TECHNOLOGY • RESEARCH HIGHLIGHTS • VISIONS • SCIENCE

242

Measuring broad-based innovation

Mika Nieminen & Olavi Lehtoranta (eds.)

VTT

VTT TECHNOLOGY 242

Measuring broad-based innovation

Mika Nieminen & Olavi Lehtoranta

(eds.)

ISBN 978-951-38-8385-0 (Soft back ed.)
ISBN 978-951-38-8386-7 (URL: http://www.vttresearch.com/impact/publications)

VTT Technology 242

ISSN-L 2242-1211
ISSN 2242-1211 (Print)
ISSN 2242-122X (Online)
http://urn.fi/URN:ISBN:978-951-38-8386-7

Copyright © VTT 2015

JULKAISIJA – UTGIVARE – PUBLISHER

Teknologian tutkimuskeskus VTT Oy
PL 1000 (Tekniikantie 4 A, Espoo)
02044 VTT
Puh. 020 722 111, faksi 020 722 7001

Teknologiska forskningscentralen VTT Ab
PB 1000 (Teknikvägen 4 A, Esbo)
FI-02044 VTT
Tfn +358 20 722 111, telefax +358 20 722 7001

VTT Technical Research Centre of Finland Ltd
P.O. Box 1000 (Tekniikantie 4 A, Espoo)
FI-02044 VTT, Finland
Tel. +358 20 722 111, fax +358 20 722 7001

Juvenes Print, Tampere 2015

Preface

This book deals with a question which has become increasingly important during the last decades: measurement, indicators and statistics of innovation activity. Our starting point behind the book was a project in which we were studying broad-based innovation indicators, what they are, and is there gaps in the innovation statistics in terms of broad-based innovation activity. We soon realized, however, that if we are going to give an answer to the original question, we also need to discuss more widely about the innovation measurement as a whole and try to clarify somehow (at least to ourselves) the basic definitions and approaches which relate to the innovation measurement.

Thus, we went “back to basics” and extended our view to cover more widely and deeply indicators and measurement. This effort is reflected in the contents and structure of the book. We are not trying only to suggest new indicators and approaches, and indicate gaps in the measurement, but provide also critical perspectives and background understanding for the existing innovation statistics.

This wide approach to the innovation measurement would not have been possible without our colleagues who have kindly contributed to the book from various perspectives. We thank Bernd Ebersberger (innovation system), Carter Bloch (public sector innovations), Mervi Niemi and Jari Kuusisto (user innovation), Kaisa Still, Jukka Huhtamäki, Martha Russell and Neil Rubensfor (big data and networked innovation) for their learned contributions to the book. The whole project would not have been possible without our colleague Janne Huovari, who worked with us in the project. We also thank our colleagues for their patience as the completion of the book has been delayed due to our other responsibilities.

Finally we would like to thank Tekes – the Finnish Funding Agency for Innovation for the financial support that made this study possible. We are also grateful to the expert members of the steering group of the project for their help and invaluable comments: Petri Lehto, Christopher Palmberg, Kai Husso, Timo Hämäläinen, Ari Mikkelä and Ari Leppälahti.

We hope that the book is able to provide some new perspectives to the ongoing debate on innovation statistics.

Mika Nieminen and Olavi Lehtoranta

Contents

1. Introduction

Mika Nieminen & Olavi Lehtoranta

Measuring innovation and impacts of STI have become an increasingly important issue in policy-making during the last few decades, as investments in STI have increased and STI has been understood as a competitive advantage in economic competition. As STI yields social benefits and is expensive, there is an evident need to manage it in the most effective way, which, in turn, requires information on investments, processes and impacts of STI (Godin 2011).

There are two traditions of measuring STI. The first one could be called the academic tradition and the second one the institutional tradition. The latter covers the activities of such organisations as OECD, UNESCO, EU and national statistical bureaus. Benoit Godin has put forward that there have been at least eight conceptual frameworks used in the formulation of STI policy and statistics during the past decades. These can be grouped into three generations: First generation (Cultural lags, Linear model of innovation), Second generation (Accounting, Economic growth, Industrial competitiveness), and Third generation (Knowledge-based economy, Information society, National innovation system). Our ideas of innovation as well as the way we measure innovation have changed significantly during these generations. Earlier ideas have not been abandoned altogether, but they are intertwined with newer ones. The input-related indicators dominated until the 1980s, when the OECD, among others, started to develop increasingly output-related indicators as impacts of policy and efficiency of investments became a gradually increasingly important issue in STI policy. This has meant especially that indicators have a strong economic focus and are developed from the perspective of economy. (Godin 2011; 2005; 2003; 2002.)

The OECD has constantly attempted to improve STI indicators, and its work is also closely connected to indicators used at the national and EU levels. The latest turn relates to the now relatively widely accepted idea that innovation policy should be more “broad-based”. This refers to a number of issues discussed in innovation studies earlier and now adopted as building blocks of effective STI policy. These trends are summarised in the recent OECD innovation strategy (OECD 2010a). The basic issue is the observation that the scope of innovation activities has broadened beyond the traditional R&D perspective. This means, for instance, that non-technological innovations such as service and marketing innovations have a growing importance alongside technological innovations; there are a number of various innovation patterns firms use; even low-technology sectors innovate; and innovation processes have become more open and require multi-faceted collaboration (e.g. the concept of open innovation). In practice, in policy-making these observations have led to an effort to increase public and private demand for innovations (e.g. innovative public procurement), to emphasise innovation activities

based on user needs, to highlight the role of service innovations as a source of public-sector renewal and to underline the significance of intangible value creation (e.g. marketing, design, branding).

Collectively, the observations and policy needs addressing broad-based innovation activities have highlighted the fact that the existing STI indicators describe these activities poorly or not at all. Consequently, during the last few years several indicator development projects have been launched (e.g. by the OECD and EU), focusing on the measurement shortages. In addition, the Oslo Manual (OECD 2005) and Community Innovation Surveys (CIS) have included some aspects of broad-based innovation activities, including for instance a module on user-driven innovation (in Finland), information on innovation sources and information on ecological impacts and public procurement. Despite this, there is still room for indicator development and discussion about measurement.

This publication contributes to the discussion of monitoring and measuring broad-based innovation. Our major questions in this book are: are available indicators working properly, and can we find new perspectives on or indicators for innovation processes? We introduce a number of various complementary perspectives on measuring and indicators. We are convinced that we need multifarious indicators and measurement methods in order to describe such a complex and systemic phenomenon as innovation. This means that there is no single truth about innovation indicators and that there is room for various different – and sometimes even conflicting – ways of understanding and measuring of innovation. This is also reflected in the articles in the book.

We start our journey by discussing the 'basics' of innovation measurement. We believe that every now and then it is useful to go back to the basics and reflect on what we are actually doing. Therefore the first articles in this collection discuss the definition of innovation and what kinds of measurement frameworks we are using at the moment. The standard definition of innovation is nowadays very wide and covers broad-based innovation quite well. This broad definition is considered analytically problematic, since if all new products, services, methods and practices are defined as innovations, the concept covers practically all revisions and reforms in an organisation. Likewise, existing measurement frameworks are claimed to be too loose, more theoretically argued and dynamical meta-frameworks being needed to present indicators especially from the perspective of policy formulation and impact assessment. The general framework reflecting linear thinking from inputs to processes, outputs and impacts is perhaps neglecting the systemic nature of innovation (cf. Arnold 2004; OECD 2010b) and cannot establish a well-argued relationship between policy measures and impacts.

A complementary perspective to these critical insights is provided by Bernd Ebersberger in his article thereafter, in which he argues that the currently prevailing innovation system concept has opened our eyes to see the multifarious and multi-actor character of innovation and made possible the improved measurement and monitoring of innovation. The challenge is, however, that innovation measurement is still, despite the multi-actor nature of innovation, focusing too much on corporate innovation activities. We need to broaden our innovation measurement.

The next article takes a closer look at existing indicators and their underlying theory-base, starting from framework conditions for innovation and moving on to innovation activities, inputs, outputs and impacts. The writers argue that innovation statistics should focus more on major innovations such as new-to-market concepts, products and services. Especially in the case of organisation, marketing and process innovations, innovation surveys should try to differentiate real innovations from incremental adoptions.

