method for better meeting the needs of users relative to what competitors can deliver and a profit formula for earning income from delivering utility to customers (Johnson, Christensen and Kagermann, 2008).

3.52. There is no single, recognised definition of a business model innovation, which can vary from partial business model innovations that only affect either a firm's products or business functions, to comprehensive business model innovations that involve both products and business functions. In many cases it is difficult to distinguish partial business model innovations from product and business process innovations.

3.53. Comprehensive business model innovations are of greater interest because they can have substantial effects on supply chains and economic production, transforming markets and potentially creating new ones. They can influence how a firm creates utility for users (product innovation) and how products are produced, brought to market, or priced (business process innovations).

3.54. There are three types of comprehensive business model innovations in existing firms: (i) a firm extends its business to include completely new types of products and markets that require new business processes to deliver; (ii) a firm ceases its previous activities and enters into new types of products and markets that require new business processes; and (iii) a firm changes the business model for its existing products, for example it switches to a digital model with new business processes for production and delivery and the product changes from a tangible good to a knowledge-capturing service.

3.55. It is not recommended to directly collect data on business model innovation as a distinct, stand-alone category through innovation surveys because of the difficulty in differentiating partial business model innovations from other types. However, the occurrence of comprehensive business model innovations could be estimated through analysis (see Chapter 11) that combines information on the types of innovations introduced by a firm with other questions on innovation objectives, including a question on the objective of establishing a new business model (see Chapter 8). Identifying the third type of comprehensive business model innovation could require dedicated questions on changes to existing products.

3.3.2. Types of innovation according to novelty and impacts

3.56. The basic requirement for an innovation is that it must be significantly different from the firm's previous products or business processes. As "significantly different" is subjective and will vary according to the firm's capabilities and context, the interpretation and comparability of innovation statistics can benefit from additional data on the significance of innovations in terms of their *novelty* or economic *impacts*. Some forms of novelty, such as *disruptive* or *radical* innovations, and some types of economic impacts are difficult to identify within the limited observation period recommended for innovation surveys. Alternative measures of novelty, "innovativeness" and economic impacts that are suitable for survey observation periods include:

- whether an innovation is new to the firm only, new to the firm's market, or new to the world
- the firm's expectation of the potential to transform the market in which it operates
- the firm's expectation of the potential to improve its competitiveness.

3.57. The first and most widely used approach is to determine the novelty of a firm's innovations (or at least one of its innovations) in comparison with the state of the art in the market or industry in which the firm operates. A firm can serve a single market (if it only offers one type of product) or several markets (if it offers different types of products). A market can be geographically restricted (if a firm only serves customers in specific regions) or it can be global. A firm can sell its products directly on local, regional, national or international markets or through the use of intermediaries. Innovation can also create new markets, which could allow the innovative firm to benefit from monopoly prices for a certain period of time.

3.58. It is recommended to ask respondents if their firm has one or more product innovations or business process innovations that are a market novelty (i.e. a first to their market innovation). The interpretation of market novelty must be combined with information on the geographical area served by the firm. A local or regional market novelty could be based on imitating what is already available in other geographical markets, whereas a world-first innovation will be a market leader.

3.59. Respondents can find it difficult to estimate if they have a world-first product innovation, unless the innovation is based on one or more patented inventions that underwent rigorous screening to establish global novelty. A world-first product innovation implies a qualitatively greater degree of novelty than a new-to-market innovation.

3.60. Firms that first develop innovations are often drivers of follow-on innovation within an industry. New ideas and knowledge often originate from these firms, but the economic impact of their innovations will usually depend on the adoption (or imitation) of their innovations by other firms. Information on the degree of novelty can be used to identify the developers, adopters and imitators of innovations, to examine patterns of diffusion, and to identify market leaders and followers.

3.61. The novelty of business process innovations in comparison to what is already in use by other firms can be difficult for respondents to determine due to the importance of secrecy and confidentiality for protecting business processes. However, evidence from cognitive testing suggests that many managers are able to assess the novelty of process innovations in their market, particularly for their most important business process innovations. Furthermore, a “don’t know” response can provide valuable information on the extent to which secrecy is used in specific industries or types of firms.

3.62. The second option on the potential for an innovation to transform (or create) a market can provide a possible indicator for the incidence of a radical or a disruptive innovation. Radical innovations are considered to transform the status quo, while a disruptive innovation takes root in simple applications in a niche market and then diffuses throughout the market, eventually displacing established competitors (Christensen, 1997). Although managers may be able to estimate the potential of an innovation to transform a market, radical and disruptive innovations are likely to be very rare and therefore innovation surveys may be a poor instrument for their detection. Relevant questions should be limited to a single, most important innovation (see Chapter 10).

3.63. The third option on the effect of innovations on the firm’s competitiveness can be assessed for product innovations through the observed change in sales over the observation period (see Chapter 4) or by asking directly about future expectations of the effect of innovations on competitiveness (see Chapter 7).

3.4. Changes that are not innovations

3.64. This section discusses changes that are either not an innovation or which can only be considered an innovation if specific conditions are met. The basic principles are those introduced earlier in section 3.2, namely that an innovation must have been implemented and must be significantly different from the firm’s previous products or business processes.

3.65. **Routine changes or updates** do not by themselves represent product innovations. This includes software updates that only identify and remove coding errors and seasonal changes in clothing fashions.

3.66. **Simple capital replacement or extension** is not an innovation. This includes the purchase of identical models of installed equipment or minor extensions and updates to existing equipment or software. New equipment or extensions must be new to the firm and involve a significant improvement in specifications.

3.67. Product introductions that only involve **minor aesthetic changes**, such as a change in colour or a minor change in shape, do not meet the requirement for a "significant difference" and are therefore not product innovations.

3.68. Firms engaged in **custom production** make single and often complex goods or services for sale on the market (e.g. computer games, films) or according to customer orders (e.g. buildings, production plants, logistic systems, machinery, consulting reports). Unless the one-off item displays significantly different attributes from products that the firm has previously made, it is not a product innovation. It is not a business process innovation unless developing the one-off item required the firm to develop and use significantly different or enhanced capabilities. However, the first use of customised production can be a business process innovation.

3.69. An **advertised concept, prototype or model of a product that does not yet exist** is in general not a product innovation because it does not meet the implementation requirement, even if customers can pre-order or make advance payments for the concept, such as a product concept funded by crowdsourcing. The concept can fail or take considerably longer than expected before it is available for use.

3.70. It may be more difficult to decide whether implementation has taken place in the case of new knowledge products that have been sold to other parties. While the seller has brought a new product to the market, the buyer may hold on from using it in their business processes or taking it to their own markets. Such information may not be known to the knowledge provider that is the subject of measurement and has to decide on whether to report an innovation. If the knowledge product meets the novelty and significance requirements to be considered a product innovation, a knowledge product can be considered to pass the implementation test if it has been sold in the market by a firm to another party or parties.

3.71. The **outputs of creative and professional service firms**, such as reports for clients, books, or films are not by default an innovation for the firms that develop them. For example, a report by a consulting firm that summarises the results of a design project without major novelty elements conducted under contract for a client is not a product innovation for the consulting firm. The report's role in innovation for the buying firm depends on whether or not its results are used in the client firm's innovation activities. However, the consulting firm could be credited with an innovation if it implemented new business processes as part of conducting the project for its client, or if the blueprints or designs that are sold on the market meet the innovation requirements of novelty and significance. These phenomena are considered in more detail in Chapters 4 and 6.

3.72. Actions by retail, wholesale, transport and storage, and personal service firms to **extend the range of products handled or offered to customers** are only an innovation if the extension requires significant changes by the firm to its business processes. A fruit importer or wholesaler who adds a new variety of fruit for sale to retailers is not engaged in innovation unless the extension requires a major change to business processes such as developing a new supply chain or the purchase of novel refrigerating equipment (e.g. to permit the delivery of fresh produce that was not previously possible).

3.73. The **activities of newly created firms** (most of which are service firms) present a potential source of confusion with respect to the basic definition of an innovation because for a period of time a new firm will have no previous products or business processes for comparison. In this case, the comparison group is what is available in the relevant market. A product of a new firm is an innovation if it differs significantly from products available in its markets. Likewise, a business process of a new firm is a process innovation if it differs significantly from the business processes used by its competitors. However, respondents from new firms may view all of their products or business processes as innovations. Consequently it may be necessary to provide separate results for newly created firms such as start-ups. In addition, it would be worthwhile for specialised surveys of start-up firms to experiment with measuring product and business process novelty.

3.74. In the absence of further qualification, **mergers or the acquisition of other firms** are not business process innovations in their own right. Mergers and acquisitions can drive business process innovations, however, if the firm develops or adopts a new business process as a result of the merger or for the purpose of improving the success of the merger or acquisition.

3.75. **Ceasing to use a business process, ceasing to outsource a business process, or withdrawing a product from the market** are not innovations. However, the first implementation of business processes to determine when an activity should cease could meet the requirements for an innovation.

3.76. A change due to **externally determined factor prices** is unlikely to represent an innovation. For example, an innovation does not occur when the same model of a mobile phone is constructed and sold at a lower price simply because the price of a video processor chip falls.

3.77. The formulation of a new **corporate or managerial strategy** is not an innovation if it is not implemented. Furthermore, a change in a business process is not an innovation if it is already in use in an identical form in other divisions of the firm.

3.5. Innovation and business profiling

3.5.1. Innovative and innovation-active firms

3.78. The innovation status of a firm is defined on the basis of its engagement in innovation activities and its introduction of one or more innovations over the observation period of a data collection exercise. As discussed in Chapter 9, the recommended observation period can vary between one and three years.

3.79. During the observation period, any given innovation activity of the firm can:

- Result in an innovation. The innovation activity can consequently cease during the observation period after implementation or it could still be ongoing if it is undertaken for other innovation projects.
- Be ongoing without an innovation. Work can still be in progress and proceeding according to plan, or delayed due to various reasons, such as technical difficulties or a shortage of expertise or finance.
- Be aborted, discontinued, or put on hold, for instance when activities to develop an innovation are stopped before implementation.

3.80. These three outcomes apply to the wide array of innovation activities and projects within a firm. The combination of data on the incidence of innovation and innovation activity (innovation status) produces four possible categories for the innovative status of a firm, as shown in Table 3.3.

Table 3.3. Innovative and innovation-active firms

		The firm has innovation activities in the observation period	
		Yes	No
The firm has at least one innovation in the observation period.	Yes	The firm has one or more innovations and is therefore an innovative firm. Innovation activities can be ongoing, put on hold, completed, or abandoned.	It might occur if all work to introduce an innovation was conducted before the observation period.
	No	The firm is innovation-active, but has not introduced an innovation, although it might do so in the future.	The firm is not engaged in innovation activities and has not introduced any innovations in the observation period.

3.81. The combinations in Table 3.3 result in three core definitions that apply to firms:

*An **innovative firm** reports one or more innovations within the observation period. This applies equally to a firm that is individually or jointly responsible for an innovation.*

*A **non-innovative firm** reports no innovations within the observation period.*

*An **innovation-active firm** is engaged at some time during the observation period in one or more activities to develop or implement new or improved products or business processes for an intended use. Both innovative and non-innovative firms can be innovation-active during an observation period.*

3.82. The fourth category of an innovative firm with no innovation activities during the observation period is very rare. It would for example occur if a firm undertook all innovation activities except implementation before the observation period and the implementation required no additional resources. It may also occur if an innovation results from generic business activities that were not explicitly aimed at introducing an innovation.

3.83. It is important for measurement practices to account for the dynamic relationship between innovation viewed as a process (innovation activities) and as an outcome. The length of the observation period will also directly influence the distribution of firms across the four categories in Table 3.3. In industries with short development times and long product life cycles, a short observation period could result in a low percentage of innovative and innovation-active firms. In industries with long development times, a short observation period could result in a high share of innovation-active firms combined with a low share of innovative firms that report at least one innovation. Chapter 9 provides further discussion of the effect of the observation period length on innovation status.

3.6. Use of innovation definitions in data collection

3.84. Innovation is a subjective construct with the potential for measurement to give diverging results, depending on the respondent's perspective, beliefs and context (Galindo-Rueda and Van Cruysen, 2016). To ensure statistical quality and comparability, the definitions used in surveys and other data collection methods must therefore capture the intended meaning of the definitions in this manual, while taking into account differences in language and the vocabulary used and understood by potential respondents.

3.6.1. Use of the term "innovation" in surveys

3.85. An innovation survey can be designed to never use the term "innovation" in order to avoid conflicts between the formal definition of an innovation and each respondent's own understanding. This could result in more objective responses and reduce issues of comparability across industries or countries. An example is the Australian Business Characteristics Survey, which replaces the term "innovation" with a description of all types of innovations. For instance, the 2013 survey (based on the third edition of the *Oslo Manual*) asks respondents "where did this business source ideas and information for the development or introduction of new goods, services, processes or methods?". This also illustrates an important disadvantage of avoiding the use of "innovation": it can require listing all types of innovations in multiple questions. However, the adoption in this manual of only two major categories of innovations, products and business processes, will improve the ability of data collection exercises to avoid the term "innovation" while ensuring some economy of language.

3.6.2. Innovation profiles

3.86. The minimum definition of an innovative firm is a poor indicator for comparing innovation across industries, firm size classes or countries because it does not capture variations in the novelty of innovations or each firm's capacity to develop innovations. Information on firms' innovation status can be combined with other information on innovation novelty, innovation activities (see Chapter 4), or the division of innovation effort (see Chapter 5) to produce indicators for the novelty of innovations and the innovation capability of each firm. These indicators can be aggregated to produce innovation profiles for firms by industry, firm size category or country. When combined with outcome data (see Chapter 11), profiles can be used to explore the contribution of innovation to firm performance and the utility for users of the innovation.

3.6.3. Priorities for data collection about innovations

3.87. It is recommended to collect data on the following topics of relevance to research on innovation status and innovation profiles (see Chapter 11).

3.88. Data on each main innovation type by object (product and business process) can be collected through a single question for each type, but it is useful for interpretation to include additional questions on the two types of product innovations and the six types of business process innovations. This will result in considerably more detailed information on the innovations of each firm and permit replication of the generic innovation types (i.e. product or process innovations) defined in the third edition of this manual.

3.89. The collection of data on innovation characteristics and novelty is recommended in order to create innovation profiles that classify firms according to the characteristics of their innovations and innovation efforts. Relevant questions for the construction of profiles include:

- The different levels of innovation novelty, as per subsection 3.3.2.
- The characteristics of product innovations, including design, as per subsection 3.3.1.
- The role of third parties in developing and implementing innovations, as per subsection 3.2.2 and Chapter 5.
- The existence of ongoing or discontinued innovation activities, as per subsection 3.5.1.

3.90. The concept of novelty is applicable to both product and business process innovations, but questions on novelty are likely to be easier for managers to answer for product innovations.

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Chapter 4. Measuring business innovation activities

This chapter deals with the measurement of innovation activities, complementing the measurement of innovations as outcomes. It identifies eight major types of activities that firms may undertake in pursuit of innovation, namely research and experimental development; engineering, design and other creative work; marketing and brand equity activities; intellectual property; employee training; software development and databases; acquisition or lease of tangible assets; and innovation management activities. Acknowledging that these activities may be carried out for purposes other than innovation, this chapter provides guidelines for identifying the innovation-related content of resources dedicated to these activities. It also makes proposals for identifying follow-on activities to innovations as well as planned innovation activities and expenditures shortly after the reference year.

4.1. Introduction and main features of innovation activities

4.1. This chapter provides a framework for measuring business innovation activities, which are defined in Chapter 3 as "all developmental, financial and commercial activities, undertaken by a firm, that are intended to result in an innovation" carried out during the observation period for data collection. Therefore, this chapter deals with the measurement of innovation *efforts*, complementing the measurement of innovations as *outcomes* which were covered in the previous chapter.

4.2. Business innovation activities have the following features:

- Firms can perform innovation activities in-house or source goods or services for innovation activities from external organisations.
- Innovation activities may be postponed or abandoned during the observation period due to multiple reasons.
- Innovation activities can create knowledge or information that is not used to introduce an innovation during the observation period. This includes knowledge from activities that fail to meet their primary innovation goals.
- Firms can use the results of their innovation activities, including innovations, new knowledge, and new information for their own benefit within the observation period, they can retain the results for their own use until a later date, or they can transfer, sell or license the results to other firms or organisations.

4.3. Different innovation activities are typically linked to each other as part of a goal-oriented process that can require multiple recursive steps before resulting in an innovation. Innovation activities can be undertaken informally or follow a systematic approach comprising organised and formal processes to evaluate opportunities for introducing changes, for example through the use of analysis, creativity and problem-solving methods.

4.4. Many activities of potential relevance to innovation can be conducted for other purposes that serve to enhance business performance without necessarily being intended for innovation. Indeed, some firms may not be aware of the innovation potential of their activities. It is recommended in this chapter to collect data on a range of innovation-relevant activities, for all types of firms, including non-innovative firms. This recommendation is in recognition of the value of such data for research into the performance (e.g. productivity) effects of expenditures that are not directly related to innovation compared to those that are. In addition, data on expenditures for knowledge-based capital (KBC) (intellectual property [IP], know-how, skills, etc.) and tangible capital (equipment, buildings, machinery, etc.) are useful for analysing embodied technological change.

4.5. Qualitative data on business involvement in different activities of potential value to innovation can provide evidence on the capabilities of all types of firms – whether innovative or innovation-active (see subsection 3.5.1) –, the specific activities that firms undertake to develop innovations, and the types of activities that are conducted internally versus acquired from external sources. This information can be used to create different profiles of how firms innovate and identify the different types of knowledge and other assets that are used to develop innovations.

4.6. Innovation activities can be managed as separate "innovation projects" or undertaken as an ad hoc addition to other business functions. All activities for innovation exhibit some degree of overlap or close interrelationship and can be conducted sequentially or concurrently for one or more innovation projects.

4.7. This chapter is structured as follows. Section 4.2 of this chapter identifies eight types of activities that are relevant for innovation. Section 4.3 contains guidance on collecting qualitative data on the incidence of innovation activities in firms. Two methods for collecting expenditure data on innovation activities are described in section 4.4. Section 4.5 provides suggestions for additional data collection on innovation activities. Section 4.6 summarises the recommendations of this chapter.

4.2. Types of activities of relevance to innovation

4.8. This chapter identifies eight broad types of activities that firms can undertake in pursuit of innovation:

1. research and experimental development (R&D) activities
2. engineering, design and other creative work activities
3. marketing and brand equity activities
4. IP-related activities
5. employee training activities
6. software development and database activities
7. activities related to the acquisition or lease of tangible assets
8. innovation management activities.

4.9. While these activities may be part of business innovation efforts, they may not be carried out with that explicit goal. The measurement of these generic activities complements the characterisation of firms as innovation-active or non-active, as defined and explained in Chapter 3. This section describes these eight activities and gives guidance on how to assess whether they constitute innovation activities.

4.2.1. Research and experimental development activities

4.10. Research and experimental development (R&D) comprises creative and systematic work undertaken in order to increase the stock of knowledge and to devise new applications of available knowledge. According to the *Frascati Manual 2015* definition (OECD, 2015: § 2.5 to 2.7), R&D activities must meet five criteria: (i) novel; (ii) creative; (iii) address an uncertain outcome; (iv) systematic; and (v) transferable and/or reproducible. R&D comprises basic research, applied research, and experimental development.

4.11. **R&D as an innovation activity**: by definition, applied research is directed towards a specific practical aim or objective, while experimental development seeks to produce new products or processes or to improve existing products or process. Hence, there is an intention for innovation. Although basic research to enlarge a firm's knowledge stock may not be used to pursue specific innovations during the observation period, for practical reasons, all types of R&D carried out or paid for by business enterprises are considered by definition as innovation activities of those firms. Sections 4.3 and 4.4 below provide further clarification.

4.2.2. Engineering, design and other creative work activities

4.12. Engineering, design and other creative work cover experimental and creative activities that may be closely related to R&D, but do not meet all of the five R&D criteria. These include follow-up or auxiliary activities of R&D, or activities that are performed independently from R&D.

4.13. Engineering involves production and quality control procedures, methods and standards. Activities include the planning of technical specifications, testing, evaluation, setup and pre-production for goods, services, processes or systems; installing equipment, tooling up, testing, trials and user demonstrations; and activities to extract knowledge or design information from existing products or process equipment ("reverse engineering").

4.14. For many service firms, design and other creative work constitutes their main creative activity for innovation. While these activities often result in knowledge, they seldom meet the functional novelty and uncertainty requirements for R&D, or are conducted on an ad hoc basis.

4.15. Design includes a wide range of activities to develop a new or modified function, form or appearance for goods, services or processes, including business processes to be used by the firm itself. The goal of product design is to improve the attractiveness (aesthetics) or ease of use (functionality) of goods or services. Process design, which can be closely linked to engineering, improves the efficiency of processes. Common features of product design activities include involving potential users in the design process (through surveys of potential users, ethnographic research, co-creation, or project user groups), pilot testing on a sample of potential users, and post-implementation studies to identify or solve problems with a particular design. Product design capabilities and design thinking methods are discussed in greater detail in Chapter 5.

4.16. Other creative work includes all activities for gaining new knowledge or applying knowledge in a novel way that do not meet the specific novelty and uncertainty (also relating to non-obviousness) requirements for R&D. Other creative work includes ideation (the creative process of generating new ideas), the development of concepts for innovations, and activities related to organisational change as part of product or business process innovation activities.

4.17. **Engineering, design and other creative work as an innovation activity**: most design and other creative work are innovation activities, with the exception of minor design changes that do not meet the requirements for an innovation, such as producing an existing product in a new colour. Identifying the use of design thinking methodologies by firms can help to differentiate minor design changes from innovation activities. Many engineering activities are not innovation activities, such as day-to-day production and quality control procedures for existing processes. Engineering activities for reverse engineering, or to alter or introduce new production processes, services or delivery methods, may or may not be an innovation activity, depending on whether these activities are conducted for innovation or for other reasons.

4.2.3. Marketing and brand equity activities

4.18. Marketing and brand equity activities include market research and market testing, methods for pricing, product placement and product promotion; product advertising, the promotion of products at trade fairs or exhibitions and the development of marketing strategies. They also include advertising for trademarks that are not directly related to a specific product, such as advertising linked to the firm's name, as well as public relations activities that contribute to a firm's reputation and brand equity. Sales and distribution activities are not part of marketing and brand equity activities.

4.19. **Marketing and brand equity activities as an innovation activity**: marketing activities for existing products are only innovation activities if the marketing practice is itself an innovation. For many companies only a small fraction of marketing expenditures is likely to be linked to product innovations introduced within the observation period. Relevant innovation activities include preliminary market research, market tests, launch advertising, and the development of pricing mechanisms and product placement methods for product innovations. In some cases, the advantages of a business process innovation could also be marketed, for instance if the business process innovation has environmental benefits or improves product quality.

4.2.4. Intellectual property related activities

4.20. IP related activities include the protection or exploitation of knowledge, often created through R&D, software development, and engineering, design and other creative work. IP activities include all administrative and legal work to apply for, register, document, manage, trade, license-out, market and enforce a firm's own intellectual property rights (IPRs), all activities to acquire IPRs from other organisations such as through licensing-in or the outright purchase of IP, and activities to sell IP to third parties. IPRs include patents, utility patents, industrial designs, trademarks, copyright, integrated circuit designs, plant breeder's rights (new plant varieties), geographical indications and confidential information such as trade secrets (WIPO, 2004).

4.21. **IP- related activities as an innovation activity**: IP activities for ideas, inventions and new or improved products or business processes developed during the observation period are innovation activities. Examples include activities to apply for IP rights for an innovation or for an invention, licensing-in the right to use an invention or an innovation, or licensing-out IP for inventions and innovations. All IP activities for inventions made before the observation period and for products and business processes that existed before the observation period should be excluded.

4.22. Respondents to data collection exercises may find it difficult to differentiate IP activities for innovation from IP activities for existing products or business processes, particularly if IP is managed in a separate division with its own budget and there is a large IP portfolio under management.

4.2.5. Employee training activities

4.23. Employee training includes all activities that are paid for or subsidised by the firm to develop knowledge and skills required for the specific trade, occupation or tasks of a firm's employees. Employee training includes on-the-job training and job-related education at training and educational institutions.

4.24. **Employee training as an innovation activity**: employee training activities for the use of existing products or business processes, the upgrading of general skills, or language training are not innovation activities. Examples of training as an innovation activity include training personnel to use innovations, such as new software logistical systems or new equipment; and training relevant to the implementation of an innovation, such as instructing personnel or customers on the features of a product innovation. Employee training that is required to develop an innovation, such as training for R&D or for design, are respectively part of R&D activities or part of engineering, design and other creative work.

4.2.6. Software development and database activities

4.25. Software development and database activities include:

- The in-house development and purchase of computer software, programme descriptions and supporting materials for both systems and applications software (including standard software packages, customised software solutions and software embedded in products or equipment).

- The acquisition, in-house development and analysis of computer databases and other computerised information, including the collection and analysis of data in proprietary computer databases and data obtained from publicly available reports or the Internet.
- Activities to upgrade or expand the functions of information technology (IT) systems, including computer programmes and databases. This includes statistical data analysis and data mining activities.

4.26. Costs associated with the use of and access to computer and other information and communication technology (ICT) services, such as cloud storage and processing services, can be part of software development and database activities if incurred with that purpose. However, computer and IT services to maintain hardware systems are generally not a software development and database activity.

4.27. Software development and database activities include activities that may be unrelated to innovation, such as minor upgrades to existing software (either developed in-house or purchased) and the purchase and analysis of databases for accounting and other routine business functions.

4.28. **Software development and database activities as innovation activity**: software development is an innovation activity when used to develop new or improved business processes or products, such as computer games, logistical systems, or software to integrate business processes. Database activities are an innovation activity when used for innovation, such as analyses of data on the properties of materials or customer preferences.

4.2.7. Activities related to the acquisition or lease of tangible assets

4.29. These activities include the purchase, lease, or acquisition through a takeover of buildings, machinery, equipment, or the in-house production of such goods for own-use. Equipment includes items such as instruments, transport equipment and computer hardware for IT systems. Tangible assets owned by the firm remain in corporate balance sheets for more than one year. The acquisition of tangible assets is covered within the category of gross fixed capital formation in national accounts for the relevant asset categories. A firm's financial statements will provide information on expenditures for additions to property, plant and equipment. Balance sheets will reflect the overall value of the stock of assets. In addition to acquiring or developing on own account such assets, firms may secure their services by leasing or renting them from external parties. This includes payments for cloud services to use assets such as servers. Such costs represent an indirect measure of use.

4.30. **Acquisition or lease of tangible assets for innovation**: the acquisition or lease of tangible assets can be innovation activities in their own right, such as when a firm purchases or leases equipment with significantly different characteristics than the existing equipment that it uses for its business processes. The acquisition of tangible capital goods is generally not an innovation activity if it is for replacement or capital-widening investments that are unchanged, or if it consists of only minor changes compared to the firm's existing stock of tangible capital.

4.31. The lease or rental of tangible assets is an innovation activity if these assets are required for product or business process innovations. The measurement of innovation activity should be robust to business decisions on whether to own outright or rent an asset to be used for innovation. For example, leasing additional building space for a design lab may be an innovation activity. Likewise, the use of third-party cloud services for transforming and making operations more efficient may contribute to a business process innovation or support the delivery of new products to customers.

4.2.8. Innovation management

4.32. Innovation management includes all systematic activities to plan, govern and control internal and external resources for innovation. This includes how resources for innovation are allocated, the organisation of responsibilities and decision-making among employees, the management of collaboration with external partners, the integration of external inputs into a firm's innovation activities, and activities to monitor the results of innovation and to support learning from experience. Innovation management includes activities for establishing policies, strategies, objectives, processes, structures, roles and responsibilities to deal with innovation in the firm, as well as mechanisms to assess and review them. Information on innovation management is relevant to research on the efficiency of expenditures on innovation activities to generate sales or other innovation outcomes (see Chapter 5 for further details on innovation management).

4.33. Innovation management practices are relevant to innovation-active firms, although the degree of formality and the complexity of these practices can differ considerably between firms. Respondents from firms with only ad hoc innovations based on the acquisition or lease of tangible assets may not recognise that their firm has innovation management practices. As innovation management activities are not relevant to non-innovative firms, it is recommended to collect qualitative data on innovation management practices for innovation-active firms only. Subsections 4.3.2 and 5.3.4 discuss the type of data that can be collected on firms' innovation management activities and capabilities.

4.34. An innovation management practice that is potentially relevant to all firms is searching external sources for ideas for innovation. Firms that search external sources for ideas will not be innovation-active if they decide not to develop an idea during the observation period. It is recommended to collect data on search activities in questions on knowledge sources for innovation (see subsection 6.3.3**)** for all types of firms if possible.

4.3. Collecting qualitative data on the incidence of innovation activities

4.35. The guidance in this section concerns the collection of qualitative data on the incidence of specific activities of potential relevance to innovation within firms, identifying those that are explicitly conducted in pursuit of innovations.

4.3.1. Internal and externally sourced activities

4.36. Many innovation activities can be conducted in-house, procured from external organisations, or based on a combination of intramural and extramural activities. Furthermore, inputs to the innovation process can be obtained from other enterprises or from organisations outside the Business enterprise sector. Other enterprises include affiliated enterprises linked by ownership to the respondent firm, either located in the same country or abroad. Firms that belong to an enterprise group should be instructed to consider other enterprises of their group as external organisations. Procurement typically includes activities that are contracted-out for a fee to an external organisation that conducts a series of activities as a service to the firm that may be pursuing an innovation. There may be other arrangements for sourcing activities externally (see Chapter 6).

4.37. Firms can provide a series of knowledge-based services, such as design, training, marketing, consulting, software or IP services, to other firms or organisations on a contractual basis. However, the firms that provide these services are not considered to be innovation-active (see Chapter 3) unless they conduct innovation activities with the intention to introduce an innovation themselves. This restriction is necessary from a measurement perspective because the firm that provides these activities as a service may not know if the contractor intends to use their services for innovation or not.

4.38. An exception to this restriction is for firms that provide R&D services to other firms or organisations. By convention, all R&D is an innovation activity and consequently it is generally not necessary to determine if R&D services are for innovation. Applied research and experimental development are directed towards producing specific outcomes. Even basic research may be ultimately aimed towards innovation even though, as defined, it may not have a specific immediate commercial application or use in mind (OECD, 2015: § 7.47).

4.39. Data on the incidence of activities and expenditures for innovation activities other than R&D (design, training, software, etc.), that are conducted by external organisations, should be collected from the firm that procured such services. The firm that purchases these activities will know if the activities were intended to support its innovation efforts or not. However, data on extramurally performed R&D can be collected from firms that perform R&D as a service and from firms that procured R&D. Data from both groups can be of interest in countries where specialised R&D firms conduct a considerable amount of R&D for foreign firms. However, when aggregating R&D expenditure data at the national level, it is important to avoid double counting R&D reported by both the procurer and the service provider.

4.40. One consequence of the division of labour for innovation (see Chapters 3 and 6) is that firms providing services that generate knowledge of potential value to the innovation activities of other firms or organisations can represent an important input to an economy's total innovation performance. Consequently, it may be of interest for research on the division of labour for innovation to collect data on the prevalence of such firms.

4.3.2. Qualitative data on specific activities related to innovation

4.41. It is recommended to collect qualitative data on the performance of activities listed in section 4.2 above for all types of firms (innovative and non-innovative as defined in Chapter 3). Questions on innovation management should only be addressed to firms that report one or more activities for innovation. For all firms, qualitative data should be collected on:

1. whether each activity was conducted, regardless of its purpose
2. whether each activity (other than R&D) was conducted in pursuit of one or more innovations.

4.42. It may also be of interest to collect additional data on whether the identified innovation activities were conducted in-house or procured from external organisations, as shown in Table 4.1.

Table 4.1. Collection of qualitative data on activities relevant to innovation

Type of activity	Any activity (either in-house or procured)	Activity conducted in-house for innovation	Activity procured from external sources for innovation
R&D activities			
Engineering, design and other creative work activities			
Marketing and brand equity activities			
IP-related activities			
Employee training activities			
Software development and database activities			
Activities related to the acquisition or lease of tangible assets			
Innovation management activities			

4.43. Although each type of innovation activity is distinct, there are areas of overlap. For example, some software development, design, and employee training activities can be part of R&D (see below). It is recommended that qualitative data collection on the use of each activity should accept possible overlaps and avoid the use of detailed instructions aimed at preventing them.

4.44. Additional information can be collected for specific activities. Examples are if in-house R&D activities are conducted continuously or occasionally, if investment in tangible assets includes ICT equipment or not, or if IP-related activities include acquiring different types of IPRs (patents, industrial designs, trademarks, etc.). In addition, it may be of interest to further disaggregate data collection for specific innovation activities. For instance, it could be of interest to collect separate data for "engineering activities" and for "design and other creative work", or for "software development" and "database activities".

4.4. Collecting expenditure data on innovation activities

4.45. Data on the cost of activities of relevance to innovation are in high demand for both research and policy purposes. This section describes two methods for collecting expenditure data: collecting data for specific activities and collecting data by accounting categories.

4.4.1. Conceptual issues in measuring innovation expenditures

4.46. Expenditures on most innovation activities, other than expenditures on tangible assets, are closely related to the measurement of capital formation on what the System of National Accounts (SNA) defines as intellectual property products (IPPs) and comprise (EC et al., 2009; OECD, 2010):

- research and experimental development
- mineral exploration and evaluation
- computer software and databases
- entertainment, literary and artistic originals; and other IPPs.

4.47. **Capital expenditures** are the annual gross amount paid for the acquisition of fixed assets and the costs of internally developing fixed assets. These include gross expenditures on land and buildings, machinery, instruments, transport equipment and other equipment, as well as IPPs such as computer software and databases, R&D-based assets and other IP assets. Fixed assets must have a useful life of greater than one year (EC et al., 2009). **Current expenditures** include all costs for labour, materials that last for less than one year, and the costs for leasing fixed assets.

4.48. Other types of knowledge-based assets are still not considered to be within the SNA production boundary and are therefore excluded from official estimates of capital formation. The scope of measurement efforts to capture an enlarged category of **intangible or knowledge-based assets** (see Corrado, Hulten and Sichel 2006; Awano et al., 2010; Goodridge, Haskel and Wallis, 2014) is very close to the list of activities in Table 4.1. In addition to the SNA's IPPs, the concept of knowledge-based assets also includes efforts to invest in brand equity, design, and organisational capital (see also subsections 2.4.2 and 5.2.2).

4.49. The measurement of capital formation in IPPs or extended KBC focuses on capturing additions to the asset stock of the relevant IPP, and therefore excludes activities which are not expected to deliver benefits for more than one year. Expenditures on activities of relevance to innovation include capital and current expenditures. On the other hand, not all capital formation is aimed at innovation.

4.50. Although there are slight differences in the way in which IPP capital formation and innovation expenditures are accounted for in general and the way in which specific items are conceptualised, it is useful to compare any figures collected for consistency.

Reference period

4.51. While collecting data for a multi-year observation period is feasible for qualitative indicators on activities, it is recommended that data collection should **focus on the survey reference year** in order to reduce the response burden and thereby improve data quality. An exception is when the object method is used to collect data on the resources used for an individual innovation project (see Chapter 10), which could cover several years. In case the firm's fiscal year deviates from the reference year, data on expenditures should be requested for the fiscal year that best matches the reference year.

Challenges

4.52. The quality of data on expenditures on innovation activities can be impaired by several factors. For example, many types of expenditure by activity are not directly available from a firm's accounting systems. A firm may collect data for all training expenditures, but it might not divide these into general training and training for innovation. Furthermore, information may be dispersed across different parts of the firm in a manner that it is difficult for respondents to bring together consistently.

