19 Innovation indicators and measurement: challenges

Fred Gault

1. INTRODUCTION

Innovation indicators are part of the policy process and measurement activities provide the statistics that become the indicators. This handbook has covered many of the issues related to measuring the activity of innovation, producing and presenting the indicators, and, then, using them. In Part VI, some evolving subjects were presented. In this chapter the first section addresses issues that are ongoing in indicator production and use. Then there is a discussion of developments anticipated in the short and in the longer term.

Language and Governance

Throughout the handbook, there has been reference to the language used to discuss indicator development by the community of practice that is part of the process, and it is clear that the language will continue to evolve, to add words and rules of grammar. A common language supports clarity of thought, improves communication and avoids confusion. This dependence on common language is not peculiar to the *Oslo Manual* and the innovation discourse.

One of the more striking precedents is the King James Bible, which came into being when King James, assuming the throne of England in 1603, found a number of bibles in use that hindered the discussion of theological matters that, at that time, were of considerable importance, certainly to the King. In 1604 he convened the Hampton Court Conference, provided clear instructions and the result was published in 1611, just over 400 years ago. The book solved the immediate problems of the King, and went on to transform the English language (Bragg 2011). Language matters.

The King James Bible also provides an example of governance (Davis et al. 2012), from the top down, which contrasts with the consensus and bottom–up approach to the creation of the *Oslo Manual* by the OECD Working Group of National Experts on Science and Technology Indicators (NESTI). The NESTI process is open, builds on evidence, and requires consensus before a manual can be recommended for publication and use. As discussed in Chapter 2, in the EU, the 'most recent *Oslo Manual*' is part of a regulation and there is a different governance structure dealing with the use of the manual in the conducting of the EU Community Innovation Survey (CIS) in member states. CIS and CIS-like surveys are a means of implementing the rules in the *Oslo Manual*.

Communities of Practice

Innovation indicators and measurement involve five communities of practice with, in some cases, overlapping membership. They are: the rule makers; the implementers of the rules; producers of the data; analysts of the data; and the policy analysts who use the indicators and analytical insights from the other communities of practice.

The NESTI community – making the rules

NESTI has already been discussed above and in Chapters 1 and 2. Members of NESTI, in collaboration with Eurostat, produce and revise the *Oslo Manual*. The manual, by regulation in EU countries, then governs the surveys that are used to implement the rules, CIS and CIS-like questionnaires.

The CIS community – implementing the rules

As Chapters 3, 4 and 8 have shown, implementing the *Oslo Manual* (Chapter 2) is not a simple task if the surveys, conducted in different countries in different languages, are to produce results that are comparable over time and that can be compared, with confidence, across jurisdictions. And there are different ways of doing innovation surveys. They can be repeated cross-sectional surveys that support trend analysis and microdata analysis but that cannot deal with the demonstration of causal links between a policy intervention and a possible outcome. For that, as was discussed in Chapter 6, a panel survey is required and, even then, there are difficulties in demonstrating causal relationships. Whether an innovation survey is combined, or not, with a survey of R&D is a question addressed in Chapter 7 and there are arguments for and against doing this.

The CIS is revised every two years by a group of experts convened by Eurostat. New questions undergo cognitive testing and a collaborative project on cognitive testing involving Eurostat and the OECD ensures that the questions produce results that are internationally comparable.

The producer and the analytical communities – learning from the data

Once the surveys are in place, they produce statistics, some of which may be used as innovation indicators, such as the propensity of a firm to innovate in a particular industry or in a region, or the percentage of total turnover (revenue) in the last year resulting from the introduction of new or significantly improved products over the last three years. Many other indicators are possible, some of which have been discussed in Chapter 11, including the *OECD Science, Technology and Industry Scoreboard* (OECD 2011) with over 180 indicators and the *Innovation Union Scoreboard* (*IUS*) (EC 2011). In addition, in CIS 2010 (Chapter 1: appendix), there are 27 questions, some with multiple sub-categories, all of which could provide innovation statistics, and some of which could be used as indicators and presented, for example, by industry, by region, or by degree of novelty of the innovation. Finding combinations of statistics that, through cross-tabulation, yield useful indicators for policy purposes is a policy-dependent exercise, but there are core indicators common to most applications (Chapter 11). CIS data can also be linked to economic and social data from other sources, providing even more indicators of innovation.

One of the ways that data quality is assured and valuable insights are gained is through use of the data on innovation gathered through surveys, from administrative sources or by other means. The analysis of the data by those who produce it is an important part of this process, although it is not done in all organizations that produce data and is discouraged in some. In addition to data quality monitoring, producers who work with their own data are able to talk to analysts from outside their organizations about the strengths and weaknesses of the data and of the sources from which the data are derived.

Gaining access to microdata for analytical purposes is deliberately not easy as the data producer is bound, in many cases by law, to protect the confidentiality of the respondent that provided the data. Eurostat provides secure access to microdata from CIS, and some statistical offices have procedures for gaining such access. If access can be gained, there are two approaches to the analysis.

Researchers who wish to understand the national or regional aspects of innovation can be granted access to the relevant data sets and allowed to do the appropriate econometric analysis, assuming the data can support it. For international comparisons, the OECD has run a microdata analysis project (OECD 2009) where the first step was agreement on an econometric model. Then researchers in each of the participating countries gained access to the data and ran the model. The results were published in OECD (2009). The use of innovation survey microdata for economic analysis is intrinsically important, but it is also part of data quality assurance. Mairesse and Mohnen (2010) provide a comprehensive review of the use of innovation survey data for economic analysis.

An underlying requirement for this work is the availability of a researcher database that contains the final data, after editing and imputation, and the metadata that define each variable in the data set and the extent to which the variable has been populated with imputed data as opposed to data resulting from measurement. This is necessary if access to the data is to be facilitated as it is very difficult to work with the production database which is used as part of the survey process.

However, researcher databases are expensive and additional costs are incurred in training researchers in their use and then reviewing the outputs to ensure that there has been no breach of confidentiality. It is the protection of confidentiality that leads some statistical offices to allow regression coefficients to be removed from the secure site, but not tabulations, which remain the province of the statistical office. There is a reason for this. Each tabulation of aggregates from a database reveals more information about the microdata. A series of tabulations can then reveal the identity of a respondent if there are no measures in place to prevent this, one of which is knowing about every tabulation made from the database.