This theme continues in the article reporting the results of a Finnish pilot survey exploring how firms see innovations and their mutual relationships. The survey utilised open-ended questions about changes in the products, processes and organisation and their novelty values. Open-ended questions were used to alleviate the measurement problem in the questionnaire: closed-form surveys restrict and lead respondents to agreed definitions. In general, the survey indicated that firms undertake a lot of organisation and strategy-related reforms but that it is difficult to determine how innovative these reforms actually are. It is difficult to assess the innovativeness of changes other than product and production process changes. For these 'traditional' innovations, the results of the questionnaire and answers drawn from the open-ended questions were in accordance. By contrast, in the case of organisation and strategy, changes were frequently described as novel ones. In the open-ended answers, their innovativeness did not seem to be equally common, raising the question of whether a particular change can actually have been a significant and novel one (innovation) if there is no mention of it in the open-ended answer. Apparently, the questionnaire may steer respondents' ideas about newness and innovativeness.

The following article by Carter Bloch extends the study of innovations to the public sector by conducting an analysis of the MEPIN pilot study results for Finland. The analysis focuses on the examples of innovations provided by respondents, the main question being whether we are able to measure public-sector innovation with a measurement exercise such as MEPIN. Carter Bloch indicates that even though there are a number of examples of innovations, there are only some truly novel innovations. Furthermore, a broader view of innovation is most appropriate for public-sector innovation measurement, and it would be important to be able to distinguish between major innovations and more moderate or incremental changes in the public sector.

Another theme which extends the traditional producer-centred and technology-centred perspective on innovations is user and consumer innovation, which is discussed in the contribution by Mervi Niemi and Jari Kuusisto. They report on user innovation indicator developments and present the results of user innovation activities in Finland on the basis of a consumer innovation survey and Community Innovation Survey (CIS). Interestingly, the results indicate among other things that more than 80% of all consumer innovations are not diffused more widely in society but remain in the use of inventor or people close to them. Furthermore, a bit surprisingly, even though the results indicate that users are an important source of innovation for businesses, enterprises in the manufacturing industry are more active in utilising user innovations than service-based firms.

This discussion on the measurement of broad-based innovation with traditional statistical measures is concluded by Olavi Lehtoranta in an article discussing broad-based innovation investments in statistics, the main question being: what can we measure on the basis of existing statistical data? Lehtoranta indicates that even though we already have data for many investment items that should be included in broad-based innovation, many items are partly missing or lumped together with other items. This would not, however, be solved by adding new questions to questionnaires, as respondents probably would not be able to answer due to deficiencies in their own accounting systems.

The last article in the book focuses on new methods of studying innovation by making use of data freely available on the Internet. This data can be utilised to describe and analyse networked innovation activities. Advanced computer technology and new visualisation methods make it possible to study actor networks and to formulate new kinds of indicators. Sample analyses are given of the collaboration between European Institute of Innovation and Technology ICT labs and of a funding program for young innovative enterprises. Examples indicate how Internet-based data can be used systematically to describe innovation-related networks and to reveal patterns in interaction that otherwise would remain invisible.

References

Arnold, E. (2004), Evaluating research and innovation policy: a systems world needs systems evaluations. Research Evaluation 13 (1): 3-17. doi: 10.3152/147154404781776509.

Godin, B. (2002), Outline for a History of Science Measurement. In Science, Technology, & Human Values, Vol. 27 No. 1, Winter 2002 3-27, Sage Publications.

Godin, B. (2003), Measuring Science, Is There Basic Research Without Statistics? *Social Science Information*, 42(1): 57-90.

Godin, B. (2005) Measurement and Statistics on Science and Technology 1920 to the present, London & New York: Routledge.

Godin, B. (2011), The Culture of Science and the Politics of Numbers, in M. Bauer (ed.), The Culture of Science: How Does the Public Relate to Science Across the Globe, London: Routledge.

OECD (2005), Oslo Manual (3rd edition): Guidelines for Collecting and Interpreting Innovation Data, Paris: OECD & Eurostat.

OECD (2010a), The OECD Innovation Strategy: Getting A Head Start on Tomorrow. Innovation. OECD Publishing.

OECD (2010b), Measuring Innovation: A new Perspective, Paris: OECD.

2. Defining innovation – a fuzzy concept with extending scope

Olavi Lehtoranta, Mika Nieminen & Janne Huovari

2.1 Introduction

Statistical measures are based on operational definitions of the measured phenomenon. Definitions specify the phenomenon, include some aspects of it and exclude some others. This, in turn, affects not only the very idea of the phenomenon but also the quality of the information of the statistical indicators. This also concerns innovation statistics and measures.

At the core of innovation statistics is the concept of innovation. In the following we will discuss the various definitions of innovation and how the measurement of innovation is operationalised. At the core of the definitions is the international standard-setting definition provided by the OECD. The broadening of the concept of innovation has been a trend in recent decades. It is no longer an exclusively technology-centred concept; it includes elements such as organisational methods and services. This, however, raises the question of how extensive the concept can be while still having operational validity. This also relates to recent discussions about broader or broad-based innovation activities. We start with a short review of various recent definitions of innovation and continue with a review of the idea of broader innovation. In the final part of the chapter, we discuss the broadening scope of innovation and its challenges.

2.2 Defining innovation

Until the 1970s, innovation was measured mainly via proxies such as patents and industrial expenditure on R&D. The concept of innovation was included in the Frascati Manual for the first time in 1981. The definition excluded innovation activities and focused on outputs. The OECD, however, was actively involved in discussions on innovation indicators and as a result the 'Oslo Manual', focusing on innovation, was released at the beginning of the 1990s. The adopted approach emphasised activities but was still mainly techno-centric, even though non-technological innovations were discussed and service activities were added to the second edition of the manual (Godin 2005). The definition was significantly ex-

panded in the 2000s when the third edition of the Oslo Manual extended the definition to cover four components: the implementation of a new or significantly improved product (good or service); a process; a new marketing method; or a new organisational method in business practices, workplace organisation or external relations. The definition was now changed to the following: “An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organisation or external relations” (OECD 2005, 46).

What is of interest here is the fact that innovations are defined practically as various types of changes, which naturally increases the scope of the concept significantly: “Innovations are defined in the Manual as significant changes, with the intention of distinguishing significant changes from routine, minor changes. However, it is important to recognise that an innovation can also consist of a series of minor incremental changes.” (OECD 2005, 40) Furthermore, it is noted that “Innovation activities are all scientific, technological, organisational, financial and commercial steps which actually, or are intended to, lead to the implementation of innovations. Some innovation activities are themselves innovative, others are not novel activities but are necessary for the implementation of innovations. Innovation activities also include R&D that is not directly related to the development of a specific innovation.” (ibid., 47)

Thus, according to this definition innovation is practically anything that is somehow new or improved in an organisation. Innovation does not need to be new to the world, new to the sector, nor even developed by the organisation in question. Innovation is both inventing and adopting something new (Godin 2010). Besides being innovative in implementing product or process innovations, a firm can be innovative if it implements new business practices, new knowledge management systems, new methods for workplace organisation, new methods of organising external relations, significant changes to product design, new media, new techniques for product promotion, new methods for product placement or new methods of pricing products (Gault 2010, 56–57).

The inclusive approach does not distinguish very well between forms of innovation, their significance and role in the organisation – even though the role of various forms of innovation is discussed in the Oslo Manual (OECD 2005). An alternative to this kind of inclusive approach is to classify innovations according to how radical they are. From this perspective, continuous improvement may be characterised as ‘incremental’ or ‘marginal’ innovation, as opposed to ‘radical’ innovation or ‘technological revolution’, which leads to broader technological change and even social change (Freeman and Soete 1997; Freeman and Perez 1988). It is a widely held view, however, that the cumulative impact of incremental innovations is just as great (if not greater), and to ignore these would lead to a biased view of long-term economic and social change (Lundvall et al. 1992). Arguably, the bulk of economic and social benefits come from incremental innovations and improvements (Fagerberg 2003).