4.4.2. Expenditures for specific innovation activities

4.53. It is recommended to collect total expenditure data for each of seven activities for all firms, as shown in Table 4.2. Additional data on expenditures for each (innovation) activity can be collected for innovation-active firms only in order to determine the share of innovation-related expenditures within each activity. Details on the assignment of innovation expenditures to each activity are given below. Although there is an eighth type of innovation activity relating to innovation management (see subsection 4.2.8), it is only recommended to collect qualitative data on this category (see subsection 4.3.2) and not expenditure data, hence why it is excluded from Table 4.2.

Table 4.2. Collecting expenditure data on specific activities of relevance to innovation

	Type of activity	Total expenditures (all firms)	Expenditures for innovation (innovation-active firms only)
1.	R&D activities (include definition)		
2.	Engineering, design and other creative work activities		
3.	Marketing and brand equity activities		
4.	IP-related activities		
5.	Employee training activities		
6.	Software development and database activities		
7.	Activities related to the acquisition or lease of tangible assets		

4.54. The overlap between some innovation activities can cause respondents to incorrectly assign expenditures to the wrong activity or, in some cases, to double count expenditures in two or more activities. The assignment of expenditures is based on a hierarchical structure that gives preference to creative activities such as R&D over supporting activities such as IP-related activities, marketing and brand equity activities, and employee training. In addition, there is a hierarchy within creative and supporting activities. For creative activities, R&D is given preference over software development and database activities, which in turn is given preference over engineering, design and other creative work. For supporting activities, the category of IP and related activities is given preference over the category of marketing and brand equity activities, which is then given priority over employee training.

4.55. Details on what is included as an innovation expenditure for each innovation activity are as follows:

- **R&D expenditures** are described in subsection 4.2.1 above. These should include expenditures on IP licenses for generic research tools for use in R&D and expenditures on tangible goods for R&D purposes; as well as expenditures on design activities or software development activities that meet the five criteria for R&D activity as defined above. Design and software development activities can also be part of R&D if the results are incorporated in an R&D project and if the outcome is uncertain (OECD, 2015: § 2.62). Firms that perform R&D or other innovation activities as a service to other firms can be instructed to include these expenditures under the column "Total expenditures" and to only include their expenditures for their own innovations in the (second) column "Expenditures for innovation".
- Expenditures for **engineering, design and other creative work** activities include all activities identified in subsection 4.2.2, except for the costs of design and engineering activities that meet the criteria for R&D and which should be reported under R&D. Expenditures to train employees in design, engineering or creative methods should in principle be included here. Data on expenditures for the acquisition of external design services can usually be obtained from a firm's income statement.
- Expenditures for **marketing and brand equity** activities include all activities identified in subsection 4.2.3, including expenditures for training for marketing and brand marketing activities. Expenditures for trademarks should be reported under IP activities. Data on expenditures for the acquisition of external marketing and advertising services can often be obtained from a firm's income statement.
- Expenditures for **IP-related activities** include all current expenditures for the activities identified in subsection 4.2.4. These should include expenditures on training for

managing IP and on the acquisition of trademarks for marketing and brand equity activities. The cost of purchasing external IP for R&D should be reported under R&D. Data on expenditures for managing IPRs can often be obtained from the cost of the respective department in the firm (in the case of larger organisations) or by combining the labour costs of in-house personnel, application and registration costs, and costs for external services. Data on expenditures for the acquisition of external IP often can be obtained from balance sheet data (additions to the respective categories of intangible assets). It is advisable, whenever possible, to break down this category by different types of IP.

- Expenditures for **employee training** include all direct and indirect costs related to training for a firm's employees, as identified in subsection 4.2.5. Direct costs include fees for external courses, travel and subsistence payments while attending training courses, teaching materials, labour costs for in-house training of personnel, and administrative and other costs for in-house training centres. Indirect costs refer to the labour costs of employees for time spent on training, including time for on-the-job training. Two activities should be excluded from expenditures on employee training: (i) expenditures for training customers or other persons not employed by the firm; and (ii) expenditures for initial vocational training (e.g. training of apprentices). Data on the direct costs for employee training often can be obtained from a firm's human resources department.
- Expenditures for **software development and database** activities include all expenditures on the activities identified in subsection 4.2.6. Data on software development and database activities should be available from balance sheet data (additions to capitalised software and databases), although some additions for non-capitalised costs will need to be made. There are two exclusions for this activity: expenditures on computer software that is used to perform R&D should be reported under R&D, and data collection costs for market research should be reported as part of marketing expenditure.
- Expenditures for the acquisition or lease of **tangible assets** include the costs of all activities listed in subsection 4.2.7 obtained through purchase or lease, plus the costs of in-house production of such goods for own-use as a capitalised service, but excluding capitalised expenditures for R&D. This expenditure category consists of capital expenditures on the purchase of tangible assets and current expenditures for leasing tangible assets. Data on capital expenditures can be obtained from a firm's balance sheet (additions to property, plant and equipment). Data on leasing costs can be obtained from a firm's income statement.

4.56. Respondents may find it difficult to assign the resources for innovation to the correct activity, even when provided with instructions. For example, respondents in service sector firms that perform design work but do not have an R&D department could fail to recognise that some of their design activities may meet the criteria for R&D. This could result in underestimates or overestimates of the amount of resources given to specific activities, but it should not substantially affect estimates of total innovation expenditures

4.57. The sum of expenditures for specific innovation activities in Table 4.2 may not equal a firm's total innovation expenditure since firms may conduct innovation activities other than those listed, e.g. activities related to business process innovation in administration and management. The following section provides an alternative means for collecting data on total innovation expenditure.

4.4.3. Expenditures by accounting categories for innovation-active firms

4.58. The accounting method collects data on innovation expenditures for five standard accounting categories that are widely used by firms: R&D, personnel costs, purchases of external services, purchases of materials, and expenditures on capital goods.

4.59. Firms that perform R&D usually maintain records about their R&D expenditures for a range of possible statistical and administrative reporting requirements. At the same time, some R&D-performing firms might only report R&D expenditure when asked for their total innovation expenditure, for instance if they do not use the concept of innovation in their internal accounting and reporting system and therefore believe that R&D is the accounting category that comes closest to the concept of innovation. In order to collect data on total innovation expenditure that is as accurate and complete as possible, it is recommended to clearly separate between R&D and non-R&D expenditure and to include guidance to help firms identify the latter. Table 4.3 shows the categories to be used for collecting total innovation expenditure. The data should be collected for the reference year.

Table 4.3. Accounting method for collecting expenditure data on activities for innovation

	Expenditure on	Total expenditures for innovation (innovation-active firms only)
1.	R&D (include definition)	
1.a	Intramural R&D (include personnel cost, materials and other supplies and purchase of capital goods for R&D activities)	
1.b	Extramural R&D (purchase of R&D services from other parties)	
2.	Innovation activities other than R&D	
2.a	Own personnel (excluding cost of R&D personnel)	
2.b	Services purchased from other parties (excluding purchase of R&D services)	
2.c	Materials and other supplies (excluding materials/supplies for R&D)	
2.d	Capital goods (purchased tangible and intangible assets) (excluding purchase of capital goods directly related to R&D activities)	

4.60. Firms should be instructed to provide their best estimates for non-R&D expenditure, for example by estimating the share on non-R&D personnel conducting innovation activities and using this share to determine "own personnel costs for innovation activities other than R&D". Similar guidance can be given for the other three categories of non-R&D expenditure. Extramural innovation expenditures are captured by the items "purchase of R&D services" and "services purchased from other parties (excluding purchase of R&D services)".

4.61. Additional details on each accounting category for innovation expenditures are as follows:

- **R&D expenditure data** can be collected following the recommendations in Chapter 4 of the *Frascati Manual 2015* (OECD, 2015). **Intramural R&D expenditures** are all current expenditures plus gross fixed capital expenditures for R&D. Intramural R&D costs on capital items should also be included, whereas any depreciation costs on capitalised R&D or physical assets used in R&D should be excluded. **Extramural R&D expenditures** cover the purchase of R&D services from other parties.

- **Expenses for own personnel** include all wage and salary expenses for employees engaged in innovation activities other than R&D. The personnel costs of employees that spent only a part of their time on non-R&D innovation activities should be covered proportionally. An alternative method, based on person-months, can be offered to respondents that cannot estimate personnel costs.

- **Expenditures for services** purchased from other parties include all expenses for services that are used in innovation activities and not already part of R&D (extramural R&D).
- **Expenditures for materials and other supplies** include all expenses for material inputs that are used in innovation activities and have not been included in R&D.
- **Capital expenditures** include the costs of the acquisition of tangible and intangible capital goods, such as machinery, equipment, buildings, land, capitalised software and other externally purchased capital goods. The acquisition of capital goods that are included in intramural R&D expenditure should be excluded. Capitalised own-produced assets (e.g. in-house produced capitalised software, capitalised development costs) that are not for R&D should be included.

4.62. Respondents should be instructed to include both capital and current expenditures for innovation activities under the relevant headings. No depreciation provisions for tangible or intangible assets should be included in the current expenditure data to avoid double counting with related capital expenditures.

4.63. When using the accounting method for collecting innovation expenditure, special instructions need to be given for firms with R&D expenditure to report only non-R&D expenditure in the categories 2.a to 2.d listed in Table 4.3 and not to include any R&D expenditure on personnel, materials, capital goods or purchased R&D services in these categories.

4.4.4. Sources of funds for innovation activities

4.64. Expenditures on innovation activities can be disaggregated by the source of funds. Collecting data on the funding source is useful for assessing the role of government investments and financial markets in the innovation process. There are many potential sources of funding for innovation including:

- own funds (retained profits or income from asset disposal)
- transfers from affiliated firms (holding, subsidiary or associated companies located in the domestic country or abroad)
- customer orders (including procurement contracts from domestic or foreign governments or international organisations)
- shareholder loans
- debt funding from commercial loans (banks, credit cards etc.), overdraft facilities or suppliers' credit
- loans from governments
- loans from international organisations
- equity from private equity or venture capital firms, business angels or other individuals (family and friends)
- grants or subsidies from domestic or foreign governments, international organisations, non-governmental organisations, etc.
- bonds and obligations
- other sources (e.g. crowdfunding).

4.65. Data collection can aggregate the above categories, for instance by creating one category for all internal sources of finance and a second category for all external sources of finance. Alternatively, data collection can focus on specific sources, such as funds provided by governments, or divide external sources into domestic and international sources of funds.

4.66. It may be sufficient for a variety of policy and research issues to collect information on whether or not each source is used, instead of seeking an estimate of the amount (either in monetary or percentage terms) contributed by each source.

4.5. Other data on innovation activities

4.5.1. Collecting data on human resources for innovation activities

4.67. For specific innovation activities, managers can find it difficult to estimate expenditures that are not performed by a separate reporting unit within the firm and which mainly involve internal labour costs. This can result in poor quality expenditure estimates for innovation activities that mostly consist of labour costs, such as training; engineering, design and other creative work; and marketing and brand equity activities.

4.68. For these activities, requesting estimates of the number of person-months (on a full-time equivalent [FTE] basis) allotted to each activity could improve data quality. Person-month data on innovation activities should only be collected for activities that mostly involve labour costs, or in industries where firms are unlikely to be able to provide accurate expenditure data, such as small firms in service industries. If other data are available on average hourly wages or monthly salary costs, expenditures could be estimated by combining person-month estimates with wage and salary data.

4.5.2. Data on innovation projects

4.69. Many innovation-active firms organise their innovation activities as innovation projects, defined as a set of activities that are organised and managed for a specific purpose and with their own objectives, resources and expected outcomes (see Chapter 3). Respondents can be asked if their firm organises some or all of its work to develop innovations into recognised projects, or they can be asked about a specific innovation project (see Chapter 10).

4.70. Information on innovation projects can complement other qualitative and quantitative data on innovation activities. Data on the number of projects for innovation can provide indicators on the variety and diversity of innovation activities. Disaggregated data on the number of projects for product and for business process innovations can be used to determine the relationships between innovation goals, firm capabilities, and business strategies (see Chapter 5).

4.71. Collecting data on a single innovation project can provide detailed information on innovation investments, using the "object approach" discussed in Chapter 10. Cognitive testing indicates that respondents find it easier to provide expenditure or FTE data for innovation activities relating to a single innovation project than for all innovation activities combined (the "subject approach").

4.72. For firms that organise their innovation activities on a project basis, it can be useful to obtain the following information, either for all innovation projects combined or disaggregated into projects for product and business process innovations:

- the number of innovation projects undertaken during the observation period
- the number of innovation projects completed during the observation period

- the number of innovation projects ceased before completion during the observation period
- the number of ongoing innovation projects at the end of the observation period.

4.73. The number of completed, ceased, and ongoing innovation projects should equal the total number of innovation projects during the observation period. The exact definition of what constitutes an innovation project should be left to the firm's actual practice, allowing the respondents to collect the required information from the firms' project management tools or similar sources.

4.74. Information on the number of innovation projects is not primarily intended to produce an aggregate figure of the total number of projects for a firm or industry, but rather to derive indicators at the firm level, such as the share of completed projects, the share of projects stopped before completion, or the share of projects to develop product vs. business process innovations.

4.5.3. Follow-on activities

4.75. Innovation activities occur before and up to the date of introduction of a product innovation or implementation of a business process innovation. Firms can also conduct marketing activities, employee training, demonstrations and other services for users of an innovation after its implementation, but within the observation period. These follow-on activities can be critical for the success of an innovation, but they are not included in the definition of an innovation activity.

4.76. Data collection can obtain qualitative data on three particular follow-on activities:

- **Follow-on marketing** comprises all efforts to promote the sale of a product innovation in the market, including advertising, sales promotion at trade fairs, altering distribution channels, etc.
- **Follow-on training** includes all in-house training of employees related to the use of product or business process innovations during the observation period. It also includes activities to familiarise potential and current users with a firm's product or process innovations, e.g. through demonstration activities or the training of users.
- **After-sales services** include all services provided by an innovative firm to improve the utility of an innovation for its users. These can include installation, updating and repair services, guarantee and return schemes (which can reduce uncertainty for users), and information services (including websites or other forums to facilitate communication among users).

4.77. Collecting information on follow-on activities can be particularly useful if the information is collected for specific innovations, as in the object-based approach discussed in Chapter 10.

4.5.4. Planned innovation activities and expenditures

4.78. Data on a firm's future plans for innovation activities can provide information about the possible development of innovation in an economy or industry in the near future. Data on planned innovation activities can also be useful for producing more timely indicators that help assess the likely impact of recent changes in the innovation environment of firms, for instance changes in innovation support programmes or innovation-related regulation.

4.79. Given the uncertain nature of innovation, collecting data on planned innovation activities should refer to the immediate present and the very near future. Information on planned activities can be collected for the year in which data are being collected (nowcasting), which is usually the year after the reference year, and for no more than two years after the reference year.

4.80. If data on planned activities are collected, it is of interest to ask respondents if their firm plans to conduct any innovation activities in the one or two years after the reference year on a "yes" or "no" basis and if the total innovation expenditures compared to the reference year (if any) are expected to increase, stay the same, or decrease. Questions on planned expenditures should immediately follow questions on innovation expenditures in the reference year to ensure that the same definitions of innovation expenditures are used.

4.81. Additional questions could query the types of innovations that are planned for the near future (using the innovation typology in section 3.3) or the types of planned innovation activities outlined in this chapter.

4.82. Since many firms will not have decided on whether or not to invest in innovation activities in the near future or how much they will spend, a separate "Don't know" response category must be provided. This information can be useful in its own right because it provides information on the level of uncertainty about future innovation activities and expenditures.

4.6. Summary of recommendations

4.83. This chapter identifies innovation activities of value to policy and for research. Recommendations of questions for general data collection are given below. Other types of data covered in this chapter are suitable for specialised data collection exercises.

4.84. Key questions for general data collection include:

- qualitative data on whether or not each of the eight activities were conducted, identifying in each affirmative case whether the activity was conducted for innovation (subsection 4.3.2)
- whether or not each activity was conducted in-house or procured from external organisations (subsection 4.3.1)
- total expenditures for each of seven activities (subsection 4.4.2)
- total innovation expenditures using the accounting method (subsection 4.4.3)
- funding sources for innovation (subsection 4.4.4).

4.85. Supplementary questions for general data collection (given space or resources) are:

- additional information for specific activities, such as whether R&D activities are conducted continuously or on an occasional basis (subsection 4.3.2)
- innovation expenditures by funding source (subsection 4.4.4)
- follow-on activities (subsection 4.5.3)
- planned innovation activities and expenditures (subsection 4.5.4).

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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 to 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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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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Chapter 7. Measuring external factors influencing innovation in firms

Understanding the context in which firms operate is essential for collecting and interpreting data on business innovation. The systems view of innovation stresses the importance of external factors that can influence a firm's incentives to innovate, the types of innovation activities that it undertakes, and its innovation capabilities and outcomes. External factors can also be the object of a business strategy, public policy or concerted social action by public interest groups. This chapter discusses the characteristics of the firm's external environment that can influence innovation and the associated challenges and opportunities that managers need to consider when making strategic choices, including for innovation. These factors include the activities of customers, competitors and suppliers; labour market, legal, regulatory, competitive and economic conditions; and the supply of technological and other types of knowledge of value to innovation.

7.1. Introduction

7.1. The systems view of innovation stresses the importance of the external environment by conceptualising the innovation activities of firms as embedded in political, social, organisational and economic systems (Lundvall [ed.], 1992; Nelson [ed.], 1993; Edquist, 2005; Granstrand, Patel and Pavitt, 1997). These external factors can influence a firm's incentives to innovate and its innovation activities, capabilities and outcomes. External factors can also be the object of a business strategy, public policy or concerted social action by public interest groups.

7.2. Building on the innovation literature and previous measurement experiences, this chapter identifies the main elements of interest in the external environment and priorities for data collection. These include external environmental or contextual factors that are often closely intertwined with the firm's internal drivers, strategies and behaviours. A firm's environmental context is partly the outcome of management choices, such as a decision to enter a given market. Consequently, research on outcomes, such as business performance, requires data on a firm's internal capabilities and strategies (see Chapter 5) as well as on external factors.

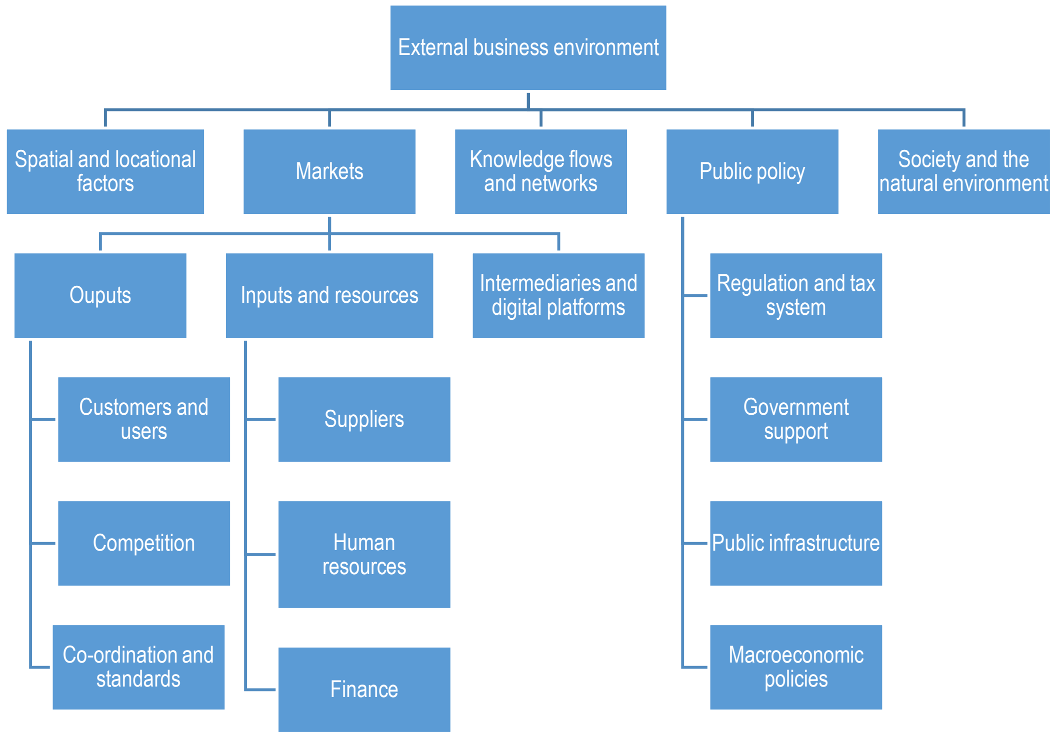
7.3. External influences on the innovation activities of firms can be measured directly or indirectly. Indirect measurement obtains information on the influence of external factors on the firm without referring specifically to innovation. In this case, the effects of external factors on innovation are identified after data collection, for example through econometric analysis. The advantage of indirect measurement is that data can be collected for all types of firms, regardless of their innovation status. In contrast, direct measurement methods ask respondents to self-assess the relevance and impact of an external factor on a specific dimension of innovation. These questions require limited additional analysis. However, direct questions can introduce cognitive biases, or insufficient time could have passed to allow the respondent to evaluate the effects of an external factor on the firm's innovation activities or outcomes.

7.4. As highlighted in Chapter 2, contextual information on the framework conditions for business innovation can be collected from multiple sources. In some instances, reliable quantitative and qualitative information can be obtained from experts or from administrative sources such as budgetary and legislative records. The number of external factors of potential relevance to innovation is large enough to warrant dedicated data collection on the business environment. This chapter contains proposals for obtaining data (either by linking existing information or collecting new information) on the external environment of firms that can help explain the incidence of innovation and its outcomes.

7.2. Main elements of the external environment for business innovation

7.5. A firm's external environment includes factors that are beyond the immediate control of management. These factors create challenges and opportunities that managers need to consider when making strategic choices. Such factors include the activities of customers, competitors and suppliers; the labour market; legal, regulatory, competitive and economic conditions; and the supply of technological and other types of knowledge of value to innovation. The internal environment of a firm is ostensibly under the control of management and refers to the firm's business model, production and innovation capabilities, as well as financial and human resources (see Chapter 5).

Figure 7.1. Main elements of the external environment for business innovation



7.6. Figure 7.1 provides an overview of the external factors that can influence business innovation. There are five main elements: spatial and locational factors, markets, knowledge flows and networks, public policy, and society and the natural environment. Four of these elements are discussed below, while knowledge flows and networks are covered in Chapter 6.

7.7. **Spatial and locational factors** define the firm's jurisdictional location and its proximity to product and labour markets (see section 7.4). These factors can influence costs and awareness of consumer demand (Krugman, 1991). When detailed data on policy, taxation, public infrastructure, society and other factors that vary by location are unavailable, a firm's location at the regional or national level can act as a proxy for these factors.

7.8. **Markets** are leading contextual factors (see Chapter 2) that are also shaped by the firm's own decisions. Relevant information for data collection (see section 7.4) includes the characteristics of suppliers that provide inputs of goods and services to the firm, the structure of demand in the firm's current and potential markets, the markets for finance and labour, as well as data on the extent of competition in product markets and standards. Information on intermediaries and platforms is of growing importance because of the reorganisation of several markets around online platforms (see subsection 7.4.4).

7.9. **Public policy** can influence business activities in direct and indirect ways. The regulatory and enforcement framework influences how firms can appropriate the outcomes of their innovation efforts (see Chapter 5) and the multiple relationships and transactions that firms engage in, while the tax system affects the cost of business activities. Governments can also use the tax system and other policies to target support to firms, including support for innovation. Other aspects of the public sector that can influence firms include the delivery of infrastructure services and the management of macroeconomic policy, which can affect the ability of firms to launch and successfully exploit innovations. The collection of data on public policy is examined in section 7.5.

7.10. **Society and the natural environment** can directly and indirectly affect business activities. Societal aspects can influence the public acceptance of innovations as well as firm policies on corporate social responsibility. Larger societal changes can drive system-wide innovations, such as a move to a low-carbon economy. The impact of business activities and products on the natural environment can also drive business innovation, for instance when firms seek to reduce these impacts through "green" innovations. Firms can also engage in innovation activities in response to predicted changes in the natural environment, as in the case of adaptation to climate change. The collection of data on this dimension is examined in section 7.6.

7.11. These various elements exhibit a great deal of overlap and interaction with each other. For example, public policy can influence the evolution of a firm's business environment through markets by regulating monopolies or by using market mechanisms to mitigate the negative environmental effects of business activities. Markets, governmental and social institutions and norms can underpin the availability of useful knowledge that firms draw upon for innovation and shape the knowledge flows and networks discussed in Chapter 6.

7.3. Location of business activities

7.12. A firm's position in the market is also influenced by decisions on where specific business activities are conducted. A firm can conduct an activity itself (within the firm) or a firm can purchase business activities as a service from a supplier (outside the firm). The decision to perform an activity within or outside the firm will influence the types of innovations undertaken by the firm. In addition, data on whether a specific business activity is conducted domestically or in the "Rest of the world" can be used to position the firm within global value chains. This information can be collected by asking respondents to indicate which business activities (aligned to the types of business process innovations in Chapter 3) are conducted within or outside the firm's enterprise group and the location of activities (domestic or in the rest of the world) (see Table 7.1). Collecting this information is particularly important for documenting the outsourcing and offshoring activities of affiliates of multinational enterprises (MNEs) and the domestic parents of their affiliates abroad (see Chapter 5).

Table 7.1. Business activities by location

		Within the firm or the firm's group		Outside the firm and firm's group	
	Business activities	Domestic	Rest of the world	Domestic	Rest of the world
a)	Production of goods and services				
b)	Distribution and logistics				
c)	Marketing and sales				
d)	Information and communication				
e)	Administration and management				
f)	Product and business process development				

Source: Based on the business process taxonomy used in Chapter 3 and surveys on the location and outsourcing of business functions.

7.13. A firm's location also affects many other external and internal factors that influence innovation. Where relevant, these locational aspects are discussed below.

7.4. Markets and the environment for business innovation

7.14. Markets provide the medium in which firms exchange goods and services to fulfil their objectives. This section identifies market-mediated influences on innovation and describes options for measurement.

7.4.1. Markets for the firm's products

Industry and products

7.15. Competition and technological opportunities vary by product market and can directly influence decisions on innovation activities and investments. The firm's product market can be identified using the United Nations' Central Product Classification (CPC) system, which is the main global reference for all goods and services and provides a framework for the international comparison of statistics on goods and services. The CPC classifies products by their physical properties, other intrinsic characteristics, and industrial origin into one CPC class. Alternatively, firms can be classified by their main economic activity or industry, based on the types of products produced and the methods of production in use (see Chapter 9).

Main product market

7.16. Data on the classification of a firm's products or industry are rarely sufficient for identifying the effects of market conditions on the activities of firms, hence the need for supplementary data, for example on a firm's main market.

7.17. A firm's main market (by product or industry) can influence its market power, the level of competition that it faces, and potential barriers to entry. Relevant questions on the main market include the amount of sales, the number of competitors, and the presence or absence of MNEs in a firm's main market. Further discussion of competition is provided below.

Geographical markets

7.18. Data on the geographical coverage of a firm's markets are useful for interpreting information on whether the firm has "new-to-market" innovations (see Chapter 3) and the location of competitors and the variety of user demand (see Chapter 5). In addition, users of innovation data may be interested in data on firms that were "born global" by serving foreign or digital markets from their inception.

Types of customers

7.19. Firms can sell products to three main types of customers: governments (business-to-government [B2G]), other businesses (business-to-business [B2B]), and individual consumers (business-to-consumer [B2C]). A firm can sell products to more than one type of customer at a given time.

7.20. Identifying B2G-active firms is relevant for research on the role of government in innovation. It is of interest to collect data on whether firms entered into new agreements to sell products to governments and to identify agreements by the level of government (national, regional or local). For B2B-active firms, data collection should differentiate between sales to independent firms and sales to firms that are affiliated through ownership.

Main customer

7.21. Due to survey response burden, it is not possible to collect data on the characteristics of all of a firm's customers. One option is to focus on the firm's main customer, which could be a business, a government or private non-profit organisation, or an individual consumer. Data on the identities of main customers that are businesses or government organisations are of value to research on competition and networks. However, respondents might be reluctant to provide this information due to concerns over confidentiality. Some of this information could be available from other sources such as annual reports. Of note, the collection and processing of data on named sources requires careful governance, resources and data handling capabilities on the part of agencies or organisations running innovation surveys. If the name and other details for a firm's main customer cannot be obtained, an alternative is to ask if a firm has a dominant customer (e.g. accounting for 10% or more of total sales), the sales share of its three largest customers, and the industry of the firm's dominant or three largest customers.

Influence of customers on innovation

7.22. Customer and user demand for products from businesses, governments and individuals are major drivers of all types of innovation, not only product. Firms can use several methods or channels to identify customer demand for new or improved products (or business processes), including:

- Surveys or focus groups of customers, including surveys or discussions with those who attended product demonstrations.
- Development or co-creation with customers of concepts and ideas for new or improved products or business processes (see subsection 5.5.2).
- User innovation, whereby consumers or end-users modify a firm's products, with or without the firm's consent (von Hippel, 2005, 1988), or when users develop entirely new products. These modifications or new products can then be adopted and sold by firms.
- Computer or sensor data generated through the use of products.

7.23. Firms can use these channels to collect the following types of information from their customers or users:

- detailed specification requirements, for instance when a business customer provides technical and other specifications for new business processes, software, services, etc.
- information about the price that customers are willing to pay for new or improved product characteristics
- evaluations of the quality or reliability of the firm's business processes, such as service delivery
- other data that may be used to improve the firm's products or business processes, such as behavioural and performance data on the interaction between users and products.

7.24. These questions are relevant for all firms, regardless of their innovation status (see Chapter 3). Interpretation can be improved by collecting data on the firm's main type of customer (business/government/consumers), or by collecting data on customer engagement for each of the three main customer types. The methods used to obtain valuable information from customers, and the intensity with which these methods are used, are likely to vary by type of customer.

7.25. An evaluation of the role of customers in innovation can also benefit from information on how (or if) the firm used data from customers in its innovation activities. Data collection can ask respondents about the use of specific actions to meet customer requirements, such as cost reductions, improvements in product quality, reduced lead times, enhanced after-sales functions, greater risk-sharing (i.e. consignment-based payments), extended business hours, etc.

7.26. Evidence on the influence of government demand on innovation activities can be obtained through questions that distinguish between participation in government procurement agreements that:

- formally required an innovation to meet the procurement specifications
- did not formally require innovation, but where innovation was needed to meet the specifications
- neither required nor needed innovation to fulfil the contract specifications.

7.27. Although most research on procurement and innovation focuses on contractual agreements with governments, the same structure can be used to collect data about procurement requirements from businesses or other entities to which the firm provides goods or services (Appelt and Galindo-Rueda, 2016).

7.4.2. Competition and collaboration in markets

Competition

7.28. Competition is a defining characteristic of markets and can have a substantial influence on innovation. Information on market competition can be obtained indirectly from data on the geographical location of the firm's markets, from the types of customers served by a firm (see above), or directly from questions on the extent or type of competition faced by firms.

7.29. Key indicators of competition in product markets include the number of competitors, the relative size of competitors (larger or smaller than the respondent firm), or qualitative measures of the intensity of competition in the firm's market. Surveys can include questions on the characteristics or identity of a firm's main competitor, for example whether it is an MNE.

7.30. Innovation surveys can capture information on the entry of new competitors into the firm's market and expectations about future sources of competitive pressures, including new entrants with disruptive business models or firms with competing innovations. Competitive pressure from the unregulated or informal sector can be an important driver of innovation activities in some industries, countries and regions. Firms can also be asked to rate the current or expected competitive pressure from different types of firms or organisations.

7.31. Innovation surveys can query whether any of a firm's products or business processes has been rendered fully or partially obsolete as a result of a competitor's innovations. Information on obsolescence would provide evidence on the process of creative destruction, a major tenet of the innovation and growth literature.

7.32. The response of firms to competitive pressures and the role of innovation in this response are of interest to innovation research. Possible responses include the innovation objectives discussed in Chapter 8, and other actions such as changes to prices, adjustments to personnel, disinvestment, mergers and acquisitions, etc.

7.33. Situations of monopsony (a market situation in which there is a single buyer) can affect a firm's operations, profitability and ability to enter new markets or redesign its business processes. From a firm's perspective, this can apply to both the demand for its products (number of potential buyers) and its suppliers (if the firm is the sole buyer for a certain type of input).

7.34. Data collection can capture features of the market for business inputs by querying the extent of competition in the firm's main markets for inputs, the existence of alternative sources of essential goods or services, the adoption of strategies to reduce supplier dependence, and the establishment of strategic partnerships or risk-sharing agreements with suppliers.

7.35. Intense competition, along with a high rate of technological change and high demand for innovation in a firm's market, can result in short product life cycles. Under these conditions, firms must update their products frequently, resulting in a high rate of product innovation and consequently a high share of total sales from product innovations (see subsection 8.3.1).

7.36. Data collection can identify the importance of competition and product market conditions in driving innovation. A list of relevant factors is provided in Table 7.2. Respondents can be asked about the importance of each factor or the respondent's level of agreement with each item.

Table 7.2. Competition and product market characteristics that can influence innovation

Proposed items for inclusion in questions on competition

Basic measures
Number of competitors[1]
Characteristics of main competitor – e.g. whether an MNE, a digital platform[2]
Qualitative measures of potential competition intensity
Your firm's goods/services need to be quickly upgraded to remain relevant.
Technological developments in your firm's main markets are difficult to predict.
Your firm's goods/services are easily substituted by your competitors' offerings.
The entry of new competitors is a major threat to your firm's market position.
The actions of your competitors are difficult to predict.
Your firm faces strong competition in its markets.
Price increases in your markets tend to lead to an immediate loss of clients.
Customers in your markets find it difficult to assess the quality of products before purchasing them.

1. In the case of firms operating in more than one product market, it may be necessary to focus on the most important market.
2. Competitors with digital business models are also relevant (see subsection 7.4.4).
Source: Based on questions on competition used in various innovation surveys.

Co-ordination and standards in markets

7.37. In market environments, co-ordination through collaboration or standards plays an important role as an enabler and instrument of business strategy and activity.

7.38. Section 6.3 describes how to collect data on collaboration practices for innovation. This information can be complemented by data on collaborative arrangements that do not necessarily involve innovation, such as alliances, joint ventures, public-private partnerships, supplier-customer networks, consortia and other collaborative initiatives with other businesses and trade associations.

7.39. **Standards** play an important co-ordination role in many markets and can influence the characteristics of product and business process innovations. Standards are often defined by consensus and approved by a recognised body that provides, for common and repeated use, rules or guidelines for the characteristics of products, processes and organisations (Blind, 2004). A firm that has accreditation for specific standards can offer potential customers a guarantee that its products and processes are fully compliant (Frenz and Lambert, 2014).

7.40. Surveys can evaluate the role of standards in a firm's markets and for its innovation activities through questions on the importance to the firm of the following actions involving:

- accreditation for important industry or market standards (a priority list of standards can be provided to firms active in specific industries)
- ability to demonstrate that product or business process innovations meet relevant industry or market standards
- active engagement in the formulation of relevant industry standards
- ownership of – or access to – intellectual property (IP) rights that are essential for the use of industry standards, i.e. when an unlicensed party cannot comply with a standard without infringing IP rights.

7.41. Standards can be important sources of knowledge and therefore can be included in the list of information sources for innovation (see Table 6.6) or innovation objectives. Compliance with standards can also be an innovation objective (see Table 8.1).