The communities of practice dealing with data production and analysis are valuable components of the process of producing, understanding and using data and indicators of innovation. A fifth community of practice is made up of the policy analysts.

The policy community – using the indicators and the analytical insights

The policy community, those responsible for developing, implementing, monitoring and evaluating policy initiatives, has made limited use of indicators of innovation, and one of the findings of Chapter 11 was that scoreboards use few indicators that result from the direct measurement of innovation. This may change and, if it does, the preferred outcome would be a policy community that was able to make intelligent use of indicators of innovation while understanding the limitations of the measurement process. Chapters 12, 13 and 14 illustrate some of the challenges to using direct measures of innovation, and their analysis, in the policy process.

Chapter 13 raises the danger of using 'old' indicators in a current context to guide or monitor policy. This issue has been raised by Marburger (2007: 32), who observed that 'in the face of rapid global change, old correlations do not have predictive value' and by Freeman and Soete (2007: 272): 'the link between the measurement of national STI[1] activities and their national economic impact, while always subject to debate, . . . has now become so loose that national STI indicators are in danger of no longer providing relevant economic insights'. The use of innovation indicators must take account of the context of change. The number of kilometres of railways in a country may once have been an indicator that informed policy and in the context of social goals and industrial development provided the policy maker with the knowledge needed to change the system. The lesson that those responsible for innovation indicators and measurement, and the policy community that uses the indicators, must adapt is very clear from Chapter 13.

Innovation Indicators

This handbook has concentrated on direct measurement of the activity of innovation, giving rise to indicators of the activity. However, there is a long history of using other indicators as proxies for indicators of innovation, reviewed next, and that is followed by a short discussion of data quality measures. Quality assurance is important for all statistical indicators, not just those of innovation, but it is particularly important for a field that is still developing. Finally, ten essential properties of indicators are introduced.

What are the indicators?

Before there were behavioural measures of innovation found in CIS, or in technology use surveys, analysts used R&D, patents and publications as proxy indicators of innovation. These indicators have advantages: they are readily available and they are understood by the policy community. However, there are disadvantages.

As has been repeatedly mentioned, more firms innovate than do R&D, so to argue that R&D is a proxy for innovation rules out many firms, especially SMEs. Large firms have a higher propensity to do R&D and to innovate, and the propensity to do R&D is greater in some industries that dominate the R&D statistics. A correlation between R&D performance and the activity of innovation will be present for large firms, but this has implications for the use of such analysis in policy, especially policy directed at SMEs. Not all academics are driven by influencing the policy process, but the readers of this handbook should be prepared to ask questions about any analytical work that uses R&D as a proxy for innovation.

The same caution applies to patents and to publications; the emphasis is on caution as both can produce useful indicators. Nagaoka et al. (2010) provide a review of patents and their use as indicators of innovation. The caution is based on the fact that not all firms protect their intellectual property with patents and not all firms publish in the peer-reviewed literature. The propensity to do either is size dependent and, for patents, there are significant sectoral differences. While indicators based on patents and publications have limitations as indicators of the activity of innovation, they have many other uses, including detecting emerging technologies (Chapter 15) and supporting foresight analysis (Chapter 16).

Co-publication statistics demonstrate collaboration between sectors and regions, and the propensity of some fields of science to collaborate more than others. The OECD is collaborating with SCImago research group (http://scimaps.org/) to report on key trends and country differences in scientific production, excellence and collaboration. However, innovation indicators, while linked to the science system, are fundamentally different because of the connection to the market (or potential users).

Before leaving publication analysis there is a variation on the theme of analysing peer-reviewed papers that involves examining the titles of books on technology over a period to determine the impact of technological change (Alexopoulos 2011). It is noted here as another initiative that may, in time, contribute to the development of innovation indicators.

Quality of innovation statistics

Indicators are expensive, especially reliable, timely and relevant indicators, and the justification for that expense is in their use. Indicators that are not used are not indicators. This introduces the question of data quality. Statistics Canada (2002) uses six dimensions in its quality assurance framework: relevance; accuracy; timeliness; accessibility; interpretability; and coherence. Achieving these objectives is a necessary part of producing indicators that can be used. However, the objectives are interrelated. Accurate, accessible and coherent indicators may be of no relevance if they are released the day after the policy debate they were expected to inform has taken place.

Desirable properties of innovation indicators

In 2010, the EU Commissioner for Research and Innovation called for 'headline indicators for innovation in support of the Europe 2020 strategy'. A high-level panel was convened and, in the course of its deliberations, it proposed ten essential properties of indicators, acknowledging that these were desirable but difficult to achieve (EC 2010). The ten properties are that the indicators: be simple and understandable; be sizeable and direct; be objective; be presently computable; be stable; be internationally comparable; be decomposable; have a low susceptibility to manipulation; be easy to handle technically; and be sensitive to stakeholders' views. A detailed explanation of these properties can be found in EC (2010) and an agenda for the development of indicators is given in the next section.

Current and Ongoing Activities

This section has reviewed the importance of language, codified in the *Oslo Manual*, for discussing the activity of innovation and the governance structure that gives rise to the *Manual*. It has made reference to the five overlapping communities of practice involved in innovation indicators and measurement. It has looked briefly at proxy indicators and data quality guidelines and a set of ten desired properties of indicators. All the activities described are part of the ongoing work of producing innovation indicators based on measurement and they would continue even if there were no changes in the indicators produced or new ways of using them. However, there is change. The next section deals with change in the short term.

2. THE SHORT TERM

In the short term, the ongoing work just outlined is part of the agenda of the community of practice responsible for the *Oslo Manual* that includes the OECD, Eurostat, and experts in member and observer countries of the OECD, member states of the EU and other countries. Elements of an agenda for indicator development can be found in OECD (2007, 2010a) and are summarized in OECD (2010a). They are to:

- improve the measurement of broader innovation and its link to macroeconomic performance;
- invest in high-quality and comprehensive data infrastructure to measure the determinants and impacts of innovation;
- recognize the role of innovation in the public sector and promote its measurement;
- promote the design of new statistical methods and interdisciplinary approaches to data collection; and
- promote the measurement of innovation for social goals and of social impacts of innovation.