The definition of ‘radical’ and ‘incremental’ innovation is difficult. How they could be distinguished from each other? Garcia and Calantone (2002) define radical

innovations as innovations that cause marketing and technological discontinuities on both a macro (world, industry, market) and micro (firm and customer) level. A somewhat similar distinction was suggested by Henderson and Clark (1990). They distinguish between the components (or modules) of a product or service and the way these components are combined in the product 'design' or 'architecture'. A change in the former is called 'modular innovation' and a change in the latter 'architectural innovation'. In the same spirit, innovations may be described as autonomous or systemic innovations (Teece 1984, 1988). An autonomous innovation is a product or component that can be introduced without having to change the characteristics of other products or components. Systemic innovation, by contrast, requires remarkable changes to other components, products or systems.

While systemic innovation seems also to refer to process innovations, there are various processes that can be included in the category of process innovations. For instance, Edquist (2011) has suggested dividing the category of process innovation into "technological process innovations" and "organisational process innovations", the former relating to new types of machinery and the latter to new ways of organising work. However, Walker (2007) states that process innovations affect organisational construction, relationships, rules, roles and communication more broadly, both internally and externally. Thus, organisational changes (improvements) may include changes such as the implementation of teamwork in production, new organisational concepts, supply chain management systems, new client interfaces and quality-management systems (European Commission 2011). While this list is rather long, it can be also argued that not all reforms or changes are innovations. All innovations do not lead to improvements (Hartley 2008); some may rather be connected with everyday development work by ordinary personnel (Fuglsang 2009).

It also seems that the inclusive OECD definition does not take very well into account that "there is a qualitative difference between (a) commercialising something for the first time and (b) copying it and introducing it in a different context (Fagerberg, Mowery and Nelson 2004). This does not exclude the possibility that imitation may lead to new innovation(s). In fact, as pointed out by Kline and Rosenberg (1986), many economically significant innovations occur while a product or process is diffusing." (Fagerberg et al. 2004) Consequently, the innovation process is not only a process of inventing, designing, testing, redesigning and marketing (Kline and Rosenberg 1986) but also of adopting, modifying, testing, re-modifying and marketing or implementing (Fagerberg and Godinho 2004).

While the definitions above refer predominantly to technological innovations, in recent decades the concept of innovation has been broadened to include services and service processes (e.g. Toivonen and Tuominen 2009). The novelty of a service innovation is often non-technological, and therefore the degree of novelty of a service will seldom be assessed from the technological perspective. Service innovations may include networking, process and quality dimensions. It may be more common for service organisations to speak about customer satisfaction and quality improvements than innovation (Gallouj 2002, Sundbo and Gallouj 2000). Service innovations will often be created together with customers and may not result

from the development activities of the organisations themselves. They are often unplanned and may include incremental improvements rather than large changes. Understanding the expectations of end-users and the definition of the quality requirements are the most important steps in service innovation processes (Edvardsson and Olsson 1996, 156).

Service innovations relate to public-sector innovations, which have recently come into focus. However, it is evident that innovations in the public sector are not exclusively service innovations; they may also relate to technologies and processes. As a result, the definitions of innovation in the public sector have come close to the definition of innovation in the business sector as defined in the Oslo Manual. For instance, the Measuring Public Innovation (MEPIN) project, launched by the Nordic countries in 2008, defined innovation as "the implementation of a significant change in the way [an] organisation operates or in the products it provides. Innovations comprise new or significant changes to services and goods, operational processes, organisational methods, or the way [an] organisation communicates with users. Innovations must be new to [an] organisation, although they can have been developed by others. They can either be the result of decisions within [the] organisation or in response to new regulations or policy measures."

The brief review and discussion above outline to the difficulty of providing a definition that would be extensive enough to include various aspects of innovation yet analytical enough to distinguish it from other related phenomena. This is partly due to the fact that the scope of and our understanding of innovation activities has expanded beyond the scope of traditional R&D. Thus, business models, service designs and systems and even social or systemic renewal are of growing importance alongside technological innovations. At the same time, innovation processes have become more open and require multifaceted collaboration as reflected for instance in the concepts of open and inclusive innovation, democratising innovation and consumer innovation (von Hippel 2005). This broadening of the concept is also reflected in the recently introduced policy-driven idea of broad-based innovation.

2.3 What is meant by broad-based innovation?

The need for broadening the scope of innovation policy and innovation activities has apparently emerged from a concern that we are wasting innovation potential by concentrating too narrowly on the industrial sector and the exploitation of scientific-technological knowledge only. We should understand shared value creation in innovation ecosystems, learn from users about service business models and systems and concentrate on societal challenges such as green and clean growth, wellbeing, sustainability, environment and energy efficiency (Kulkki 2012).

Broad-based innovation does not have a clear definition; the term is used to refer to wide range of issues relating to the broadening of the scope of both innovation activities and policy. It is used to refer at least to:

- Broadening the scope of innovation activities beyond traditional supply-driven R&D based innovations to e.g. demand/user-driven innovation activities
- Broadening the scope of innovation beyond product and process innovations to other forms of innovation (organisation, marketing, etc.)
- Moving from a linear model of innovation to a systemic approach
- Broadening the industry scope to low-tech and service industries and to the public sector
- Broadening policy instruments beyond traditional innovation and science policies to 'all' policy sectors
- Broadening policy goals beyond productivity, employment and firm performance

Broad-based innovation activities embrace the whole innovation system, its actors, activities, linkages, outcomes and impacts as innovation producers or enablers, processes or targets for innovation (Gault 2010). Accordingly, it may include various forms of innovation such as policy innovations, cultural innovations, social innovations, institutional innovations, structural innovations, technological innovations and innovations in services (Sveiby et al. 2012). Inter-linkages between various dimensions in the context of innovation refer also to systemic changes. Such changes may be called structural innovations (Rotmans 2011), i.e. fundamental changes of structures, culture and practices in a societal systems or subsystems.

The broadening scope of the innovation concept also has important consequences for the scope and concept of innovation policy. The scope of policy is broadening accordingly, from a technological and industrial perspective to policies covering services and social, organisational and behavioural aspects, via systemic cross-organisational innovations to complex socio-economic systems and changes in them, and also towards horizontal policies. These broader policies encompass not only research and innovation administrations but also 'substance' administrations such as administrations of natural resources and environment, energy, transportation, social and health care, safety and security, and so on. When considered from the indicator or impact assessment perspectives, the broader innovation policy concept also complicates the analysis of final consequences and impacts of innovations in the economy and society at large (Tekes 2012).

The concept is predominantly policy-driven, and in the policy documents the definition is usually left rather vague and fuzzy. For instance, a couple of years ago in the evaluation of the Finnish national innovation system it was considered that "a broad-based innovation policy would support the reform of policy sectors (such as social affairs and health, energy, transport, the information society, edu-

cation and training and regional development) through innovation, focusing on the importance of close partnerships between policy sectors and strategically led innovation efforts in the public sphere". In addition, it is stated that "successful innovations are usually based on the open-minded combination of various competencies, while too narrow a concept of innovation activity results in part of innovation potential remaining untapped. The introduction of broad-based innovation activities in Finland is impeded by the fact that a number of low productivity branches of the industry and the public sector have not yet systematically utilised innovation activity in the development of their operations and productivity." (TEM 2009, 23.)

Broad-based innovation particularly refers to the application of a systemic approach referring to interconnections and mutual dependencies in the system as innovations are applied. In general, changing one process or functionality requires the corresponding development of other, related processes (Government Communication on Finland's National Innovation Strategy).

The European Commission has extended this idea by referring to regional aspects in Europe. According to the Europe 2020 Strategy, "broad-based innovation means involving all actors and all regions in the innovation cycle; not only major companies but also SMEs in all sectors, including the public sector, the social economy and citizens themselves (social innovation); not only a few high-tech areas, but all regions in Europe and every Member State, each focusing on its own strengths with Europe, Member States and regions acting in partnership." (CEC 2010.)

In its strategy, the OECD (2010) has, for its part, discussed the broadening scope of innovation activities rather extensively. The target of broad-based innovation activities is economic growth and social challenges such as climate change, health, food security. These challenges require better coordination among countries and both supply-side and demand-side interventions. The idea includes such dimensions such as non-technological innovation, complementarities of technological innovation (branding, training, organisational investments), low-technology sectors, complex innovations (convergence of disciplines and technologies), open innovations, spin-offs, public-sector innovations and demand for innovations. The application of broad-based innovation requires "mixed modes of innovation" including product innovation with marketing strategy changes, upgrading of processes with spending on equipment, broader innovation involving organisational and marketing-related innovation strategies, and networked innovating.