7.42. Widespread policy and research interest in the transformation of innovation systems (see subsection 2.2.1) could also warrant the inclusion of questions on the importance of complementary innovations introduced by other actors in the system. For instance, the widespread adoption of an innovation can depend on complementary innovations occurring in other industries or in supporting infrastructure.

7.4.3. The market for inputs

7.43. In addition to customers as a source of ideas for innovation, firms can obtain other inputs for their innovation activities from their suppliers, the labour market, and financial markets.

Suppliers

7.44. Firms can obtain inputs from firms or organisations that supply goods (equipment, materials, software, components etc.), services (consulting, business services, etc.) or IP rights.

7.45. Data collection is unlikely to be able to identify all of a firm's suppliers of goods, services or IP rights. One option is to collect data for specific types of suppliers, such as suppliers of equipment or business services, or for the most important supplier of goods or services. Relevant information on a firm's most important supplier includes its main economic activity, location, multinational status, and if it is linked by ownership to the respondent's firm. The identity of the supplier can also be requested to support data linking and network analysis, but this approach faces the same challenges of confidentiality and response burden as for questions on the firm's main customer. An alternative is to collect data on the share of materials, equipment, etc. obtained from the firm's three most important suppliers. Further details can be requested on the nature of supplier-based relationships, for instance if they involve collaboration, co-investment and risk-sharing, or franchising agreements. This may also include a question on criteria used to select suppliers (technical capabilities, prestige, prices, accreditation, geographic proximity, etc.).

7.46. Surveys consistently identify suppliers as important sources of information and collaboration partners for innovation (see Chapter 6). Further insight on the role played by suppliers in innovation can be acquired through questions on the engagement of suppliers in each of the activities listed in Table 7.1, with some adaptation for the context of different supplier relationships. The influence of suppliers on innovation can also be assessed through questions on whether procurement contracts with suppliers required innovation to meet contract specifications.

Human resources and the labour market

7.47. Guidance on the measurement of human resources used by the firm and contributing to its internal capabilities is provided in Chapter 5. Such internal capability is closely related to the labour market in which the firm operates. Firms search for individuals and hire their services on the labour market. Some of these individuals are responsible for building and maintaining the internal competencies of the firm, including the competencies required for innovation. The market for skilled and highly qualified labour warrants attention because of the close links between human capital and innovation capabilities (Cohen and Levinthal, 1990; Jones and Grimshaw, 2012). The efficiency and characteristics of the labour market can have a wide range of implications for the firm's strategy and performance. Labour market transactions between firms and individuals are also subject to regulatory oversight (see section 7.5 below) and social norms that can be difficult to disentangle from other market characteristics.

7.48. Two labour market characteristics that are relevant to skilled workers, or workers involved in innovation, are the geographical scope of the labour market and the employment history of new hires. The geographical scope concerns where a firm sources its employees from: locally, regionally, nationally, or internationally. Data collection on this topic can identify the need to attract workers from increasingly distant locations and is relevant to research on domestic and international migration. The employment history concerns the primary source of a firm's new hires, which is relevant to research on knowledge flows. Individuals can be hired directly as they leave the education system, for instance new graduates with a master's or doctoral degree, from a period of inactivity or unemployment, or from previous employment. The latter can be disaggregated into hiring primarily from competitors, from other firms (such as suppliers), or from government.

7.49. Data on labour market conditions can be collected for the entire workforce and for highly skilled or qualified personnel involved in innovation. It is important to specify if a question refers to all employees, or only to employees involved in innovation activities.

Markets for finance

7.50. Financial markets play a central role in allocating resources to innovation and other activities (Kerr, Nanda and Rhodes-Kropf, 2014). They shape the innovation investment efforts of firms and their actual sources of funds (see Chapter 4).

7.51. A basic distinction when considering markets for finance is between equity (provided in exchange for a share in ownership of the firm) and debt (generating an obligation to repay the amount borrowed). Table 7.3 provides a summary list with different types of internal and external sources of finance. Respondents may find it difficult to map sources of finance to specific activities that may or may not involve innovation, such as business investment, mergers and acquisitions, payment of liabilities, or shareholder buyouts. An alternative is to collect information on the overall financing of the firm. Questions can be framed in terms of past behaviour during the observation period or in terms of future plans.

In addition, respondents may be asked about the availability and affordability of different sources of finance. Evidence on the use of intangible assets as collateral can be of high relevance to research on the financing of innovation.

Table 7.3. Types of finance for general and specific innovation activities

Source	Type of finance	Examples
Internal		Through retained profits or asset disposal Transfers and loans from affiliated firms or owners
External	Equity	Ordinary/common stock Venture capital or private equity Business angel
	Debt	Bonds and obligations, convertible debt Bank loans, overdraft facilities Trade credit, factoring, leasing, advance orders Credit cards Loans from family and friends Loans from government or government-backed credit institutions
	Mixed	Subordinated loans/bonds, mezzanine finance, convertible bonds, preferred stock
	Financial transfers	Grants and subsidies Private donations and philanthropy

7.4.4. Intermediaries and digital platforms

7.52. Markets can include intermediaries that encourage and support transactions between different types of customers, creating supplier-customer relationships. Network effects can create interchangeable roles for suppliers and customers that alter market dynamics and relations. An example is when networks allow media firms, content providers, and advertisers to act as both suppliers and users of content. Intermediaries such as knowledge brokers or knowledge transfer offices at universities and research institutes connect potential users of knowledge with knowledge producers. Data can be collected on the use of knowledge brokers and IP rights to mediate knowledge transfer (see subsection 6.3.5).

7.53. Digitalisation has contributed to the emergence of technology-based virtual market platforms that capture, transmit and monetise data over the Internet through competitive and collaborative transactions between different users, buyers, or suppliers (see subsection 5.5.3). These virtual market platforms provide a space for established and new firms to develop and sell complementary technologies, products or services (Evans and Gawer, 2016). Consequently, these platforms provide fertile ground for the development and diffusion of innovations.

7.54. Data collection on digital platforms is primarily conducted in information and communication technology surveys. However, innovation surveys could include basic questions on whether or not the firm provides, uses or competes on digital platforms, and if goods or services are digitally ordered or delivered. Data collection can ask respondents whether their firm:

- provides digital platform services, or has a digital platform business model
- uses the services of digital platform providers
- competes with (or is exposed to competition from) providers of digital platform services (see Table 7.2)
- competes with (or is exposed to competition from) users of digital platform services.

7.5. The public policy environment for business innovation

7.5.1. Regulations

7.55. Regulation refers to the implementation of rules by public authorities and governmental bodies to influence market activity and the behaviour of private actors in the economy (OECD, 1997). A wide variety of regulations can affect the innovation activities of firms, industries and economies (Blind, 2013), including regulations on product markets, trade and tariffs, financial affairs, corporate governance, accounting and bankruptcy, IP rights, health and safety, employment and the labour market, immigration, environment, and energy. In order to be of use for research, data on regulations must be obtained for specific markets or purposes. For example, product market regulations can be disaggregated into regulations to ensure the health or safety of users, energy efficiency, recycling after use, etc. Data collection can determine if each regulatory area acted as a barrier to change, required innovation for compliance, or was not relevant to the firm. If a firm made changes in response to a regulation, the firm can be asked if the changes required investment in innovation to comply with the regulation.

7.56. Alternatively, surveys can collect information on the types of regulations that create the highest compliance costs and which regulations have the largest effect on decisions to develop product or business process innovations or enter new markets. The jurisdiction of regulations (local, regional, national, supranational) is also of research interest.

7.5.2. Government support programmes

7.57. Government support programmes represent direct or indirect transfers of resources to firms. Support can be of a financial nature or may be provided in kind. This support may come directly from government authorities or indirectly, for example when consumers are subsidised to purchase specific products. Firms can benefit from public support that targets business activities (for instance expenditures on research and experimental development [R&D] or the acquisition of new machinery) or the outcomes of business activities (for instance revenue streams arising from past innovation activities or reduced pollutant emission levels). Innovation-related activities and outcomes are common targets of government support. National and international regulations oversee the conditions under which support can be provided to firms, thus generating specific demand for evidence on the extent and impact of different forms and levels of government support for innovation.

7.58. Data collection can obtain information on whether a firm received direct financial support from public authorities and, if possible, the level of government that provided the support. Research into the effect of government financial support for innovation requires data on the nature and amount of government support by innovative, innovation-active and non-innovative firms. This includes identifying the component of government support that is specifically aimed at promoting innovation. Chapter 4 guidance on the sources of finance for innovation is helpful in this respect.

7.59. Both survey and administrative data sources on government support can be usefully combined to analyse the effects of public support policies. Administrative data on participation in government support programmes can be linked to innovation survey respondents, preferably using common business identification numbers if available in both databases. In addition to reducing response burden, this can provide more granular and accurate quantitative information for research on the individual and combined impacts of government programmes to support innovation. However, when administrative data are used, it is important to achieve full coverage for all substantive innovation support programmes. Data requirements for the evaluation of government policy are also discussed in section 11.5.

7.60. Survey respondents can be asked whether they were aware of government support for innovation, whether they considered applying, if they applied, whether they received support and, if so, the amount (value) of support received. Policy research can also benefit from data on the firm's experience with specific local, regional or national support programmes.

International comparisons

7.61. For international comparisons, data on the experience with or use of government support programmes should be mapped into categories that fit into a common policy instrument taxonomy. Table 7.4 suggests potential approaches for classifying such instruments. Ideally, information should also be collected by type of instrument, since this will affect the interpretation of questions on the amount of support received. For example, the net value to a firm from a secured loan at near commercial rates could be lower than a significantly smaller grant that does not need to be paid back.

Table 7.4. Possible approaches for classifying government policy instruments in innovation surveys

Characteristics	Examples and comments for measurement
By intention to support innovation capability or activity	Use the list of innovation activities in Chapter 4. plus a list of capabilities that are related to innovation, such as personnel development and network integration Could also include subsidies for the production of goods or services
By policy objective	Can use the classification of socio-economic objectives, but this has not been comprehensively tested and could be difficult for firms to answer
By type of instrument	Grants and subsidies, vouchers, tax subsidies, loans, loan guarantees, equity injections; inducement prizes; services and other in kind support
By level of government agency responsible	Local, regional, national, supranational and international rules
By conditions on the support	Policies can provide unconditional transfers, or support can be provided on a discretionary (e.g. competitive) or non-discretionary, on-demand basis
Financial value of support	Different instruments require different valuation methods (OECD, 1995) and consequently respondents may be unable to provide reliable estimates of the financial value of support, other than for basic transfers such as direct grants

Source: Adapted from OECD (2015), *Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development*, http://oe.cd/frascati and the taxonomy adopted by the OECD's STIP COMPASS database of innovation policy initiatives and instruments (https://stip.oecd.org/).

7.62. The *Frascati Manual 2015* (OECD, 2015: § 12.20-12.38) provides a classification system for different types of instruments to support R&D. This classification can be adapted to cover instruments to support innovation (see Table 7.5).

7.63. In addition to the transfer or subsidy content of these support instruments, firms may also value other elements, such as the experience acquired in the application and granting process, or the signal conveyed to other actors in the innovation system by a successful application.

Table 7.5. Main types of policy instruments to support innovation

Grants	Government grants or other transfers for innovation activities. These are often related to specific innovation projects and help meet part of their related costs.
Equity finance	Government investment in business equity
Debt finance	Government loans for innovation
Guarantees for debt financing	Government guarantees to facilitate third-party financial investment in the firm's innovation activities
Payment for goods and services	Buying goods or services from firms, implicitly or explicitly requiring firms to innovate as part of the agreement
Tax incentives	Tax relief for innovation activities and related outcomes, such as incentives for R&D expenditures or favourable IP regimes
Use of infrastructure and services	Direct or indirect provision of infrastructure and services for business innovation activities, such as subsidised access to R&D, testing or prototyping facilities, or allowing access to relevant data, networking or advisory resources This may include allocating vouchers to firms to allow them to acquire certain types of specialised services from approved providers, such as universities, research centres or design consultants.

Source: Adapted from OECD (2015), *Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development*, http://oe.cd/frascati.

7.5.3. Innovation and public infrastructure

7.64. Public infrastructure can be defined by government ownership or by government control through direct regulation. Consequently regulated infrastructure that is partly or fully financed, delivered, and managed by firms can still be considered public. Such infrastructure, including systems and facilities, can serve multiple, interdependent uses. The specific technical and economic characteristics of public infrastructure strongly influence the functional capabilities, development and performance of an economy. This warrants the inclusion of public infrastructure as an external factor that can influence innovation. Table 7.6 provides a general typology of public infrastructure for data collection on the relevance and quality of infrastructure to firms, such as accessibility, affordability for users, resilience and adaptability.

Table 7.6. Types of public infrastructure of potential relevance to innovation in firms

General type	Examples	Level of assessment of relevance/quality
Transport	Airports, rail, roads, bridges, waterways and marine facilities (e.g. ports)	
Energy	Generation, storage, transmission/distribution	
Information and communication	Telecommunication networks, postal services, broadcasting, etc.	
Waste management	Solid waste management, hazardous waste, wastewater	
Water supply	Collection and purification, storage, distribution	
Knowledge infrastructure	Educational institutions, libraries, repositories, databases, etc.	
Health	Hospitals, clinics, outreach services, etc.	

7.65. Public policy for infrastructure can have different incentive effects on innovation for firms that provide or use infrastructure. The types of infrastructure included in Table 7.6 are implicitly defined by specific industry codes (International Standard Industrial Classification of All Economic Activities [ISIC]), which can be used to identify those firms that provide infrastructural services. If ISIC data are insufficiently detailed or unreliable, data collection can ask if a respondent is a provider or user of each type of infrastructure.

7.5.4. Macroeconomic policy environment

7.66. It may be relevant to assess business views on the macroeconomic policies implemented by governments, including monetary, public expenditures and taxation policies. In addition, respondents can be asked which macroeconomic variables have the greatest influence on their firm's plans for its innovation activities (e.g. inflation, exchange rates, consumer demand).

7.6. The social and natural environment for innovation

7.6.1. The social context for innovation

7.67. Surveys of innovation in the Business sector are unsuitable for the collection of information on the general social environment for innovation, such as citizen attitudes to IP, entrepreneurship or new technologies. This information should be collected through social surveys. However, innovation surveys can obtain data from business managers about the role of social factors on their firms' decisions, as shown in Table 7.7. The proposed items distil several factors captured in a variety of surveys conducted by national statistical organisations and academic researchers. They mainly focus on the roles of individuals as consumers or as potential employees. The response options can vary from "strongly disagree" to "strongly agree". The results can be aggregated by firm size or industry and related to actual innovation performance data.

Table 7.7. Collecting information on characteristics of the firm's social environment

	Level of agreement/ disagreement
Consumers like to receive detailed information about your firm's goods and services.	
Consumers are willing to provide personal data to your firm in return for (better) goods and services.	
Consumer preferences for your firm's goods and services change very quickly.	
Consumers are willing to pay more for goods or services that incorporate new technology or design.	
Intellectual property is respected by consumers and firms in your market.	
Corrupt behaviours are encountered by your firm on a regular basis.	
Public interest groups have influenced your firm's business investment decisions.	
Environmental organisations have influenced your firm's business investment decisions.	
University graduates are prepared to undertake creative and innovative work within your firm.	
University graduates are attracted to work for your firm.	
Your firm's employees are interested in establishing spin-off firms to exploit opportunities.	

7.6.2. The natural environment

7.68. The natural environment can be an important external factor that influences the decisions of firms. In addition to firms whose economic activity partly depends on the natural environment (tourism, agriculture, fishing, mining, etc.), firms in all industries can find it necessary to develop strategies to manage their relationship with the natural environment.

7.69. Possible environmental factors that can affect all businesses include changes in environmental amenities, flooding and other natural disasters, pandemics and epidemics, climate change, and water, soil and air pollution. Relevant information on these conditions can be obtained from other sources, including insurance data and national data on pollutant levels.

7.70. In industries or geographic locations particularly affected by the natural environment, it may be of interest to collect data on whether firms respond to environmental factors through innovation, or if environmental factors create a barrier to innovation.

7.7. External factors as drivers and obstacles to business innovation

7.71. Depending on the context, an external factor can act as a driver of innovation or a barrier to innovation. An example is product quality regulations for pharmaceuticals. These regulations can create barriers to new entrants while motivating specific types of innovation activities for firms active in the market. External factors can also provide opportunities and incentives to develop a competitive advantage and thereby create new value for the firm. External factors and innovation objectives (covered in section 8.1) are therefore closely interrelated.

7.7.1. External factors as drivers of innovation

7.72. The external factors that can drive innovation can be grouped into three main categories: (i) the firm's market environment; (ii) public policies including regulations; and (iii) the social environment. Table 7.8 provides a list of potential drivers in each category. Depending on policy interests, data on more detailed drivers can be collected. For example, the category covering regulations can be disaggregated into specific types, or the category on the availability/cost of finance can focus on specific sources of finance.

Table 7.8. Proposal for integrated collection of data on external drivers of innovation

General area	Specific area	Importance as a driver of innovation (low, medium, high, not relevant)
Markets	Domestic customers	
	Access to international markets	
	Suppliers and value chains	
	Availability/cost of skills	
	Availability/cost of finance	
	Competitors	
	Standards	
	Markets for knowledge	
	Digital platforms	
Public policy	Regulations	
	Functioning of courts and rules enforcement	
	Taxation	
	Public spending (level and priorities)	
	Government support for innovation	
	Government demand for innovations	
	Public infrastructure	
	General policy stability	
Society	Consumer responsiveness to innovation	
	Favourable public opinion towards innovation	
	Level of trust among economic actors	

7.7.2. External factors as barriers or obstacles to innovation

7.73. An innovation barrier prevents a non-innovative firm from engaging in innovation activities or an innovation-active firm from introducing specific types of innovation. Innovation obstacles increase costs or create technical problems, but are often solvable. Data collection on innovation barriers or obstacles should ensure that all questions are applicable to both innovation-active and non-innovative firms and can capture differences in the awareness of barriers between both types of firms (D'Este et al., 2012). Asymmetries in awareness can hamper the analysis of the factors that influence business innovation. Furthermore, responses to questions on barriers can represent *ex post* "justifications" that fail to capture actual barriers or the role of some barriers as drivers of innovation.

7.74. Data collection on barriers or obstacles can follow the list of factors provided in Table 7.8 above, with some modifications. For example, the "availability/cost of skills" can be changed to a "lack of/high cost of skills", "public infrastructure" can be changed to "inadequate public infrastructure", etc.

7.75. Questions on barriers or obstacles can also include internal factors within the firm, such as a lack of internal finance for innovation, a lack of skilled employees within the firm, or a lack of resources to discourage high-skilled employees from leaving the firm to work for competitors.

7.76. An alternative to asking separate questions for drivers and barriers is to use a single list of items, as in Table 7.8, and ask respondents the extent to which each item contributed to or deterred innovation.

7.8. Summary of recommendations

7.77. This chapter identifies a range of external factors in the firm's environment that can influence innovation activities. For the measurement of these factors, it is recommended to:

- Adopt neutral and balanced language for measuring potential external drivers of innovation, taking into account the dual barrier/incentive effect of environmental or contextual factors.
- Use, whenever possible, questions that are relevant to all firms, regardless of their innovation status.
- Use questions on the behaviour of firms in response to external factors, instead of questions that require respondents to apply heuristics to estimate impacts.

7.78. The generic recommendation in this manual to prioritise items taking into account policy user needs for the study of framework conditions for innovation is most relevant in the context of this chapter, as it is not possible to include all dimensions in one survey.

7.79. Recommendations for general data collection are given below. Other types of data covered in this chapter are suitable for specialised data collection exercises.

7.80. Key questions for data collection should cover:

- the firm's industry and main market (see also Chapter 5)
- competition and product market characteristics (Table 7.2)

7.81. government policy and support for innovation (Table 7.4 and the use of different types of instruments in Table 7.5)

- drivers or barriers to innovation (Table 7.8).

7.82. Supplementary questions for data collection, depending on national priorities, space or resources include:

- additional characteristics of customers, including user requirements, the main customer's share of sales and the industry of the main customer (subsection 7.4.1)
- location of business activities and value chains (Table 7.1)
- effect of regulations on innovation (subsection 7.5.1).

7.83. Other topics presented in this chapter are suggested for occasional or experimental use in surveys.

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Chapter 8. Objectives and outcomes of business innovation

This chapter discusses different approaches to measuring business innovation objectives and outcomes, extending the measurement of innovation characteristics introduced in Chapter 3. It discusses several qualitative measures of the variety of innovation objectives and outcomes pursued by firms. This is complemented by an evaluation of quantitative measures of innovation outcomes for both product and business process innovations. An overview of the challenges to measuring innovation outcomes is presented before providing a final set of recommendations.

8.1. Introduction

8.1. The planning and development stage for an innovation includes the identification of a set of one or more **objectives** that the innovation is expected to achieve. The objectives can refer to the characteristics of the innovation itself, such as its specifications, or its market and economic objectives. The **outcomes** of an innovation can be captured by a similar list of items as the objectives, but consist of the innovation's realised effects. These can also include unexpected effects that were not identified among the firm's initial objectives.

8.2. A firm's economic objectives for its innovations can include the generation of profits, an increase in sales or brand awareness from product innovation, and cost savings or productivity improvements from business process innovation (Crépon, Duguet and Mairesse, 1998). Other objectives include changes to the firm's capabilities, markets, or the types of customers that buy its products, and the establishment of new external linkages.

8.3. Innovation outcomes include the extent to which a firm's objectives are met and the broader effects of innovation on other organisations, the economy, society, and the environment. The broader effects may or may not have been identified by a firm as innovation objectives. They include different types of spillovers and externalities that can change the structure of competition in markets and stimulate or hamper the innovation activities of other organisations. Broader effects of innovation can also contribute to or hinder societal goals such as improvements to employment, health and environmental conditions, or help solve or influence other societal challenges.

8.4. Common objectives for many firms are to increase overall profits and growth in terms of sales or market share. Research on the effects of innovation on such outcomes should ideally use administrative data and identify the effect of innovation through econometric analysis (see Chapter 11). However, it is also of value for research to collect data on outcomes that are limited to innovations, such as the sales share or profit margin of innovations.

8.5. This chapter presents different approaches to measuring innovation objectives and outcomes. Section 8.2 discusses qualitative measures of the variety of innovation objectives and outcomes pursued by firms. Section 8.3 includes an evaluation of quantitative measures of innovation outcomes for product and business process innovations. An overview of the challenges for measuring innovation outcomes is presented in section 8.4, before providing a final set of recommendations.

8.2. Qualitative measures of business innovation objectives and outcomes

8.2.1. Types of innovation objectives and outcomes

8.6. Innovation objectives consist of a firm's identifiable goals that reflect its motives and underlying strategies with respect to its innovation efforts (see subsection 5.3.1) Collecting data on innovation objectives is useful for research on the factors that drive a firm's decision to engage in innovation activities, such as the intensity of competition or the opportunities for entering new markets, and how the firm responds to these drivers, such as improvements to the efficiency of the firm's operations or enhancements to its innovation capabilities. Data on objectives can also provide insights into the planned characteristics of innovations, for instance if a firm's objective is to substantially change its business processes or to only make minor adjustments. In addition, data on innovation objectives can be used to construct innovation profiles (see subsection 3.6.2) or other systems for classifying innovative firms.

8.7. Innovation outcomes are the observed effects of innovations. In a survey context, outcome data are based on the perceptions of respondents in innovative firms. Firms may or may not succeed in achieving their innovation objectives, or innovations can entail additional effects that were not part of the firm's original objectives.

8.8. Many innovation objectives and outcomes can be captured by the same list of items. Table 8.1 lists common objectives that can become outcomes if realised, grouped by areas of influence: markets, production and delivery, firm organisation, and environment and society. Objectives are always intentional, but outcomes can be unintended.

8.9. Objectives and outcomes that influence **markets** mainly concern product innovations, although some business process innovations can also play an indirect role, such as those that improve the quality or marketing of services thus enhancing the visibility or reputation of these services. The objectives listed under "markets for the firm's products" capture whether or not the firm planned to change its product portfolio (increase its range of goods or services), enter new markets, target existing markets (increase or maintain market share), or change customer perceptions of the firm's products (increase its reputation or visibility). Firms may also need to comply with market regulations, for instance by meeting product emissions or recycling standards.

8.10. Objectives and outcomes for **production and delivery** concern the cost and quality of a firm's operations. They are mainly related to business process innovation, although some product innovations can contribute. An example is a change in the materials used for a product that reduces the material costs per unit of output.

8.11. The objectives and outcomes that influence the firm's **business organisation** capture the effects of business process innovations on a firm's capabilities. Some of these effects can improve the firm's capabilities for absorbing, processing and analysing knowledge. Others influence the ability of the firm to adapt to changes or improve working conditions as well as ensuring the continued existence of the firm itself.

8.12. Outcomes that affect an **economy, society or the environment** are influenced by innovation objectives that target externalities, such as reducing environmental impacts or improving health and safety. Other items refer to the contribution of innovations to wider societal goals such as social inclusion, public security or gender equality. Both product and business process innovations undertaken to comply with standards or regulations can contribute to environmental and societal goals.

8.13. At a minimum, it is recommended to collect data on either the objectives or the outcomes of innovations. As some objectives and outcomes are common, data collection should use an ordinal scale of their importance to the firm. Data on outcomes can only be collected for innovations, while for objectives, data collection should encompass all completed, ongoing, postponed or abandoned innovation activities.

8.14. If data are collected for both innovation objectives and innovation outcomes, then it is recommended to limit both sets of questions to innovations to ensure comparability between objectives and outcomes, and exclude those innovation activities that are ongoing, postponed or ceased.

8.15. A single question can be used to collect data on both objectives and outcomes. In this case, it is recommended to use an importance scale for the objectives. The response options for the outcomes should include whether or not the objective was achieved, if the outcome occurred without a corresponding objective (i.e. it was unintended), and if it is "too early to tell".

Table 8.1. Innovation objectives and outcomes for measurement, by area of influence

Markets for the firm's products
Upgrade goods or services
Expand the range of goods or services
Create new markets
Enter new markets or adapt existing products to new markets
Increase or maintain market share
Increase the reputation, brand awareness, or visibility of goods or services
Comply with market regulations
Adopt standards and accreditation
Production and delivery
Upgrade outdated process technology or methods
Improve quality of goods or services
Improve flexibility for producing goods or services
Increase speed of producing goods or delivering services
Reduce labour costs per unit of output
Reduce material, energy costs or operating costs per unit of output
Reduce time to market
Business organisation
Improve capabilities for absorbing, processing and analysing knowledge
Improve sharing or transfer of knowledge with other organisations
Improve the efficiency or function of the firm's value chain
Improve communication within the firm
Improve or develop new relationships with external entities (other firms, universities, etc.)
Increase business resilience and adaptability to change
Improve working conditions, health or safety of the firm's personnel
Implement a new business model
Contribute to the development of standards
Economy, society or environment
Reduce negative environmental impacts /deliver environmental benefits
Improve public health, safety or security
Improve social inclusion
Improve gender equality
Improve quality of life or well-being
Comply with mandatory regulations
Comply with voluntary standards

8.16. Outcomes are only observable if they occur within the observation period for data collection; some effects may only occur after this period and consequently will be unobservable. It is not recommended to either extend the length of the observation period to more than three years or to collect outcome data for innovations that occurred before the observation period. Although both approaches could produce a more complete picture of innovation outcomes, they will also decrease data reliability due to a decline in the accuracy of the respondents' ability to recall past objectives. Furthermore, collecting outcome data for innovations before the observation period could damage the logic of data collection and negatively influence responses to other questions.

8.2.2. Innovation objectives and outcomes in relation to business strategies

8.17. In addition to the basic objectives and outcomes listed in Table 8.1, data can be collected on the relationship between innovation and business strategies, including the contribution of innovation to the firm's business strategy (see subsection 5.3.1), the extent to which innovations require substantial internal changes in the firm, and the effects of innovation on the market in which a firm operates. Relevant data can be collected for objectives only, or for both objectives and outcomes, as described above. All strategic innovation objectives or outcomes should be measured on an ordinal scale.

8.18. Table 8.2 provides options for data collection on the objectives or outcomes of innovation in relation to a firm's business strategy. The first set of innovation objectives and outcomes concerns how firms position their product innovations in their **market**. Relevant strategies include a focus on distinct market segments (specialisation), the diversification or extension of existing offerings (diversification), and solutions for specific customers (customisation). Objectives and outcomes for **internal capabilities** include improvements in the skill levels of employees, for instance to enhance absorptive capacity (see subsection 5.3.4), more efficient or effective methods for organising innovation activities, and methods to manage risk.

8.19. Innovation objectives can also be part of a firm's strategy in respect to its **competitors** (see subsection 5.3.1). For example, a firm can focus on imitation or adoption, first-to-market strategies, or technology, design or cost leadership. A focus on imitation or adoption is a "follower" strategy in which a firm's innovations lag behind those of its competitors. Conversely, a firm that pursues a leadership strategy seeks to remain ahead of its competitors. Leadership can be based on the design characteristics or technical functions of product innovations, or on quality or cost advantages from business process innovations. A first-to-market strategy can be based on imitating goods or business processes in other markets, or on technology, design or cost leadership.

Table 8.2. Measurement of innovation objectives and outcomes for business strategies

Positioning a firm's products in the market
Strengthen the position in distinct market segments
Diversify or extend existing product offerings
Develop solutions for specific customers
Establish a new business model
Internal capabilities and organisation
Upgrade employee skills
Organisation of innovation activities
Managing risks that can impede innovation (security and cyber risks, etc.)
Positioning a firm in respect to its competitors
Imitate or adapt competitors' innovations
First-to-market good or service innovations
First in market to use business process innovations
Technology leadership
Design leadership
Cost leadership

8.20. Innovation can have major impacts on the structure and dynamics of markets, such as driving competitors out of a market or blocking the entry of new competitors, for instance as a result of significant cost advantages, novel product characteristics, or network effects. Other market-transforming outcomes include changes to the business strategies of suppliers or other businesses that use the firm's innovations. Changes in the business models of other firms can occur when an innovation renders some products or processes obsolete, or when a firm creates a novel online platform that other firms can use.

8.21. Information on the market impacts of a firm's innovation strategies is of high relevance to policy. However, respondents may be unwilling to comment on the effects of their own firm's strategies if they have the potential to contravene existing legislation, for example through anti-competitive behaviour. Consequently, it could be preferable to ask basic and neutral questions on the general effects of innovation by all firms active in the respondent's markets, as shown in Table 8.3.

Table 8.3. Measurement of potential market impacts from business innovation

Change in the number of competitors in the firm's market (increase/decrease/no change)
Change in capital and human resource investments required to enter the firm's market (increase/decrease/no change)
Change in business strategies of suppliers active in the firm's market (yes/no)
Change in strategies of business users of the products in the firm's market[1] (yes/no)

1. Only relevant to firms in markets selling to other businesses.

8.3. Quantitative measures of innovation outcomes

8.22. Quantitative outcome measures for both product and business process innovations are of interest for three reasons. First, quantitative data are required for research on the economic significance of innovations for the innovative firm and for the markets where the innovations are sold. Second, these data can be used to analyse the effectiveness and efficiency of innovation expenditures and the effects on innovation outcomes, of how firms organise their innovation activities (for example their use of collaboration, information sources, methods to protect their intellectual property and receipt of public funding support). Third, quantitative outcome data are relevant to research on the impacts of innovation on other organisations, the economy, society and the environment.

8.3.1. Quantitative measures for product innovation

Share of sales accounted for by product innovations

8.23. The "innovation sales share" indicator can be defined as the share of a firm's total sales in the reference year that respondents estimate is due to product innovations. It is an indicator of the economic significance of product innovations at the level of the innovative firm (Brouwer and Kleinknecht, 1996). In addition, data on the innovation sales share at the firm level can be aggregated to measure the share of sales from product innovations in the total sales of a specific industry or market. Sales share data can also be used to estimate the share of total demand in an industry that is met by domestic product innovations, if data on total sales from imports and domestic production are also available.

8.24. Innovations can result in very low or no sales if the time between the innovation and the measurement of sales is relatively short. Several factors will influence the time gap between product innovation and sales, including when the innovation occurred during the observation period and the time required to market and sell an innovation. Customised and expensive machinery are likely to be pre-sold (for instance aircraft), while some consumer products could experience a slow, gradual uptake in sales. On average, questions on innovation sales are likely to obtain better results if a three-year observation period is used compared to a one-year period.

8.25. It is recommended to collect data on the innovation sales share as an output measure of product innovation. It is further recommended to collect the sales share of product innovations (both new and improved products combined) for the following three types of markets (the responses should add up to 100%):

- product innovations introduced during the observation period that were **new to the firm's market**
- product innovations introduced during the observation period that were **only new to the firm**
- products that were **unchanged or only marginally modified** during the observation period.

8.26. Under some conditions it may be possible to disaggregate the innovation sales share by type of product innovation (goods or services), or by the location of sales (domestic or foreign markets). However, disaggregation by type of innovation will be difficult for firms that combine goods and services into a single product, such as when capital equipment manufacturers combine equipment sales with a service maintenance contract.

8.27. A useful disaggregation for research and policy is by the level of novelty, as in the example given above. Other methods of disaggregating by novelty include:

- sales from new products or improved products
- sales from world-first, market-first, or only first to the firm innovations (see subsection 3.3.2)
- sales from innovations that are not available from any of the firm's competitors, or from innovations that are identical or very similar to products already offered by competitors.

8.28. Respondents may find it difficult to provide an exact figure for the innovation sales share. An alternative is to provide response categories such as "0%," "more than 0% to less than 5%", "5% to less than 10%", etc. The response categories need to be narrowly defined to provide useful data.

8.29. Information on the innovation sales share by type of market is useful for differentiating between the diffusion of product innovations that were previously available in the firm's markets and product innovations that are market novelties. In addition, accurate interpretation of the share of sales from market novelties requires data on the geographic market where these products were sold. The degree of novelty is likely to differ if the product innovation is only new to a local market compared to a national or international market. Respondents can be asked if any of their new-to-market product innovations were new to their local, regional or national markets, or were a "world-first" product innovation (see subsection 3.3.2). It is also of value for research on capabilities and profiles (see subsection 3.6.2) to collect data on the innovation sales share of "world-first" product innovations.

8.30. The innovation sales share is affected by the speed of change in technology and demand in a firm's market, with high rates of change resulting in short product life cycles. These and other external factors that can lead to short product life cycles are discussed in subsection 7.4.2.

Other quantitative measures of product innovation

8.31. A quantitative output indicator for product innovation is the number of product innovations during the observation period. This needs to be measured cautiously because respondents can find it difficult to estimate innovation counts, particularly for large firms with multiple innovations, highly complex products containing several sub-systems, or multiple products that can be subject to substantial or minor variations. To address these issues, data collection for innovation counts should use predefined categories (e.g. 0, 1, 2, 3-5, 6-10, 11-20, more than 20) and instruct respondents not to consider minor variations of the same product as different product innovations.

8.32. Count data on the number of product innovations is useful for interpreting data on the objectives and outcomes of innovation. For instance, the variety of innovation objectives is likely to be positively correlated with the number and diversity of product innovations. Indicators on the share of innovation projects that are completed during the observation period can also be calculated from count data for the number of innovation projects (see subsection 4.5.2).

8.33. Data on the economic significance or market success of product innovations can be collected by asking respondents for their firm's general performance expectations (in terms of an increase in sales or profits), and the share of product innovations that met these expectations. Questions on performance expectations and outcomes for a change in sales or profits can use predefined response categories (e.g. "0%", "more than 0% to less than 25%", "25% to less than 50%", "50% to less than 75%", "75% to less than 100%", "100%").