There is also the community of practice that implements the rules, an example of which is the Eurostat group that prepares the CIS and develops the survey over time. The current version of the CIS 2010 questionnaire is reproduced in the appendix to Chapter 1. However, there are areas that need more attention.

Organizational and Marketing Innovation

The third edition of the *Oslo Manual* extended the definition of innovation to include industrial organization and practices, and market development or the development of new markets, but they are not yet probed to the same degree as product and process innovation in the CIS (Chapter 1: appendix). This can be seen by comparing the questions at the front of the questionnaire on product and process innovation with those later in the questionnaire on organizational innovation and marketing innovation.

There may be a limited market for the answers to these questions in a world where R&D policies outweigh innovation policies. However, understanding organizational and marketing innovation is part of understanding the activity of innovation, and that discussion should be held. In the case of organizational innovation, Chapter 10 provides a guide to current work that illustrates how firms learn. Going back to Lundvall (1992), learning is part of the activity of innovation and it is still not part of the standard practice of innovation measurement and indicator development. There is also the issue of how knowledge flows within the innovation system and how those flows influence the activity of innovation.

There is a substantial literature on organizational learning (Dierkes et al. 2001), on the learning economy (Archibugi and Lundvall 2001) and on the dynamics of the knowledge economy (Dolfsma and Soete 2006). However, the findings from this literature are not having a substantial influence on the discussions of the communities of practice that are responsible for innovation indicators and measurement.

There is some work on organizational innovation and business practices, but there is comparatively little on marketing innovation.[2] While more is needed now, in the longer term the 'market' part of the innovation definition in the *Oslo Manual* will become more a matter for discussion, and a better knowledge of market development as part of the activity of innovation will help. It would take few changes to CIS and similar surveys to collect information that applied to all components of the definition of innovation.

Innovators that are Not R&D Performers

Innovation indicators for firms that do not do R&D are becoming more available and they raise different policy needs for these firms. As mentioned in Chapter 1, these firms do not benefit from R&D tax credits or direct support to R&D, but they may need support through voucher schemes that allow them to access knowledge in local colleges or universities, or management and networking support, or support for staff training or for visiting staff experts in areas needed by the firm such as management, finance or human resource development. Some of these services are provided by venture capital firms, some by banks, but there is a case for looking at the public services available to non-R&D-performing innovative firms.

Table 19.1 Breakdown of the population of innovative firms

Innovative firms	Non-R&D performers	R&D performers	Comment
SMEs	SMEs using organization and marketing change to gain competitive advantage	Spinoffs from universities and research labs. High-tech start-ups	Domain of Schumpeterian creative destruction (Mark I)
Large firms	Some service firms and firms in the extraction industries innovating through organizational change	All industries with firms engaged in Schumpeter Mark II creative accumulation	Domain of Schumpeterian creative accumulation of knowledge (Mark II)
Comment	Problem solvers using available knowledge from doing, using and interacting	Formal knowledge creation leading to new products or processes	All firms that innovate

Source: Author.

As mentioned in Chapter 1, the distribution of R&D performance is quite different from that for the activity of innovation. R&D performance is dominated by a few large performers in a few industries; innovation is more pervasive and can be found in the large number of SMEs that do no R&D. These are quite different from the SMEs that do R&D, which may be high-tech spinoffs from firms or universities. The proposal is that the indicators be presented in such a way as to suggest different policy approaches. A first step could be the provision of the percentage breakdown of innovative firms by size and performance of R&D, or not, and by industry or by region. This is illustrated in Table 19.1, where the two Schumpeterian domains of creative destruction (Mark I) and creative accumulation (Mark II) are introduced. Soete (2006) provides a discussion of the two domains and they suggest different approaches to analysis and to policy.

As SMEs account for at least 95 per cent of firms, and they play a role in job creation, there are many policies to support entrepreneurship, start-ups and R&D performance in small businesses. SMEs act in a competitive arena with limited resources. Small firms, with limited resources, can make just one mistake in their business strategy and they are finished, victims of creative destruction. Ideally, the people involved in the failed business go on to create new firms, having learned from the mistake. Large firms can make more than one mistake and they can accumulate knowledge as a result, this is part of the corporate accumulation of knowledge by the firm that prevents the large firm from making the same mistake again. The policy domain is different for large firms as they may use their accumulated knowledge to dominate the market and to reduce competition, but they may also create jobs and wealth, the taxes on which support public services.

Returning to Table 19.1, while core indicators are needed for all firms that innovate, additional and different indicators are needed to support the understanding of innovation in small and large firms and in those that do and do not do R&D. The present gap is information on large firms and their affiliates, and on how knowledge flows within the firm and to and from other parts of the innovation system.

Use and Planned Use of Technologies and Practices

Technologies and practices are part of the processes of the firm: transformation and delivery; organizational change and use of business practices; and market improvement or new market development. As such, they are an integral part of the activity of innovation.

As Chapter 15 makes clear, work is being done on developing indicators for emerging and enabling technologies, and this raises a question about earlier work on the use and planned use of technologies (and practices). The work on foresight in Chapter 16 is also part of this discussion as it deals with where technologies (and practices) may be going, how they could be used, and the possible consequences. Foresight also builds a community of practice, a network, that can influence the trajectories of the technology identified.

Using a technology as part of the production process is only an innovation if it is new to the firm. All firms, as part of their capital investment, buy and use technologies. However, what may be interesting are the other ways of adopting technologies. One is by buying and modifying the technology to suit the needs of the firm. Another is adoption by developing the technology by a firm that cannot find the needed technology on the market. The last two cases are examples of user innovation by firms (Chapter 5). From a CIS perspective, the firms that modify or develop technologies are process innovators, as are the firms that buy off-the-shelf technology that is new to the firm. Earlier work has shown that in Canadian manufacturing firms, of those that are adopting advanced technologies, about 20 per cent adopt by modifying and about 20 per cent adopt by developing the technologies. While these are significant figures, the question is the policy relevance of identifying the activity of user innovation and probing further to find out how the firms dealt with the intellectual property gained as a result of the user innovation. Some of this has been addressed in Gault and von Hippel (2009).