However, the policy documents recognise that the implementation of the broad-based innovation strategy is probably not without challenges. For instance, as innovation policy needs to reflect the ways innovation actually occurs, there is a need to move beyond supply-side policies to a more systemic approach. This means among other things that policies need "to foster innovation beyond science and technology in recognition of the fact that innovation involves a wide range of investments in intangible assets and of actors" (OECD 2010). Broad-based innovation activities are also compromised by firms and the public sector, since low-productivity branches of industry and the public sector are not systematically utilis-

ing innovation activities, and users and customers are not participating sufficiently in the innovation processes (Government's Communication on Finland's National Innovation Strategy to the Parliament). Interestingly, it has also been suspected that the scope of innovation policy may become too broad as its core disappears if all policies are seen as part of innovation policy. The content of the concept is in this sense too vague. On the other hand, the system may be too complex to apply the idea successfully (TEM 2009).

2.4 Conclusions

The concept of innovation has changed during the 2000s. The concept of innovation has broadened from traditional technological product and process innovations towards broader content, encompassing service innovations, various social innovations related to innovative organisational and behavioural changes and systemic innovations that also relate to the consideration of the emergence of innovation in wider socio-economic context.

While the scope of innovation activities has broadened, the concept of innovation has become fuzzier. On the one hand, this is understandable. Kline and Rosenberg (1986, 283), for instance, point out that "it is a serious mistake to treat an innovation as if it were a well-defined, homogenous thing that could be identified as entering the economy at a precise date – or becoming available at a precise point in time." Fagerberg et al. (2004) point out, in turn, that "what we think of as a single innovation is often the result of a lengthy process involving many interrelated innovations. This is one of the reasons why many students of technology and innovation find it natural to apply a systems perspective rather than to focus exclusively on individual inventions/innovations." Thus, the fuzziness and broad scope of the concept would be due to the very essence of innovation – its nature as a heterogeneous and systemic process.

A less essentialistic perspective would argue that the concept is broadening because of the actions of researchers, statisticians and policy-makers. The concept of innovation is negotiated, and it is the interaction between ideas of innovation and policy needs that push forward new definitions and measures for statistical purposes (Godin 2005). Thus, the measurement of innovation has changed significantly over the years as the concept of the innovation process has changed. The idea of the linear, one-way innovation chain generates different monitoring needs than the systemic view of innovation. Now it seems that recent ideas about broadening innovation activities are again putting pressure on measurement practices, as the OECD in particular has claimed new and better measurement frameworks for measuring the broader concept of innovation and how it guides policy-making (OECD 2010).

While the claim is understandable, it may also cause some unease. Current statistical definitions of innovation are already broad, including practically almost all

changes and reforms in the organisational life of firms. Similar definitions have been applied in the public sector. However, if practically all significant changes and implementation of new elements in an organisation are defined as innovations, there is a danger of the concept is losing its meaning – innovation no longer being a specific change or reform, but any change or reform in the organisation, especially if the broadening of the scope of innovation towards service, design, social and system innovations, etc., is taken into account. Consequently, as pointed out earlier, the lines between various policies are blurring as the idea of innovation is expanding, which poses increasing challenges for the coordination of the whole.

References

CEC (2010), Europe 2020, A Strategy for Smart, Sustainable and Inclusive Growth, Brussels.

Edquist, C. (2011), Innovation Policy Design: Identification of Systemic Problems, Circle, Paper no. 2011/06, Lund University.

Edvardsson, B., Olsson, J. (1996), Key concepts for New Service Development, The Service Industries Journal, 16 (2), pp. 140–164.

European Commission (2011), Service Innovation, Organizational Innovation and Value Chain: What Role for Policy Making, Programme for the Sectoral Innovation Watch (SIW) – Thematic Workshop, January 25th 2011, Brussels.

Fagerberg, J. (2003), Innovation: A Guide to the Literature, Paper presented at the Workshop "The Many Guises of Innovation: What we have learnt and where we are heading", Ottawa, October 2003, organized by Statistics Canada.

Fagerberg, J., Godinho, M. M. (2004), 'Innovation and Catching-up' in Fagerberg, J., Mowery, D. C., Nelson, R. (eds.), The Oxford Handbook of Innovation, Oxford: Oxford University Press, pp. 514–544.

Fagerberg, J., Mowery, D. C., Nelson, R. (eds.) (2004), The Oxford Handbook of Innovation, Oxford: Oxford University Press.

Freeman, C., Perez, C. (1988), Structural crises of adjustment, business cycles and investment behaviour. In: Technical change and economic theory, Ed. by Giovanni Dosi et al., London: Pinter, pp. 38–65.

Freeman, C., Soete, L. (1997), The Economics of Industrial Innovation, Third Ed., London: Pinter.

Fuglsang, L. (2009), Attachment to work in home care: Active and passive socially sustained actions in innovation. Paper read at the 25th EGOS Colloquium: Sub-theme 06: (SWG): Forms of attachment to the objects of work, July 2–4, at Barcelona.

Gallouj, F. (2002), Innovation in the service economy: The new wealth of nations, Cheltenham and Northampton: Edward Elgar.

Garcia, R., Calantone, R. (2002), A critical look at technological innovation typology and innovativeness terminology: a literature review, Journal of Product Innovation Management 19 (2): 110–132.

Gault, F. (2010), Innovation Strategies for a Global Economy: Development, Implementation, Measurement and Management, Edward Elgar, Cheltenham, UK, Northampton, MA, USA.

Godin, B. (2005), Measurement and Statistics on Science and Technology 1920 to the present, New York: Routledge.

Godin, B. (2010), Taking Statistics (More) Seriously: The Measurement of Science, Technology and Innovation and its Future, A first draft for a UNESCO Workshop on "New Dimensions of STI Indicators", Paris 9–10 December 2010.

Government's Communication on Finland´s National Innovation Strategy to the Parliament. Available at: http://www.tem.fi/files/21010/National_Innovation_Strategy_March_2009.pdf

Hartley, J (2008), Does innovation lead to improvement in public services? Lessons from the Beacon Scheme in the UK. In: Borins, Sandford F. ed. Innovations in Government: Research, Recognition, and Replication. Brookings/ASH Institute Series, "Innovative Governance in the 21st Century. Washington, DC: Brookings Institution Press, pp. 159–187.

Henderson, R.M., Clark, K.B. (1990), "Architectural innovation", Administrative Science Quarterly, Vol. 35 March, pp. 9–30.

Kline, S.J., Rosenberg, N. (1986), "An Overview of Innovation", in: R. Landau and N. Rosenberg (eds.) The Positive Sum Strategy: Harnessing Technology for Economic Growth, Washington D.C.: National Academy Press, pp. 275–304.

Kulkki, S. (2012), How to address the grand challenges in Nordic Countries and Europe through demand-side innovation policies? Presentation given in the Helsinki conference on demand-driven innovation and public procurement in Nordic countries, November 7th–8th 2012.

Lundvall, B-Å. (1992) (ed.), National Systems of Innovation. Towards a Theory of Innovation and Interactive Learning, London and New York: Pinter.

OECD (2005), Oslo Manual (3rd edition): Guidelines for Collecting and Interpreting Innovation Data, Paris: OECD & Eurostat.

OECD (2010), The OECD Innovation Strategy: Getting A Head Start on Tomorrow. Innovation. OECD Publishing.

Rotmans, J. (2011), Sustainability Transitions & Transition Management. Presentation given in Tekes, Helsinki, 15.02.2011.

Sundbo, J., Gallouj, F. (2000), Innovation as a Loosely Coupled System in Services, in J.S. Metcalfe and I. Miles (eds.), Innovation Systems in the Service Economy. Measurement and Case Study Analysis, Boston, Dordrecht and London: Kluwer Academic Publishers.

Sveiby, K-E., Gripenberg, P., Segercrantz, B. (2012) (eds.), Challenging the Innovation Paradigm, Routledge Studies in Technology, Work and Organizations, Routledge.

Teece, D.J. (1984), Economic Analysis and Strategic Management, California Management Review, 26 (3), 87–110.