8.34. Other quantitative outcome indicators for product innovation include the profit margin of product innovations and the market share of the firm's product innovations out of all sales in the market for similar products (including the sales of products sold by competitors). Both indicators provide a better measure of the economic and market success of product innovations than the innovation sales share. The profit margin (degree of markup) is a measure of economic success that is positively correlated with the competitive advantage of the firm's product innovations over other products offered in the same market. Similarly, a high market share indicates that a product innovation is able to outcompete offerings by other firms in the market. In contrast, a high innovation sales share for product innovations can still result in lower economic advantages to the firm, for instance when a firm ceases to sell older products or if a firm sells high volumes of a product innovation at low profit margins.

8.35. Respondents can find it more difficult to provide data on the profit margin or market share of product innovations than for the innovation sales share, particularly if the firm has a large number of product innovations with varying profit margins and market shares that need to be averaged. In addition, respondents can regard data on the profit margin and market share as highly sensitive. Data collection can reduce the response burden by asking for relative measures, such as the difference between the average profit margin for product innovations and the average profit margin for other products. Another option is to only collect data on the profit margin and market share for the firm's most important product innovation (see Chapter 10).

8.3.2. Quantitative outcome data for business process innovations

8.36. In comparison with product innovations, respondents can face greater difficulty in providing estimates of quantitative outcomes for business process innovations. Data on the savings from business process innovations are often not collected by firms. Furthermore, business process innovation can relate to very different areas of operations, requiring different indicators for each type of business process (Davenport, 1993). An alternative is to collect quantitative data on the firm's most important business process innovation (see Chapter 10).

8.37. A relevant indicator for some types of business process innovations is the percentage of a firm's personnel who were directly affected by these innovations during the observation period. This indicator is of value for measuring the influence of business process innovations across an organisation. It does not, however, provide any information on whether business process innovations were successful or if they had any positive or negative effects on operations.

8.38. A second indicator is the change in sales that can be attributed to business process innovation. This measure can be driven by efficiency-enhancing business process innovations that reduce costs or that enhance product quality. Respondents can be asked if business process innovations led – directly or indirectly – to an increase in sales, and, if so, the size of the increase using a predefined scale. Useful categories are: "0%", "more than 0% to less than 1%", "1% to less than 2%", "2% to less than 5%", "5% to less than 10%", and "10% or more". This indicator is conceptually similar to the innovation sales share indicator for product innovations.

8.39. Both of these quantitative outcome indicators for business process innovation are likely to be very difficult for respondents from large firms to estimate, or for specific types of business process innovations that are not directly used in production activities, such as in administration and management. The indicators are more suitable for small and medium-sized firms, or for a question that focuses on business process innovations that are directly linked to products. An example is the share of sales affected by business process innovations in production, delivery and logistics.

8.40. Many business process innovations aim to improve the efficiency of a firm's operations, though it is usually difficult to map individual innovations to specific outcomes. Efficiency-enhancing innovations should, directly or indirectly, result in lower costs compared to the situation before their use or compared to business process innovations that did not improve efficiency. In order to quantify the cost reduction resulting from business process innovations, respondents can be asked if such innovations led – directly or indirectly – to a reduction in operating costs, and, if so, the size of the reduction (Piening and Salge, 2015). Questions on cost reduction should refer to costs per unit of output or per operation, in order to exclude scale-related cost changes from an increase or decrease in production or operations. To reduce response burden, predefined response categories should be used. Experience with this approach in surveys indicates that the response categories should be weighted to small differences, such as "0%", "more than 0% to less than 2%", "2% to less than 5%", "5% to less than 10%", "10% to less than 20%", and "20% or more".

8.41. Other business process innovations aim to improve the quality characteristics of processes, such as flexibility, adaptability, speed, precision, accuracy or customer-friendliness (relevant to many business processes for delivering services). In some cases, quality-enhancing business process innovations can increase unit costs, but these additional costs can be matched or exceeded by an increase in the value of the resulting output.

8.42. Quantitative indicators on quality-enhancing business process innovations have been developed as part of quality management (Powell, 1995). These cover improvements in the timeliness of business processes due to innovations (lead time, processing time, on-time delivery) and improvements in the quality of outputs from business process innovations (customer satisfaction rate, defect rate, accuracy rate, reworking rate, scrap rate). Quantitative indicators for many of these outcomes require individualised scales built into each question, for instance the share of products delivered on time, the share of customers that were satisfied with the process, the share of scrap in total production volume, or the share of products that had to be reworked. Other indicators include improvements to process complexity (the number of steps) and employee satisfaction. Some of these quality indicators are designed for manufacturing processes that produce distinct units of output and are less relevant for business process innovations in continuous manufacturing industries such as chemicals, or in service industries. Other indicators can be applied to all industries, such as the customer satisfaction rate (share of customers that are usually satisfied with the good or service), the accuracy rate (share of operations that produce the intended process result) or the employee satisfaction rate. Many of these indicators are difficult to apply or less relevant (e.g. the scrap rate) to firms in service industries.

8.4. Issues for measurement

8.43. The choice of a subject or object method for data collection will have a substantial effect on the information obtained for innovation objectives and outcomes. The subject approach requires asking firms about the objectives or outcomes of all innovations (or innovation activities) during the observation period. If the objectives or outcomes differ among innovations (or innovation activities), it will be difficult for respondents to derive an average level of importance for each objective or outcome. Conversely, the object approach (see Chapter 10), with a focus on a single innovation, will reduce the response burden and increase the accuracy of the data for specific objectives and outcomes, but at the expense of data for a broader range of objectives.

8.44. The inclusion of questions on outcomes in data collection assumes that respondents are able to assess the consequences of their firm's innovations. For some outcomes, such as a change in sales, this assumption could be valid, whereas respondents could find it difficult to assess other outcomes, such as a reduction in environmental impacts outside the firm.

8.45. Questions that ask respondents about the performance effects of their firm's innovations could be subject to biases in favour of positive effects, which can be more visible to respondents than the secondary effects of an innovation. For example, a product innovation could result in the hiring of new employees to develop, produce and market the innovation, but also cause a fall in the demand for other products of the same firm as customers shift to the new or improved product, resulting in the layoff of employees involved in the production and marketing of these other products. Respondents are more likely to recall the positive increase in employment due to the innovation than the negative employment effects from the innovation replacing other product lines. In addition, respondents may find it difficult to assess positive or negative indirect effects, for instance when an innovation reduces the sales of old products with a better safety record than the new product.

8.46. Some of the above issues can be addressed through the use of econometric methods that estimate innovation outcomes while controlling for the effects of possible biases (see subsection 11.5.2). Econometric methods have been developed for analysing productivity performance, employment outcomes, profitability, and measures of competitiveness. These analyses benefit from data on innovation outcomes as described in this chapter, such as sales from product innovations or the effect of business process innovations on sales or costs.

8.5. Summary of recommendations

8.47. Recommendations for general data collection are given below. Supplementary data are suitable for specialised data collection exercises.

8.48. Key recommendations for data collection include:

8.49. innovation objectives and outcomes by area of influence (Table 8.1)

- innovation objectives and outcomes for business strategies (Table 8.2)
- innovation sales share in total business sales.

8.50. At the time of publication, there is a serious lack of quantitative outcome data for business process innovation, which significantly hinders understanding of the role of business process innovation in economic growth. Consequently, a key recommendation is to experiment with one or more of the proposed indicators discussed in subsection 8.3.2 above.

8.51. Supplementary recommendations (given space or resources) include:

- counts of product innovations
- major impacts of innovations for markets (Table 8.3).

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Part III. Methods for collecting, analysing and reporting statistics on business innovation

Chapter 9. Methods for collecting data on business innovation

This chapter provides guidance on methodologies for collecting data on business innovation, based on the concepts and definitions introduced in previous chapters. The guidance is aimed at producers of statistical data on innovation as well as advanced users who need to understand how innovation data are produced. While acknowledging other potential sources, this chapter focuses on the use of business innovation surveys to collect data on different dimensions of innovation-related activities and outcomes within the firm, along with other contextual information. The guidance within this chapter covers the full life cycle of data collection, including setting the objectives and scope of business innovation surveys; identifying the target population; questionnaire design; sampling procedures; data collection methods and survey protocols; post-survey data processing, and dissemination of statistical outputs.

9.1. Introduction

9.1. This chapter provides guidance on methodologies for collecting data on business innovation. As noted in Chapter 2, methodological guidance for the collection of data on innovation is an essential part of the measurement framework for innovation. Data on innovation can be obtained through object-based methods such as new product announcements on line or in trade journals (Kleinknecht, Reijnen and Smits, 1993), and from expert assessments of innovations (Harris, 1988). Other sources of innovation data include annual corporate reports, websites, social surveys of employee educational achievement, reports to regional, national and supranational organisations that fund research and experimental development (R&D) or innovation, reports to organisations that give out innovation prizes, university knowledge transfer offices that collect data on contract research funded by firms and the licensing of university intellectual property, business registers, administrative sources, and surveys of entrepreneurship, R&D and information and communication technology (ICT) use. Many of these existing and potential future sources may have "big data" attributes, namely they are too large or complex to be handled by conventional tools and techniques.

9.2. Although useful for different purposes, these data sources all have limitations. Many do not provide representative coverage of innovation at either the industry or national level because the data are based on self-selection: only firms that choose to make a product announcement, apply for R&D funding, or license knowledge from universities are included. Information from business registers and social, entrepreneurship, and R&D surveys is often incomplete, covering only one facet of innovation. Corporate annual reports and websites are inconsistent in their coverage of innovation activities, although web-scraping techniques can automate searches for innovation activities on documents posted on line and may be an increasingly valuable source of innovation data in the future. Two additional limitations are that none of these sources provide consistent, comparable data on the full range of innovation strategies and activities undertaken by all firms, as discussed in Chapters 3 to 8, and many of these sources cannot be accurately linked to other sources. Currently, the only source for a complete set of consistent and linkable data is a dedicated innovation survey based on a business register.

9.3. The goal of a business innovation survey is to obtain high-quality data on innovation within firms from authoritative respondents such as the chief executive officer or senior managers. A variety of factors influence the attainment of this goal, including coverage of the target population, the frequency of data collection, question and questionnaire design and testing, the construction of the survey sample frame, the methods used to implement the survey (including the identification of an appropriate respondent within the surveyed unit) and post-survey data processing. All of these topics are relevant to national statistical organisations (NSOs) and to international organisations and researchers with an interest in collecting data on innovation activities through surveys and analysing them.

9.4. Business innovation surveys that are conducted by NSOs within the framework of national business statistics must follow national practices in questionnaire and survey design. The recommendations in this chapter cover best practices that should be attainable by most NSOs. Surveys implemented outside of official statistical frameworks, such as by international organisations or academics, will benefit from following the recommendations in this chapter (OECD, 2015a). However, resource and legal restrictions can make it difficult for organisations to implement all best practices.

9.5. The decision on the types of data to collect in a survey should be taken in consultation with data users, including policy analysts, business managers and consultants, academics, and others. The main users of surveys conducted by NSOs are policy makers and policy analysts and consequently the choice of questions should be made after consultations with those government departments and agencies responsible for innovation and business development. Surveys developed by academics could also benefit from consultations with governments or businesses.

9.6. The purpose(s) of data collection, for instance to construct national or regional indicators or for use in research, will largely influence survey methodology choices. The sample can be smaller if only indicators at the national level are required, whereas a larger sample is necessary if users require data on sub-populations, longitudinal panel data, or data on rare innovation phenomena. In addition, the purpose of the survey will have a strong influence on the types of questions to be included in the survey questionnaire.

9.7. This manual contains more suggestions for questions on innovation than can be included in a single survey. Chapters 3 to 8 and Chapter 10 recommend key questions for collection on a regular basis and supplementary questions for inclusion on an occasional basis within innovation survey questionnaires. Occasional questions based on the supplementary recommendations or on other sections of the manual can be included in one-off modules that focus on specific topics or in separate, specialised surveys. The recommendations in this chapter are relevant to full innovation surveys, specialised surveys, and to innovation modules included in other surveys.

9.8. This chapter provides more details on best practice survey methods than previous editions of this manual. Many readers from NSOs will be familiar with these practices and do not require detailed guidance on a range of issues. However, this edition is designed to serve NSOs and other producers and users of innovation data globally. Readers from some of these organisations may therefore find the details in this chapter of value to their work. In addition to this chapter, other sources of generic guidelines for business surveys include Willeboordse (ed.) (1997) and Snijkers et al. (eds.) (2013). Complementary material to this manual's online edition will provide relevant links to current and recent survey practices and examples of experiments with new methods for data collection (http://oe.cd/oslomanual).

9.9. The chapter is structured as follows: Section 9.2 covers the target population and other basic characteristics of relevance to innovation surveys. Questionnaire and question design are discussed in section 9.3. A number of survey methodology issues are discussed in the subsequent sections including sampling (section 9.4), data collection methods (section 9.5), survey protocol (section 9.6) and post-survey processing (section 9.7). The chapter concludes with a brief review of issues regarding the publication and dissemination of results from innovation surveys (section 9.8).

9.2. Population and other basic characteristics for a survey

9.2.1. Target population

9.10. The Business enterprise sector, defined in Chapter 2 and OECD (2015b), is the target for surveys of business innovation. It comprises:

- All resident corporations, including legally incorporated enterprises, regardless of the residence of their shareholders. This includes quasi-corporations, i.e. units capable of generating a profit or other financial gain for their owners, recognised by law as separate legal entities from their owners, and set up for the purpose of engaging in market production at prices that are economically significant. They include both financial and non-financial corporations.

- The unincorporated branches of non-resident enterprises deemed to be resident and part of this sector because they are engaged in production on the economic territory on a long-term basis.
- All resident non-profit institutions that are market producers of goods or services or serve businesses. This includes independent research institutes, clinics, and other institutions whose main activity is the production of goods and services for sale at prices designed to recover their full economic costs. It also includes entities controlled by business associations and financed by contributions and subscriptions.

9.11. The Business enterprise sector includes both private enterprises (either publicly listed and traded, or not) and government-controlled enterprises (referred to as "public enterprises" or "public corporations"). For public enterprises, the borderline between the Business enterprise and Government sectors is defined by the extent to which the unit operates on a market basis. If a unit's principal activity is the production of goods or services at economically significant prices it is considered to be a business enterprise.

9.12. Consistent with the definition in the System of National Accounts (SNA) (EC et al., 2009), the residence of each unit is the economic territory with which it has the strongest connection and in which it engages for one year or more in economic activities. An economic territory can be any geographic area or jurisdiction for which statistics are required, for instance a country, state or province, or region. Businesses are expected to have a centre of economic interest in the country in which they are legally constituted and registered. They can be resident in different countries than their shareholders and subsidiary firms may be resident in different countries than their parent organisations.

9.13. The main characteristics of the target population that need to be considered for constructing a sample or census are the type of statistical unit, the unit's industry of main activity, the unit's size, and the geographical location of the unit.

9.2.2. Statistical units and reporting units

9.14. Firms organise their innovation activities at various levels in order to meet their objectives. Strategic decisions concerning the financing and direction of innovation efforts are often taken at the enterprise level. However, these decisions can also be taken at the enterprise group level, regardless of national boundaries. It is also possible for managers below the level of the enterprise (i.e. establishment or kind-of-activity unit [KAU]) to take day-to-day decisions of relevance to innovation.

9.15. These decisions can cut across national borders, especially in the case of multinational enterprises (MNEs). This can make it difficult to identify and survey those responsible for decision-making, particularly when NSOs or other data collection agencies only have the authority to collect information from domestic units.

Statistical unit

9.16. A **statistical unit** is an entity *about which* information is sought and for which statistics are ultimately compiled; in other words, it is the institutional unit of interest for the intended purpose of collecting innovation statistics. A statistical unit can be an **observation unit** for which information is received and statistics are compiled, or an **analytical unit** which is created by splitting or combining observation units with the help of estimations or imputations in order to supply more detailed or homogeneous data than would otherwise be possible (UN, 2007; OECD, 2015b).

9.17. The need to delineate statistical units arises in the case of large and complex economic entities that are active in different industry classes, or have units located in different geographical areas. There are several types of statistical units according to their ownership, control linkages, homogeneity of economic activity, and their location, namely enterprise groups, enterprises, establishments (a unit in a single location with a single productive activity), and KAUs (part of a unit that engages in only one kind of productive activity) (see OECD [2015b: Box 3.1] for more details). The choice of the statistical unit and the methodology used to collect data are strongly influenced by the purpose of innovation statistics, the existence of records of innovation activity within the unit, and the ability of respondents to provide the information of interest.

9.18. The statistical unit in business surveys is generally the **enterprise**, defined in the SNA as the smallest combination of legal units with "autonomy in respect of financial and investment decision-making, as well as authority and responsibility for allocating resources for the production of goods and services" (EC et al., 2009; OECD, 2015b: Box 3.1).

9.19. Descriptive identification variables should be obtained for all statistical units in the target population for a business innovation survey. These variables are usually available from statistical business registers and include, for each statistical unit, an identification code, the geographic location, the kind of economic activity undertaken, and the unit size. Additional information on the economic or legal organisation of a statistical unit, as well as its ownership and public or private status, can help to make the survey process more effective and efficient.

Reporting units

9.20. The **reporting unit** (i.e. the "level" within the business *from which* the required data are collected) will vary from country to country (and potentially within a country), depending on institutional structures, the legal framework for data collection, traditions, national priorities, survey resources and ad hoc agreements with the business enterprises surveyed. As such, the reporting unit may differ from the required statistical unit. It may be necessary to combine, split, or complement (using interpolation or estimation) the information provided by reporting units to align with the desired statistical unit.

9.21. Corporations can be made up of multiple establishments and enterprises, but for many small and medium-sized enterprises (SMEs) the establishment and the enterprise are usually identical. For enterprises with heterogeneous economic activities, it may be necessary for regional policy interests to collect data for KAUs, or for establishments. However, sampling establishments or KAUs requires careful attention to prevent double counting during data aggregation.

9.22. When information is only available at higher levels of aggregation such as the enterprise group, NSOs may need to engage with these units to obtain disaggregated data, for instance by requesting information by jurisdiction and economic activity. This will allow better interoperability with other economic statistics.

9.23. The enterprise group can play a prominent role as a reporting unit if questionnaires are completed or responses approved by a central administrative office. In the case of holding companies, a number of different approaches can be used, for example, asking the holding company to report on the innovation activities of enterprises in specific industries, or forwarding the questionnaire, or relevant sections, to other parts of the company.

9.24. Although policy interests or practical considerations may require innovation data at the level of establishments, KAUs, and enterprise groups, it is recommended, wherever possible, to collect data at the **enterprise level** to permit international comparisons. When this is not possible, careful attention is required when collecting and reporting data on innovation activities and expenditures, as well as linkage-related information, that may not be additive at different levels of aggregation, especially in the case of MNEs. Furthermore, innovation activities can be part of complex global value chains that involve dispersed suppliers and production processes for goods and services, often located in different countries. Therefore, it is important to correctly identify whenever possible statistical units active in global value chains (see Chapter 7) in order to improve compatibility with other data sources (such as foreign investment and trade surveys).

Main economic activity

9.25. Enterprises should be classified according to their main economic activity using the most recent edition of the United Nation's (UN) International Standard Industrial Classification (ISIC Rev.4) (see UN, 2008) or equivalent regional/national classifications. ISIC supports international comparability by classifying industries into economic activities by section, division, group and class, though in most cases the target population can be defined using the section and division levels. The recommendations given below use the sections and divisions as defined in ISIC Rev.4. These should be updated with future revisions of ISIC.

9.26. When there is significant uncertainty about the true economic activity of firms (for instance if this information is not available from a business register, refers to non-official classifications or is likely to be out of date) innovation surveys can include a question on the main product lines produced by each firm and, if possible, questions on the relative importance of different types of product lines (for instance the contribution of different product categories to turnover). This information is required to assign an economic activity to the enterprise, both for stratification, sampling and analytical purposes.

9.27. As noted in Chapters 1 and 2, this manual recommends the collection of innovation data for businesses in most ISIC-defined industries, with some qualifying exceptions discussed below. Key considerations when defining the recommended scope of business innovation surveys by economic activity, especially for international comparison purposes, are the prevalence of non-business actors in an industry, the presence of specific measurement challenges such as unstable business registers, and previous international experience measuring innovation within an industry.

9.28. Table 9.1 provides the broad structure of industries by ISIC Rev.4 at the section and division level and identifies economic activities that are recommended for international comparisons, supplementary economic activities that may be worth including for national purposes, and economic activities that are not currently recommended for surveys of innovation in the Business sector.

9.29. The **recommended** economic activities for national data collection and for international comparisons include ISIC Rev.4 sections B to M inclusive with the exception of section I (Accommodation and food service activities). In these areas there is substantive national and international comparative experience with data collection.

9.30. **Supplementary** economic activities that are worth collecting, but are still largely untested from an international comparison perspective, include ISIC Rev.4 sections A (Agriculture, forestry and fishing), I (Accommodation and food services activities), N (Administrative and support activities), and divisions 95-96 of section S (Repair activities, other personal service activities). For these industries, the international standardisation of business registers is still incomplete (particularly for agriculture) and current experience is limited to surveys in only a few countries. Any ongoing efforts should provide better guidance for innovation measurement in the future.

Table 9.1. Economic activities for inclusion in international comparisons of business innovation

Based on UN ISIC Rev.4 sections and divisions

Section	Division	Description
Economic activities recommended for inclusion for international comparisons		
B	05-09	Mining and quarrying
C	10-33	Manufacturing
D	35	Electricity, gas, steam and air conditioning supply
E	36-39	Water supply; sewerage, waste management and remediation activities
F	41-43	Construction
G	45-47	Wholesale and retail trade; repair of motor vehicles and motorcycles
H	49-53	Transportation and storage
J	58-63	Information and communication
K	64-66	Financial and insurance activities
L	68	Real estate activities
M	69-75	Professional, scientific and technical activities
Supplementary economic activities for national data collections		
A	01-03	Agriculture, forestry and fishing
I	55-56	Accommodation and food service activities
N	77-82	Administrative and support service activities
S	95-96	Repair activities, other personal service activities
Economic activities not recommended for data collection		
O	84	Public administration and defence; compulsory social security
P	85	Education
Q	86-88	Human health and social work activities
R	90-93	Arts, entertainment and recreation
S	94	Membership organisations
Economic activities outside the scope of this manual		
T	97-98	Activities of households as employers; activities of households for own-use
U	99	Activities of extraterritorial organisations and bodies

9.31. A number of economic activities are *not generally recommended* for data collection by business innovation surveys and should be excluded from international comparisons of business innovation. From an international comparison perspective, sections O (Public administration), P (Education), Q (Human health and social work), R (Arts, entertainment and recreation) and division 94 of section S (Membership organisations) are not recommended for inclusion because of the dominant or large role of government or private non-profit institutions serving households in the provision of these services in many countries. However, there may be domestic policy demands for extending the coverage of national surveys to firms active in these areas, for example if a significant proportion of units active in this area in the country are business enterprises, or if such firms are entitled to receive public support for their innovation activities.

9.32. Other sections recommended for exclusion are dominated by actors engaged in non-market activities and therefore *outside the scope* of this manual, namely section T (Households) and section U (Extraterritorial bodies).

Unit size

9.33. Although innovation activity is generally more extensive and more frequently reported by larger firms, units of all sizes have the potential to be innovation-active and should be part of the scope of business innovation surveys. However, smaller business units, particularly those with higher degree of informality (e.g. not incorporated as companies, exempt from or not declaring some taxes, etc.), are more likely to be missing from statistical business registers. The relative importance of such units can be higher in countries in earlier stages of development. Comparing data for countries with different types of registers for small firms and with varying degrees of output being generated in the informal economy can therefore present challenges. An additional challenge, noted in Chapter 3, stems from adequately interpreting innovation data for recently created firms, for which a substantial number of activities can be deemed to be new to the firm.

9.34. Therefore, for international comparisons, it is recommended to limit the scope of the target population to comprise all statistical business units with *ten or more persons employed* and to use *average headcounts* for size categories. Depending on user interest and resources, surveys can also include units with fewer than ten persons employed, particularly in high technology and knowledge-intensive service industries. This group is likely to include start-ups and spin-offs of considerable policy interest (see Chapter 3).

9.2.3. Data linkage

9.35. An official business register is often used by NSOs to identify the sample for the innovation survey and for the R&D, ICT, and general business statistics surveys. This creates opportunities for linking the innovation survey with other surveys in order to obtain interval data on several variables of interest, such as on R&D, ICT, employment, turnover, exports or investments. Over the years, an increasing number of NSOs have used data linkage to partially eliminate the need to collect some types of data in the innovation survey, although data linkage is only possible when the surveys to be linked use the same statistical units, which for NSOs is usually the enterprise.

9.36. Data linkage can reduce respondent burden, resulting in higher response rates, and improve the quality of interval data that are obtained from mandatory R&D and business surveys. However, questions must be replicated in an innovation survey when respondents need a reference point for related questions, either to jog their memory or to provide a reference for calculating subcategories or shares. For example, questions on innovation expenditures should include a question on R&D expenditures for reference, and questions on the number (or share) of employees with different levels of educational attainment should follow a question on the total number of employees. Once the survey is completed, the innovation survey values for R&D, employment, or other variables can be replaced for some analyses by values from the R&D and business surveys, if analysis indicates that this will improve accuracy.

9.37. Another option created by the ability to combine administrative and survey data is to pre-fill online innovation questionnaires with data obtained from other sources on turnover, employment, R&D expenditures, patent applications, etc. These can provide immediate reference points for respondents and reduce response burden. A disadvantage is that pre-filled data could be out of date, although older data could still be useful for pre-filling data for the first year of the observation period. Respondents should also be given an option to correct errors in pre-filled data.

9.38. Linkage to structural business statistics data on economic variables after a suitable time lag (one or more years after the innovation survey) is useful for research to infer causal relationships between innovation activities and outcomes. Relevant outcomes include changes in productivity, employment, exports and revenue.

9.39. Selected innovation questions may be added occasionally to other surveys to assist in improving, updating and maintaining the innovation survey frame.

9.2.4. Frequency of data collection

9.40. The frequency of innovation surveys depends on practical considerations and user needs at the international, national and regional level. Considerations such as cost, the slow rate of change in many variables, the effect of frequent surveys on response burden, and problems due to overlapping observation periods between consecutive surveys influence the recommended frequency for innovation surveys. The importance of innovation for economic growth and well-being creates a policy demand for more frequent and up-to-date data collected on an annual basis, particularly for innovation activities that can change quickly. Annual panel surveys can also facilitate analysis of the lag structure between innovation inputs and outputs, or the effects of innovation on economic performance (see Chapter 11).

9.41. It is recommended to conduct innovation surveys every **one to three years**. For a frequency of two or three years, a shorter survey that only collects key innovation variables can be conducted in alternating years, resources permitting. However, caution is required when comparing the results of short and long surveys because responses can be affected by survey length (see section 9.3 below). Information on innovation can also be obtained from the Internet or other sources in years without an innovation survey. Options for using alternative sources of innovation data in non-survey years have yet to be investigated in detail.

9.2.5. Observation and reference periods

9.42. To ensure comparability among respondents, surveys must specify an observation period for questions on innovation. The observation period is the length of time covered by a majority of questions in a survey. In order to minimise recall bias, it is recommended that the observation period **should not exceed three years**. The reference period is the final year of the overall survey observation period and is used as the effective observation period for collecting interval level data items, such as expenditures or the number of employed persons. The reference and observation periods are identical in surveys that use a one-year observation period.

9.43. The length of the observation period qualifies the definition of innovation and therefore the share of units that are reported as innovative (see Chapter 3). For example, the choice of an observation period can affect comparisons between groups of units (e.g. industries) that produce goods or services with varying life cycles (industries with short product life cycles are more likely to introduce product innovations more frequently). This has implications for interpretability and raises the need for adequate standardisation across national surveys (see Chapter 11).

9.44. In some instances, interpretation issues favour a longer observation period. For example, if an innovation project runs over several years, a short observation period might result in assigning different innovation activities and outputs to different years, such as the use of co-operation, the receipt of public funding, and sales from new products. This could hamper some relevant analyses on innovation patterns and impacts.

9.45. Data quality concerns favour a shorter observation period in order to reduce recall errors. This applies for instance when respondents forget to report an event, or from telescoping errors when respondents falsely remember events that happened before the observation period as occurring during that period.

9.46. The quality advantages of short observation periods and the potential interpretation advantages of longer observation periods may be combined through the construction of a longitudinal panel linking firms in consecutive cross-sectional innovation surveys (see subsection 9.4.3 below). For example, if the underlying data have a one-year observation period, the innovation status of firms over a two- (three-) year period can be effectively calculated from data for firms with observations over two (or three) consecutive annual observation periods. Additional assumptions and efforts would be required to deal with instances where repeated observations are not available for all firms in the sample, for example due to attrition, or the use of sampling methods to reduce the burden on some types of respondents (e.g. SMEs). A strong argument in favour of a longitudinal panel survey design is that it enhances the range of possible analyses of causal relationships between innovation activities and outcomes (see subsection 9.4.3 below).

9.47. Observation periods that are longer than the frequency of data collection can affect comparisons of results from consecutive surveys. In such cases, it can be difficult to determine if changes in results over time are mainly due to innovation activities in the non-overlapping period or if they are influenced by activities in the period of overlap with the previous survey. Spurious serial correlation could therefore be introduced as a result.

9.48. At the time of publication of this manual, the observation period used by countries varies between one and three years. This reduces international comparability for key indicators such as the incidence of innovation and the rate of collaboration with other actors. Although there is currently no consensus on what should be the optimal length of the generic observation period (other than a three-year maximum limit), convergence towards a common observation period would considerably improve international comparability. It is therefore recommended to conduct, through concerted efforts, additional experimentation on the effects of different lengths for the observation period and the use of panel data to address interpretation issues. The results of these experiments would assist efforts to reach international agreement on the most appropriate length for the observation period.

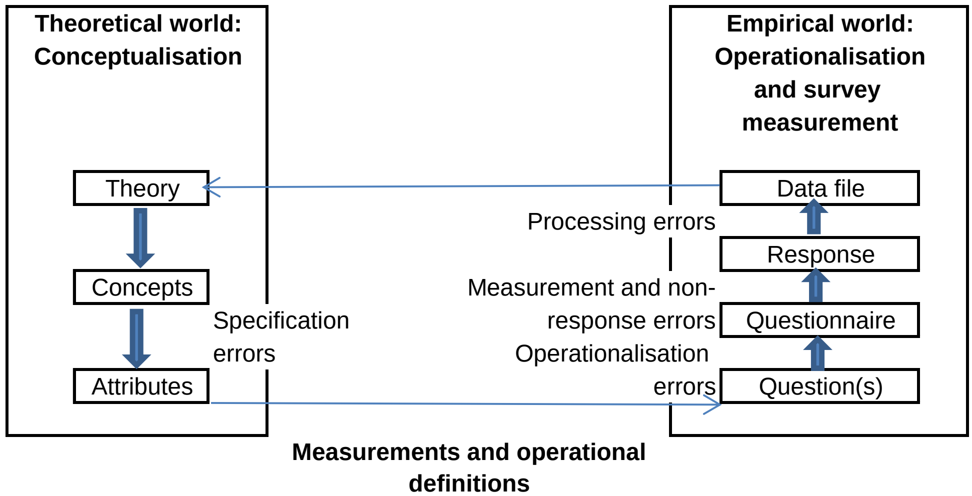
9.3. Question and questionnaire design

9.49. Chapters 3 to 8 of this manual identify different concepts and characteristics of business innovation for measurement. These need to be operationalised in the form of questions that create useful data for empirical analysis, as indicated in Figure 9.1.

9.50. The operationalisation of theoretical concepts can result in a number of possible errors that can be minimised through careful question and questionnaire design. This manual does not provide full examples of survey questions because the phrasing of final questions is likely to differ depending on contextual conditions that vary across and within countries. Instead, the following sections provide guidelines for best practice in the design of questions and the layout of the questionnaire. Good question design and questionnaire layout can improve data quality, increase response rates, and improve comparability across different survey methods (see subsection 9.5.4 below).

9.51. The design of individual questions and questionnaire layout are influenced by the ability to obtain data from other sources (which makes some questions unnecessary), and by the choice of survey method (see section 9.5 below). For example, grid or matrix questions are difficult and time-consuming when heard, as in telephone surveys, but are easily understood when presented visually, as in online and mailed questionnaire surveys. These differences in survey methods need to be taken into consideration when multiple methods are used.

Figure 9.1. From innovation theory to innovation data



Source: Based on Snijkers and Willimack (2011), "The missing link: From concepts to questions in economic surveys".

9.3.1. Question design

Question adaptation and translation

9.52. All questions need to be carefully adapted and translated to ensure that respondents interpret the questions as intended by the concepts and definitions in this manual. First, many concepts and definitions cannot be literally applied as questions. For example, more than one question could be required to obtain data that capture a single concept (see Chapter 3). Second, key terms must be adapted to match the language used by respondents in different cultural, regional and national contexts (Harkness et al. [eds.], 2010). For instance, Australia and Canada use the term "business" instead of "enterprise" because the latter is not part of common English usage in either country and is therefore open to misunderstanding. The words "enterprise" or "business" could also be confusing to respondents from establishments or KAUs.

9.53. Translation issues are particularly important for innovation surveys that cover multiple countries or countries with more than one language, since even minor differences between national questionnaires can reduce the comparability of the results. These differences can stem from translation, changes in the order of questions, or from adding or deleting categories or questions. Translation needs to take account of country-specific circumstances (such as a country's legal system and regulations) to avoid misunderstandings of concepts and definitions.

Question comprehension and quality

9.54. Questions need to be short, written in simple language, and unambiguous. It is important to eliminate repetition, such as when two questions ask for similar information, and to eliminate questions that ask for two or more information items (often identifiable by the use of "and" between two clauses). Wherever possible, concepts and definitions should be included in the questions because respondents often do not read supplementary information. The inclusion of explanatory information in footnotes or online hypertext links should be used as little as possible.

9.55. Data quality can be improved by reducing respondent fatigue and by maintaining a motivation to provide good answers. Both fatigue and motivation are influenced by question length, but motivation can be improved by questions that are relevant and interesting to the respondent. The latter is particularly important for respondents from non-innovative units, who need to find the questionnaire relevant and of interest, otherwise, they are less likely to respond. Therefore, all questions should ideally be relevant to all units in all industries (Tourangeau, Rips and Rasinski, 2000).

9.56. "Satisficing" refers to respondent behaviours to reduce the time and effort required to complete an online or printed questionnaire. These include abandoning the survey before it is completed (premature termination), skipping questions, non-differentiation (when respondents give the identical response category to all sub-questions in a question, for example answering "slightly important" to all sub-questions in a grid question), and speeding through the questionnaire (Barge and Gelbach, 2012; Downes-Le Guin et al., 2012). The main strategies for minimising satisficing are to ensure that the questions are of interest to all respondents and to minimise the length of the questionnaire. Non-differentiation can be reduced by limiting the number of sub-questions in a grid to no more than seven (Couper et al., 2013). Grid questions with more than seven sub-questions can be split into several subgroups. For instance, a grid question with ten sub-questions could be organised around one theme with six sub-questions, and a second theme with four.

Nominal and ordinal response categories

9.57. Qualitative questions can use nominal response categories ("yes or no") or ordinal ones such as an importance or frequency scale. Nominal response categories are simple and reliable, but provide only limited information; while ordinal response categories may introduce a degree of subjectivity. Both types of questions may require a "don't know" or "not applicable" response category.