As technology modifiers tend to be smaller than technology developers, and to be less likely to do R&D, the same policy questions arise as were raised above when discussing innovative firms that are not R&D performers. The work on technology use and the development of related indicators described in Chapter 15 should continue, taking note of the questions about user innovation in firms in Chapter 5, but with consideration of the policy relevance of the indicators produced. Ideally it should lead to guidelines for measurement and interpretation of the results in the longer term.

Chapters 2 and 15 make reference to the way the OECD dealt with technology use, by separating the subject from the *Oslo Manual* in the third edition and starting what became the Working Party on Indicators for the Information Society (WPIIS) in 1997 to deal with information and communication technologies (ICTs) and their applications. Also, NESTI created an *ad hoc* group for biotechnology statistics until the measurement programme was established (www.oecd.org/sti/biotechnology/indicators) and also provides input to work on statistics for nanotechnologies.

Chapter 10 deals with measures of the dynamics of organizations and the place of work practices. Becker (2008) discusses organizational routines, Lam (2005) organizational innovation, and Foray and Gault (2003) the measurement of knowledge management, a set of business practices. The approach to the measurement of the use and planned use of business practices is similar to that used for the measurement of the use and planned use of technologies, and there are the same expectations that firms will buy and modify their business practices or develop practices in the absence of their availability on the market. This is an area where more work is needed to produce robust indicators of how firms function and how that influences innovation.

Indicators of Knowledge Flows

A full set of indicators would support a better understanding of the system of innovation, and that includes information on the actors, their activities and linkages, the outcomes of the activities and the linkages, and the longer impacts of the outcomes. Data on linkages provide evidence of flows between actors that can be uni- or bi-directional and that may involve the transfer of energy, material or finance, of knowledge or people. Energy, material or finance can be quantified by physical or financial measures. People can be counted and their characteristics identified. Knowledge flow is more complicated.

Knowledge can be codified and exchanged through many media. It can be tacit and transferred by moving people or teams that hold the knowledge and it can be embedded in technology or practices. The measuring of knowledge flows and knowledge markets, as part of the innovation system, is both a short- and a long-term objective that builds on the chapter on linkages in the *Oslo Manual* (OECD/Eurostat 2005: 75).

An OECD project on Knowledge Networks and Markets (KNM) has been examining the types of knowledge flows used by firms and organizations with a view to producing a taxonomy leading to a common language for discussing KNM. An output expected from the project is a set of indicators of knowledge flows (www.oecd.org/sti/knowledge).

Platforms for Innovation

The current example of platforms for innovation is the production of applications (Apps) for existing products such as the iPhone. The Apps would not diffuse rapidly were it not for the App store to promote them, and the large number of devices on which they can be used. The advantage of a platform is that the innovator needs knowledge only of the interface to the devices supported by the platform. Given that knowledge, the innovator can design a new or significantly improved product and bring it to market, and anyone can participate in the activity of innovation. There is a place here for new innovation indicators that take account of the environment, or the framework conditions under which the innovation is developed. The App is not the only example. Readily available molecules provide a platform for innovation in biotechnology and infrastructure of any kind invites innovators to take advantage of it. Chapter 13 provides the example of healthcare as a platform in Nordic countries where new hospitals will support the testing by firms of new products or practices that might then be made available to potential users, subject to the appropriate regulations. This is a good example of taking what could be perceived as a problem, an ageing population (Gault 2010: 106, 119), and turning it to advantage, given that significant public money will have to be spent on activities related to the ageing population in any case. The building of a widely accessible platform for innovation may reduce the cost of healthcare in the long run, while providing increased tax revenues from innovative firms. As with the App, the challenge is to develop innovation indicators that include the platform as a facilitator of innovation.

Diffusion of Existing Indicators and their Understanding

As measures of the activity of innovation develop, there is a need for more diffusion of indicators based on direct measurement of innovation

(Chapter 11) and their use. Rather than comparison of country aggregates, there is a need for more breakdowns by industry and by region within countries if the indicators are to be used to influence policy. In federal countries, such as the USA, the states lead in industrial policy and that is the level at which innovation indicators could be used.

At the OECD Blue Sky II Forum in 2006, John Marburger argued that the minister of research/education/technology/innovation should receive advice comparable to that received by the equivalent of the minister of finance/economy, based on complex and intimidating models such as those used by economists (Marburger 2007). As part of this, he advocated the creation of a new social science, the science of science and innovation policy (SciSIP). SciSIP will be discussed further in the next section.

Since 2006, as the OECD developed the Innovation Strategy (OECD 2010b), the target of influence has begun to shift to the equivalent of the minister of finance/economy. The reason is that this minister controls resources and makes decisions that affect other departments of government. In the short term there is a case for producing indicators that mean something to those who control financial decisions at all levels of government – municipal, state/province and federal levels – as a result making the use of evidence, supported by indicators, more common at all levels of government than it currently is.

Other Indicators of Innovation?

Headline indicator of innovation

The High-Level Panel convened by European Commission Directorate General (DG) Research and Innovation (EC 2010) was charged with finding a headline indicator for innovation to complement the ratio of gross domestic expenditure on R&D (GERD) to GDP, the GERD/GDP ratio, which has been produced and tracked for the last 50 years and is used for target setting. As noted in Chapter 14, the target in the Obama innovation strategy is 3 per cent and that is also the target for the EU, with 2 per cent coming from the business sector.

This is a challenge as it is difficult, if not impossible, to measure the cost of innovation whereas R&D is a measure of the expenditure on R&D performed in the reference year in the firm, no matter how funded (OECD 2002). The statistic that can be produced for innovation is the propensity to innovate by a firm in a given industry. To produce this statistic, the population of firms in the industry must be known, and for this a reliable business register is required. However, the question that then arises is whether knowing that 20 per cent of firms in one industry innovate and 60 per cent do so in another is helpful for policy purposes without additional information about the activity of innovation, such as the level of novelty, the sources of information for innovation, or the relevance of collaboration. Consider also that no country uses the propensity to do R&D in an industry as an indicator as it would be very small. R&D is a rare event.