Teece, D. J. (1988), Technological change and the nature of the firm. In: Dosi, G. & Freeman, C. & Nelson, R. & Silverberg, G. & Soete, L. (eds.): Technical Change and Economic Theory, London: Pinter publishers.

Tekes (2012), Funder, activator, networker, investor, Exploring Roles of Tekes in Fuelling Finnish Innovation, Tekes Review 289/2012.

TEM (2009), Evaluation of the Finnish National Innovation System – Policy Report, www.evaluation.fi, Publisher: Taloustieto Oy (on behalf of the Ministry of Education and the Ministry of Employment and the Economy), Helsinki University Print.

Toivonen, M., Tuominen, T. (2009), Emergence of Innovations in Services, The Service Industries Journal, Vol. 29, No. 5.

Von Hippel, E. (2005), Democratizing Innovation, Cambridge, Massachusetts: The MIT Press.

Walker, R. M. (2007), An Empirical Evaluation of Innovation Types and Organizational and Environmental Characteristics: Towards a Configuration Framework, Advance Access Publication: Published by Oxford University Press on behalf of the Journal of Public Administrative Research and Theory, 591–615.

3. Constructing our understanding of STI with frameworks for measurement

Mika Nieminen & Olavi Lehtoranta

3.1 Introduction

Indicators, various measurements and how they are used are decisive in constructing our understanding of science, technology and innovation (STI) activities. Essentially, they make visible something which we usually call the science, technology and innovation system.

Usually, the use of measurements and indicators is based on a theoretical background idea that gives the rationale for them and defines the relationships between various measurements. As a whole, this could be called a measurement framework. The measurement framework is a way of combining, organising and presenting measurements and indicators. The framework is usually embedded in an assumption of the relationships between indicators (and the phenomena they are describing) and may also include a more explicated theoretical understanding of the phenomenon the indicators are describing.

While there are various frameworks for measuring innovation processes (Milbergs 2007), they often tend to structure the relationships between measured phenomena as self-evident facts. An example of this kind of relationship is the notion that the amount of R&D investments affects overall economic performance. If economic performance is at a high level while the level of R&D investments is low, the situation may be seen as an “innovation paradox” (OECD 2011).

In the following, we attempt to go ‘back to basics’ and ask what assumptions our measurements are based on and what alternatives there could be for current frameworks. We believe that this is increasingly important as our measurements and measurement systems expand and become increasingly complex. It is time to stop for a while to think about the basics of measurements instead of just discussing the need for new indicators and their flawless technical implementation. This is not to say that we do not need new and better indicators, but to say that we also need to think about what they are expected to reflect and what their relevance is. We will begin by discussing our understanding of measurements and indicators. They are always of limited capacity and make sense only in the context of an interpretative framework. We continue by introducing some current indicator sets.

In the last part of this article, we ask what kind of alternative examples there might be to organise STI indicators.

3.2 The power of indicators – how do we understand them?

While in everyday language the terms 'statistical measure' and 'indicator' are often used interchangeably, they refer to different things. A *measure* refers to measurement values, while an *indicator* is expected to reflect a particular phenomenon. For instance, the OECD defines a statistical measure as "a summary (means, mode, total, index, etc.) of the individual quantitative variable values for the statistical units in a specific group (study domains)". A statistical indicator is, in turn, "a data element that represents statistical data for a specified time, place, and other characteristics." (OECD, Glossary of Statistical Terms.) The Oxford on-line dictionary provides an alternative definition for indicator, which is "a thing that indicates the state or level of something: car ownership is frequently used as an indicator of affluence". A *composite indicator* is a more complex measurement unit that usually measures multi-dimensional concepts such as competitiveness or environmental development that cannot be captured by a single indicator. The OECD notes that "a composite indicator is formed when individual indicators are compiled into a single index, on the basis of an underlying model of the multi-dimensional concept that is being measured." (OECD, Glossary of Statistical Terms.) In short, the underlying theoretical assumptions increase when we move from single measures towards composite indicators. This reflects the fact that indicators are never 'pure reflections' of reality but reflect their measurement techniques and motivations rather than the actual phenomenon (Alastalo & Pösö 2011).

One consequence of this 'constructed nature' of indicators is that they can describe or illustrate a phenomenon only in a limited way. Indicators are like telescopes that provide at best an accurate image of the landscape, but only of limited range and reach. Sometimes the lenses may distort the image. The phenomena described are usually so complex that it is impossible to describe them by using only a few indicators. For a proper description, a number of indicators is needed. This is also the reason why, for instance, the number of STI indicators is constantly increasing. As our understanding of a phenomenon becomes more complex, more indicators are needed to describe (we believe) this complexity. The history of STI measurement interestingly reflects this development from resource-based indicators to output indicators and finally to an attempt to catch the systemic nature of innovation by various ad hoc measurements and surveys (Godin 2005, Millbergs 2007).

Indicators may, over time, become normative. While originally created for follow-up purposes, some indicators may become a target for action and begin to define what the actors are doing. A normative indicator may have a very strong influence on defining our reality and what we are doing. An example is the gross

domestic expenditure on R&D as a percentage of GDP, which has transformed from a follow-up measurement to a political target in its own right (Godin 2005). Although as a macro indicator it is vulnerable to economic fluctuations and difficult to interpret, we tend to think that it is not a positive sign from the perspective of innovation performance if the indicator is showing low percentages.

Indicators and measurements obtain their taken-for-granted meaning in the context of politico-administrational procedures, in which indicators and measurements have a significant role as an element guiding and legitimating the chosen policy tracks. Another important character of indicators is their ability to create comparability and equivalency between various issues and elements (Desrosières 1998). Thus, gross domestic expenditure on R&D relates directly to R&D funding policy, being the single most effective policy instrument in the policy-makers' toolbox, and creates at least ostensible comparability among countries and their R&D performance.

Another example may be found in indicators created to indicate the efficiency of STI investments. Rather typically, such indicators compare a country's total R&D investments with patents granted or peer-reviewed articles yielded (cf. Moed et al. 2005). Quantification makes these phenomena comparable and links them together even though publication propensity, for instance, is a multi-dimensional process that does not depend only on resources. Measurement simplifies the relationships between real-life objects. Making this simplification meaningful requires interpretation or a theory to explain the changing relationship of measured phenomena. An example of such politico-administrational interpretation is the idea that increasing competition of research funding may produce more and better results. The currently dominant interpretative framework based on New Public Management doctrines supports this idea even though there is contradictory evidence of its efficiency (Auranen & Nieminen 2010). However, it provides a rationale to measure and simplify the relationship between publications and resources and a rationale for policy measures linked to this measurement.

This example also reveals another essential feature of such interpretative frameworks: They often assume causal linkages between measured phenomena, creating a logical relationship from causes to consequences. In the context of STI, a typical general frame is that of inputs–processes–outputs–impacts. This framework can be found behind almost all measurement frameworks, even the most advanced ones.

This framework is relatively simple, straightforward and easy to understand. The relationships between the constituent measurements can, however, be less clear than the framework leads us to believe. For instance, macro-economic phenomena such as employment, growth, etc. (impacts) cannot be unquestionably attached to STI investments (inputs), or the percentage of growth attributed to STI investments is difficult to estimate. There are concurrent factors and feedback loops complicating the assumption of straightforward causal linkages. Social impacts are always "co-produced" (Rip 2000).

The aforementioned situation is rather typical in various evaluation contexts, especially in impact assessment. Evaluation has been used first and foremost to

measure the effectiveness of policy interventions or measures, and it is assumed that by studying changes in the context of those measures we are able to identify their significance (Rip 2000). It has been noted, however, that input-output models cannot explain how interventions turn into outcomes (Chen 2005) and the complex relationships between the elements and dimensions that comprise a system (Patton 2011).

3.3 Examples of measurement frameworks

As noted above, existing innovation measurement frameworks usually share a common understanding that there are causal relationships between input factors and outcomes. A close relative of this view is the linear model of innovation which most of the measurement frameworks make use of (for alternative views, see e.g. Kline & Rosenberg 1986; Edqvist 1997; Etzkowitz & Leydedorff 2000). Another common feature is that innovation processes are conceptualised almost exclusively from the viewpoint of economics (Smith 2005). Actually, the first character follows from this, because in economics relationships between factors and outcomes are often presented in a simplified manner and need to be interpreted by experts. Such frameworks typically regroup or recombine existing indicators or construct composite indicators from publicly available data.