9.3.2. Questionnaire design

9.58. The questionnaire should be as short as possible, logically structured, and have clear instructions. In voluntary surveys, unit response rates (the percentage of the sample that completes the questionnaire) decline with questionnaire length. The quality of responses can also decline for questions placed towards the end of a long questionnaire (Galesic and Bosnjak, 2009). Survey implementation factors that affect unit response rates are discussed in section 9.6 below.

9.59. Respondent comprehension and willingness to respond can be affected by the questionnaire layout, with best practices being similar between printed and online questionnaires. Skip routines or branching instructions on printed questionnaires need to be clearly visible. The layout needs to incorporate national preferences for font sizes and the amount of blank space on a page. Instructions should be repeated wherever applicable to improve the likelihood that respondents follow them.

Filters

9.60. Filters and skip instructions direct respondents to different parts of a questionnaire, depending on their answers to the filter questions. Filters can be helpful for reducing response burden, particularly in complex questionnaires. Conversely, filters can encourage satisficing behaviour whereby respondents answer "no" to a filter question to avoid completing additional questions.

9.61. The need for filters and skip instructions can be minimised, for instance by designing questions that can be answered by all units, regardless of their innovation status. This can provide additional information of value to policy and to data analysis. However, filters are necessary in some situations, such as when a series of questions are only relevant to respondents that report one or more product innovations.

9.62. The online format permits automatic skips as a result of a filter, raising concerns that respondents who reply to an online questionnaire could provide different results from those replying to a printed version which allows them to see skipped questions and change their mind if they decide that those skipped questions are relevant. When both online and printed questionnaires are used, the online version can use "greying" for skipped questions so that the questions are visible to respondents. This could improve comparability with the printed version. If paradata – i.e. the data about the process by which surveys are filled in – are collected in an online survey (see section 9.5 below), each respondent's path through the questionnaire can be evaluated to determine if greying has any effect on behaviour, for instance if respondents backtrack to change an earlier response.

Question order

9.63. A respondent's understanding of a question can be influenced by information obtained from questions placed earlier in the questionnaire. Adding or deleting a question can therefore influence subsequent answers and reduce comparability with previous surveys or with surveys conducted in other jurisdictions.

9.64. Questions on activities that are relevant to all units regardless of their innovation status should be placed before questions on innovation and exclude references to innovation. This applies to potential questions on business capabilities (see Chapter 5).

9.65. Wherever possible, questions should be arranged by theme so that questions on a similar topic are grouped together. For instance, questions on knowledge sourcing activities and collaboration for innovation should be co-located. Questions on the contribution of external actors to a specific type of innovation (product or business process) need to be located in the section relating to that type of innovation.

9.3.3. Short-form questionnaires

9.66. For many small units and units in sectors with little innovation activity, the response burden for a full innovation questionnaire can be high relative to their innovation activity, thereby reducing response rates. In such cases, shorter survey questionnaires that focus on a set of core questions could be useful. Short-form questionnaires can also be used to survey units that have not reported innovation activity in previous innovation surveys. However, empirical research for Belgium (Hoskens et al., 2016) and various developing countries (Cirera and Muzi, 2016) finds significant differences in the share of innovative firms among respondents to short and long questionnaires, with higher rates of innovative firms found for short questionnaires. These results suggest that comparisons of data on innovation from short-form and long-form questionnaires may reflect design factors that should be carefully taken into account.

9.3.4. Combining innovation and other business surveys

9.67. Several NSOs have combined their innovation surveys with other business surveys, in particular with R&D surveys, due to the conceptual and empirical proximity between R&D and innovation. In principle, various types of business surveys can be integrated with innovation surveys, for instance by combining questions on innovation with questions on business characteristics, ICT or knowledge management practices.

9.68. There are several advantages of combining surveys including:

- A combined survey can reduce the response burden for reporting units as long as the combined survey is shorter in length and less difficult than separate surveys due to avoiding repeated questions.
- A combined survey permits analyses of the relationship between innovation and other activities within the responding unit, for instance ICT use. This is advantageous if separate surveys cannot be linked or if the innovation survey and other surveys use different samples.
- A combined survey can reduce the printing and postage costs for questionnaires provided by mail and the follow-up costs for all types of surveys.

9.69. On the other hand, there are also disadvantages from combining surveys such as:

- Both the unit and item response rates can decline if the combined questionnaire is much longer than the length of the separate survey questionnaires. This is most likely to be a problem for voluntary surveys.
- If the topics are sufficiently distinct and relate to different functional areas within the business, several persons within an organisation, especially large ones, may need to be contacted in order to answer all questions.
- Combining an innovation and an R&D survey can result in errors in the interpretation of questions on innovation and R&D. Some respondents from units that do not perform R&D could incorrectly assume that innovation requires R&D, or that they are only being invited to report innovations based on R&D. This can lower the observed incidence of innovation, as reported in some countries that have experimented with combined R&D and innovation surveys (the observed incidence of R&D is not affected) (e.g. Wilhelmsen, 2012). In addition, some respondents could erroneously report innovation expenditures as R&D expenditures.
- The sampling frames for the innovation survey and other business surveys can differ. In the case of combining innovation and R&D surveys, the sample for innovation can include industries (and small units) that are not usually included in R&D surveys.

9.70. Based on the above considerations, the guidelines for combining an innovation survey with one or more other business surveys are as follows:

- A combined R&D and innovation survey needs to reduce the risk of conceptual confusion by non-R&D-performing units by using two distinct sections and by placing the innovation section first.
- Separate sections need to be used when combining innovation questions with other types of questions, such as on ICT or business characteristics. Questions that are relevant to all units should be placed before questions on innovation.
- A combined R&D and innovation survey can further reduce conceptual problems by ensuring that the R&D section is only sent to units that are likely to perform R&D.
- To avoid a decline in response rates, the length of a combined survey should be comparable to the summed length of the separate surveys, particularly for voluntary surveys.

- Care should be taken in comparisons of innovation results from combined surveys with the results from separate innovation surveys. Full details on the survey method should also be reported, including steps to reduce conceptual confusion.

9.71. Therefore, as a general rule, this manual recommends **not combining R&D and innovation surveys** because of the drawbacks mentioned earlier, for instance by suggesting to some respondents that innovation requires R&D. Although untested, it seems at this point that there could be fewer problems with combining an innovation survey with other types of surveys, such as surveys on business strategy or business characteristics.

9.3.5. Questionnaire testing

9.72. Innovation surveys undergo regular updates to adapt to known challenges and address emerging user needs. It is strongly recommended to subject all new questions and questionnaire layout features to cognitive testing in face-to-face interviews with respondents drawn from the survey target population.

9.73. Cognitive testing, developed by psychologists and survey researchers, collects verbal information on survey responses. It is used to evaluate the ability of a question (or group of questions) to measure constructs as intended by the researcher and if respondents can provide reasonably accurate responses. The evidence collected through cognitive interviews is used to improve questions before sending the survey questionnaire to the full sample (Galindo-Rueda and Van Cruysen, 2016). Cognitive testing is not required for questions and layout features that have previously undergone testing, unless they were tested in a different language or country. Descriptions of the cognitive testing method are provided by Willis (2015, 2005).

9.74. Respondents do not need to be selected randomly for cognitive testing, but a minimum of two respondents should be drawn from each possible combination of the following three subgroups of the target population: non-innovative and innovative units, service and manufacturing units, and units from two size classes: small/medium (10 to 249 employees) and large (250+ employees). This results in 16 respondents in total. Two (or more) rounds of cognitive testing may be required, with the second round testing revisions to questions made after the first round of testing.

9.75. In addition to cognitive testing, a pilot survey of a randomly drawn sample from the target population is recommended when substantial changes are made to a questionnaire, such as the addition of a large number of new questions, or new questions combined with a major revision to the layout of the questionnaire. Pilot surveys can help optimise the flow of the questions in the questionnaire and provide useful information on item non-response rates, logical inconsistencies, and the variance of specific variables, which is useful for deciding on sample sizes (see also subsection 9.4.2 below).

9.4. Sampling

9.4.1. The survey frame

9.76. The units in a survey sample or census are drawn from the frame population. When preparing a survey, the intended target population (for instance all enterprises with ten or more employed persons) and the frame population should be as close as possible. In practice, the frame population can differ from the target population. The frame population (such as a business register) could include units that no longer exist or no longer belong to the target population, and miss units that belong to the target population due to delays in updating the register. The latter can fail to identify small firms with rapid employment growth.

9.77. The frame population should be based on the reference year of the innovation survey. Changes to units during the reference period can affect the frame population, including changes in industrial classifications (ISIC codes), new units created during the period, mergers, splits of units, and units that ceased activities during the reference year.

9.78. NSOs generally draw on an up-to-date official business register, established for statistical purposes, to construct the sample frame. Other organisations interested in conducting innovation surveys may not have access to this business register. The alternative is to use privately maintained business registers, but these are often less up to date than the official business register and can therefore contain errors in the assigned ISIC industry and number of employed persons. The representativeness of private registers can also be reduced if the data depend on firms responding to a questionnaire, or if the register does not collect data for some industries. When an official business register is not used to construct the sampling frame, survey questionnaires should always include questions to verify the size and sector of the responding unit. Units that do not meet the requirements for the sample should be excluded during data editing.

9.4.2. Census versus sample

9.79. While a census will generate more precise data than a sample, it is generally neither possible nor desirable to sample the entire target population, and a well-designed sample is often more efficient than a census for data collection. Samples should always use probability sampling (with known probabilities) to select the units to be surveyed.

9.80. A census may be needed due to legal requirements or when the frame population in a sampling stratum is small. In small countries or in specific sectors, adequate sampling can produce sample sizes for some strata that are close in size to the frame population. In this case using a census for the strata will provide better results at little additional cost. A census can also be used for strata of high policy relevance, such as for large units responsible for a large majority of a country’s R&D expenditures or for priority industries. A common approach is to sample SMEs and use a census for large firms.

Stratified sampling

9.81. A simple random sample (one sampling fraction for all sampled units of a target population) is an inefficient method of estimating the value of a variable within a desired confidence level for all strata because a large sample will be necessary to provide sufficient sampling power for strata with only a few units or where variables of interest are less prevalent. It is therefore more efficient to use different sampling fractions for strata that are determined by unit size and economic activity.

9.82. The optimal sample size for stratified sample surveys depends on the desired level of precision in the estimates and the extent to which individual variables will be combined in tabulated results. The sample size should also be adjusted to reflect the expected survey non-response rate, the expected misclassification rate for units, and other deficiencies in the survey frame used for sampling.

9.83. The target sample size can be calculated using a target precision or confidence level and data on the number of units, the size of the units and the variability of the main variables of interest for the stratum. The variance of each variable can be estimated from previous surveys or, for new variables, from the results of a pilot survey. In general, the necessary sample fraction will decrease with the number of units in the population, increase with the size of the units and the variability of the population value, and increase with the expected non-response rate.

9.84. It is recommended to use higher sampling fractions for heterogeneous strata (high variability in variables of interest) and for smaller ones. The sampling fractions should be 100% in strata with only a few units, for instance when there are only a few large units in an industry or region. The size of the units could also be taken into consideration by using the probability proportional to size (pps) sampling approach, which reduces the sampling fractions in strata with smaller units. Alternatively, the units in each stratum can be sorted by size or turnover and sampled systematically. Different sampling methods can be used for different strata.

9.85. Stratification of the population should produce strata that are as homogeneous as possible in terms of innovation activities. Given that the innovation activities of units differ substantially by industry and unit size, it is recommended to use principal economic activity and size to construct strata. In addition, stratification by region can be required to meet policy needs. The potential need for age-based strata should also be explored.

9.86. The recommended size strata by persons employed are as follows:

- small units: 10 to 49
- medium units: 50 to 249
- large units: 250+.

9.87. Depending on national characteristics, strata for units with less than 10, and 500 or more persons employed can also be constructed, but international comparability requires the ability to accurately replicate the above three size strata.

9.88. The stratification of units by main economic activity should be based on the most recent ISIC or nationally equivalent industrial classifications. The optimal classification level (section, division, group or class) largely depends on national circumstances that influence the degree of precision required for reporting. For example, an economy specialised in wood production would benefit from a separate stratum for this activity (division 16 of section C, ISIC Rev.4), whereas a country where policy is targeting tourism for growth might create separate strata for division 55 (Accommodation) of section I, for division 56 (Food services) of section I, and for section R (Arts, entertainment and recreation). Sampling strata should not be over-aggregated because this reduces homogeneity within each stratum.

Domains (sub-populations of high interest)

9.89. Subsets of the target population can be of special interest to data users, or users may need detailed information at industry or regional levels. These subsets are called domains (or sub-populations). To get representative results, each domain must be a subset of the sampling strata. The most frequent approach is to use a high sampling fraction to produce reliable results for the domains. Additionally, establishing domains can allow for the co-ordination of different business surveys, as well as for comparisons over time between units with similar characteristics. Potential sub-populations for consideration include industry groupings, size classes, the region where the unit is located (state, province, local government area, municipality, metropolitan area etc.), R&D-performing units, and enterprise age. Stratification by age can be useful for research on young, innovative enterprises.

9.90. Relevant preliminary data on domains can be acquired outside of representative surveys run by NSOs, for instance by academics, consultancies or other organisations using surveys or other methods described in the introduction. Academic surveys of start-ups or other domains can produce good results or useful experiments in data collection, as long as they follow good practice research methods.

9.4.3. Longitudinal panel data and cross-sectional surveys

9.91. As previously noted, innovation surveys are commonly based on repeated cross-sections, where a new random sample is drawn from a given population for each innovation survey. Cross-sectional innovation surveys can be designed in the form of a longitudinal panel that samples a subset of units over two or more iterations of the survey, using a core set of identical questions. Non-core questions can differ over consecutive surveys.

9.92. Longitudinal panel data allow research on changes in innovation activities at the microeconomic level over time and facilitate research aimed at inferring causal relationships between innovation activities and economic outcomes, such as the share of sales due to innovation (see Chapter 8), by incorporating the time lag between innovation and its outcomes.

9.93. A number of procedures should be carefully followed when constructing a panel survey:

- Panel units should be integrated within the full-scale cross-sectional survey in order to reduce response burden, maintain an acceptable level of consistency between the results from the two surveys, and collect good quality cross-sectional data for constructing indicators. A panel does not replace the need for a cross-sectional survey.
- Analysis should ensure that the inclusion of results from the panel does not bias or otherwise distort the results of the main cross-sectional survey.
- Panel samples need to be updated on a regular basis to adjust for new entries as well as panel mortality (closure of units, units moving out of the target population) and respondent fatigue. Sample updating should follow the same stratification procedure as the original panel sample.

9.5. Data collection methods

9.94. Four main methods can be used to conduct surveys: online, postal, computer-assisted telephone interviewing (CATI), and computer-assisted personal interviewing (CAPI or face-to-face interviewing). Online and postal surveys rely on the respondent reading the questionnaire, with a visual interface that is influenced by the questionnaire layout. CATI and face-to-face surveys are aural, with the questions read out to the respondent, although a face-to-face interviewer can provide printed questions to a respondent if needed.

9.95. The last decade has seen a shift from postal to online surveys in many countries. Most countries that use an online format as their primary survey method also provide a printed questionnaire as an alternative, offered either as a downloadable file (via a link in an e-mail or on the survey site) or via the post.

9.96. The choice of which survey method to use depends on costs and potential differences in response rates and data quality. Recent experimental research has found few significant differences in either the quality of responses or in response rates, between printed and online surveys (Saunders, 2012). However, this research has mostly focused on households and has rarely evaluated surveys of business managers. Research on different survey methods, particularly in comparison to online formats, is almost entirely based on surveys of university students or participants in commercial web panels. It would therefore be helpful to have more research on the effects of different methods for business surveys.

9.5.1. Postal surveys

9.97. For postal surveys, a printed questionnaire is mailed to respondents along with a self-addressed postage paid envelope which they can use to return the survey. A best practice protocol consists of posting a cover letter and a printed copy of the questionnaire to the respondent, followed by two or three mailed follow-up reminders to non-respondents and telephone reminders if needed.

9.98. Postal surveys make it easy for respondents to quickly view the entire questionnaire to assess its length, question topics, and its relevance. If necessary, a printed questionnaire can be easily shared among more than one respondent, for instance if a separate person from accounting is required to complete the section on innovation expenditures (see section 9.6 below on multiple respondents). A printed questionnaire with filter questions requires that respondents carefully follow instructions on which question to answer next.

9.5.2. Online surveys

9.99. The best practice protocol for an online survey is to provide an introductory letter by post that explains the purpose of the survey, followed by an e-mail with a clickable link to the survey. Access should require a secure identifier and password and use up-to-date security methods. Follow-up consists of two or three e-mailed or posted reminders to non-respondents, plus telephone reminders if needed.

9.100. Online questionnaires can be shared, if necessary, among several respondents if the initial respondent provides the username and password to others (see section 9.6).

9.101. Online surveys have several advantages over postal surveys in terms of data quality and costs:

- The software can notify respondents through a pop-up box if a question is not completed or contains an error, for instance if a value exceeds the expected maximum or if percentages exceed 100%. With a postal survey, respondents need to be contacted by telephone to correct errors, which may not occur until several weeks after the respondent completed the questionnaire. Due to the cost of follow-up, missing values in a postal survey are often corrected post-survey through imputation.
- Pop-up text boxes, placed adjacent to the relevant question, can be used to add additional information, although respondents rarely use this feature.
- Respondents cannot see all questions in an online survey and consequently are less likely than respondents to a printed questionnaire to use a "no" response option to avoid answering follow-on questions. An online survey can therefore reduce false negatives.
- Survey costs are reduced compared to other survey methods because there is less need to contact respondents to correct some types of errors, data are automatically entered into a data file, data editing requirements are lower than in other methods, and there are reduced mailing and printing costs.

9.102. The main disadvantage of an online survey compared to other survey methods is that some respondents may be unable to or refuse to complete an online form. In this case an alternative survey method is required (see subsection 9.5.4 below). The online system may also need to be designed so that different persons within a unit can reply to different sections of the survey.

Collecting paradata in online surveys

9.103. Online survey software offers the ability to collect paradata on keystrokes and mouse clicks (for instance to determine if help menus have been accessed) and response time data, such as the time required to respond to specific questions, sections, or to the entire survey (Olson and Parkhurst, 2013). Paradata can be analysed to identify best practices that minimise undesirable respondent behaviour such as premature termination or satisficing, questions that are difficult for respondents to understand (for instance if question response times are considerably longer than the average for a question of similar type), and if late respondents are more likely than early ones to speed through a questionnaire, thereby reducing data quality (Belfo and Sousa, 2011; Fan and Yan, 2010; Revilla and Ochoa, 2015).

9.104. It is recommended to **collect paradata when using online surveys** in order to identify issues with question design and questionnaire layout.

9.5.3. Telephone and face-to-face interviews

9.105. Telephone and face-to-face surveys use computer-assisted data capture systems. Both methods require questions to be heard, which can require changes to question formats compared to visual survey methods. Interviewers must be trained in interview techniques and how to answer questions from the respondent, so that the respondent's answers are not biased through interactions with the interviewer. For both formats, filters are automatic and the respondent does not hear skipped questions, although interviewers can probe for additional information to ensure that a "no" or "yes" response is accurate.

9.106. The CATI method has a speed advantage compared to other methods, with results obtainable in a few weeks. Both CATI and CAPI can reduce errors and missing values, as with online surveys. Their main disadvantage, compared to an online survey, is higher costs due to the need for trained interviewers. Secondly, compared to both online and postal surveys, CATI and CAPI methods are unsuited for collecting quantitative data that require the respondent to search records for the answer.

9.107. The main reason for using the CAPI format is to obtain high response rates. This can occur in cultures where face-to-face interviews are necessary to show respect to the respondent and in areas where online or postal surveys are unreliable.

9.5.4. Combined survey methods

9.108. The use of more than one survey method can significantly increase response rates (Millar and Dillman, 2011). Where possible, surveys should combine complementary survey methods that are either visual (printed or on line) or aural (CATI or face-to-face) because of differences by survey methods in how respondents reply to questions. Telephone surveys can also elicit higher scores than online or mailed surveys on socially desirable questions (Zhang et al., 2017). As innovation is considered socially desirable, this could result in higher rates of innovation reported to CATI surveys compared to printed or online surveys. Possible survey method effects should be assessed when compiling indicators and comparing results across countries that use different survey methods.

9.6. Survey protocol

9.109. The survey protocol consists of all activities to implement the questionnaire, including contacting respondents, obtaining completed questionnaires, and following up with non-respondents. The protocol should be decided in advance and designed to ensure that all respondents have an equal chance of replying to the questionnaire, since the goal is to maximise the response rate. Nonetheless, the optimum survey protocol is likely to vary by country.

9.6.1. Respondent identification

9.110. Choosing a suitable respondent (or department within a large firm) is particularly important in innovation surveys because the questions are specialised and can be answered by only a few people, who are rarely the same as the person who completes other statistical questionnaires. In small units, managing directors are often good respondents. As much as possible, knowledgeable respondents should be selected to minimise the physical or virtual "travel" of a questionnaire to multiple people within a firm. Travel increases the probability that the questionnaire is lost, misplaced or that no one takes responsibility for its completion. In large units where no single individual is likely to be able to respond to all questions, some travel will be inevitable. However, a single, identified contact person or department should be responsible for co-ordinating questionnaire completion.

9.6.2. Support for respondents

9.111. Innovation surveys contain terms and questions that some respondents may not fully understand. Survey managers need to train personnel to answer potential questions and provide them with a list of basic definitions and explanations of questions.

9.6.3. Mandatory and voluntary surveys

9.112. Completion of innovation surveys can be either voluntary or mandatory, with varying degrees of enforcement. Higher non-response rates are expected for voluntary surveys and are likely to increase with questionnaire length. Sampling fractions can be increased to account for expected non-response rates, but this will not solve potential bias due to differences in the characteristics of non-respondent and respondent units that are correlated with survey questions. Reducing bias requires maximising response rates and representativeness (see below).

9.113. Whether a survey is voluntary or mandatory can also affect results. For example, the calculated share of innovative firms in a voluntary survey will be biased upwards if managers from non-innovative firms are less likely to respond than the managers of innovative firms (Wilhelmsen, 2012).

9.6.4. Non-response

9.114. Unit non-response occurs when a sampled unit does not reply at all. This can occur if the surveying institute cannot reach the reporting unit or if the reporting unit refuses to answer. Item non-response refers to the response rate to a specific question and is equal to the percentage of missing answers among the responding units. Item non-response rates are frequently higher for quantitative questions than for questions using nominal or ordinal response categories.

9.115. Unit and item non-response are only minor issues if missing responses are randomly distributed over all units sampled and over all questions. When unit non-responses are random, statistical power can be maintained by increasing the sampling fraction. When item non-responses are random, simple weighting methods can be used to estimate the population value of a variable. However, both types of non-response can be subject to bias. For example, managers from non-innovative units could be less likely to reply because they find the questionnaire of little relevance, resulting in an overestimate of the share of innovative units in the population. Or, managers of innovative units could be less likely to reply due to time constraints.

Improving response rates

9.116. Achieving high response rates, particularly in voluntary surveys, can be supported by good question and questionnaire design (see section 9.3) as well as good survey protocols. Two aspects of the survey protocol can have a large positive effect on response rates: (i) good follow-up with multiple reminders to non-respondents; and (ii) the personalisation of all contacts, such as using the respondent's name and changing the wording of reminder e-mails. Personalisation includes sending a first contact letter by post, which can significantly increase response rates in comparison to a first contact via e-mail (Dykema et al., 2013). Clearly communicating the purpose and use of the survey data is critical for generating trust and participation. Participation can be further enhanced if managers anticipate direct benefits for their business from providing truthful and carefully thought-out answers.

Managing low unit response rates

9.117. There are no clear boundaries for high, moderate and low unit response rates. The rule of thumb is that high response rates exceed 70% or 80%, moderate response rates are between 50% and 70% or 80%, and low response rates are below 50%.

9.118. Unless the response rate is very high (above 95%), differences between respondents and non-respondents should be compared using stratification variables such as unit size or industry. If the response rate is high and there are no significant differences by stratification variables, population weighting can be calculated on the basis of the units that replied. This procedure assumes that the innovation behaviour of responding and non-responding units conditional on these characteristics is identical. Challenges can arise when behaviour is very heterogeneous within strata (e.g. between large and very large firms).

9.119. If the response rate is moderate or low, it is recommended to conduct a non-response survey (see subsection 9.6.5 below).

9.120. If the unit response rate is very low (below 20%), a non-response survey may be insufficient for correcting for potential bias, unless it is of very high quality and covers a large share of non-responding units. The data can be analysed to determine if response rates are acceptable in some strata and to conduct a non-response survey for those strata. Otherwise, the results should not be used to estimate the characteristics of the target population because of the high possibility of biased results. It is possible to use the data to investigate patterns in how variables are correlated, as long as the results are not generalised to the target population.

9.6.5. Conducting non-response surveys

9.121. Many NSOs have their own regulations for when a non-response survey is necessary. Otherwise, a non-response survey is recommended when the unit non-response rate in a stratum exceeds 30%. The non-response survey should sample a minimum of 10% of non-respondents (more for small surveys or for strata with a low population count).

9.122. The objective of the non-response survey is to identify significant differences between responding and non-responding units in innovation activities. To improve future surveys, it is possible to obtain information on why non-respondent units did not answer. In the ideal case, the unit response rate for the non-response survey is sufficiently high and replies are sufficiently reliable to be useful for adjusting population weightings. However, survey method effects in the non-response survey (different survey methods or questionnaires compared to the main survey) should also be considered when adjusting population weights.

9.123. The non-response survey questionnaire must be short (no more than one printed page) and take no more than two to three minutes to complete. The key questions should replicate, word for word, "yes or no" questions in the main survey on innovation outputs (product innovations and business process innovations) and for some of the innovation activities (for instance R&D, engineering, design and other creative work activities, etc.). If not available from other sources, the non-response survey needs to include questions on the unit's economic activity and size.

9.124. Non-response surveys are usually conducted by CATI, which provides the advantage of speed and can obtain high response rates for a short questionnaire, as long as all firms in the sample have a working contact telephone number. The disadvantage of a CATI survey as a follow-up to a postal or online survey is that short telephone surveys in some countries could be more likely than the original survey to elicit positive responses for questions on innovation activities and outputs. The experience in this regard has been mixed, with different countries obtaining different results. More experimental research on the comparability of business survey methods is recommended.

9.7. Post-survey data processing

9.125. Data processing involves checks for errors, imputation of missing values and the calculation of weighting coefficients.

9.7.1. Error checks

9.126. As noted in subsections 9.5.2 and 9.5.3 above, the use of online, CATI and CAPI survey methods can automatically identify potential errors and request a correction from respondents. All of the following types of error checks are required for printed questionnaires, but only the check for out of scope units might be required for an online survey. When errors are identified, the respondent or reporting unit should be contacted as soon as possible to request a correction.

Out of scope units

9.127. Responses can be obtained from out of scope units that do not belong to the target population, such as a unit that is below the minimum number of persons employed, a unit that is not owned by a business, or a unit in an excluded ISIC category. Responses from these units must be excluded from further analysis.

Data validation checks

9.128. These procedures test whether answers are permissible. For example, a permissible value for a percentage is between 0 and 100.

9.129. An additional check for data quality should be applied to ratio and interval level data, particularly for innovation expenditures. Current best practice is to compare interval level data against other available sources (for instance for R&D expenditures and for expenditures on capital equipment). In addition, estimates of the innovation sales share and other interval level data should be checked for outliers or other unexpected values. These methods are particularly important for large units that account for a high share of total reported R&D and innovation expenditures.

Relational checks

9.130. These evaluate the relationship between two variables and can identify hard and soft errors. Hard errors occur when a relationship must be wrong, for instance if percentages do not sum to 100% or if the number of reported persons employed with a tertiary education exceeds the total reported number of persons employed. Other relational checks identify soft errors where a response could be wrong. For instance, a unit with ten persons employed could report EUR 10 million of innovation expenditures. This is possible, but unlikely.

Routing error checks

9.131. These checks test whether all questions that should have been answered have been answered, i.e. respondents from innovation-active units answered all questions on innovation expenditures. An error indicates that the respondent did not understand or follow the filtering instructions.

9.7.2. Imputation of missing data

9.132. Another type of error is when a respondent fails to answer a question, for instance several sub-questions in a grid question are left blank, either intentionally or accidentally. Respondents can also refuse to answer a question if they find that none of the response categories are appropriate or if they don't know the answer and a "don't know" option is not provided. Online survey software can force the respondent to reply, but this is not recommended for voluntary surveys because it may cause the respondent to abandon the questionnaire.

9.133. To reduce costs and response burden, missing values can in some cases be imputed through the use of additional information, instead of re-contacting the respondent. The use of additional information should provide a more accurate estimate of missing values than simply using the mean observed value in a stratum. Imputed values should always be flagged to prevent their possible use as dependent values in multivariate analyses to avoid biased coefficients.

9.134. Cold-deck imputation techniques estimate missing values using data in other statistical surveys (including previous surveys) or from other related sources. For instance, data on the number of employees with a tertiary education could be available in a separate survey for similar types of units.

9.135. Hot-deck imputation uses other data from the innovation survey to impute some missing values. The choice of which hot-deck method to use depends on the measurement level for the variable. Interval level data can be imputed either by using the mean value of the variable in the responding unit's stratum, or by using regression to predict the value of the interval level variable. In the latter case, the results need to be checked to identify non-credible estimated values, such as negative values.

9.136. Nearest-neighbour techniques can be used to impute missing nominal and ordinal level values. This technique uses data from clean records (a donor case with a record not violating any error check), in order to replace the missing value with the value in the donor record. The donors are chosen on the basis of similar stratification variables and for maximum comparability on related variables. For example, the donor for a missing ordinal variable on collaboration partners should be as similar as possible for related variables on information sources.

9.7.3. Calculating weights

9.137. The results of sample surveys need to be weighted to provide estimates that are representative of the target population. There are various methods for weighting sampling results. The simplest is weighting by the reciprocal (inverse) of the sampling fractions of the stratum for each sampled unit, corrected by the unit non-response for each stratum, which gives the realised sample. For instance, if the sampling fraction is 10/100, but 10% of the sampled units did not respond, the corrected sampling fraction is 9/100. This procedure assumes that the distribution of innovation activities among responding and non-responding units is identical. This assumption can be tested through a non-response analysis, and even if the assumption is wrong, the bias introduced can be disregarded if the fraction of non-responding units is fairly small.

9.138. Not all sample surveys use stratification – a census by definition is not stratified. For a non-stratified survey, weighting should use the reciprocal of the overall sampling fraction, adjusted for the reciprocal of the total response rate. For a census, strata can be constructed post-survey to identify non-response rates in strata defined by firm size, sector, region etc. Census weighting variables can be constructed from the reciprocal of the strata response rates.

9.139. The final weighting factors should be further corrected if a non-response survey identifies statistically significant differences between the original survey respondents and the respondents to the non-response survey, for instance if a lower percentage of non-innovative units replied to the full survey compared to the non-respondent survey. One approach is to divide each stratum into a number of response homogeneity groups (RHGs) with (assumed) equal response probabilities within groups. RHGs can be determined using the results of the non-response survey. A second approach is to use auxiliary information at the estimation stage for reducing the non-response bias or two-phase sampling estimation methods. In the latter case, the sample is split by the phenomenon for which a likely non-response bias has been investigated (e.g. innovative versus non-innovative firms) and weighting factors are calculated separately for each group. In a second step, weighting factors are adjusted by a non-response correction factor that represents the bias between responding and non-responding firms with respect to the investigated phenomenon.

9.140. The weights can be further refined by calibration if the frame population includes some quantitative or qualitative information on all units, such as number of employees, turnover, legal status or region. The calibration ensures that the weighted sample sums to the total population or distribution for the frame variables and can increase precision and reduce bias. Effective calibration software, in particular CLAN from Statistics Sweden, CALMAR from the French National Statistical Insitute (INSEE) in France, and G-Est from Statistics Canada, are available for use by other countries. Many of the software packages used for calculating weights can also calculate measures of sampling variability.

9.8. Publication and dissemination of results

9.141. Innovation surveys are used to produce tables of innovation statistics and indicators and in econometric analyses of a variety of topics concerning innovation. The production of statistics and indicators requires using population weights to produce representative results for the target population. Most innovation surveys use a probability sample for many strata. Surveys can create two types of errors for indicators: random errors due to the random process used to select the units, and systematic errors containing all non-random errors (bias). The probability of random errors should be provided with the results by including the confidence intervals, standard errors and coefficients of variation where applicable. Confidence limits span the true but unknown values in the survey population with a given probability. If possible, data quality reports should also provide an evaluation of non-random errors.

9.8.1. Metadata and quality reports

9.142. The presentation of statistics and indicators should contain metadata, including information on the procedure used to collect data, sampling methods, procedures for dealing with non-response, and quality indicators. This will allow users to better interpret the data and judge its quality. International organisations should continue to provide detailed information about the common and idiosyncratic methodologies adopted by countries covered in their databases and reports.

9.8.2. Data access

9.143. Descriptive data can be provided through press releases, tables, databases and reports. Econometric analysis of innovation survey data is of considerable value to policy development (see section 11.5), but this is not the main task of NSOs. In-house econometric analyses by NSOs can be supplemented at low cost by providing researchers with access to innovation survey microdata. This requires maintaining confidentiality, either through the provision of a safe centre for data access by external academics or through the construction of anonymised data sets.

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Chapter 10. The object method for innovation measurement

This chapter provides guidance on collecting data on innovation from an object-based perspective. The object-based method collects data on a single, focal, most important innovation, facilitating information retrieval about enablers, features and outcomes of business innovations. Although the method can also be applied to unconventional data sources, this chapter describes how to implement the object approach within subject-based innovation surveys that cover the full range of innovation activities and innovations of the firm. Because focal innovations are not representative of the business as a whole, the main purpose of the object approach is to collect data for analytical and research purposes. The method can also be used to assess whether innovation is over- or under-reported by business respondents.

10.1. Introduction

10.1. The ***object*** approach to innovation measurement collects data on a single, “focal” innovation (the object of the study), in contrast to the ***subject*** approach, which focuses on the firm and collects data on all its innovation activities (the subject) (see Chapter 2). The main purpose of the object approach is not to produce aggregate innovation statistics but to collect data for analytical and research purposes. The method can also provide useful information for quality assurance purposes on how respondents interpret questions on innovation and whether they over-, under- or misreport innovation.

10.2. The object method can identify focal innovations through expert evaluations, or through announcements of innovations in trade publications (Kleinknecht and Reijnen, 1993; Santarelli and Piergiovanni, 1996; Townsend, 1981) or online sources (company websites, reports, investor announcements, etc.). An alternative method of using the object method is to incorporate the object approach within a subject-based innovation survey. In addition to questions on all of the firm’s innovation activities, a module of questions can focus on a single innovation. DeBresson and Murray (1984) were the first to use a version of this method as part of an innovation survey in Canada. More recently, this approach has been used in business enterprise surveys, for instance by Statistics Canada and the Japanese Statistical Office, academic researchers in Australia (O’Brien et al., 2015, 2014) and the United States (Arora, Cohen and Walsh, 2016), and in surveys of innovation in the Government sector (Arundel et al., 2016).

10.3. The inclusion of the object method within a subject-based innovation survey has several advantages over the use of experts or announcements to identify focal innovations. First, it can obtain information on a focal innovation for a representative sample of all innovative firms, whereas other methods will be prone to self-selection biases. Second, it can collect data on all types of innovations. Using experts or announcements to identify innovations will produce a bias towards successful product innovations. Third, it can collect information on innovations that are new to the firm only, or not sufficiently novel to be reported on line or in trade journals. It is therefore recommended, where cost-effective, to collect data on a focal innovation through representative surveys.