The High-Level Panel looked at five indicators: hourly labour productivity; patent applications weighted by GDP; percentage of employment in knowledge-intensive activities; share of fast-growing (or young?) and innovative firms in the economy; and the contribution of innovation-related trade in manufactured goods to the balance of trade goods. In the end, two options were offered. Option A was a list of three indicators: patent applications weighted by GDP; percentage of employment in knowledge-intensive activities; and the contribution of innovation-related trade in manufactured goods to the balance of trade in goods. Option B was fast-growing innovative firms.

As this handbook has focused on direct measures of innovation, leading to innovation indicators, option B will be considered as it is closest to a direct measure of innovation, depending upon how it is implemented.

Measuring the presence and the economic and social contribution of fast-growing innovative firms is part of the broader subject of business demographics and its change with time, giving rise to evidence of business dynamics. To measure business demographics requires a business register and the following of the same rules in every country that is part of the indicator project. The report of the High-Level Panel notes that EU regulation (EC) No. 177/2008 provides a common framework for statistical purposes but suggests that further legislation is needed, which may move this topic into the long-term rather than the short-term category.

Assuming a good business register, making use of or linked to tax data, for example, firms with and without employees, by industry and by region, can be tracked over time. What is required in a good register is the ability to register in a timely manner the birth and deaths of firms (and of establishments within firms). Deaths can result from mergers and acquisitions, and so can births, depending on how the surviving entity is registered. Given this, information industries at any level of industrial classification can be classified according to their growth and their volatility. Both matter.

Consider an industry in which some firms are growing rapidly, based on employment, and some are shrinking rapidly. This volatile industry will differ from one in which there are rapidly growing firms and few in decline, or the reverse. The report of the High-Level Panel notes that the employment resulting from high-growth firms will reflect the framework conditions of the innovation system such as the availability of financial services, education and the orientation of economic institutions towards entrepreneurship. The employment would also indicate structural change as it happened. These are important points and they are part of entrepreneurship studies.[3]

The question to be resolved is where innovation enters the picture as not all of these high-growth firms will be covered by CIS and not all will be innovative. Growth does not necessarily require innovation, and innovation can also contribute to the decline of the firm if the market does not respond positively to the new or significantly improved product it is offered. A possibility is to measure high-growth firms in industries where there is a higher propensity for firms to innovate, based on CIS findings.

From the perspective of this handbook, the reader is encouraged to watch the progress of this indicator, the possibility of setting targets for the share of employment in an industry (or region) of high-growth firms, and the extent to which these firms are truly innovative.

Productivity growth as an indicator of innovation

This handbook has focused on direct measures of innovation through surveys, but it has considered other indicators that may be correlated with innovation, such as the headline indicators just discussed. Hall (2011), in a report prepared for the High-Level Panel on measuring innovation, looked at productivity growth as an innovation indicator. The conclusion was that multi-factor productivity (MFP) growth, as measured in a growth-accounting approach, could serve as an indicator of innovation. The paper goes on to discuss the data issues and the influence of business cycles on the results. Hall (2011) also reviewed firm-level productivity and innovation analysis based on the Crépon, Duguet and Mairesse (CDM) model (Crépon et al. 1998) and noted that there was a positive relationship between innovation in firms and their growth, based on revenue, and that it appeared to be due primarily to product innovation.

A Council of Canadian Academies expert panel on business innovation made use of an MFP approach in its assessment of innovation in Canada (CCA 2009) and explored shortcomings of Canadian industry. While there are data challenges in doing MFP analysis within a country, and more so for international comparisons, the MFP statistics could be used as an indicator of the activity of innovation.

The US Conference Board[4] is developing a new database on total factor productivity (TFP, synonymous with MFP), both in the advanced industrial economies and in many developing countries. To date, the TFP series are available only for 1990 onward, although there are plans to extend them back in time.

Public Sector Innovation

As Chapter 17 demonstrates, considerable work is now ongoing measuring 'innovation' in the public sector. One approach is to use a CIS approach for surveying the public sector units of observation, but there is still the question of how to deal with the definition of innovation and what 'market' means in this context. There has been a suggestion, mentioned in Chapter 5, that the phrase 'introduced on the market' in paragraph 150 of the *Oslo Manual* (OECD/Eurostat 2005: 47) be replaced by 'made available to potential users' (Gault 2012), but that is not for a short-term discussion as it will be a matter for consideration for the revision of the *Oslo Manual*, discussed in the next section. Meanwhile, the measurement work and the production of indicators should continue, in the same way that the original experimental work on innovation was done in the 1980s, before any internationally agreed guidelines are proposed.

The importance of gaining experience of measuring 'innovation' in the public sector is that it will contribute to a better understanding of innovation in the business sector, especially if there is more attention to knowledge flows and institutional learning, and to the interaction of the public and private sector in ways that influence innovation, such as procurement policy, regulation coming from the public sector, and technologies and practices coming from the business sector.

Developing standards and guidelines for measuring public sector innovation activities and interpreting the results goes beyond NESTI and the *Oslo Manual* as there is a new Observatory of Public Sector Innovation established at the OECD. The Observatory aims, systematically, to collect, categorize, analyse and share innovative practices from across the public sector, through an online interactive database. This is an opportunity for the Directorate for Science, Technology and Industry (DSTI) to collaborate with the Directorate for Public Governance and Territorial Development.

Public Sector Procurement as a Promoter of Private Sector Innovation

One aspect of public sector activity that could have a more direct impact on innovation in the private sector is procurement. If governments are prepared to set the performance standards for goods and services that it procures and leave to the bidding firms how those standards are to be met, there is an incentive for innovation and for indicators that identify the public sector as a source of information for innovation or of collaboration. The CIS team preparing CIS 2012 is considering asking specifically about innovation related to procurement contracts and if that is approved it will be the start of indicators of innovation that highlight the involvement of public sector procurement.

3. THE LONGER TERM

Looking beyond two or three years from the publication of this handbook, there are a number of activities that will affect indicators of innovation and measurement. Some of these are discussed here.

OECD Blue Sky Forum

In 2016, the third OECD Blue Sky Forum, Blue Sky III, is anticipated and its purpose, as with the previous two (Chapter 1), will be to look at new indicators for science, technology and innovation (STI), better use of existing STI indicators and new uses for existing indicators that have not been included in STI analysis.