An illustrative example of such a framework is the European Innovation Scoreboard (EIS). It has tried to capture the capacity of Member States to generate innovative goods and services by studying 29 innovation-related indicators categorised into three groups: enablers, firm activities and outputs. Enablers capture the principal drivers of innovation performance external to the firm such as human resources, open, excellent and attractive research systems, and finance and support. Firm activities include innovation efforts at the level of the firm, differentiating between firm investments, linkages and entrepreneurship, and intellectual assets. Outputs cover the effects of firms' innovation activities in such dimensions as innovators and economic effects (Innovation Union Scoreboard 2013).

Another example of this kind of organisation of indicators is provided by Eurostat in its Science, technology and innovation in Europe (Eurostat 2010), which is clearly divided into the categories of inputs, processes, outputs and impacts. It is rather typical that the publication does not discuss the relationships between various indicator sets, which remain implicit. The publication begins with R&D and human capital investments, continues with innovation processes in firms and ends up with present patent and high-technology statistics.

Interestingly, a similar framework is provided also by the Innovation Vital Signs project (Milbergs 2007), based on a wide survey of various measurement frameworks. The project organised indicators rather conventionally into innovation inputs, outputs and the processes connecting inputs to outputs and impacts. While being rather conventional, it also recognises the context in which innovation takes

place as well as changes in the nature of innovation including new business models, service innovation and the diffusion of innovations.

An attempt towards a wider broad-based framework is the 'Innovation Index' by the National Endowment for Science, Technology and the Arts (NESTA). The NESTA framework is an ambitious "attempt to provide a measurement of innovation that reflects how innovation really happens and one that can both quantify the importance of innovation and act as a guide to better policy." The aim of the Innovation Index is to improve existing statistics, "by making clear the contribution of innovation to productivity and growth, and by capturing hidden innovation". In particular, the Index was intended to create measurements for investment in intangible assets and to broaden traditional R&D measurement (NESTA 2009).

The first challenge for NESTA was defining what investments to count as investments in innovation. "It was decided to define innovation investments as investments in knowledge, or, as macroeconomists would put it, intangible assets. This means that the Index measures not only scientific research and developments, but the downstream co-investments needed to commercialise and profit from new ideas." NESTA has also developed and tested indicators for user innovation. It has analysed user innovation by user firms and consumers and explored to what extent user innovation reveals "hidden innovation" not recorded by traditional indicators (NESTA 2009). The latest extension of the Index includes public-sector innovation, internationally agreed indicators such as expenditure on research and development (R&D), patent production and numbers of science and technology graduates (http://www.nesta.org.uk/).

Another example of an attempt towards a wider framework is a recent development project on impact statistics in Finland. In 2010, Tekes and the Academy of Finland launched a project aiming at creating a new comprehensive framework for the measurement of STI activities in Finland. The resulting work was based on the impact model, in which impact chains from RDI (research, development, innovation) to societal impacts in four impact areas were described. The impact areas were: economy and economic renewal; environment; well-being; and knowledge, education and culture. Relevant indicators were sought to describe inputs, activities, outputs and societal impacts. The final result was a wide indicator framework describing these four impact areas (Luoma et al. 2011).

Thus, as the examples above indicate, in spite of the fact that our understanding of the nature of innovation has changed significantly during the past few decades towards emphasising multi-dimensional interaction and systemic feedback, our indicator systems still largely reflect technology-centred and linear ideas of the innovation chain. For example, even though the aforementioned impact model developed by Tekes and the Academy of Finland is very advanced, it still reflects, for the sake of simplicity, linear thinking from inputs to impacts. However, the writers of the report (Luoma et al. 2011) also note that these are rarely one-way relationships and that it should be taken into account that there are usually multiple factors affecting the formation of causal relationships.

In practice, this means that the measurements may bypass systemic complexity and instead strengthen simplified causal understanding of the operation of the

system. If this view, in turn, affects policy guidelines and decisions, we need to ask how well policy actions match the complex reality. For instance, might there be crucial unintended impacts of policy actions not covered by causal descriptions that might question the implemented policy measures?

These relatively open frames of measurement not based on explicit theory also make it possible to increase the number of indicators indefinitely. Thus, if a new perspective on innovation activities is introduced, the usual and rational reaction from the policy-making perspective is to ask whether we have appropriate indicators to describe this phenomenon. While the request is fully legitimate, the challenge is that the request usually leads to the formulation of new indicators and measurements added to the existing indicator repertoire, without asking whether our new understanding of the phenomenon should also lead to a more profound reorganisation or reform of existing indicators and frameworks. In other words, if our empirical and theoretical understanding of innovations is changing, should it not also be reflected in measurements and indicators? If this question is not put forward, the number of various measures and indicators can increase without limit. Paradoxically, this may lead to a situation in which the increased amount of information can no longer be used efficiently, as it is atomistic and the connections between various measurements and the phenomena they are reflecting remain insufficient (even if each individual item is theoretically reasoned). Therefore, we suggest that measurements and indicators should form a more holistic and theoretically sound whole that would support the interpretation of the acquired data as a whole and make it possible to analyse the complexity of the system.

3.4 Towards alternative frameworks?

Indicators and various frameworks of measurement are essential for our understanding of the STI system. We claim, however, that we should pay more attention to the underlying assumptions of such frameworks and their potential impacts on policy-making. Thus, we should make our understanding more explicit and be able to assess our assumptions and what impacts these assumptions may have.

The current dominant innovation model (e.g. Edqvist 2005) fits with the current practices of STI measurement in the sense that it focuses on the measurement of organisations and institutions (cf. Godin 2005). Thus, the system 'reveals' itself as a flow of resources and results among and between organisations, contextualised by enabling factors. However, this framework has not been fully explicated in the sense that it would form a holistic description of the system which would then be used to organise measurements and indicators. Rather, as indicated in the previous section, innovation statistics are usually collections of indicators which are held together by relatively loose input-processes-outputs assumptions – even though extensive empirical and theoretical work might have gone into any individual measures and indicators.

We should also have alternative ways of organising indicators. In order to provide an alternative system level view, we suggest as an example a functional view of system provided by Wieczorek and Hekkert (2012; cf. Hekkert et al. 2007). We put it forward as an example of a holistic framework that could be used to interpret individual measures and indicators in relation to each other. The measures and indicators should answer the questions put forward in the framework. The framework then provides the general theoretical context in which various measures can be linked to each other and their significance assessed as part of a wider whole.

Without going into the details of the analysis they suggest, what is of specific interest for us here is their functional-structural analysis of the system. While their framework also requires qualitative analysis, we consider it suitable for quantitative and statistical purposes. It is usual that quantitative information needs to be complemented with qualitative data for sound interpretations to be made.

Wieczorek and Hekkert's starting point is to identify the essential structural and functional components for the functioning of the innovation system. They suggest seven such functions (Wieczorek & Hekkert 2012) and a number of structural elements for analysis within each of them. In this way, the functions of the system are analysed through the structural elements, which, in turn, allows the identification of problems in the system and of the exact policy tools to correct the functioning of the system. Ultimately "the purpose of such an integrated instrument is to create opportunities for system development by influencing those elements and connections within the system that would not emerge spontaneously" (ibid., 83).

The functions are entrepreneurial activities, knowledge development, knowledge dissemination, guidance of the search, market formation, resource mobilisation, and creation of legitimacy. Of these functions, the first six are especially useful for considering measurement of the functioning of the system. The questions which should be answered in the context of each function can be, for instance, the following (ibid., 84): Entrepreneurial activities (e.g. Are there enough entrepreneurs? What types of business are involved? Are there new entrepreneurs?); knowledge development (e.g. What is the knowledge base? Are there many projects, articles and patents? Which actors are active?); knowledge dissemination (e.g. Are there partnerships and between whom? Is the knowledge development demand-driven?); guidance of the search (e.g. Is there a system goal, which is supported by specific programs and governments activities?); market formation (e.g. What is the market size? Are there institutional incentives or barriers to market formation?); resources mobilisation (e.g. Are there sufficient resources for the system development? Is there sufficient risk capital? Is there adequate public funding?).