10.2. Including an “object module” in an innovation survey

10.4. In the survey context, there are several advantages of collecting data on a focal innovation in addition to data on all of the innovation activities of a firm. First, the inclusion of an object method module in an innovation survey can support the use of in-depth, quantitative and interval level questions that are too difficult for respondents to answer for all their innovations combined, for instance questions that require respondents to calculate the average importance of a variable across multiple innovations or innovation activities. Potentially difficult questions include expenditures on different innovation activities and the use of specific technical capabilities. Other difficult questions are those that require respondents to construct an “average” representation across the entire firm, such as questions on the importance of different knowledge sources, obstacles and outcomes.

10.5. Second, the use of questions on a single focal innovation ensures that the set of data collected refer to the same innovation. This is primarily an advantage for analyses on the relationships between innovation inputs, activities and outcomes, as in the research by Arora, Cohen and Walsh (2016) on the economic value of alternative knowledge sources for innovation. It can also assist other types of research, such as an evaluation of how respondents understand innovation survey questions (Arundel, O’Brien and Torugsa, 2013), and research into blended innovations that span both product and business processes (Bloch and Bugge, 2016), including changes to business models.

10.6. Nonetheless, it is not recommended to only include object-based questions in an innovation survey, or to allot a significant percentage of survey questions to an object module. Many research and policy questions cannot be addressed through questions on a focal innovation. These include questions that are relevant to the firm as a whole, such as questions on the firm's internal capabilities and strategies (see Chapter 5) and external environment (see Chapter 7), as well as questions that are used to create aggregate indicators for all innovation activities, such as data on innovation expenditures (see Chapter 4) or the innovation sales share (see Chapter 8).

10.7. The object method is seldom useful for constructing simple statistics and indicators at the national or industry level because the answers do not fully reflect the overall innovation inputs, outputs and outcomes of an economy or industry. Furthermore, the focal innovation is unlikely to be representative of all of the responding firm's own innovations or innovation activities. Data for a firm's most important innovation should therefore not be used to produce indicators that require data for all of a firm's innovations, such as total expenditures for specific innovation activities, the importance of different types of knowledge sources for innovation, or the frequency of collaboration with different types of partners.

10.8. Many of the guidelines in this manual for collecting data on innovation at the subject level can be directly applied to collecting data at the object level. There are no additional methodological limitations to including an object-based module in a subject-based innovation survey.

10.2.1. Identifying a focal innovation within surveys

10.9. An object module must include an initial prompt that asks respondents from innovative firms to think of a single innovation and limit all subsequent questions in the module to this innovation. Respondents from firms that are innovation-active, but with no innovations in the observation period, can be also asked to think about a single innovation project. As a device to ensure that the responses are focused on the innovation, it is helpful to ask the respondent, in an open question, to provide a short description of the innovation.

10.10. It is recommended to ask respondents to select a focal innovation that was introduced or implemented during the observation period. This ensures that other data from an innovation survey on the general capabilities or strategies of the firm are relevant to the focal innovation and that data on the focal innovation can be linked to outcome data from other surveys with a known time lag interval. It also reduces recall biases for innovations that occurred before the observation period (see Chapter 9). However, respondents should be permitted in their responses to include activities, where relevant, that occurred before the start of the observation period, such as collaboration with specific types of partners or the receipt of government subsidies for the innovation.

10.11. The questionnaire should also provide guidance for the choice of a focal innovation (or innovation project) to improve comparability between respondents. Possible options include:

- the most important innovation with respect to its actual or expected contributions to the firm's economic performance
- the innovation with the highest share of total innovation expenditures invested in its development
- the product innovation with the greatest actual or expected contribution to sales
- the business process innovation with the greatest actual or expected contribution to reducing costs
- the most recent innovation.

10.12. The first option has several advantages. The question is usually well understood by respondents and the innovation is memorable, which ensures that respondents can answer questions about it. In addition, the most important innovation is relevant to many areas of research, such as on the factors that lead to success. Leaving the first option open to all types of innovations can collect useful data on the types of innovations that firms find important. It can also identify innovation inputs that are likely to be of high value to a firm. For instance, a respondent could give a moderate importance ranking to universities as a source of knowledge for all innovation activities, but the use of this source for its most important innovation would indicate that the value of knowledge from universities could vary by the type of innovation.

10.13. The second option requires respondents to have a good knowledge of the development cost for different innovations. The third and fourth options are a variant of the first option, but limited to either product or business process innovations and therefore will not be relevant to firms that did not introduce an innovation of that type. The fifth option is useful for research that requires a random selection of all types of innovations.

10.14. Unless there are good research reasons for using a different option, the first option is recommended because it is better understood by respondents and is relevant to all firms. Furthermore, the first option is useful for research into the types of innovations with the largest expected economic benefits to the firm. These results can be used to construct aggregate indicators by industry, firm size, or other firm characteristic on the types of innovations (i.e. product or business process innovations) that respondents find of greatest economic value to their firm.

10.15. Cognitive testing shows that respondents are able to identify their most important innovation as defined by its actual or expected contribution to the firm's economic performance. For small and medium-sized enterprises (SMEs), there is usually one innovation that stands out from all others. Respondents from firms with many different innovations (often, but not always large firms) can find it difficult to identify a single innovation that stands out in comparison with the rest, but this does not affect their ability to select a single innovation and answer subsequent questions about it. Respondents from firms with many innovations are still likely to find it easier to answer questions on a focal innovation than to summarise results for multiple innovations.

10.16. If resources permit, written information in an open-ended description of the most important innovation can be coded and analysed to assess how respondents interpret questions on the types of innovation and the novelty of the innovation (Arundel, O'Brien and Torugsa, 2013; Cirera and Muzi, 2016; EBRD, 2014). This requires written information to be coded by experts, but text mining software tools can significantly reduce coding costs. Textual data on novelty can also be used to estimate if respondents understood the questionnaire definition of an innovation (Bloch and Bugge, 2016).

10.2.2. Non-innovative firms

10.17. Firms with no innovations or innovation activities cannot be asked about a focal innovation or a focal innovation project. However, it can be useful to ask respondents from non-innovative firms to describe their **most important change** to products or business processes during the observation period. This information can be analysed to determine whether respondents correctly report innovations and can distinguish them from changes that are not innovations (Arundel O' Brien and Torugsa, 2013). Combined with information on the novelty of reported innovations, the object approach can help identify potential biases towards under- or over-reporting innovations of different types by firm characteristics such as size or industry.

10.3. Questions on a focal innovation

10.18. Subject-based innovation surveys that include an object-based module should place such module after all other innovation questions in order to ensure that respondents do not confuse questions about all innovation activities with questions limited to a focal innovation.

10.3.1. Characteristics of the focal, most important innovation

10.19. It is recommended to include a list of innovation types (two types of product innovations and six types of business process innovations) and ask respondents to identify all innovation types that are part of their focal innovation (see Chapter 3). This can provide data on the prevalence of "bundled" innovations that have the characteristics of more than one innovation type (for instance both a service innovation and a business process innovation for product delivery) and which types of innovations are most important to firms.

10.20. It is recommended to collect information on the comparative importance for the responding firm of the focal innovation. Useful measures include the share of total innovation costs spent on the focal innovation and the contribution of the focal innovation to a firm's performance outcomes (e.g. sales or profits) (see subsection 10.3.2 below). Outcome questions will not be relevant to respondents reporting on an innovation project.

10.21. Respondents can be asked several questions on the novelty of their focal innovation, including if it is new to their market or only new to their firm, if it is part of a new business model, or if it is a radical or disruptive innovation (see subsection 3.3.2). However, data collection on radical, disruptive and related types of innovations will require experimentation to determine if these concepts can be properly measured in an innovation survey.

10.3.2. Innovation activities contributing to the focal innovation

10.22. Cognitive testing shows that respondents find it easier to provide interval level expenditure data (either in currency units or in person-months) for a single innovation than for all innovations combined (see Chapter 4). Consequently, it may be possible to obtain expenditure data for the entire period that the focal innovation was under development, instead of only for the reference year.

10.23. A question on expenditures for a single innovation can be particularly appropriate for SMEs or service sector firms that do not organise their innovation activities into clearly defined projects with a separate accounting budget.

10.24. It may be possible to obtain the following data for the focal innovation:

- the total time, in calendar months, from the initial idea for the focal innovation, to its introduction or implementation
- the year of introduction for a product innovation or the year of implementation for a business process innovation
- total expenditures in currency units or person-months on the focal innovation
- total external expenditures by type of activity on the focal innovation (research and experimental development, training, design, engineering, and other creative work activities, etc.)
- the use of and expenditures on follow-on activities after the introduction of a product innovation onto the market. This can include marketing, training, and after-sales services (see subsection 4.5.3).

10.25. Some of these questions could ask for data on activities before the observation period, such as the question on calendar months or total expenditures, but this is only likely to be relevant for major innovations.

10.3.3. Business capabilities contributing to the focal innovation

10.26. Business capabilities related to management or workforce skills are a characteristic of the firm (see Chapter 5) and generally not limited to a focal innovation. However, intellectual property (IP) strategies and technological capabilities can vary significantly among different types of innovations.

10.27. Depending on research interests, it can be worthwhile to ask about the use of different IP protection methods for the focal innovation, for instance whether a patent, design, trademark, or other IP right application was made for the focal innovation or if it is covered by copyright or trade secrecy. In addition, respondents can be asked if they licensed-in technology for their focal innovation or if the focal innovation was licensed-out (Arora, Cohen and Walsh, 2016).

10.28. Questions on technical capabilities are appropriate for an object module that can link capabilities to specific types of innovations. Relevant capabilities include design capabilities (engineering design, product design, and design thinking), digital capabilities, and digital platforms (see section 5.5).

10.3.4. Knowledge flows contributing to and generated by the focal innovation

10.29. The types of internal and external knowledge sources of value to innovation activities can differ between those used to identify an idea for an innovation, to develop and test an idea, including problem-solving; and to implement business process innovations or introduce a product innovation onto the market (see section 6.1). Differences in the use or importance of knowledge sources at different stages of the innovation process can be too complex for a respondent to track for all innovations, but it may be possible to include questions on such topics for a single focal innovation. An option is to ask for the knowledge sources of the original idea for the innovation, and the knowledge sources used to develop the innovation. These questions can list both internal and external sources (see Table 6.6).

10.30. It is also of interest to collect data on the contribution of external actors to the development of the focal innovation, such as whether the innovation replicates products or business processes already available on the market, was developed as part of a collaborative agreement with other organisations, or was mainly developed by the firm on its own (see Table 6.2). Further information on collaboration with different types of partners for the focal innovation can also be of value.

10.3.5. External factors influencing the focal innovation

10.31. The effect of some external factors can vary by the type of innovation (see Chapter 7). External factors of interest include the type of customer and customer engagement in a focal product innovation, the use of government support policies and other external drivers for the focal innovation.

10.32. Questions on innovation obstacles can be applied to the most important innovation or to a focal ongoing or abandoned innovation project or an innovation that did not meet expectations. This information can be used to differentiate between the factors that impede the implementation of an innovation, result in unsatisfactory outcomes, or result in an innovation project being cancelled or put on hold.

10.3.6. Objectives and outcomes of the focal innovation

10.33. Innovation objectives and outcomes can vary substantially by the type of innovation and therefore it can be useful to collect this information for a focal innovation. Table 8.1 provides a list of common innovation objectives and outcomes, such as increasing customer satisfaction or reducing environmental impacts that can be measured on a nominal or ordinal scale. Data collection for quantitative outcomes is particularly suitable for a focal innovation because respondents should find it easier, compared to all innovations combined, to provide data on the innovation sales share in the reference year, the market share or profit margin for a focal product innovation, or the cost savings for a focal business process innovation.

10.34. Data on all types of outcomes can also be collected by asking respondents if a specific outcome of the focal innovation was above, at the same level, or below the outcome level typically obtained by the firm for other innovations of the same type. For instance, respondents can be asked about the relative outcome of a focal product innovation on sales compared to the firm's other product innovations.

10.35. The factors that influence outcomes can be investigated if data on inputs and innovation activities are also collected for the focal innovation.

10.4. Summary of recommendations

10.36. The decision to include an object-based module in an innovation survey depends on the needs of users, particularly policy analysts and researchers, and if there are sufficient available resources to conduct analyses of the object data, for instance on the effect of inputs and strategies on outcomes. An object module is not recommended if use of the relevant data is limited to constructing aggregate indicators. Recommended questions for an object-based module are given below. Other types of data covered in this chapter are suitable for specialised data collection exercises.

10.37. Key items for data collection using an object-based module include:

- define the focal innovation as the most important innovation with respect to its expected contribution to the firm's economic performance (subsection 10.2.1); or the most important change for non-innovative firms (subsection 10.2.2), providing an open-ended description if possible
- the type of innovation (subsection 10.3.1)
- a measure of the novelty of the innovation (subsection 10.3.1) and the sources of knowledge contributing to the innovation
- the year in which the innovation was introduced on the market or implemented in the firm's business processes (subsection 10.3.2). This will be implicit if the observation period is one year
- the time span between the beginning of the relevant innovation project or activities and implementation (subsection 10.3.2)
- a measure of the efforts made towards the innovation by the firm, such as the total expenditure (in currency units or person-months) on the focal innovation (subsection 10.3.2)

- the contribution of internal and external actors to the development of the focal innovation, in order to identify potential success factors (subsection 10.3.4)
- an outcome measure such as the innovation sales share for a focal product innovation or cost savings from a focal business process innovation (subsection 10.3.6).

10.38. Supplementary topics for data collection using an object-based module include:

- use of IP rights for the focal innovation (subsection 10.3.3)
- obstacles to innovation (subsection 10.3.5)
- use of government support policies (subsection 10.3.5).

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Chapter 11. Use of innovation data for statistical indicators and analysis

This chapter provides guidance on the use of innovation data for constructing indicators as well as statistical and econometric analysis. The chapter provides a blueprint for the production of innovation indicators by thematic areas, drawing on the recommendations in previous chapters. Although targeted to official organisations and other users of innovation data, such as policy analysts and academics, the guidance in this chapter also seeks to promote better understanding among innovation data producers about how their data are or might be used. The chapter provides suggestions for future experimentation and the use of innovation data in policy analysis and evaluation. The ultimate objective is to ensure that innovation data, indicators and analysis provide useful information for decision makers in government and industry while ensuring that trust and confidentiality are preserved.

11.1. Introduction

11.1. Innovation data can be used to construct indicators and for multivariate analysis of innovation behaviour and performance. Innovation indicators provide statistical information on innovation activities, innovations, the circumstances under which innovations emerge, and the consequences of innovations for innovative firms and for the economy. These indicators are useful for exploratory analysis of innovation activities, for tracking innovation performance over time and for comparing the innovation performance of countries, regions, and industries. Multivariate analysis can identify the significance of different factors that drive innovation decisions, outputs and outcomes. Indicators are more accessible to the general public and to many policy makers than multivariate analysis and are often used in media coverage of innovation issues. This can influence public and policy discussions on innovation and create demand for additional information.

11.2. This chapter provides guidance on the production, use, and limitations of innovation indicators, both for official organisations and for other users of innovation data, such as policy analysts and academics who wish to better understand innovation indicators or produce new indicators themselves. The discussion of multivariate analyses is relevant to researchers with access to microdata on innovation and to policy analysts. The chapter also includes suggestions for future experimentation. The ultimate objective is to ensure that innovation data, indicators and analysis provide useful information for decision makers in both government and industry, as discussed in Chapters 1 and 2.

11.3. Most of the discussion in this chapter focuses on data collected through innovation surveys (see Chapter 9). However, the guidelines and suggestions for indicators and analysis also apply to data obtained from other sources. For some topics, data from other sources can substantially improve analysis, such as for research on the effects of innovation activities on outcomes (see Chapter 8) or the effect of the firm's external environment on innovation (see Chapters 6 and 7).

11.4. Section 11.2 below introduces the concepts of statistical data and indicators relating to business innovation, and discusses desirable properties and the main data resources available. Section 11.3 covers methodologies for constructing innovation indicators and aggregating them using dashboards, scoreboards and composite indexes. Section 11.4 presents a blueprint for the production of innovation indicators by thematic areas, drawing on the recommendations in previous chapters. Section 11.5 covers multivariate analyses of innovation data, with a focus on the analysis of innovation outcomes and policy evaluation.

11.2. Data and indicators on business innovation

11.2.1. What are innovation indicators and what are they for?

11.5. An **innovation indicator** is a statistical summary measure of an innovation phenomenon (activity, output, expenditure, etc.) observed in a population or a sample thereof for a specified time or place. Indicators are usually corrected (or standardised) to permit comparisons across units that differ in size or other characteristics. For example, an aggregate indicator for national innovation expenditures as a percentage of gross domestic product (GDP) corrects for the size of different economies (Eurostat, 2014; UNECE, 2000).

11.6. Official statistics are produced by organisations that are part of a national statistical system (NSS) or by international organisations. An NSS produces official statistics for government. These statistics are usually compiled within a legal framework and in accordance with basic principles that ensure minimum professional standards, independence and objectivity.

Organisations that are part of an NSS can also publish unofficial statistics, such as the results of experimental surveys. Statistics about innovation and related phenomena have progressively become a core element of the NSS of many countries, even when not compiled by national statistical organisations (NSOs).

11.7. Innovation indicators can be constructed from multiple data sources, including some that were not explicitly designed to support the statistical measurement of innovation. Relevant sources for constructing innovation indicators include innovation and related surveys, administrative data, trade publications, the Internet, etc. (see Chapter 9). The use of multiple data sources to construct innovation indicators is likely to increase in the future due to the growing abundance of data generated or made available on line and through other digital environments. The increasing ability to automate the collection, codification and analysis of data is another key factor expanding the possibilities for data sourcing strategies.

11.8. Although increasingly used within companies and for other purposes, indicators of business innovation, especially those from official sources, are usually designed to inform policy and societal discussions, for example to monitor progress towards a related policy target (National Research Council, 2014). Indicators themselves can also influence business behaviour, including how managers respond to surveys. An evaluation of multiple innovation indicators, along with other types of information, can assist users in better understanding a wider range of innovation phenomena.

11.2.2. Desirable properties of innovation indicators

11.9. The desirable properties of innovation indicators include relevance, accuracy, reliability, timeliness, coherence and accessibility, as summarised in Table 11.1. The properties of innovation indicators are determined by choices made throughout all phases of statistical production, especially in the design and implementation of innovation surveys, which can greatly affect data quality (see Chapter 9). To be useful, indicators must have multiple quality characteristics (Gault [ed.], 2013). For example, accurate, reliable and accessible indicators will be of limited relevance if a delay in timeliness means that they are not considered in policy discussions or decisions.

Table 11.1. Desirable properties of business innovation indicators

Feature	Description	Comments
Relevance	Serve the needs of actual and potential users	Innovation involves change, leading to changes in the needs of data users. Relevance can be reduced if potential users are unaware of available data or data producers are unaware of users' needs.
Accuracy/ validity	Provide an unbiased representation of innovation phenomena	There may be systematic differences in how respondents provide information depending on the collection method or respondent characteristics. Indicators can fail to capture all relevant phenomena of interest.
Reliability/precision	Results of measurement should be identical when repeated. High signal-to-noise ratio	Results can differ by the choice of respondent within a firm. Reliability can decline if respondents guess the answer to a question or if sample sizes are too small (e.g. in some industries).
Timeliness	Available on a sufficiently timely basis to be useful for decision-making	Lack of timeliness reduces the value of indicators during periods of fast economic change. Timeliness can be improved through nowcasting or collecting data on intentions. However, some aspects of innovation are structural and change slowly. For these, timeliness is less of a concern.

Feature	Description	Comments
Coherence/comparability	Logically connected and mutually consistent	
	Additive or decomposable at different aggregation levels	High levels of aggregation can improve reliability/precision, but reduce usefulness for policy analysis. Low levels of aggregation can influence strategic behaviour and distort measurement.
	Decomposable by characteristics	For example, by constructing indicators for different types of firms according to innovations or innovation activities, etc.
	Coherence over time	Use of time series data should be promoted. Breaks in series can sometimes be addressed through backward revisions if robustly justified and explained.
	Coherence across sectors, regions or countries, including international comparability	Comparability across regions or countries requires standardisation to account for differences in size or industrial structure of economies.
Accessibility and clarity	Widely available and easy to understand, with supporting metadata and guidance for interpretation	Challenges to ensure that the intended audience understands the indicators and that they "stir the imagination of the public" (EC, 2010).

11.2.3. Recommendations and resources for innovation indicators

Basic principles

11.10. In line with general statistical principles (UN, 2004), business innovation statistics must be useful and made publicly available on an impartial basis. It is recommended that NSOs and other agencies that collect innovation data use a consistent schema for presenting aggregated results and apply this to data obtained from business innovation surveys. The data should be disaggregated by industry and firm size, as long as confidentiality and quality requirements are met. These data are the basic building blocks for constructing indicators.

International comparisons

11.11. User interest in benchmarking requires internationally comparable statistics. The adoption by statistical agencies of the concepts, classifications and methods contained in this manual will further promote comparability. Country participation in periodical data reporting exercises to international organisations such as Eurostat, the OECD and the United Nations can also contribute to building comparable innovation data.

11.12. As discussed in Chapter 9, international comparability of innovation indicators based on survey data can be reduced by differences in survey design and implementation (Wilhelmsen, 2012). These include differences between mandatory and voluntary surveys, survey and questionnaire design, follow-up practices, and the length of the observation period. Innovation indicators based on other types of data sources are also subject to comparability problems, for example in terms of coverage and reporting incentives.

11.13. Another factor affecting comparability stems from national differences in innovation characteristics, such as the average novelty of innovations and the predominant types of markets served by firms. These contextual differences also call for caution in interpreting indicator data for multiple countries.

11.14. Some of the issues caused by differences in methodology or innovation characteristics can be addressed through data analysis. For example, a country with a one-year observation period can (if available) use panel data to estimate indicators for a three-year period. Other research has developed "profile" indicators (see subsection 3.6.2) that improve the comparability of national differences in the novelty of innovations and markets on headline indicators such as the share of innovative firms (Arundel and Hollanders, 2005).

11.15. Where possible and relevant, it is recommended to develop methods for improving the international comparability of indicators, in particular for widely used headline indicators.

International resources

11.16. Box 11.1 lists three sources of internationally comparable indicators on innovation that follow, in whole or in part, *Oslo Manual* guidelines and are available at the time of publishing this manual.

Box 11.1. Major resources for international innovation data using *Oslo Manual* guidelines

Eurostat Community Innovation Survey (CIS) indicator database

Innovation indicators from the CIS for selected member states of the European Statistical System (ESS): http://ec.europa.eu/eurostat/web/science-technology-innovation/data/database.

Ibero-American/Inter-American Network of Science and Technology Indicators (RICYT)

Innovation indicators for manufacturing and service industries for selected Ibero-American countries: www.ricyt.org/indicadores.

OECD Innovation Statistics Database

Innovation indicators for selected industries for OECD member countries and partner economies, including countries featured in the *OECD Science, Technology and Industry Scoreboard*: http://oe.cd/inno-stats.

UNESCO Institute for Statistics (UIS) Innovation Data

Global database of innovation statistics focused on manufacturing industries: http://uis.unesco.org/en/topic/innovation-data.

The NEPAD (New Partnership for Africa's Development) for the African Union is also active in promoting the use of comparable indicators in Africa. Online links to this manual will provide up-to-date links to international and national sources of statistical data and indicators on innovation.

11.3. Methodologies for constructing business innovation indicators

11.3.1. Aggregation of statistical indicators

11.17. Table 11.2 summarises different types of descriptive statistics and methods used to construct indicators. Relevant statistics include measures of central tendency, dispersion, association, and dimension reduction techniques.

Micro and macro indicators

11.18. Indicators can be constructed from various sources at any level of aggregation equal to or higher than the statistical unit for which data are collected. For survey and many types of administrative data, confidentiality restrictions often require indicators to be based on a sufficient level of aggregation so that users of those indicators cannot identify values for individual units. Indicators can also be constructed from previously aggregated data.

11.19. Common characteristics for aggregation include the country and region where the firm is located and characteristics of the firm itself, such as its industry and size (using size categories such as 10 to 49 persons employed, etc.). Aggregation of business-level data requires an understanding of the underlying statistical data and the ability to unequivocally assign a firm to a given category. For example, regional indicators require an ability to assign or apportion a firm or its activities to a region. Establishment data are easily assigned to a single region, but enterprises can be active in several regions, requiring spatial imputation methods to divide activities between regions.

11.20. Indicators at a low level of aggregation can provide detailed information that is of greater value to policy or understanding than aggregated indicators alone. For example, an indicator for the share of firms by industry with a product innovation will provide more useful information than an indicator for all industries combined.

Table 11.2. Descriptive statistics and methods for constructing innovation indicators

	Generic examples	Innovation examples
Types of indicators		
Statistical measures of frequency	Counts, conditional counts	Counts of product innovators
Measures of position, order or rank	Ranking by percentile or quartiles	Firms in the top decile of innovation expenditure distribution
Measures of central tendency	Mean, median, mode	Share of firms with a service innovation, median share of income/ turnover from product innovations
Measures of dispersion	Interquartile ranges, variance, standard deviation, coefficient of variation	Coefficient of variation presented for error margins, standard deviation of innovation expenditures
Indicators of association for multidimensional data		
Statistical measures of association	Cross-tabulations, correlation/covariance	Jaccard measures of co-occurrence of different innovation types
Visual association	Scatter plots, heat maps and related visuals	Heat maps to show propensity to innovate compared across groups defined by two dimensions
Adjustments to data for indicators		
Indicators based on data transformations	Logs, inverse	Log of innovation expenditures
Weighting	Weighting of the importance of indicators when constructing composite indicators, by major variables etc.	Indicators weighted by firm size or adjusted for industry structure
Normalisation	Ratios, scaling by size, turnover, etc.	Percent of employees that work for an innovative firm, etc.
Dimension reduction techniques		
Simple central tendency methods	Average of normalised indicators	Composite innovation indexes
Other indicator methods	Max or min indicators	Firms introducing at least one type of innovation out of multiple types
Statistical dimension reduction and classification methods	Principal component analysis, multidimensional scaling, clustering	Studies of "modes" of innovation, e.g. Frenz and Lambert (2012)

Dimensionality reduction for indicators

11.21. Surveys often collect information on multiple related factors, such as different knowledge sources, innovation objectives, or types of innovation activities. This can provide a complex set of data that is difficult to interpret. A common approach is to reduce the number of variables (dimensionality reduction) while maintaining the information content.

Several statistical procedures ranging from simple addition to factor analysis can be used for this purpose.

11.22. Many indicators are calculated as averages, sums, or maximum values across a range of variables (see Table 11.2). These methods are useful for summarising related nominal, ordinal, or categorical variables that are commonly found in innovation surveys. For example, a firm that reports at least one type of innovation out of a list of eight innovation types (two products and six business processes) is defined as an innovative firm. This derived variable can be used to construct an aggregate indicator for the average share of innovative firms by industry. This is an example of an indicator where only one positive value out of multiple variables is required for the indicator to be positive. The opposite is an indicator that is only positive when a firm gives a positive response to all relevant variables.

11.23. Composite indicators are another method for reducing dimensionality. They combine multiple indicators into a single index based on an underlying conceptual model (OECD/JRC, 2008). Composite indicators can combine indicators for the same dimension (for instance total expenditures on different types of innovation activities), or indicators measured along multiple dimensions (for example indicators of framework conditions, innovation investments, innovation activities, and innovation impacts).

11.24. The number of dimensions can also be reduced through statistical methods such as cluster analysis and principal component analysis. Several studies have applied these techniques to microdata to identify typologies of innovation behaviour and to assess the extent to which different types of behaviour can predict innovation outcomes (de Jong and Marsili, 2006; Frenz and Lambert, 2012; OECD, 2013).

11.3.2. Indicator development and presentation for international comparisons

11.25. The selection of innovation indicators reflects a prioritisation of different types of information about innovation. The ability to construct indicators from microdata creates greater opportunities for indicator construction, but this is rarely an option for experts or organisations without access to microdata. The alternative is to construct indicators from aggregated data, usually at the country, sector, or regional level.

11.26. Reports that use multiple innovation indicators for international comparisons tend to share a number of common features (Arundel and Hollanders, 2008; Hollanders and Janz, 2013) such as:

- The selection of specific innovation indicators at a country, sector, or regional level is usually guided by innovation systems theory.
- The selection is also partly guided by conceptual and face validity considerations, although this is constrained by data availability.
- Indicators are presented by thematic area, with themes grouped within a hierarchical structure, such as innovation inputs, capabilities, and outputs.
- Varying levels of contextual and qualitative information for policy making are provided, as well as methodological information.

11.27. NSS organisations and most international organisations tend to address user requests for international comparisons through reports or dashboards based on official statistics, often drawing attention to headline indicators. The advantage of reports and dashboards is that they provide a fairly objective and detailed overview of the available information. However, due to the large amount of data presented, it can be difficult to identify the key issues.

Composite innovation indexes, presented in scoreboards that rank the performance of countries or regions, were developed to address the limitations of dashboards. They are mostly produced by consultants, research institutes, think tanks and policy institutions that lack access to microdata, with the composite indexes constructed by aggregating existing indicators.

11.28. Compared to simple indicators used in dashboards, the construction of composite innovation indexes requires two additional steps:

- The normalisation of multiple indicators, measured on different scales (nominal, counts, percentages, expenditures, etc.), into a single scale. Normalisation can be based on standard deviations, the min-max method, or other options.
- The aggregation of normalised indicators into one or more composite indexes. The aggregation can give an identical weight to all normalised indicators or use different weights. The weighting determines the relative contribution of each indicator to the composite index.

11.29. Composite indexes provide a number of advantages as well as challenges over simple indicators (OECD/JRC, 2008). The main advantages are a reduction in the number of indicators and simplicity, both of which are desirable attributes that facilitate communication with a wider user base (i.e. policy makers, media, and citizens). The disadvantages of composite indexes are as follows:

- With few exceptions, the theoretical basis for a composite index is limited. This can result in problematic combinations of indicators, such as indicators for inputs and outputs.
- Only the aggregate covariance structure of underlying indicators can be used to build the composite index, if used at all.
- The relative importance or weighting of different indicators is often dependent on the subjective views of those constructing the composite index. Factors that are minor contributors to innovation can be given as much weight as major ones.
- Aside from basic normalisation, structural differences between countries are seldom taken into account when calculating composite performance indexes.
- Aggregation results in a loss of detail, which can hide potential weaknesses and increase the difficulty in identifying remedial action.

11.30. Due to these disadvantages, composite indicators need to be accompanied by guidance on how to interpret them. Otherwise, they can mislead readers into supporting simple solutions to complex policy issues.

11.31. The various innovation dashboards, scoreboards and composite indexes that are currently available change frequently. Box 11.2 provides examples that have been published on a regular basis.

11.32. The combination of a lack of innovation data for many countries, plus concerns over the comparability of innovation survey data, has meant that many innovation rankings rely on widely available indicators that capture only a fraction of innovation activities, such as R&D expenditures or IP rights registrations, at the expense of other relevant dimensions.

Box 11.2. Examples of innovation scoreboards and innovation indexes

OECD Science, Technology and Innovation (STI) Scoreboard

The *OECD STI Scoreboard* (www.oecd.org/sti/scoreboard.htm) is a biennial flagship publication by the OECD Directorate for Science, Technology and Innovation. Despite its name, it is closer to a dashboard. A large number of indicators are provided, including indicators based on innovation survey data, but no rankings based on composite indexes for innovation themes are included. Composite indicators are only used for narrowly defined constructs such as scientific publications or patent quality with weights constructed from auxiliary data related to the construct.

***European Innovation Scoreboard* (*EIS*)**

The *EIS* is published by the European Commission (EC) and produced by consultants with inputs from various EC services. It is intended as a performance scoreboard (see: http://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_en). The *EIS* produces a hierarchical composite index (Summary Innovation Index) that is used to assign countries into four performance groups (innovation leaders, strong innovators, moderate innovators, modest innovators). The index uses a range of data sources, including innovation survey indicators. The European Commission also publishes a related *Regional Innovation Scoreboard*.

***Global Innovation Index* (*GII*)**

The *Global Innovation Index* (www.globalinnovationindex.org) is published by Cornell University, INSEAD and the World Intellectual Property Organization (WIPO). The *GII* is a hierarchical composite index with input and output dimensions that are related to different aspects of innovation. The *GII* aims to cover as many middle- and low-income economies as possible. It uses research and experimental development (R&D) and education statistics, administrative data such as intellectual property (IP) statistics and selected World Economic Forum indicators that aggregate subjective expert opinions about topics such as innovation linkages. The *GII* does not currently use indicators derived from innovation surveys.

11.3.3. Firm-level innovation rankings

11.33. A number of research institutes and consultants produce rankings of individual firms on the basis of selected innovation activities by constructing composite indicators from publicly available data, such as company annual reports or administrative data provided by companies subject to specific reporting obligations, for example those listed on a public stock exchange. Notwithstanding data curation efforts, these data are generally neither complete nor fully comparable across firms in the broad population. Privately owned firms are not required to report some types of administrative data while commercially sensitive data on innovation are unlikely to be included in an annual report unless disclosure supports the strategic interests or public relations goals of the firm (Hill, 2013). Consequently, there can be a strong self-selection bias in publicly available innovation data for firms. Furthermore, reported data can be misleading. For example, creative media content development activities or other technology-related activities may be reported as R&D without matching the OECD definition of R&D (OECD, 2015).

11.34. Despite these self-selection biases (see Chapter 9), publicly available firm-level data from annual reports or websites offer opportunities for constructing new experimental innovation indicators provided that the data meet basic quality requirements for the intended analytical purposes.

11.4. A blueprint for indicators on business innovation

11.35. This section provides guidelines on the types of innovation indicators that can be produced by NSOs and other organisations with access to innovation microdata. Many of these indicators are in widespread use and based on data collected in accordance with previous editions of this manual. Indicators are also suggested for new types of data discussed in Chapters 3 to 8. Other types of indicators can be constructed to respond to changes in user needs or when new data become available.

11.36. Producers of innovation indicators can use answers to the following questions to guide the construction and presentation of indicators:

- What do users want to know and why? What are the relevant concepts?
- What indicators are most suitable for representing a concept of interest?
- What available data are appropriate for constructing an indicator?
- What do users need to know to interpret an indicator?

11.37. The relevance of a given set of indicators depends on user needs and how the indicators are used (OECD, 2010). Indicators are useful for identifying differences in innovation activities across categories of interest, such as industry or firm size, or to track performance over time. Conversely, indicators should not be used to identify causal relationships, such as the factors that influence innovation performance. This requires analytical methods, as described in section 11.5 below.

11.4.1. Choice of innovation indicators

11.38. Chapters 3 to 8 cover thematic areas that can guide the construction of innovation indicators. The main thematic areas, the relevant chapter in this manual that discusses each theme, and the main data sources for constructing indicators are summarised in Table 11.3. Indicators for many of the thematic areas can also be constructed using object-based methods as discussed in Chapter 10, but these indicators will be limited to specific types of innovations.