In 2006, 250 people from 25 countries gathered in Ottawa to consider the same agenda and the outcome of that Forum provided input to the OECD measurement agenda (Chapter 9) and influenced the OECD Innovation Strategy (Chapter 12). The same outcome from Blue Sky III is anticipated and the issues raised in this handbook form part of the agenda. These include more indicators of the innovation system to provide a better understanding of how the system works, or does not, and new ways of gathering data on innovation at a time when response rates to traditional surveys are declining and some governments are reducing survey activity.

Also feeding into this will be the recommendations of the US National Academies Panel on *Improving Measures of Science, Technology and Innovation* (National Research Council 2012), which will appear in the final report of the panel in 2013. The work of this Panel is broader than innovation indicators and measurement, but innovation, especially given the new measurements of innovation through the Business R&D and Innovation Survey (BRDIS) of the NSF National Center for Science and Engineering Statistics (NCSES), will have a prominent place.

In Canada, the Council of Canadian Academies (CCA) Panel on Socio-economic Impacts of Innovation Investments will also have reported and some of its recommendations will bear on innovation indicators and measurement. More broadly, the CCA Panel on *The State of Science and Technology in Canada 2012* (CCA 2012) uses a variety of indicators discussed in this chapter to provide an evidence-based assessment.

The *Oslo Manual*

The *Oslo Manual* (OECD/Eurostat 2005) was last revised in the three-year period 2003–05 and it extended the definition of innovation and emphasized the systems approach to understanding innovation implicit in earlier editions. As the third edition approaches its tenth anniversary, there is a case for a fourth edition. One of the issues is how to deal with intangible investment as part of innovation. In national accounting, software was capitalized in the 1993 revision of the SNA (EC 1993) and R&D in SNA 2008 (EC et al. 2009). Firms also invest in training, brand development and other firm-specific activities such as their place in knowledge networks and value and supply chains. From a measurement or indicators approach, the question is which innovation activities should be measured, with the implicit assumption that they may give rise to innovation when they connect to the market. The most established is the performance of R&D, but there are others, and the number is growing as the understanding of the innovation system grows.

Intangibles play a key role in the growth-accounting approach of Corrado et al. (2009) to measure the contribution of innovation activity to productivity at national level (Hall 2011), and there is work on this link at the OECD and in a number of countries, including the USA (Aizcorbe et al. 2009). Recognizing the importance of knowledge-based capital (KBC), the OECD has launched a two-year project, ‘New Sources of Growth: Intangible Assets’, to explore the link between investment in intangibles and growth (OECD 2012), and, more specifically, between intangible investments and innovation expenditures. On a broader front, measuring intangibles is a key part of the analysis of sustainable development (World Bank 2011).

It is also clear from the implementation of the *Oslo Manual*, mainly through the CIS, that there is still much to learn about how an innovation system functions and that knowledge is needed if policy makers are going to be able to propose policy interventions that will achieve their socio-economic objectives. This makes Eurostat, as the manager of CIS, a key player in the revision of the *Oslo Manual*.

Consumers Who Change or Create Goods or Services

Chapter 5 introduced the consumer as a ‘user innovator’ and made a case for more attention to be given to this activity in official statistics on innovation. The problem from the *Oslo Manual* perspective is that consumers are not innovators as they do not produce products and introduce them to the market, but this does not mean that their effect is not present in existing statistics on innovation collected through CIS and similar surveys.

It is important to distinguish the consumer as a 'user innovator' from the consumer as a co-innovator, or collaborator, or as a source of information for innovation. All innovation surveys show the client or customer as a significant source of information for innovation and as a cooperation partner. This, however, is not 'user innovation'. Chapter 5 discusses ongoing work to establish the magnitude of this transfer from consumer to producer, and the result may provide a case for identifying the transfer in CIS and possible private and public sector encouragement for such transfers.

A 'consumer innovator' may decide to start a business and become an entrepreneur. Identifying the magnitude of this activity is also an objective considered in Chapter 5. The new firm would be in scope for an innovation survey but might not enter the sample unless it had 5 or 10 or 20 employees, depending on the country conducting the survey. There are many policies for entrepreneurs and start-up firms. The interesting statistic will be the percentage of 'consumer innovators' that start a firm.

Not all 'consumer innovators' have commercial interests; they may prefer to transfer their knowledge to a peer group or community of practice, and this is not captured anywhere in official statistics. There has been discussion on how to include this activity in innovation as defined in the *Oslo Manual* (Gault 2012), but this would require a revision of the definition in the current manual. As a revision of the *Oslo Manual* is anticipated, it is a matter of establishing the magnitude of the transfer of knowledge and its economic and social importance. The policy issue here is supporting a culture of innovation that may or may not lead to commercial outcomes, but supporting such a culture may increase the possibility of the next world-class innovation emerging in the country supporting an innovation culture.

Social 'Innovation'

Social innovation deals with new answers to social problems and seeks to improve the welfare of individuals and communities. The *Oslo Manual* approach to innovation in the business sector requires the measurement of the delivery of a new or significantly improved good or service to the market, or of better ways of getting the goods or services to the market.

Social problems are complex as they are embedded in a complex social system with many actors engaged in activities and interacting to achieve desired outcomes. The business innovation system is also complex, and both the business innovation system and the social system are dynamic, non-linear in their response to interventions, and global. In other words, neither is easy to understand to the point where advice can be given with any certainty to a policy maker about which interventions will achieve the desired objectives.

Nonetheless, social innovation matters as it changes the well-being of people and communities, and there are many groups in many countries working on the subject, developing measurement techniques and collecting data. The subject of social innovation, perhaps because of its diversity, has yet to give rise to the equivalent of the *Oslo Manual*, or a community of practice engaged in rule making such as NESTI.

Chapter 18 brought together three organizations, the National Endowment for Science, Technology and the Arts (Nesta), the Rockefeller Foundation and the Young Foundation, which work on social innovation to provide a review of the subject and the place of measurement and indicators. Many of the challenges in Chapter 18 are found elsewhere in the handbook, and there is reference to indicators having agency and moving people and organizations to do things that were not originally anticipated. In a social environment, the development of indicators carries with it a social responsibility not found in all indicator development.