As is evident, most of the categories could be rather easily covered with existing indicators and measures. The question is more of how to place the indicators into this framework in order to gain a comprehensive picture of the functioning of the system and to see what connections the elements might have with each other. The following table gives some examples of measures and indicators that might be used for instance to assess the performance of a national system. The suggestion to use this framework would not involve any significant changes in the

measures and indicators themselves, but rather in the way we organise and interpret indicators. In addition, indicators should be valid from the policy perspective, i.e. they should measure issues which are seen as relevant targets for policy-making.

Table 1. System functions and indicator examples.

Function	Examples of indicators
Entrepreneurial activities	New firms, closed firms; spin-offs, growth firms, R&D intensive firms, innovative firms, life span of firms in various branches, resources for incubation activity etc.
Knowledge development	Number of articles, patents and innovations, public and private R&D personnel in various disciplines and branches of industry, demand-based development activities
Knowledge dissemination	Collaboration in research and innovation, co-publications, co-patenting, general knowledge infrastructure (e.g. number of libraries, open access scientific journals and articles, broadband connections)
Guidance of search	Number of specific policy programmes aimed at enhancing functions of the system, evaluations of policy instruments
Market formation	Production of goods and services, value-added in various branches, use of public procurement, domestic market size
Resources mobilisation	Amount and percentage of risk capital, firms' tangible and intangible investments, public and private R&D finance, public support for new firms and innovation

What this framework does not allow, however, is taking full account of the complexity of the system, its various inter-linkages, feedback loops and nonlinearity. This is especially important from the policy-making perspective, as the relatively static models cannot take into account interaction among actors and elements in the system, and thus conclusions based on statistical evidence may anticipate the results of policy interventions incorrectly (Squazzoni & Boero 2010). The inclusion of the system dynamic perspective would require a different approach. Such an approach can be provided by recently developed modelling approaches to innovation activities and policy-making. While these approaches, which differ utterly from the traditional linear regression models, are still in their development phase, they provide an interesting and alternative perspective to the functioning of the system

and policy-making. There are two basic approaches that have been piloted recently: agent-based modelling and system dynamic modelling.

Agent-based modelling is based on the idea that "a given outcome is understood and modelled as the result of the interaction among heterogeneous, adaptive and localised agents" (Squazzoni & Boero 2010, 293). The actual model is a computational model that may help to create alternative scenarios for policy-makers and to identify optimal policy options. An interesting example of the implementation of the agent-based model in innovation policy is provided by Rosewell et al. (2008; as cited in Squazzoni & Boero 2010, 294). They developed an empirical model to study interaction among firms and its effects on innovation. The data for the model were obtained from surveys and qualitative interviews. Firms and public agencies were the agents in the model. The results indicated that innovation spread more easily among firms in supply chains instead of clusters. This, in turn, had important policy implications, as the result questioned the support provided for the conventional cluster approach. Another example of the implementation of agent-based modelling in STI policy is provided by Scholz et al. (2010), who simulated European framework programmes by asking whether incentive-led R&D policy influenced the structures and outcomes of research. The actors in their model were various research actors from universities to firms, and data were obtained from a wide survey and interviews. In addition, The Commission's participation rules were analysed. The modelling indicated that policy rules affect both the structure and outcomes of research. An example of the application of system dynamic modelling in an innovation system is provided by Uriona et al. (2012), who created a preliminary model to describe the functioning of a regional innovation system. The simulation model describes changes in the system, its interaction and knowledge flows over time. The model indicates, for instance, what consequences decreasing or increasing the public funding may have in the system in the long run.

The advantage of such simulation models is that they may help to better predict the development of the system and policy outcomes than static explanatory models that have challenges in catching the system's non-linear dynamics. However, explanatory models have their own advantages, and all these approaches are needed to analyse and understand the functioning of the system. Alternative views and frameworks are needed, however, in order to broaden the perspective and provide alternative scenarios to reach more informed decision-making.

3.5 Conclusions

In this chapter, we have argued that indicators and statistical measurement tend to structure the relationships between measured phenomena as non-transparent and self-evident facts. Indicators and measurements obtain their taken-for-granted meaning in the context of politico-administrational procedures, in which indicators and measurements have a significant role as an element guiding and legitimating

the chosen policy tracks. Current frameworks of statistical measurement are usually based on relatively loose input-processes-outputs-impacts model that usually does not explicate the relationships between indicators at the level of the whole framework. In practice, this means that the measurements bypass systemic complexity and instead strengthen a simplified causal understanding of the operation of the system. We propose by contrast that measurements and indicators should create a more holistic and theoretically sound whole that would support the interpretation of the acquired data as a whole. As alternatives for the currently dominant linear-model-based statistical frameworks, we suggest a model based on system functions and computational modelling, which may capture the non-linear dynamics of the system.

References

Alastalo M. & Pösö T. (2011) Indikaattorin epävarmuus ja tulkinta: lastensuojelun viranomaistoiminnan ja tiedontuotannon yhteenkietoutuminen (The uncertainty and interpretation of an indicator: the intervoweness of child protection practices and knowledge production). Yhteiskuntapolitiikka 76, 6, 633–643.

Auranen O. & Nieminen M. (2010) University research funding and publication performance – an international comparison. Research Policy 39, 822–834.

Chen H.T. (2005) Theory driven evaluation. In: Mathison S. (ed.) Encyclopedia of evaluation. Thousand Oaks: Sage.

Desrosières A. (1998) Politics of large numbers: a history of statistical reasoning. Harvard: Harvard University Press.

Edquist C. (ed.) (1997) Systems of Innovation: Technologies, organizations and institutions. London and Washington: Pinter Publishers.

Edquist C. (2005) Systems of Innovation: Perspectives and Challenges. In: Fagerberg J., Mowery D.C., Nelson R.R. (eds.) The Oxford Handbook of Innovation. Oxford: Oxford University Press.

Etzkowitz, H. & Leydesdorff, L. (2000) The Dynamics of Innovation: From National Systems and Mode 2 to a Triple Helix of University-Industry-Government Relations. Research Policy, 29 (2), 109–123.

Eurostat (2010) Science, technology and innovation in Europe. Eurostat, European Commission.

Godin B. (2005) Measurement and Statistics on Science and Technology 1920 to the present. New York: Routledge.

Hekkert M., Alkemade F., Negro S., Kuhlmann S. & Smits R. (2007) Functions of innovation systems: A new approach for analysing technological change. Technological Forecasting and Social Change, 74, 413–432.

Innovation Union Scoreboard (2013) Enterprise and industry. European Commission.

Kline S.J. & Rosenberg N. (1986) An overview of innovation. In: Landau R. & Rosenberg N. (eds.), The Positive Sum Strategy: Harnessing Technology for Economic Growth. Washington, D.C.: National Academy Press.

Luoma P., Raivio T., Tommila P., Lunabba J., Halme K., Viljamaa K. & Lahtinen H. (2011) Better results, more value, A framework for analysing the societal impact of research and innovation. Tekes Review 288/2011.

Milbergs, E. (2007) Innovation Vital Signs: Framework Report. An Update v. 2.8.

Moed H.F., Glänzel W. & Schmoch U. (2005) Handbook of Quantitative Science and Technology Research. Kluwer Academic Publishers. Printed in the Netherlands.

NESTA (2009) The Innovation Index. Measuring the UK's investment in innovation and its effects. Nesta.

OECD (2011) OECD Reviews of Regional Innovation – Basque Country, Spain. Paris: OECD.

OECD, Glossary of Statistical Terms. http://stats.oecd.org/glossary/

Patton, M.Q. (2011) Developmental evaluation: Applying complexity concepts to enhance innovation and use. New York: Guilford.

Rip A. (2000) 'Fashions, Lock-Ins and the Heterogeneity of Knowledge Production'. In: Jacob M. & Hellstrom T. (eds.), The Future of Knowledge Production in the Academy. Buckingham: Open University Press, pp. 28–39.

Scholz R., Nokkala T., Ahrweiler P., Pyka A. & Gilbert N. (2010) The agent-base NEMO model (SKEIN), Simulating European Framework Programmes. In: Ahrweiler P. (ed.), Innovation in Complex Social Systems. New York: Routledge.