Table 11.3. Thematic areas for business innovation indicators

Thematic area	Main data sources	Relevant *OM4* chapters
Incidence of innovations and their characteristics (e.g. type, novelty)	Innovation surveys, administrative or commercial data (e.g. product databases)	3
Innovation activity and investment (types of activity and resources for each activity)	Innovation surveys, administrative data, IP data (patents, trademarks, etc.)	4
Innovation capabilities within firms[1]	Innovation surveys, administrative data	5
Innovation linkages and knowledge flows	Innovation surveys, administrative data, bilateral international statistics (trade, etc.), data on technology alliances	6
External influences on innovation (including public policies) and framework conditions for business innovation (including knowledge infrastructure)[1]	Innovation surveys, administrative data, expert assessments, public opinion polls, etc.	6,7
Outputs of innovation activities	Innovation surveys, administrative data	6,8
Economic and social outcomes of business innovation	Innovation surveys, administrative data	8

1. New thematic area for this edition of the manual (*OM4*).

11.39. Table 11.4 provides a list of proposed indicators for measuring the incidence of innovation that can be mostly produced using nominal data from innovation surveys, as discussed in Chapter 3. These indicators describe the innovation status of firms and the characteristics of their innovations.

Table 11.4. Indicators of innovation incidence and characteristics

General topic	Indicator	Computation notes
Product innovations	Share of firms with one or more types of product innovations	Based on a list of product innovation types. Can be disaggregated by type of product (good or service)
New-to-market (NTM) product innovations	Share of firms with one or more NTM product innovations (can also focus on new-to-world product innovations)	Depending on the purpose, can be computed as the ratio to all firms or innovative firms only
Method of developing product innovations	Share of firms with one or more types of product innovations that developed these innovations through imitation, adaptation, collaboration, or entirely in-house	Based on Chapter 6 guidance. Categories for how innovations were developed must be mutually exclusive *Relevant to innovative firms only
Other product innovation features	Depending on question items, indicators can capture attributes of product innovations (changes to function, design, experiences etc.)	*Not relevant to all firms
Business process Innovations	Share of firms with one or more types of business process innovations	Based on a list of types of business process innovations. Can be disaggregated by type of business process
NTM business process innovations	Share of firms with one or more NTM business process innovations	Depending on the purpose, can be computed as the ratio to all firms or innovative firms only
Method of developing business process innovations	Share of firms with one or more types of business process innovations that developed these innovations through imitation, adaptation, collaboration, or entirely in-house	Based on Chapter 6. Categories for how innovations were developed must be mutually exclusive *Only relevant to firms with a business process innovation
Product *and* business process innovations	Share of firms with both product and business process innovations	Co-occurrence of specific types of innovations
Innovative firms	Share of firms with at least one innovation of any type	Total number of firms with a product innovation or a business process innovation
Ongoing/abandoned innovation activities	Share of firms with ongoing innovation activities or with activities abandoned or put on hold	Can be limited to firms that only had ongoing/abandoned activities, with no innovations
Innovation-active firms	Share of firms with one or more types of innovation activities	All firms with completed, ongoing or abandoned innovation activities *Can only be calculated for all firms

Note: All indicators refer to activities within the survey observation period. Indicators for innovation rates can also be calculated as shares of employment or turnover, for instance the share of total employees that work for an innovative firm, or the share of total sales earned by innovative firms. Unless otherwise noted with an "*" before a computation note, all indicators can be computed using *all firms*, *innovation-active firms only*, or *innovative firms only* as the denominator. See section 3.5 for a definition of firm types.

11.40. Table 11.5 lists proposed indicators of knowledge-based activities as discussed in Chapter 4. With a few exceptions, most of these indicators can be calculated for all firms, regardless of their innovation status (see Chapter 3).

Table 11.5. Indicators of knowledge-based capital/innovation activities

General topic	Indicator	Computation notes
Knowledge-based capital (KBC) activities	Share of firms reporting KBC activities that are *potentially related to* innovation	Share of firms reporting at least one KBC activity (Table 4.1, column 2) *Can only be calculated for all firms
KBC activities for innovation	Share of firms reporting KBC activities *for innovation*	Share of firms reporting at least one KBC activity for innovation (Table 4.1, columns 2 or 3) Can calculate separately for in-house (column 2) and external (column 3) investments
Expenditures on KBC	Total expenditures on KBC activities *potentially related* to innovation	Total expenditures on KBC (Table 4.2, column 2) as a share of total turnover (or equivalent)
Expenditures on KBC for innovation	Total expenditures on KBC activities *for innovation*	Total expenditures for innovation (Table 4.2, column 3) as a share of total turnover (or equivalent)
Innovation expenditure share for each type of activity	Share of expenditures for innovation for each of seven types of innovation activities	Total expenditures for each innovation activity (Table 4.2, columns 2 and 3) as a share of total innovation expenditures *Not useful to calculate for all firms
Innovation expenditures by accounting category	Total expenditures for innovation activities by accounting category	Total expenditures for each of five accounting categories (Table 4.3, column 3) as a share of total turnover (or equivalent)
Innovation projects	Number of innovation projects	Median or average number of innovation projects per firm (see subsection 4.5.2) *Not useful to calculate for all firms
Follow-on innovation activities	Share of firms with ongoing follow-on innovation activities	Any of three follow-on activities (see subsection 4.5.3) *Only calculate for innovative firms
Innovation plans	Share of firms planning to increase (reduce) their innovation expenditures in the (current) next period	See subsection 4.5.4

Notes: Indicators derived from Table 4.1 refer to the survey *observation* period. Expenditure indicators derived from Table 4.2 and Table 4.3 only refer to the survey *reference* period. Unless otherwise noted with an "*" before a computation note, all indicators can be computed using *all firms*, *innovation-active firms only*, or *innovative firms only* as the denominator. See section 3.5 for a definition of firm types.

11.41. Table 11.6 lists potential indicators of business capabilities for innovation following Chapter 5. All indicators of innovation capability are relevant to all firms, regardless of their innovation status. The microdata can also be used to generate synthetic indexes on the propensity of firms to innovate.

Table 11.6. Indicators of potential or actual innovation capabilities

General topic	Indicator	Computation notes
Innovation management	Share of firms adopting advanced general and innovation management practices	Based on list of practices (see subsections 5.3.2 and 5.3.4)
IP rights strategy	Share of firms using different types of IP rights	See subsection 5.3.5
Workforce skills	Share of firms employing highly qualified personnel, by level of educational attainment or by fields of education	Average or median share of highly qualified individuals
Advanced technology use	Share of firms using advanced, enabling or emerging technologies	This may be relevant for specific sectors only (see subsection 5.5.1)
Technical development	Share of firms developing advanced, enabling or emerging technologies	This may be relevant for specific sectors only (see subsection 5.5.1)

General topic	Indicator	Computation notes
Design capabilities	Share of firms with employees with design skills	See subsection 5.5.2
Design centrality	Share of firms with design activity at different levels of strategic importance (Design Ladder)	See subsection 5.5.2
Design thinking	Share of firms using design thinking tools and practices	See subsection 5.5.2
Digital capabilities	Share of firms using advanced digital tools and methods	See subsection 5.5.3
Digital platforms	Share of firms using digital platforms to sell or buy goods or services Share of firms providing digital platform services	See subsections 5.5.3 and 7.4.4

Notes: All indicators refer to activities within the survey observation period. All indicators can be computed using *all firms*, *innovation-active firms only*, or *innovative firms only* as the denominator. See section 3.5 for a definition of firm types.

11.42. Table 11.7 provides indicators of knowledge flows for innovation, following guidance in Chapter 6 on both inbound and outbound flows. With a few exceptions, most of these indicators are relevant to all firms.

Table 11.7. Indicators of knowledge flows and innovation

General topic	Indicator	Computation notes
Collaboration	Share of firms that collaborated with other parties on innovation activities (by type of partner or partner location)	See Table 6.5 *Not useful to calculate for all firms
Main collaboration partner	Share of firms indicating a given partner type as most important	See Table 6.5 and Chapter 10 *Not useful to calculate for all firms
Knowledge sources	Share of firms making use of a range of information sources	See Table 6.6
Licensing-out	Share of firms with outbound licensing activities	See Table 6.4
Knowledge services providers	Share of firms with a contract to develop products or business processes for other firms or organisations	See Table 6.4
Knowledge disclosure	Share of firms that disclosed useful knowledge for the product or business process innovations of other firms or organisations	See Table 6.4
Knowledge exchange with higher education institutions (HEIs) and public research institutions (PRIs)	Share of firms engaged in specific knowledge exchange activities with HEIs or PRIs	See Table 6.6
Challenges to knowledge exchange	Share of firms reporting barriers to interacting with other parties in the production or exchange of knowledge	See Table 6.8

Note: All indicators refer to activities within the survey observation period. Indicators on the role of other parties in the firm's innovations are included in Table 11.4 above. Unless otherwise noted with an "*" before a computation note, all indicators can be computed using *all firms*, *innovation-active firms only*, or *innovative firms only* as the denominator. See section 3.5 for a definition of firm types.

11.43. Table 11.8 provides a list of indicators for external factors that can potentially influence innovation, as discussed in Chapter 7. With the exception of drivers of innovation, all of these indicators can be calculated for all firms.

Table 11.8. Indicators of external factors influencing innovation

General topic	Indicator	Computation notes
Customer type	Share of firms selling to specific types of customers (other businesses, government, consumers)	See subsection 7.4.1
Geographic market	Share of firms selling products in international markets	See subsection 7.4.1
Nature of competition	Share of firms reporting specific competition conditions that influence innovation	See Table 7.2
Standards	Share of firms engaged in standard setting activities	See subsection 7.4.2
Social context for innovation	Share of firms reporting more than *N* social characteristics that are potentially conducive to innovation	Can calculate as a score for different items (see Table 7.7)
Public support for innovation	Share of firms that received public support for the development or exploitation of innovations (by type of support)	See subsection 7.5.2
Innovation drivers	Share of firms reporting selected items as a driver of innovation	See Table 7.8 *Not useful to calculate for all firms
Public infrastructure	Share of firms reporting selected types of infrastructure of high relevance to their innovation activities	See Table 7.6
Innovation barriers	Share of firms reporting selected items as barriers to innovation	See Table 7.8

Note: All indicators refer to activities within the survey observation period. Unless otherwise noted with an "*" before a computation note, all indicators can be computed using *all firms*, *innovation-active firms only*, or *innovative firms only* as the denominator. See section 3.5 for a definition of firm types.

11.44. Table 11.9 lists simple outcome (or objective) indicators, based on either nominal or ordinal survey questions, as proposed in Chapter 8. The objectives are applicable to all innovation-active firms, while questions on outcomes are only relevant to innovative firms.

Table 11.9. Indicators of innovation objectives and outcomes

General topic	Indicator	Computation notes
General business objectives	Share of firms reporting selected items as general objectives[1]	See Tables 8.1 and 8.2
Innovation objectives	Share of firms reporting selected items as objectives for innovation activities[1]	See Tables 8.1 and 8.2 *Not useful to calculate for all firms
Innovation outcomes	Shares of firms attaining a given objective through their innovation activity[1]	See Tables 8.1 and 8.2 *Not useful to calculate for all firms
Sales from new products	Share of turnover from product innovations and new-to-market product innovations	See subsection 8.3.1
Number of product innovations	Number of new products (median and average)	See subsection 8.3.1, preferably normalised by total number of product lines
Changes to unit cost of sales	Share of firms reporting different levels of changes to unit costs from business process innovations	See subsection 8.3.2 *Calculate for firms with business process innovations only
Innovation success	Share of firms reporting that innovations met expectations	See section 8.3 *Calculate for innovative firms only

1. These indicators can be calculated by thematic area (e.g. production efficiency, markets, environment, etc.).
Note: All indicators refer to activities within the survey observation period. Unless otherwise noted with an "*" before a computation note, all indicators can be computed using *all firms*, *innovation-active firms only*, or *innovative firms only* as the denominator. See section 3.5 for a definition of firm types.

11.4.2. Breakdown categories, scaling, and typologies

11.45. Depending on user requirements, indicators can be provided for several breakdown characteristics. Data on each characteristic can be collected through a survey or by linking a survey to other sources such as business registers and administrative data, in line with guidance provided in Chapter 9. Breakdown characteristics of interest include:

- Enterprise **size** by the number of persons employed, or other size measures such as sales or assets.
- Industry of **main economic activity**, in line with international standard classifications (see Chapter 9). Combinations of two- to three-digit International Standard Industrial Classification (ISIC) classes can provide results for policy-relevant groups of firms (e.g. firms in information and communication technology industries).
- Administrative **region**.
- **Group affiliation and ownership**, for instance if an enterprise is independent, part of a domestic enterprise group, or part of a multinational enterprise. Breakdowns for multinationals are of value to research on the globalisation of innovation activities.
- **Age**, measured as the time elapsed since the creation of the enterprise. A breakdown by age will help differentiate between older and more recently established firms. This is of interest to research on business dynamism and entrepreneurship (see Chapter 5).
- **R&D status**, if the firm performs R&D in-house, funds R&D performed by other units, or is not engaged in any R&D activities (see Chapter 4). The innovation activities of firms vary considerably depending on their R&D status.

11.46. The level of aggregation for these different dimensions will depend on what the data represent, how they are collected and their intended uses. Stratification decisions in the data collection (see Chapter 9) will determine the maximum level that can be reported.

11.47. To avoid scale effects, many innovation input, output, intensity and expenditure variables can be standardised by a measure of the size of each firm, such as total expenditures, total investment, total sales, or the total number of employed persons.

11.48. A frequently used indicator of innovation input intensity is total innovation expenditures as a percentage of total turnover (sales). Alternative input intensity measures include the innovation expenditure per worker (Crespi and Zuñiga, 2010) and the share of human resources (in headcounts) dedicated to innovation relative to the total workforce.

11.49. For output indicators, the share of total sales revenue from product innovations is frequently used. In principle, this type of indicator should also be provided for specific industries because of different rates of product obsolescence. Data by industry can be used to identify industries with low product innovation rates and low innovation efficiency relative to their investments in innovation.

11.50. Standardised indicators for the number of IP rights registrations, or measures of scientific output (invention disclosures, publications, etc.) should also be presented by industry, since the relevance of these activities varies considerably. Indicators based on IP rights such as patented inventions can be interpreted as measures of knowledge appropriation strategies (see Chapter 5). Their use depends on factors such as the industry and the type of protectable knowledge (OECD, 2009a). Measures of scientific outputs of the Business enterprise sector such as publications are mostly relevant to science-based industries (OECD and SCImago Research Group, 2016). Furthermore, depending on a firm's industry and strategy, there may be large gaps between a firm's scientific and technological outputs and what it decides to disclose.

11.51. Indicators of innovation intensity (summing all innovation expenditures and dividing by total expenditures) can be calculated at the level of industry, region, and country. Intensity indicators avoid the need to standardise by measures of firm size.

Typologies of innovative/innovation-active firms

11.52. A major drawback of many of the indicators provided above is that they do not provide a measure of the intensity of efforts to attain product or business process innovations. The ability to identify firms by different levels of effort or innovation capabilities can be of great value for innovation policy analysis and design (Bloch and López-Bassols, 2009). This can be achieved by combining selected nominal indicators with innovation activity measures (see Table 11.5) and possibly innovation outcome measures (see Table 11.9). Several studies have combined multiple indicators to create complex indicators for different "profiles", "modes" or taxonomies of firms, according to their innovation efforts (see Tether, 2001; Arundel and Hollanders, 2005; Frenz and Lambert, 2012).

11.53. Key priorities for constructing indicators of innovation effort or capability include incorporating data on the degree of novelty of innovations (for whom the innovation is new), the extent to which the business has drawn on its own resources to develop the concepts used in the innovation, and the economic significance for the firm of its innovations and innovation efforts.

11.4.3. Choice of statistical data for innovation indicators

11.54. The choice of data for constructing innovation indicators is necessarily determined by the purpose of the indicator and data quality requirements.

Official versus non-official sources

11.55. Where possible, indicator construction should use data from official sources that comply with basic quality requirements. This includes both survey and administrative data. For both types of data, it is important to determine if all relevant types of firms are included, if records cover all relevant data, and if record keeping is consistent across different jurisdictions (if comparisons are intended). For indicators that are constructed on a regular basis, information should also be available on any breaks in series, so that corrections can be made (where possible) to maintain comparability over time.

11.56. The same criteria apply to commercial data or data from other sources such as one-off academic studies. Commercial data sources often do not provide full details for the sample selection method or survey response rates. A lack of sufficient methodological information regarding commercial and other sources of data, as well as licensing fees for data access, have traditionally posed restrictions on their use by NSS organisations. The use of commercial data by NSS organisations can also create problems if the data provider stands to obtain a commercial advantage over its competitors.

Suitability of innovation survey data for constructing statistical indicators

11.57. Survey data are self-reported by the respondent. Some potential users of innovation data object to innovation surveys because they believe that self-reports result in subjective results. This criticism confuses *self-reporting* with *subjectivity*. Survey respondents are capable of providing an objective response to many factual questions, such as whether their firm implemented a business process innovation or collaborated with a university. These are similar to factual questions from household surveys that are used to determine unemployment rates. Subjective assessments are rarely problematic if they refer to factual behaviours.

11.58. A valid concern for users of innovation data is the variable nature of innovation. Because innovation is defined from the perspective of the firm, there are enormous differences between different innovations, which means that a simple indicator such as the share of innovative firms within a country has a very low discriminatory value. The solution is not to reject innovation indicators, but to construct indicators that can discriminate between firms of different levels of capability or innovation investments, and to provide these indicators by different breakdown categories, such as for different industries or firm size classes. Profiles, as described above, can significantly improve the discriminatory and explanatory value of indicators.

11.59. Another common concern is poor discriminatory power for many nominal or ordinal variables versus continuous variables. Data for the latter are often unattainable because respondents are unable to provide accurate answers. Under these conditions, it is recommended to identify which non-continuous variables are relevant to constructs of interest and to use information from multiple variables to estimate the construct.

Change versus current capabilities

11.60. The main indicators on the incidence of innovation (see Table 11.4) capture activities that derive from or induce change in a firm. However, a firm is not necessarily more innovative than another over the long term if the former has introduced an innovation in a given period and the latter has not. The latter could have introduced the same innovation several years before and have similar current capabilities for innovation. Indicators of capability, such as knowledge capital stocks within the firm, can be constructed using administrative sources or survey data that capture a firm's level of readiness or competence in a given domain (see Table 11.6). Evidence on the most important innovations (see Chapter 10) can also be useful for measuring current capabilities.

11.5. Using data on innovation to analyse innovation performance, policies and their impacts

11.61. Policy and business decisions can benefit from a thorough understanding of the factors that affect the performance of an innovation system. Innovation indicators provide useful information on the current state of the system, including bottlenecks, deficiencies and weaknesses, and can help track changes over time. However, this is insufficient: decision makers also need to know how conditions in one part of the system influence other parts, and how the system works to create outcomes of interest, including the effects of policy interventions.

11.62. This section examines how innovation data can be used to evaluate the links between innovation, capability-building activities, and outcomes of interest (Mairesse and Mohnen, 2010). Relevant research has extensively covered productivity (Hall, 2011; Harrison et al., 2014), management (Bloom and Van Reenen, 2007), employment effects (Griffith et al., 2006), knowledge sourcing (Laursen and Salter, 2006), profitability (Geroski, Machin and Van Reenen, 1993), market share and market value (Blundell, Griffith and Van Reenen, 1999), competition (Aghion et al., 2005), and policy impacts (Czarnitzki, Hanel and Rosa, 2011).

11.5.1. Modelling dependencies and associations

11.63. Associations between the components of an innovation system can be identified through descriptive and exploratory analysis. Multivariate regression provides a useful tool for exploring the covariation of two variables, for example innovation outputs and inputs, conditional on other characteristics such as firm size, age and industry of main economic activity. Regression is a commonly used tool of innovation analysts and its outputs a recurrent feature in research papers on innovation.

11.64. The appropriate multivariate technique depends on the type of data, particularly for dependent variables. Innovation surveys produce mostly nominal or ordinal variables with only a few continuous variables. Ordered regression models are appropriate for ordinal dependent variables on the degree of novelty or the level of complexity in the use of a technology or business practice (Galindo-Rueda and Millot, 2015). Multinomial choice models are relevant when managers can choose between three or more exclusive states, for example between different knowledge sources or collaboration partners.

11.65. Machine learning techniques also open new areas of analysis having to do with classification, pattern identification and regression. Their use in innovation statistics is likely to increase over time.

11.5.2. Inference of causal effects in innovation analysis

11.66. Statistical association between two variables (for instance an input to innovation and a performance output) does not imply causation without additional evidence, such as a plausible time gap between an input and an output, replication in several studies, and the ability to control for all confounding variables. Unless these conditions are met (which is rare in exploratory analyses), a study should not assume causality.

11.67. Research on policy interventions must also manage self-selection and plausible counterfactuals: what would have happened in the absence of a policy intervention? The effects of a policy intervention should ideally be identified using experimental methods such as randomised trials, but the scope for experimentation in innovation policy, although increasing in recent years (Nesta, 2016), is still limited. Consequently, alternative methods are frequently used.

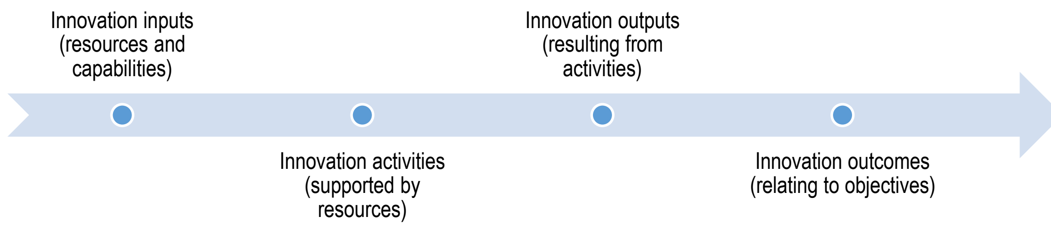
Impact analysis and evaluation terminology

11.68. The innovation literature commonly distinguishes between different stages of an innovation process, beginning with inputs (resources for an activity), activities, outputs (what is generated by activities), and outcomes (the effects of outputs). In a policy context, a logic model provides a simplified, linear relationship between resources, activities, outputs and outcomes. Figure 11.1 presents a generic logic model for the innovation process. Refinements to the model include multiple feedback loops.

11.69. Outputs include specific types of innovations, while outcomes are the effect of innovation on firm performance (sales, profits, market share etc.), or the effect of innovation on conditions external to the firm (environment, market structure, etc.). Impacts refer to the difference between potential outcomes under observed and unobserved counterfactual treatments. An example of a counterfactual outcome would be the sales of the firm if the resources expended for innovation had been used for a different purpose, for instance an intensive marketing campaign. In the absence of experimental data, impacts cannot be directly observed and must be inferred through other means.

Figure 11.1. Logic model used in evaluation literature applied to innovation

Feedback flows not presented



Source: Adapted from McLaughlin and Jordan (1999), "Logic models: A tool for telling your program's performance story".

11.70. In innovation policy design, the innovation logic model as described in Figure 11.1 is a useful tool for identifying what is presumed to be necessary for the achievement of desired outcomes. Measurement can capture evidence of events, conditions and behaviours that can be treated as proxies of potential inputs and outputs of the innovation process. Outcomes can be measured directly or indirectly. The evaluation of innovation policy using innovation data is discussed below.

Direct and indirect measurement of outcomes

11.71. Direct measurement asks respondents to identify whether an event is the result (at least in part) of one or more activities. For example, respondents can be asked if business process innovations reduced their unit costs, and if so, to estimate the percentage reduction. Direct measurement creates significant validity problems. For example, respondents might be able to determine with some degree of accuracy whether business process innovations were followed by cost reductions on a "yes" or "no" basis. However, the influence of multiple factors on process costs could make it very difficult for respondents to estimate the percentage reduction attributable to innovation (although they might be able to make an estimate for their most important business process innovation). Furthermore, respondents will find it easier to identify and report actual events than to speculate and assign causes to outcomes or vice versa. Business managers are likely to use heuristics to answer impact-related questions that conceptually require a counterfactual.

11.72. Non-experimental, indirect measurement collects data on inputs and outcomes and uses statistical analysis to evaluate the correlations between them, after controlling for potential confounding variables. However, there are also several challenges to using indirect methods for evaluating the factors that affect innovation outcomes.

Challenges for indirect measurement of outcomes

11.73. Innovation inputs, outputs and outcomes are related through non-linear processes of transformation and development. Analysis has to identify appropriate dependent and independent variables and potential confounding variables that provide alternative routes to the same outcome.

11.74. In the presence of random measurement error for independent variables, analysis of the relationship between the independent and dependent variables will be affected by attenuation bias, such that relationships will appear to be weaker than they actually are. In addition, endogeneity is a serious issue that can result from a failure to control for confounders, or when the dependent variable affects one or more independent variables (reverse causality). Careful analysis is required to avoid both possible causes of endogeneity.

11.75. Other conditions can increase the difficulty of identifying causality. In research on knowledge flows, linkages across actors and the importance of both intended and unintended knowledge diffusion can create challenges for identifying the effect of specific knowledge sources on outcomes. Important channels could exist for which there are no data. As noted in Chapter 6, the analysis of knowledge flows would benefit from social network graphs of the business enterprise to help identify the most relevant channels. A statistical implication of highly connected innovation systems is that the observed values are not independently distributed: competition and collaboration generate outcome dependences across firms that affect estimation outcomes.

11.76. Furthermore, dynamic effects require time series data and an appropriate model of evolving relationships in an innovation system, for example between inputs in a given period (t) and outputs in later periods (t+1). In some industries, economic results are only obtained after several years of investment in innovation. Dynamic analysis could also require data on changes in the actors in an innovation system, for instance through mergers and acquisitions. Business deaths can create a strong selection effect, with only surviving businesses available for analysis.

Matching estimators

11.77. Complementing regression analysis, matching is a method that can be used for estimating the average effect of business innovation decisions as well as policy interventions (see subsection 11.5.3 below). Matching imposes no functional form specifications on the data but assumes that there is a set of observed characteristics such that outcomes are independent of the treatment conditional on those characteristics (Todd, 2010). Under this assumption, the impact of innovation activity on an outcome of interest can be estimated from comparing the performance of innovators with a weighted average of the performance of non-innovators. The weights need to replicate the observable characteristics of the innovators in the sample. Under some conditions, the weights can be estimated from predicted innovation probabilities using discrete analysis (matching based on innovation propensity scores).

11.78. In many cases, there can be systematic differences between the outcomes of treated and untreated groups, even after conditioning on observables, which could lead to a violation of the identification conditions required for matching. Independence assumptions can be more valid for changes in the variable of interest over time. When longitudinal data are available, the "difference in differences" method can be used. An example is an analysis of productivity growth that compares firms that introduced innovations in the reference period with those that did not. Further bias reduction can be attained by using information on past innovation and economic performance.

11.79. Matching estimators and related regression analysis are particularly useful for the analysis of reduced-form causal relationship models. Reduced-form models have fewer requirements than structural models, but are less informative in articulating the mechanisms that underpin the relationship between different variables.

Structural analysis of innovation data: The CDM model

11.80. The model, developed by Crépon, Duguet and Mairesse (1998) (hence the name CDM), builds on Griliches' (1990) path diagram of the knowledge production function and is widely used in empirical research on innovation and productivity (Lööf, Mairesse and Mohnen, 2016). The CDM framework is suitable for cross-sectional innovation survey data obtained by following this manual's recommendations, including data not necessarily collected for indicator production purposes. It provides a structural model that explains productivity by innovation output and corrects for the selectivity and endogeneity inherent in survey data. It includes the following sub-models (Criscuolo, 2009):

1. Propensity among all firms to undertake innovation: This key step requires good quality information on all firms. This requirement provides a motivation for collecting data from all firms, regardless of their innovation status, as recommended in Chapters 4 and 5.
2. Intensity of innovation effort among innovation-active firms: The model recognises that there is an underlying degree of innovation effort for each firm that is only observed among those that undertake innovation activities. Therefore, the model controls for the selective nature of the sample.
3. Scale of innovation output: This is observed only for innovative firms. This model uses the predicted level of innovation effort identified in model 2 and a control for the self-selected nature of the sample.
4. Relationship between labour productivity and innovation effort: This is estimated by incorporating information about the drivers of the innovation outcome variable (using its predicted value) and the selective nature of the sample.

11.81. Policy variables can be included in a CDM model, provided they display sufficient variability in the sample and satisfy the independence assumptions (including no self-selection bias) required for identification.

11.82. The CDM framework has been further developed to work with repeated cross-sectional and panel data, increasing the value of consistent longitudinal data at the micro level. Data and modelling methods require additional development before CDM and CDM-related frameworks can fully address several questions of interest, such as the competing roles of R&D versus non-R&D types of innovation activity, or the relative importance or complementarity of innovation activities versus generic competence and capability development activities. Improvements in data quality for variables on non-R&D activities and capabilities would facilitate the use of extended CDM models.

11.5.3. Analysing the impact of public innovation policies

11.83. Understanding the impact of public innovation policies is one of the main user interests for innovation statistics and analysis. This section draws attention to some of the basic procedures and requirements that analysts and practitioners need to consider.

The policy evaluation problem

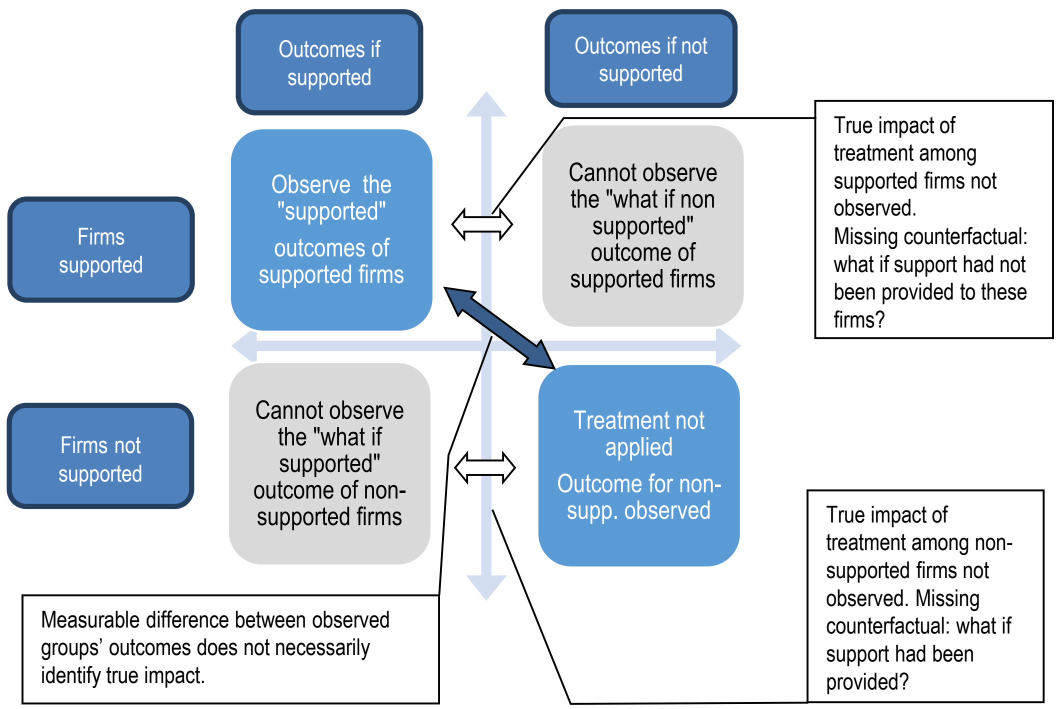
11.84. Figure 11.2 illustrates the missing counterfactual data problem in identifying the causal impacts of policies. This is done by means of an example where the policy "treatment" is support for innovation activities, for instance a grant to support the development and launch of a new product. Some firms receive support whereas others do not. The true impact of support is likely to vary across firms. The evaluation problem is one of missing information. The researcher cannot observe, for supported firms, what would have been their performance had they not been supported. The same applies to non-supported firms. The light grey boxes in the figure represent what is not directly observable through measurement. The arrows indicate comparisons and how they relate to measuring impacts.

11.85. The main challenge in constructing valid counterfactuals is that the potential effect of policy support is likely to be related to choices made in assigning support to some firms and not to others. For example, some programme managers may have incentives to select businesses that would have performed well even in the absence of support, and businesses themselves have incentives to apply according to their potential to benefit from policy support after taking into account potential costs.

11.86. The diagonal arrow in Figure 11.2 shows which empirical comparisons are possible and how they do not necessarily represent causal effects or impacts when the treated and non-treated groups differ from each other in ways that relate to the outcomes (i.e. a failure to control for confounding variables).

Figure 11.2. The innovation policy evaluation problem to identifying causal effects

Observed outcomes and unobserved counterfactuals in a business innovation support example



Source: Based on Rubin (1974), "Estimating causal effects of treatments in randomized and nonrandomized studies".

Data requirements and randomisation

11.87. Policy evaluation requires linking data on the innovation performance of firms with data on their exposure to a policy treatment. Innovation surveys usually collect insufficient information for this purpose on the use of innovation policies by firms. An alternative (see Chapter 7) is to link innovation survey data at the firm level with administrative data, such as government procurement and regulatory databases, or data on firms that neither applied for nor obtained policy support. The same applies to data on whether firms were subject to a specific regulatory regime. The quality of the resulting microdata will depend on the completeness of data on policy "exposure" (e.g. are data only available for some types of policy support and not others?) and the accuracy of the matching method.

11.88. Experiments that randomly assign participants to a treatment or control group provide the most accurate and reliable information on the impact of innovation policies (Nesta, 2016). Programme impact is estimated by comparing the behaviour and outcomes of the two groups, using outcome data collected from a dedicated survey or other sources (Edovald and Firpo, 2016).

11.89. Randomisation eliminates selection bias, so that both groups are comparable and any differences between them are the result of the intervention. Randomised trials are sometimes viewed as politically unfeasible because potential beneficiaries are excluded from treatment, at least temporarily. However, randomisation can often be justified on the basis of its potential for policy learning when uncertainty is largest. Furthermore, a selection procedure is required in the presence of budgetary resource limitations that prevent all firms from benefiting from innovation support.

Policy evaluation without randomisation

11.90. In *ex ante* or *ex post* non-randomisation evaluation exercises, it is important to account for the possibility that observed correlations between policy treatment and innovation performance could be due to confounding by unobserved factors that influence both. This can be a serious issue for evaluations of discretionary policies where firms must apply for support. This requires a double selection process whereby the firm self-selects to submit an application, and programme administrators then make a decision on whether to fund the applicant. This second selection can be influenced by policy criteria to support applicants with the highest probability of success, which could create a bias in favour of previously successful applicants. Both types of selection create a challenge for accurately identifying the additionality of public support for innovation. To address selection issues, it is necessary to gather information on the potential eligibility of business enterprises that apply for and do not receive funding, apply for and receive funding, and for a control group of non-applicants.

11.91. Comprehensive data on the policy of interest and how it has been implemented are also useful for evaluation. This includes information on the assessment rating for each application, which can be used to evaluate the effect of variations in application quality on outcomes. Changes in eligibility requirements over time and across firms provide a potentially useful source of exogenous variation.

11.92. The available microdata for policy use is often limited to firms that participated in government programmes. In this case it is necessary to construct a control group of non-applicants using other data sources. Innovation survey data can also help identify counterfactuals. Administrative data can be used to identify firms that apply for and ultimately benefit from different types of government programmes to support innovation and other activities (see subsection 7.5.2). The regression, matching and structural estimation methods discussed above can all be applied in this policy analysis and evaluation context.