Social innovation overlaps in some cases with public sector innovation (Chapter 17). However, the measurement of public sector innovation is much closer to the process that gave rise to the *Oslo Manual* and continues to support its revision. The subject of social innovation has been brought into a handbook on innovation indicators and measurement to show that there are other views and other demands that arise when people and communities try to solve problems to improve their own welfare. This can also be seen as an extension of the thinking on user innovation in Chapter 5. The reader is encouraged to follow the subject and the work of many organizations around the world working on social innovation.[5]

The Science of Innovation Policy

This is not a handbook on innovation policy, but it is through the implementation of innovation policy that indicators are used for monitoring, evaluation and benchmarking (Gault 2010). Policy issues, as seen in Chapters 12, 13 and 14, are wide-ranging, and policies are difficult to implement. This raises a question of why there is not more work on understanding innovation policy.

John Marburger called for a science of science and innovation policy (SciSIP) (Marburger 2007) and the US National Science Foundation has solicited proposals on a number of occasions giving rise to a community of academics that have a greater understanding of the policy issues, but Hill (Chapter 14) makes it very clear that moving from understanding the issues to the making of policy and then implementing that policy is a difficult process. However, learning how this is done matters as it involves understanding how the innovation system works so that the indicator and measurement communities can respond with the indicators needed to inform the policy debate. The birth of a social science that tries to understand policy, and innovation systems, is a very long-term activity (Gault 2011).

4. CONCLUSION

This handbook appears at a time when innovation indicators and measurement are being discussed in a number of countries and international organizations. There is the OECD measurement agenda (OECD 2010a), which is part of the OECD innovation strategy (OECD 2010b) and there is the research agenda associated with the call for a headline indicator of innovation in Europe (EC 2010). This thinking, within the communities of practice responsible for innovation indicators and measurement, has a long history and the knowledge of the subject was first codified in the 1990s, under the direction of Robert Chabbal (OECD 1992: 3), with the support of the Nordic Fund for Industrial Development. More recent history can be found in the work of many of the authors cited in this chapter and in Arundel et al. (2006), Colecchia (2007), and Chapters 2, 3 and 12.

The handbook has reviewed much of the work on innovation indicators and measurement that is happening in 2013 and it has examined emerging topics that could form part of the innovation measurement discussion in the near future, including innovation in the public sector and social innovation, and how they may be related to innovation in the business sector, which is the province of the *Oslo Manual* (OECD/Eurostat 2005). In the not-too-distant future the *Oslo Manual* will be revised and the OECD will convene the third of its series of Blue Sky Forums on indicator development for science, technology and innovation. The handbook is meant to be a guide to these developments as well as a tool for understanding what is now measured, how the statistics become indicators, and how they are used.

Finally, this handbook has dealt with innovation that alters wealth accumulation and distribution, and forces people to think about doing things differently. Acemoglu and Robinson (2012: 430) note that 'sustained economic growth requires innovation and innovation cannot be decoupled from creative destruction, which replaces the old with the new in the economic realm and also destabilizes established power relations in politics'. This leads to a broader discussion of the framework conditions needed to advance innovation, which is well beyond the scope of a handbook on innovation indicators and measurement, but more appropriate to a handbook on innovation policy and its implementation written by policy makers at the political level and by senior civil servants who have implemented policy.

NOTES

1. STI: science, technology and innovation.
2. The EC Directorate for Research and Innovation has initiated a study within the INNO Grips project to examine organizational and marketing innovation. There is also interest in indicators of these innovation activities.
3. See Atrostic (2008) on related US data and Haltiwanger (2011) on firm dynamics.
4. www.conference-board.org/data/economydatabase/.
5. There are many such organizations, but a review of the organizations of the authors of Chapter 18 is a start, and there is the Centre for Social Innovation in Vienna (www.zsi.at), the OECD Local Economic and Employment Development (LEED) programme, the OECD LEED Trento Centre for Local Development in Trento, Italy and the Center for Social Innovation at the Stanford Graduate School for Business.

REFERENCES

Acemoglu, Daron and James A. Robinson (2012), *Why Nations Fail: The Origins of Power, Prosperity and Poverty*, London: Profile Books.
Aizcorbe, A.M., C.E. Moylan and C.A. Robbins (2009), 'Toward better measurement of innovation and intangibles', *Survey of Current Business*, January, 10–23.
Alexopoulos, Michelle (2011), 'Read all about it! What happens following a technology shock', *American Economic Review*, **101**, 1144–79.
Archibugi, Daniele and Bengt-Åke Lundvall (2001), *The Globalizing Learning Economy*, Oxford: Oxford University Press.
Arundel, Anthony, Alessandra Colecchia and Andrew Wyckoff (2006), 'Rethinking science and technology indicators for innovation policy in the twenty-first century', in Louise Earl and Fred Gault (eds), *National Innovation, Indicators and Policy*, Cheltenham, UK and Northampton, MA, USA: Edward Elgar, pp. 167–97.
Atrostic, B.K. (2008), 'Measuring U.S. innovative activity: business data at the U.S. Census Bureau', *Journal of Technology Transfer*, **33**, 143–71.
Becker, Markus C. (2008), *Handbook of Organizational Routines*, Cheltenham, UK and Northampton, MA, USA: Edward Elgar.
Bragg, Melvyn (2011), *The Book of Books: The Radical Impact of the King James Bible 1611–2011*, London: Hodder and Stoughton.
CCA (2009), *Innovation and Business Strategy: Why Canada Falls Short, The Expert Panel on Business Innovation*, Ottawa: The Council of Canadian Academies.
CCA (2012), *The State of Science and Technology in Canada 2012*, Ottawa: The Council of Canadian Academies.
Colecchia, Alessandra (2007), 'Looking ahead: what implications for STI indicator develop-

ment?', in OECD, *Science, Technology and Innovation Indicators in a Changing World: Responding to Policy Needs*, Paris: OECD, pp. 285–98.
Corrado, C.A., C.R. Hulten and D.E. Sichel (2009), 'Intangible capital and U.S. economic growth', *Review of Income and Wealth*, International Association for Research in Income and Wealth, **55**(3), 661–85.
Crépon, B., E. Duguet and J. Mairesse (1998), 'Research, innovation and productivity: an econometric analysis at the firm level', *Economics of Innovation and New Technology*, **7**, 115–56.
Davis, K.E., A. Fischer, B. Kingsbury and S. Merry (eds) (2012), *Governance by Indicators: Global Power Through Quantification and Rankings*, Oxford: Oxford University Press.
Dierkes, Meinolf, Ariane Berthoin Antal, John Child and Ikujiro Nonaka (2001), *Handbook of Organizational Learning & Knowledge*, Oxford: Oxford University Press.
Dolfsma, Wilfred and Luc Soete (2006), *Understanding the Dynamics of a Knowledge Economy*, Cheltenham, UK and Northampton, MA, USA: Edward Elgar.
EC (2010), 'Elements for the setting up of headline indicators for innovation in support of the Europe 2020 strategy', Report of the High Level Panel on the Measurement of Innovation established by Ms Máire Geoghegan-Quinn, European Commissioner for Research and Innovation, Brussels: European Commission, DG Research and Innovation, http://ec.europa.eu/commission_2010-2014/geoghegan-quinn/hlp/documents/20101006-hlp-report_en.pdf.
EC (2011), *Innovation Union Scoreboard 2010: The Innovation Union's Performance Scoreboard for Research and Innovation*, Brussels: European Commission.
EC, IMF, OECD, UN and World Bank (1993), *System of National Accounts 1993*, Brussels/Luxembourg, New York, Paris, Washington, DC: EC, IMF, OECD, UN and World Bank.
EC, IMF, OECD, UN and World Bank (2009), *System of National Accounts, 2008*, New York: United Nations.
Foray, Dominique and Fred Gault (2003), 'Measurement of knowledge management practices', in OECD, *Measuring Knowledge Management in the Business Sector: First Steps*, Paris: OECD, pp. 11–28.
Freeman, Christopher and Luc Soete (2007), 'Science, technology and innovation indicators: the twenty-first century challenges', in OECD, *Science, Technology and Innovation Indicators in a Changing World: Responding to Policy Needs*, Paris: OECD, pp. 271–84.
Gault, Fred (2010), *Innovation Strategies for a Global Economy: Development, Implementation, Measurement and Management*, Cheltenham, UK and Northampton, MA, USA: Edward Elgar and Ottawa: IDRC.
Gault, Fred (2011), 'Developing a science of innovation policy internationally', in Kaye Husbands-Fealing, Julia Lane, John Marburger and Stephanie Shipp (eds), *Science of Science Policy: A Handbook*, Stanford, CA: Stanford University Press, pp. 156–82.
Gault, Fred (2012), 'User innovation and the market', *Science and Public Policy*, **39**, 118–28.
Gault, Fred and Eric von Hippel (2009), 'The prevalence of user innovation and free innovation transfers: implications for statistical indicators and innovation policy', MIT Sloan School of Management Working Paper no. 4722-09, Cambridge, MA: MIT.
Hall, Bronwyn H. (2011), 'Using productivity growth as an innovation indicator', Report for the High-Level Panel on Measuring Innovation, Brussels: European Commission, DG Research and Innovation.
Haltiwanger, John (2011), 'Job creation and firm dynamics in the U.S.', Working Paper, Maryland: University of Maryland.
Lam, Alice (2005), 'Organizational innovation', in Jan Fagerberg, David C. Mowery and Richard R. Nelson (eds), *The Oxford Handbook of Innovation*, Oxford: Oxford University Press, pp. 115–47.
Lundvall, Bengt-Åke (ed.) (1992), *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*, London: Pinter Publishers.
Mairesse, Jacques and Pierre Mohnen (2010), 'Using innovation surveys for econometric analysis', in Bronwyn H. Hall and Nathan Rosenberg (eds), *Handbook of the Economics of Innovation*, Amsterdam: North-Holland, pp. 1129–55.

Marburger, John (2007), 'The science of science and innovation policy', in OECD, *Science, Technology and Innovation Indicators in a Changing World, Responding to Policy Needs*, Paris: OECD, pp. 27–32.
Nagaoka, Sadao, Kazuuki Motohashi and Akira Goto (2010), 'Patent statistics as innovation indicators', in Bronwyn H. Hall and Nathan Rosenberg (eds), *Handbook of the Economics of Innovation*, Amsterdam: North-Holland, pp. 1083–27.
National Research Council (2012), *Improving Measures of Science, Technology and Innovation: Interim Report*, *Panel on Developing Science, Technology and Innovation Indicators for the Future*, eds R.E. Litan, A.W. Wyckoff and K.H. Fealing, Committee on National Statistics, Division of Behavioral and Social Science and Education, and Board on Science, Technology and Economic Policy, Division of Policy and Global Affairs, Washington, DC: The National Academies Press.
OECD (1992), *Technology and the Economy: The Key Relationships*, Paris: OECD.
OECD (2001), *Science, Technology and Industry Review, Special Issue on New Science and Technology Indicators*, No. 27, Paris: OECD.
OECD (2002), *Frascati Manual: Proposed Standard Practice for Surveys on Research and Experimental Development*, Paris: OECD.
OECD (2007), *Science, Technology and Innovation Indicators in a Changing World: Responding to Policy Needs*, Paris: OECD.
OECD (2009), *Innovation in Firms: A Microeconomic Perspective*, Paris: OECD.
OECD (2010a), *Measuring Innovation, A New Perspective*, Paris: OECD.
OECD (2010b), *The OECD Innovation Strategy: Getting a Head Start on Tomorrow*, Paris: OECD.
OECD (2011), *OECD Science, Technology and Industry Scoreboard 2011*, Paris: OECD.
OECD (2012), *New Sources of Growth: Knowledge-Based Capital Driving Investment and Productivity in the 21st Century, Interim Project Findings*, Paris: OECD.
OECD/Eurostat (2005), *Oslo Manual, Guidelines for Collecting and Interpreting Innovation Data*, Paris: OECD.
Soete, Luc (2006), 'Knowledge, policy and innovation', in Louise Earl and Fred Gault (eds), *National Innovation, Indicators and Policy*, Cheltenham, UK and Northampton, MA, USA: Edward Elgar, pp. 198–218.
Statistics Canada (2002), *Statistics Canada's Quality Assurance Framework*, Catalogue No. 12-586-XIE, Ottawa: Statistics Canada.
World Bank (2011), *The Changing Wealth of Nations: Measuring Sustainable Development in the New Millennium*, Washington, DC: World Bank.