Procedures

11.93. With few exceptions, NSOs rarely have a mandate to conduct policy evaluations. However, it is widely accepted that their infrastructures can greatly facilitate such work in conditions that do not contravene the confidentiality obligations to businesses reporting data for statistical purposes. Evaluations are usually left to academics, researchers or consultants with experience in causal analysis as well as the independence to make critical comments on public policy issues. This requires providing researchers with access to microdata under sufficiently secure conditions (see subsection 9.8.2). There have been considerable advances to minimise the burden associated with secure access to microdata for analysis. Of note, international organisations such as the Inter-American Development Bank have contributed to comparative analysis by requiring the development of adequate and accessible microdata as a condition of funding for an innovation (or related) survey.

11.94. Government agencies that commission policy evaluations using innovation and other related survey data require basic capabilities in evaluation methodologies in order to scrutinise and assess the methodologies used by contractors or researchers and to interpret and communicate the results. Replicability is an important requirement for ensuring quality, and the programming code used for statistical analysis should thus be included as one of the evaluation's deliverables. Linked databases that are created for publicly funded evaluation studies should also be safely stored and made available to other researchers after a reasonable time lapse, as long as they do not include confidential data.

11.5.4. Co-ordinated analysis of innovation microdata across countries

11.95. When non-discretionary policies are implemented at the national level, it can be very difficult to identify appropriate control groups. For example, all firms within a country are subject to identical competition regulations. A solution is to use innovation data from across countries with different policy environments.

11.96. The main constraint for cross-country policy evaluation is access to microdata for all the countries included in the analysis. Microdata access is essential for accounting for a large number of business and contextual features and for testing counterfactuals. Microdata can be combined with data at the macro level to control for differences by country.

Analysis with pooled microdata

11.97. The optimal solution is to include microdata from multiple countries in a single database. This minimises differences in data manipulation and provides researchers with access to the full sample. This is a requirement for the estimation of multi-level models with combined micro- and country-level effects. An example is a model that analyses innovation performance as a function of business characteristics and national policies.

11.98. The construction of a single database for microdata from multiple countries is constrained by regulations governing data collection and access. National legislation to protect confidentiality can bar non-nationals from accessing data or the use of data abroad. However, legally compliant solutions have been found when there is consensus on the importance of co-ordinated international analysis. An example is the European Commission's legislative arrangements to provide access to approved researchers to the CIS microdata at Eurostat's Safe Centre for agreed research projects. This resource for pooled data from different countries has made a substantial contribution to international comparative analysis, although at present it is not possible to link the Safe Centre CIS data to other data.

Distributed, multi-country microdata analysis

11.99. When microdata cannot be remotely accessed or combined in a single database for confidentiality or other reasons, other methods can be used by focussing on the non-confidential outputs. The distributed approach to microdata analysis involves, in first instance, the design and implementation of a common data analysis programming code by individuals with access to their national microdata. The code is designed to return non-confidential outputs such as descriptive indicators or coefficients from multivariate analyses that are as similar as possible across countries. The data can then be compared and further analysed by the collective of individuals involved in the project or by authorised third parties.

11.100. The use of distributed methods for the analysis of innovation began as researcher-led initiatives involving a limited group of countries (Griffith et al., 2006). Since then, the distributed approach has been increasingly adopted for comparative analysis by international organisations such as the OECD (OECD, 2009b). In addition, national teams can produce estimates of parameters for use in further comparative analysis (Criscuolo, 2009), adopting tools similar to those used in quantitative meta-analysis.

11.101. One possible application of a distributed approach to microdata analysis is the construction of a multi-country micro-moments database (MMD) that includes a set of statistical indicators, drawn from national microdata, and captures attributes of the joint distribution of variables within each country. The database comprises a number M of m-moments corresponding to different multivariate statistics, where the moments have been estimated within each country for each combination of business group *g* (e.g. size and industry) and for each period *t*. The pooled MMD database for the group of participating countries enables not only tabulations of indicators but also meso- and macro-level analysis to which additional policy and other variables can be added. The ability to build a MMD depends on the comparability of the underlying data and the use of identical protocols to construct the national MMD components (Bartelsman, Hagsten and Polder, 2017).

11.6. Conclusions

11.102. This chapter has reviewed a number of issues relating to the use of innovation data for constructing indicators as well as in statistical and econometric analysis. The recommendations in this chapter are aimed not only at those producing indicators in an official capacity, but also at other interested users of innovation data. The chapter seeks to guide the work of those involved in the design, production and use of innovation indicators. It also contributes to address a broader range of user evidence needs that cannot be met by indicators alone. The chapter has thus described methods for analysing innovation data, with a focus on assessing the impacts of innovation and the empirical evaluation of government innovation policies. It is intended to guide existing data collection and analysis, as well as to encourage future experimentation which will enhance the quality, visibility, and usefulness of data and indicators derived from innovation surveys, a key objective of this manual.

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Glossary of terms

Activities relating to the acquisition or lease of tangible assets	This includes the purchase, lease, or acquisition through a takeover of buildings, machinery, equipment, or the in-house production of such goods for own-use. The acquisition or lease of tangible assets can be innovation activities in their own right, such as when a firm purchases equipment with significantly different characteristics than the existing equipment that it uses for its business processes. The acquisition of tangible capital goods is generally not an innovation activity if it is for replacement or capital-widening investments that are unchanged, or with only minor changes compared to the firm's existing stock of tangible capital. The lease or rental of tangible assets is an innovation activity if these assets are required for the development of product or business process innovations.
Administrative data	Administrative data is the set of units and data derived from an administrative source such as business registers or tax files.
Affiliated firm	Affiliated firms include holding, subsidiary or associated companies located in the domestic country or abroad. See also *Enterprise group.*
Artificial intelligence (AI)	Artificial intelligence (AI) describes the activity and outcome of developing computer systems that mimic human thought processes, reasoning and behaviour.
Asset	An asset is a store of value that represents a benefit or series of benefits accruing to the economic owner by holding or using the asset over a period of time. Both financial and non-financial assets are relevant to innovation. Fixed assets are the result of production activities and are used repeatedly or continuously in production processes for more than one year.
Big data	Data that are too large or complex to be handled by conventional data processing tools and techniques.
Brand equity activities	See *Marketing and brand equity activities.*
Business capabilities	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 business capabilities.
Business enterprise sector	The Business enterprise sector comprises: • All resident corporations, including legally incorporated enterprises, regardless of the residence of their shareholders. This includes quasi-corporations, i.e. units capable of generating a profit or other financial gain for their owners, recognised by law as separate legal entities from their owners, and set up for the purpose of engaging in market production at prices that are economically significant. • The unincorporated branches of non-resident enterprises deemed to be resident and part of this sector because they are engaged in production on the economic territory on a long-term basis. • All resident non-profit institutions that are market producers of goods or services or serve businesses.

Business innovation	A business innovation is a new or improved product or business process (or combination thereof) that differs significantly from the firm's previous products or business processes and that has been introduced on the market or brought into use by the firm.
Business innovation activities	See *Innovation activities (business).*
Business model innovation	Business model innovation relates to changes in a firm's core business processes as well as in the main products that it sells, currently or in the future.
Business process innovation	A business process innovation is a new or improved business process for one or more business functions that differs significantly from the firm's previous business processes and that has been brought into use by the firm. The characteristics of an improved business function include greater efficacy, resource efficiency, reliability and resilience, affordability, and convenience and usability for those involved in the business process, either external or internal to the firm. Business process innovations are implemented when they are brought into use by the firm in its internal or outward-facing operations. Business process innovations include the following functional categories: • production of goods and services • distribution and logistics • marketing and sales • information and communication systems • administration and management • product and business process development.
Business strategy	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".
Capital expenditures	Capital expenditures are the annual gross amount paid for the acquisition of fixed assets and the costs of internally developing fixed assets. These include gross expenditures on land and buildings, machinery, instruments, transport equipment and other equipment, as well as intellectual property products. See also *Current expenditures.*
CDM model	The CDM model (based on the initials of the three authors' names, Crépon, Duguet and Mairesse) is an econometric model widely used in empirical research on innovation and productivity. The CDM framework provides a structural model that explains productivity by innovation output and corrects for the selectivity and endogeneity inherent in survey data.
Cloud computing	Cloud systems and applications are digital storage and computing resources remotely available on-demand via the Internet.
Cognitive testing	Cognitive testing is a methodology developed by psychologists and survey researchers which collects verbal information on survey responses. It is used to evaluate the ability of a question (or group of questions) to measure constructs as intended by the researcher and if respondents can provide reasonably accurate responses.
Co-innovation	Co-innovation, or "coupled open innovation", occurs when collaboration between two or more partners results in an innovation.

Collaboration	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. See also *Co-operation.*
Community Innovation Survey (CIS)	The Community Innovation Survey (CIS) is a harmonised survey of innovation in enterprises co-ordinated by Eurostat and currently carried out every two years in EU member states and several European Statistical System (ESS) member countries.
Composite indicator	A composite indicator compiles multiple indicators into a single index based on an underlying conceptual model in a manner which reflects the dimensions or structure of the phenomena being measured. See also *Indicator.*
Computer-assisted personal interviewing (CAPI)	Computer-assisted personal interviewing (CAPI) is a method of data collection in which an interviewer uses a computer to display questions and accept responses during a face-to-face interview.
Computer-assisted telephone interviewing (CATI)	Computer-assisted telephone interviewing (CATI) is a method of data collection by telephone with questions displayed on a computer and responses entered directly into a computer.
Co-operation	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. See also *Collaboration.*
Corporations	The System of National Accounts (SNA) Corporations sector consists of corporations that are principally engaged in the production of market goods and services. This manual adopts the convention of referring to this sector as the Business enterprise sector, in line with the terminology adopted in the OECD's *Frascati Manual*.
Counterfactual	In impact evaluation, the counterfactual refers to what would have happened to potential beneficiaries in the absence of an intervention. Impacts can thus be estimated as the difference between potential outcomes under observed and unobserved counterfactual treatments. An example is estimating the causal impacts of a policy "treatment" to support innovation activities. The researcher cannot directly observe the counterfactuals: for supported firms, what would have been their performance if they had not been supported, and similarly with non-supported firms.
Cross-sectional survey	A cross-sectional survey collects data to make inferences about a population of interest (or subset) at a specific point in time.
Current expenditures	Current expenditures include all costs for labour, materials, services and other inputs to the production process that are consumed within less than one year, and the costs for leasing fixed assets. See also *Capital expenditures.*
Design	Design is defined as an innovation activity aimed at planning and designing procedures, technical specifications and other user and functional characteristics for new products and business processes. Design includes a wide range of activities to develop a new or modified function, form or appearance for goods, services or processes, including business processes to be used by the firm itself. Most design (and other creative work) activities are innovation activities, with the exception of minor design changes that do not meet the requirements for an innovation, such as producing an existing product in a new colour. Design capabilities include the following: (i) engineering design; (ii) product design; and (iii) design thinking.

Design Ladder	The Design Ladder is a tool developed by the Danish Design Centre for illustrating and rating a company's use of design. The Design Ladder is based on the hypothesis that there is a positive link between higher earnings, placing a greater emphasis on design methods in the early stages of development and giving design a more strategic position in the company's overall business strategy. The four steps are: (i) non-design; (ii) design as form-giving; (iii) design as process; and (iv) design as strategy.
Design thinking	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. 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.
Diffusion (innovation)	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).
Digital-based innovations	Digital-based innovations include product or business process innovations that contain ICTs, as well as innovations that rely to a significant degree on information and communication technologies (ICTs) for their development or implementation.
Digital platforms	Digital platforms are information and communication technology-enabled mechanisms that connect and integrate producers and users in online environments. They often form an ecosystem in which goods and services are requested, developed and sold, and data generated and exchanged.
Digitalisation	Digitalisation is the application or increase in use of digital technologies by an organisation, industry, country, etc. It refers to how digitisation affects the economy or society. See also *Digitisation.*
Digitisation	Digitisation is the conversion of an analogue signal conveying information (e.g. sound, image, printed text) to binary bits. See also *Digitalisation.*
Dynamic managerial capabilities	Dynamic managerial capabilities refer to the ability of managers to organise an effective response to internal and external challenges Dynamic managerial capabilities include the following three main dimensions: (i) managerial cognition; (ii) managerial social capital; and (iii) managerial human capital.
Employee training activities	Employee training includes all activities that are paid for or subsidised by the firm to develop knowledge and skills required for the specific trade, occupation or vocation of a firm's employees. Employee training includes on-the-job training and job-related education at training and educational institutions. Examples of training as an innovation activity include training personnel to use innovations, such as new software logistical systems or new equipment; and training relevant to the implementation of an innovation, such as instructing marketing personnel or customers on the features of a product innovation.

Engineering, design and other creative work activities	Engineering, design and other creative work cover experimental and creative activities that may be closely related to research and experimental development (R&D), but do not meet all of the five R&D criteria. These include follow-up or auxiliary activities of R&D, or activities that are performed independently from R&D. Engineering involves production and quality control procedures, methods and standards. Design includes a wide range of activities to develop a new or modified function, form or appearance for goods, services or processes, including business processes to be used by the firm itself. Other creative work includes all activities for gaining new knowledge or applying knowledge in a novel way that do not meet the specific novelty and uncertainty (also relating to non-obviousness) requirements for R&D. Most design and other creative work are innovation activities, with the exception of minor design changes that do not meet the requirements for an innovation. Many engineering activities are not innovation activities, such as day-to-day production and quality control procedures for existing processes.
Enterprise	An enterprise is the smallest combination of legal units with autonomy in respect of financial and investment decision-making, as well as authority and responsibility for allocating resources for the production of goods and services. The term enterprise may refer to a corporation, a quasi-corporation, a non-profit institution or an unincorporated enterprise. It is used throughout this manual to refer specifically to business enterprises. See also *Business enterprise sector.*
Enterprise group	A set of enterprises controlled by the group head, which is a parent legal unit that is not controlled either directly or indirectly by any other legal unit. See also *Enterprise.*
Establishment	An establishment is an enterprise, or part of an enterprise, that is situated in a single location and in which only a single productive activity is carried out or in which the principal productive activity accounts for most of the value added. See also *Enterprise.*
Extramural innovation expenditure	Expenditures for innovation activities carried out by third parties on behalf of the firm, including extramural R&D expenditure.
Extramural R&D	Extramural research and experimental development (R&D) is any R&D performed outside of the statistical unit about which information is being reported. Extramural R&D is considered an innovation activity alongside intramural R&D. See also *Intramural R&D.*
Firm	Informal term used in this manual to refer to business enterprises. See also *Enterprise.*
Filters	Filters and skip instructions direct respondents to different parts of a questionnaire, depending on their answers to the filter questions. Filters can be helpful for reducing response burden, particularly in complex questionnaires, but they can also encourage satisficing behaviour.
Focal innovation	Data collection using the object-based method can focus on a firm's single, "focal" innovation. This is usually defined as the firm's most important innovation in terms of some measurable criteria (e.g. the innovation's actual or expected contribution to the firm's performance, the one with the highest innovation expenditures, the one with the greatest contribution to sales), but can also be the firm's most recent innovation.
Follow-on activities	Follow-on activities are efforts undertaken by firms for users of an innovation after its implementation, but within the observation period. These include marketing activities, employee training, and after-sales services. These follow-on activities can be critical for the success of an innovation, but they are not included in the definition of an innovation activity.
Framework conditions	Broader set of contextual factors related to the external environment that facilitate or hinder business activities in a given country. These usually include the regulatory environment, taxation, competition, product and labour markets, institutions, human capital, infrastructure, standards, etc.

Full-time equivalent (FTE)	Full-time equivalent (FTE) is the ratio of working hours actually spent on an activity during a specific reference period (usually a calendar year) divided by the total number of hours conventionally worked in the same period.
General government (sector)	General government consists of institutional units that, in addition to meeting their political and regulatory responsibilities, redistribute income and wealth and produce services and goods for individual or collective consumption, mainly on a non-market basis. The General government sector also includes non-profit institutions controlled by the government.
Global value chains	Pattern of organisation of production involving international trade and investment flows whereby the different stages of the production process are located across different countries.
Goods	Goods are physical, produced objects for which a demand exists, over which ownership rights can be established and whose ownership can be transferred from one institutional unit to another by engaging in transactions on markets. See also *Products.*
Government support programmes	Government support programmes represent direct or indirect transfers of resources to firms. Support can be of a financial nature or may be provided in kind. This support may come directly from government authorities or indirectly, for example when consumers are subsidised to purchase specific products. Innovation-related activities and outcomes are common targets of government support.
Households	Households are institutional units consisting of one or more individuals. In the System of National Accounts, individuals must belong to only one household. The principal functions of households are to supply labour, to undertake final consumption and, as entrepreneurs, to produce market goods and services.
Implementation	Implementation refers to the point in time when a significantly different new or improved product or business process is first made available for use. In the case of product innovation, this refers to its market introduction, while for business process innovations it relates to their first use within the firm.
Imputation	Imputation is a post-survey adjustment method for dealing with item non-response. A replacement value is assigned for specific data items where the response is missing or unusable. Various methods can be used for imputation including mean value, hot-/cold-deck, nearest-neighbour techniques and regression. See also *Item non-response*.
Informal sector (or economy)	The informal sector is broadly characterised as consisting of units engaged in the production of goods or services with the primary objective of generating employment and incomes to the persons concerned. These units typically operate at a low level of organisation, with little or no division between labour and capital as factors of production and on a small scale.
Indicator	An indicator is a variable that purports to represent the performance of different units along some dimension. Its value is generated through a process that simplifies raw data about complex phenomena in order to compare similar units of analysis across time or location. See also *Innovation indicator.*
Industry	An industry consists of a group of establishments engaged in the same, or similar, kinds of activity. See also *ISIC.*
Innovation	An innovation is a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process).

Innovation-active firm	An innovation-active firm is engaged at some time during the observation period in one or more activities to develop or implement new or improved products or business processes for an intended use. Both innovative and non-innovative firms can be innovation-active during an observation period. See also *Innovation status.*
Innovation activities	Institutional units can undertake a series of actions with the intention to develop innovations. This can require dedicated resources and engagement in specific activities, including policies, processes and procedures. See also *Innovation activities (business).*
Innovation activities (business)	Business innovation activities include all developmental, financial and commercial activities undertaken by a firm that are intended to result in an innovation for the firm. They include: • research and experimental development (R&D) activities • engineering, design and other creative work activities • marketing and brand equity activities • intellectual property (IP) related activities • employee training activities • software development and database activities • activities related to the acquisition or lease of tangible assets • innovation management activities. Innovation activities can result in an innovation, be ongoing, postponed or abandoned.
Innovation barriers and drivers	Internal or external factors that hamper or incentivise business innovation efforts. Depending on the context, an external factor can act as a driver of innovation or as a barrier to innovation.
Innovation expenditure (business)	Economic cost of innovation activities undertaken by a firm or group of firms. Expenditure can be intramural (activities carried out in-house) or extramural (carried out by third parties on behalf of the firm). See also *Innovation activities (business).*
Innovation indicator	An innovation indicator is a statistical summary measure of an innovation phenomenon (activity, output, expenditure, etc.) observed in a population or a sample thereof for a specified time or place. Indicators are usually corrected (or standardised) to permit comparisons across units that differ in size or other characteristics. See also *Indicator.*
Innovation management	Innovation management includes all systematic activities to plan, govern and control internal and external resources for innovation. This includes how resources for innovation are allocated, the organisation of responsibilities and decision-making among employees, the management of collaboration with external partners, the integration of external inputs into a firm's innovation activities, and activities to monitor the results of innovation and to support learning from experience.
Innovation objectives	Innovation objectives consist of a firm's identifiable goals that reflect its motives and underlying strategies with respect to its innovation efforts. The objectives can concern the characteristics of the innovation itself, such as its specifications, or its market and economic objectives.
Innovation outcomes	Innovation outcomes are the observed effects of innovations, including the extent to which a firm's objectives are met and the broader effects of innovation on other organisations, the economy, society, and the environment. These can also include unexpected effects that were not identified among the firm's initial objectives (e.g. spillovers and other externalities).

Innovation project	An innovation project is a set of activities that are organised and managed for a specific purpose and with their own objectives, resources and expected outcomes. Information on innovation projects can complement other qualitative and quantitative data on innovation activities.
Innovation sales share	The innovation sales share indicator is the share of a firm's total sales in the reference year that is due to product innovations. It is an indicator of the economic significance of product innovations at the level of the innovative firm.
Innovation status	The innovation status of a firm is defined on the basis of its engagement in innovation activities and its introduction of one or more innovations over the observation period of a data collection exercise. See also *Innovative firm and Innovation-active firm.*
Innovative firm	An innovative firm reports one or more innovations within the observation period. This applies equally to a firm that is individually or jointly responsible for an innovation. The term "innovative" is only used in the manual in this context. See also *Innovation status.*
Institutional unit	An institutional unit is defined in the System of National Accounts as "an economic entity that is capable, in its own right, of owning assets, incurring liabilities, and engaging in economic activities and transactions with other entities." Institutional units can undertake a series of actions with the intention to develop innovations.
Intangible assets	*See Knowledge-based capital.*
Intellectual property (IP)	Intellectual property (IP) refers to creations of the mind such as inventions; literary and artistic works; and symbols, names and images used in commerce. See also *Intellectual property rights.*
Intellectual property (IP) related activities	Intellectual property (IP) related activities include the protection or exploitation of knowledge, often created through research and experimental development (R&D), software development, and engineering, design and other creative work. IP activities include all administrative and legal work to apply for, register, document, manage, trade, license-out, market and enforce a firm's own intellectual property rights (IPRs), all activities to acquire IPRs from other organisations such as through licensing-in or the outright purchase of IP, and activities to sell IP to third parties. IP activities for ideas, inventions and new or improved products or business processes developed during the observation period are innovation activities. See also *Intellectual property and Intellectual property rights.*
Intellectual property products (IPPs)	Intellectual property products (IPPs) are the result of research, development, investigation or innovation leading to knowledge that the developers can market or use to their own benefit in production because use of the knowledge is restricted by means of legal or other protection. They include: • research and experimental development (R&D) • mineral exploration and evaluation • computer software and databases • entertainment, literary and artistic originals; and other IPPs.
Intellectual property rights (IPRs)	Intellectual property rights (IPRs) are legal rights over intellectual property. See also *Intellectual property*.

International Standard Industrial Classification of All Economic Activities (ISIC)	The International Standard Industrial Classification of All Economic Activities (ISIC) consist of coherent and consistent classification structure of economic activities based on a set of internationally agreed concepts, definitions, principles and classification rules. It provides a comprehensive framework within which economic data can be collected and reported in a format that is designed for purposes of economic analysis, decision-taking and policy-making. The scope of ISIC in general covers productive activities, i.e. economic activities within the production boundary of the System of National Accounts (SNA). The classification is used to classify statistical units, such as establishments or enterprises, according to the economic activity in which they mainly engage. The most recent version is ISIC Revision 4.
Intramural R&D	Intramural research and experimental development (R&D) expenditures are all current expenditures plus gross fixed capital expenditures for R&D performed within a statistical unit. Intramural R&D is an innovation activity alongside extramural R&D. See also *Extramural R&D.*
ISO 50500	International Organization for Standardization (ISO) standards on innovation management fundamentals and vocabulary developed by the ISO/TC 279 Technical Committee. The definitions of innovation and innovation management in the *Oslo Manual* are aligned with those used by ISO.
Item non-response	When a sampled unit responds to a questionnaire incompletely.
Kind-of-activity unit (KAU)	A kind-of-activity unit (KAU) is an enterprise, or a part of an enterprise, that engages in only one kind of productive activity or in which the principal productive activity accounts for most of the value added. See also *Enterprise.*
Knowledge	Knowledge refers to an understanding of information and the ability to use information for different purposes.
Knowledge-based capital (KBC)	Knowledge-based capital (KBC) comprises intangible assets that create future benefits. It comprises software and databases, Intellectual property products, and economic competencies (including brand equity, firm-specific human capital, organisational capital). Software, databases and intellectual property products are currently recognised by the System of National Accounts as produced assets. See also *Intellectual property products.*
Knowledge-capturing products	Knowledge-capturing products concern the provision, storage, communication and dissemination of information, advice and entertainment in such a way that the consuming unit can access the knowledge repeatedly.
Knowledge flows	Knowledge flows refer to inbound and outbound exchanges of knowledge, through market transactions as well as non-market means. Knowledge flows encompass both deliberate and accidental transmission of knowledge.
Knowledge management	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.
Knowledge network	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. Knowledge networks contain two main components: the type of knowledge and the actors that receive, supply or exchange knowledge.
Logic model	A logic model is a tool used by funders, managers, and evaluators of programmes to represent the sequence of impacts and evaluate the effectiveness of a programme.
Longitudinal survey	A longitudinal survey collects data on the same units (panel) over multiple time periods.

Management capabilities	Management capabilities can influence a firm's ability to undertake innovation activities, introduce innovations and generate innovation outcomes. For the purpose of innovation, two key areas are considered: (i) a firm's competitive strategy; and (ii) the organisational and managerial capabilities used to implement this strategy. See also *Managerial capabilities.*
Managerial capabilities	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. See also *Management capabilities.*
Marketing and brand equity activities	Marketing and brand equity activities include market research and market testing, methods for pricing, product placement and product promotion; product advertising, the promotion of products at trade fairs or exhibitions and the development of marketing strategies. Marketing activities for existing products are only innovation activities if the marketing practice is itself an innovation.
Marketing innovation	Type of innovations used in the previous edition of this Manual, currently these are mostly subsumed under business process innovation, except for innovations in product design which are included under product innovation.
Metadata	Metadata are data that define and describe other data. This includes including information on the procedure used to collect data, sampling methods, procedures for dealing with non-response, and quality indicators.
Moments (statistical)	Statistical indicators providing information on the shape of the distribution of a database. Examples include the mean and the variance.
Multinational enterprise (MNE)	A multinational enterprise (MNE) refers to a parent company resident in a country and its majority-owned affiliates located abroad, which are labelled controlled affiliates abroad. MNEs are also referred to as global enterprise groups. See also *Enterprise group.*
New-to-firm (NTF) innovation	Lowest threshold for innovation in terms of novelty referring to a first time use or implementation by a firm. A new-to-firm (NTF) innovation can also be new-to-market (NTM) (or world), but not vice versa. If an innovation is NTF but not NTM (e.g. when adopting existing products or business processes – as long as they differ significantly from what the firm offered or used previously – with little or no modification), it is referred to as "NTF only". See also *New-to-market innovation.*
New-to-market (NTM) innovation	An innovation by a firm that has not been available in the market(s) served by the firm. New-to-market innovation represent a higher threshold for innovation than a new-to-firm innovation in terms of novelty. See also *New-to-firm innovation.*
Nominal variable	Categorical variable with no intrinsic ordering. See also *Ordinal variable.*
Non-innovative firm	A non-innovative firm is one that does not report an innovation within the observation period. A non-innovative firm can still be innovation-active if it had one or more ongoing, suspended, abandoned or completed innovation activities that did not result in an innovation during the observation period. See also *Innovative firm.*
Non-profit institution (NPI)	Non-profit institutions (NPIs) are legal or social entities created for the purpose of producing goods and services, whose status does not permit them to be a source of income, profit or other financial gain for the units that establish, control or finance them. They can be engaged in market or non-market production.

Non-profit institutions serving households (NPISHs)	Non-profit institutions serving households (NPISHs) are legal entities that are principally engaged in the production of non-market services for households or the community at large and whose main resource is from voluntary contributions. If controlled by government, they are part of the General government sector. If controlled by firms, they are assigned to the Business enterprise sector. See also *Non-profit institution.*
Non-response survey	A non-response survey is a survey aimed to identify likely significant differences between responding and non-responding units and to obtain information on why non-responding units did not answer. See also *Unit non-response,*
Novelty	Novelty is a dimension used to assess whether a product or business process is “significantly different” from previous ones and if so, it could be considered an innovation. The first and most widely used approach to determine the novelty of a firm’s innovations is to compare these with the state of the art in the market or industry in which the firm operates. The second option is to assess the potential for an innovation to transform (or create) a market, which can provide a possible indicator for the incidence of radical or disruptive innovation. A final option for product innovations is to measure the observed change in sales over the observation period or by asking directly about future expectations of the effect of these innovations on competitiveness.
Object-based approach	The object approach to innovation measurement collects data on a single, focal innovation (the object of the study). See also *Subject-based approach.*
Observation period	The observation period is the length of time covered by a question in a survey. See also *Reference period.*
Open innovation	Open innovation denotes the flow of innovation-relevant knowledge across the boundaries of individual organisations. This notion of “openness” does not necessarily imply that knowledge is free of charge or exempt from use restrictions.
Ordinal variable	An ordinal variable is a categorical variable for which the values are ordered. See also *Nominal variable.*
Organisational capabilities	*See Managerial capabilities.*
Organisational innovation	Type of innovation used in the previous edition of this Manual, currently subsumed under business process innovation.
Panel	A panel is the subset of units that are repeatedly sampled over two or more iterations of a longitudinal survey. See also *Longitudinal survey.*
Paradata	Paradata refers to the data about the process by which surveys are filled in. Paradata can be analysed to identify best practices that minimise undesirable respondent behaviour such as premature termination or satisficing, in order to improve future iterations of the survey instrument.
Product	A product is a good or service (including knowledge-capturing products as well as combinations of goods and services) that results from a process of production. See also *Goods and Services.*
Product innovation	A product innovation is a new or improved good or service that differs significantly from the firm’s previous goods or services and that has been introduced on the market. Product innovations must provide significant improvements to one or more characteristics or performance specifications. See also *Product.*
Production processes	Production processes (or production activities) are defined in the System of National Accounts as all activities, under the control of an institutional unit, that use inputs of labour, capital, goods and services to produce outputs of goods and services. These activities are the focus of innovation analysis.

Public sector	The public sector includes all institutions controlled by government, including public business enterprises. The latter should not be confused with publicly listed (and traded) corporations. The public sector is a broader concept than the General government sector.
Public infrastructure	Public infrastructure can be defined by government ownership or by government control through direct regulation. The technical and economic characteristics of public infrastructure strongly influence the functional capabilities, development and performance of an economy, hence the inclusion of public infrastructure as an external factor that can influence innovation. Public infrastructure includes areas such as transport, energy, information and communication technology, waste management, water supply, knowledge infrastructure, and health.
Public research institution (PRI)	Although there is no formal definition of a public research institution (PRI) (sometimes also referred to as a public research organisation), it must meet two criteria: (i) it performs research and experimental developmentas a primary economic activity (research); and (ii) it is controlled by government. Private non-profit research institutes are therefore excluded.
Reference period	The reference period is the final year of the overall survey observation period and is used as the effective observation period for collecting interval level data items, such as expenditures or the number of employed persons. See also *Observation period.*
Regulation	Regulation refers to the implementation of rules by public authorities and governmental bodies to influence market activity and the behaviour of private actors in the economy. A wide variety of regulations can affect the innovation activities of firms, industries and economies.
Reporting unit	The reporting unit refers to the “level” within the business from which the required data are collected. The reporting unit may differ from the required statistical unit.
Research and experimental development (R&D)	Research and experimental development (R&D) comprise creative and systematic work undertaken in order to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge.
Sampling fraction	The sampling fraction is the ratio of the sample size to the population size.
Satisficing	Satisficing refers to respondent behaviours to reduce the time and effort required to complete an online or printed questionnaire. These include abandoning the survey before it is completed (premature termination), skipping questions, non-differentiation (when respondents give the identical response category to all sub-questions in a question, for example answering “slightly important” to all sub-questions in a grid question), and speeding through the questionnaire.
Services	Services are the result of a production activity that changes the conditions of the consuming units, or facilitates the exchange of products or financial assets. They cannot be traded separately from their production. Services can also include some knowledge-capturing products. *See also Products.*
Social innovation	Innovations defined by their (social) objectives to improve the welfare of individuals or communities.
Software development and database activities	Software development and database activities include: • The in-house development and purchase of computer software, programme descriptions and supporting materials for both systems and applications software (including standard software packages, customised software solutions and software embedded in products or equipment). • The acquisition, in-house development and analysis of computer databases and other computerised information, including the collection and analysis of data in proprietary computer databases and data obtained from publicly available reports or the Internet.

	• Activities to upgrade or expand the functions of information technology systems, including computer programmes and databases. This includes statistical data analysis and data mining activities. Software development is an innovation activity when used to develop new or improved business processes or products, such as computer games, logistical systems, or software to integrate business processes. Database activities are an innovation activity when used for innovation, such as analyses of data on the properties of materials or customer preferences.
Standards	Document, established by consensus and approved by a recognized body, that provides, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context.
Statistical unit	A statistical unit is an entity about which information is sought and for which statistics are ultimately compiled; in other words, it is the institutional unit of interest for the intended purpose of collecting innovation statistics. A statistical unit can be an *observation unit* for which information is received and statistics are compiled, or an *analytical unit* which is created by splitting or combining observation units with the help of estimations or imputations in order to supply more detailed or homogeneous data than would otherwise be possible.
Stratified sample	A stratified sample is a sample selected from a population which has been divided into separate groups ("strata") to control the representation of key sub-populations. Separate samples are drawn from each stratum and the target sample size for each will depend on precision criteria, as well as on the number of units, the size of the units and the variability of the main variables of interest within each stratum.
Subject-based approach	The subject approach focuses on the firm (the subject) and collects data on all its innovation activities. See also *Object-based approach.*
Success of innovations	Success of innovations refer to economic returns generated by the commercialisation or the internal use of innovations. The definition of business innovation does not require an innovation to be a commercial, financial or strategic success at the time of measurement. A product innovation can fail commercially or a business process innovation may require more time to meet its objectives.
Suppliers	Suppliers are firms or organisations that supply goods (equipment, materials, software, components etc.) or services (consulting, business services, etc.) to other firms or organisations. This includes providers of knowledge-capturing products such as intellectual property rights.
Survey frame	The frame population is the set of target population members that has a chance to be selected into the survey sample.
System of National Accounts (SNA)	The System of National Accounts (SNA) is a statistical framework that provides a comprehensive, consistent and flexible set of macroeconomic accounts for policymaking, analysis and research purposes. The most recent version is the 2008 SNA.
Tangible assets	See *Activities related to the acquisition or lease of tangible assets.*
Technological capabilities	Technological capabilities include knowledge about technologies and how to use them, including the ability to advance technologies beyond the state of the art. Technological capabilities include (i) technical expertise; (ii) design capabilities; and (iii) capabilities for the use of digital technologies and data analytics. See also *Technology.*

Technical expertise	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 intellectual property. See also *Technology.*
Technology	Technology refers to the state of knowledge on how to convert resources into outputs. This includes the practical use and application to business processes or products of technical methods, systems, devices, skills and practices.
Training	See *Employee training activities.*
Unit non-response	When a sampled unit that is contacted does not respond to a survey.
User innovation	User innovation refers to activities whereby consumers or end-users modify a firm's products, with or without the firm's consent, or when users develop entirely new products.
Value creation	The existence of opportunity costs implies the likely intention to pursue some form of value creation (or value preservation) by the actors responsible for an innovation activity. Value is therefore an implicit goal of innovation, but cannot be guaranteed on an *ex ante* basis. The realisation of the value of an innovation is uncertain and can only be fully assessed sometime after its implementation. The value of an innovation can also evolve over time and provide different types of benefits to different stakeholders.

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The Measurement of Scientific, Technological and Innovation Activities

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GUIDELINES FOR COLLECTING, REPORTING AND USING DATA ON INNOVATION
4th EDITION

What is innovation and how should it be measured? Understanding the scale of innovation activities, the characteristics of innovative firms and the internal and systemic factors that can influence innovation is a prerequisite for the pursuit and analysis of policies aimed at fostering innovation. First published in 1992, the *Oslo Manual* is the international reference guide for collecting and using data on innovation. In this fourth edition, the manual has been updated to take into account a broader range of innovation-related phenomena as well as the experience gained from recent rounds of innovation surveys in OECD countries and partner economies and organisations.

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