Scuazzoni F. & Boero R. (2010) Complexity-friendly policy modelling. In: Ahrweiler P. (ed.), Innovation in Complex Social Systems. New York: Routledge.

Smith K. (2005) Measuring Innovation. In: Fagerberg J., Mowery D.C. & Nelson R.R. (eds.), The Oxford Handbook of Innovation. Oxford: Oxford University Press.

Uriona M., Pietrobon R., Varvakis G. & Carvalho E. (2012) A Preliminary Model of Innovation Systems, Proceedings of the 30th International Conference of the System Dynamics Society, July 22–26, 2012 St. Gallen, Switzerland.

Wieczorek A.J. & Hekkert M.P. (2012) Systemic instruments for systemic innovation problems: A framework for policy makers and innovation scholars. Science and Public Policy 39, 74–87.

4. The concept of the innovation system

Bernd Ebersberger

4.1 Introduction

This section introduces the concept of the innovation system. This is important, as a thorough appreciation of the innovation system concept will lead to the insight that a broader set of innovation indicators is not only desirable but mandatory for successful broad-based innovation policy. This insight will even be more obvious when we consider the innovation system together with the current state of affairs in measuring innovation. We will exemplify this measurement by referring to the Community Innovation Surveys that are currently a prominent set of indicators that innovation policy relies on.

4.2 The innovation system

The search for the antecedents of innovation, the quest for the source of innovation, the hunt for the origin of innovation is the pursuit of an economic "holy grail" (Salter 2011). Once found, it is assumed to reveal an infinite stream of improved processes, new goods and novel services so crucially important for competitiveness, growth and wellbeing.

When searching for the origin of innovation, firms tend to break away from a previously pursued purely internal orientation based on the belief that a single firm can possess all the resources required to transform an idea into economic success and rooted in the conviction that the most valuable source of innovation can only be found within the firm itself. Firms are breaking away from this conviction, as more clearly than ever they are recognising that they have to draw on a wide range of external ideas, component technologies and complementary capabilities for the development and production of their products (e.g. Coombs, Harvey & Tether 2003; Fagerberg, Mowery & Nelson 2005).

In the current dynamic and fragmented technological and economic landscape, it is virtually impossible for any single firm to keep abreast of all relevant advances that could possibly present a valuable opportunity. Hence, growth and competitiveness of firms has become contingent on their ability to compose, establish and maintain external interfaces (Nicholls-Nixon & Woo 2003). It depends on the ability of firms to choose the right mode of governance (Fey & Birkinshaw 2005) and

strongly hinges on their skill to effectively link these external interfaces to internal knowledge accumulation and to capability development (Van den Bosch, Volberda & De Boer 1999; Kogut & Zander 1996). The activities by which firms do this have recently been labelled 'open innovation practices' (Chesbrough 2003; Christensen, Olesen & Kjaer 2005). Innovations tend to originate in firms that are continuously able to identify and link codified and scientific knowledge with their particular market insight and their specialised, often tacit, problem-solving capabilities within and outside their value chain (Jensen et al. 2007; Danneels 2002; Hargadon & Sutton 1997; Katila 2002; Katila & Ahuja 2002). The external networks maintained by individual firms and the learning interfaces therein represent the micro-foundations for interactive learning and knowledge development embedded in a larger innovation system (Giuliani & Bell 2005; Graf 2010).

In the middle and late 1980s, attempts to make this increasingly interactive innovation behaviour equally accessible to academics and policy-makers led to the introduction of the innovation system concept (Freeman 1987, 1988; Lundvall[1] 1988, 1992; Nelson 1988, 1993). The development of this concept echoed the growing dissatisfaction of both academics and policy-makers with the linear model of innovation (Sharif 2006), which at that time had already been challenged by Kline and Rosenberg's (1986) chain-linked model. It also reflected the emerging inspiration from Nelson and Winter's (1982) evolutionary theory of firms and markets (Metcalfe 1994; Lundvall et al. 2002). The concept of the innovation system provided the basis for a more systemic view of the innovation process, as it emphasised that innovation is an uncertain, disorderly and complex process (Sharif 2006) that usually depends on the co-development of socio-economic arrangements, new markets, new organisational configurations and historical conditions (Markard & Truffer 2008).

In general, a system comprises a set of components that serve a common end. An innovation system is composed of a multitude of interconnected heterogeneous actors, such as firms, universities, research institutes, funding organisations or policy-making bodies that jointly and interactively create, accumulate and disseminate knowledge, skills and artefacts. They thereby contribute to the development, diffusion and utilisation of innovations and new technologies (e.g. Freeman 1987; Lundvall 1992; Nelson 1993; Metcalfe 1994; Kuhlmann 2001). Based on the demarcation between elements that constitute the system and elements that do not, the literature distinguishes between national systems of innovation (Lundvall 1992; Nelson 1993; Freeman 1987), sectoral systems of innovation (Malerba 2002), technological systems of innovation (Carlsson 1995; Callon 1992), and regional systems of innovation (Cooke, Gomez Uranga & Etxebarria 1997).

Independent of the analytical delineation, the above definition of an innovation system indicates the common objective or the main function of innovation systems (e.g. Edquist 2005): to build, spread and use innovations. However, on the micro level this neither suggests orchestrated activities of all actors in the innovation

[1] Lundvall (e.g. Lundvall et al. 2002) and Freeman (e.g. Freeman 1995) both attribute the first usage of the term 'national innovation system' to the other.

system to collectively achieve this overall objective (Bergek, Jacobsson, Carlsson, Lindmark & Rickne 2008) nor presupposes that all actors' activities are individually targeted towards the overall goal of the system. Rather, under certain conditions innovation is an emergent property resulting from multiple micro-level interactions (e.g. Ahrweiler 2010). As a consequence, the innovation system derives its dynamics from the tension and conflict between the various actors' motives, approaches and goals creating the context for Schumpeterian competition on various levels of aggregation such as technologies, products or firms (e.g. Bergek et al. 2008). Actors may not even share the same goals. And where they do, they may pursue these goals with different means, producing a heterogeneous set of solutions from which the evolutionary processes in a market can select (e.g. Breschi & Malerba 1997).

The innovation systems concept proved successful in opening up a new and productive perspective on innovation activities (Sharif 2006). Ever since its introduction, the concept of innovation systems has been deeply ingrained in academic discourse in the social sciences and in innovation economics in particular. Furthermore, ever since its first successful introduction to country-level policy-making in Finland in 1992 (e.g. Lemola 2002; Miettinen 2002), the notion of innovation systems has also strongly affected the discussion and the implementation of regional, national and international science, technology and innovation policy (Sharif 2006; Blättel-Mink & Ebner 2009; Smits, Kuhlmann & Shapira (eds.) 2010): "If anything, modern innovation theory demonstrates that a systemic perspective on innovation is necessary." (European Commission/DG Research 2002, 5.)

However, Lundvall (2010) referring to the notion of innovation systems as focusing devices, Kuhlmann (2001) interpreting innovation systems as helpful heuristic aides and Bergek et al. (2008) labelling innovation systems as analytical constructs all suggest that the current state of affairs does not offer a coherent theory of innovation systems. Moreover, Lundvall (2010) doubts that it is a constructive and realistic approach to build general system theories in social sciences. Nevertheless, these authors (Lundvall 2010; Kuhlmann 2001; Bergek et al. 2008) and others (e.g. Metcalfe 1994; Asheim & Coenen 2005; Fagerberg, Mowery & Verspagen 2009) deem it fruitful to use the concept of innovation systems as a framework to structure and guide innovation research, as it is helpful for conceptualising and gaining a better understanding of the specific challenges – policy challenges in particular – created by the dynamic development of increasingly interactive innovation processes.

4.3 Innovation policy and governmental intervention

Innovation and policy in a broad sense

One of the key lessons for researchers and policy-makers alike is that the concept of the innovation system emphasises that the for-profit enterprise is not the only

locus of innovation. Rather, the innovation system stresses that the origin or the locus of innovation may be any of the actors involved in the system. The concept of the innovation system brings to the fore that innovation originates in private households as users and transformers of already existing products and services (von Hippel 1995; von Hippel & Katz 2002). Innovation may stem from the public sector (Bason 2010; Bekkers, Edelenbos & Steijn 2011) or from not-for-profit organisations (Habisch & Loza Adaui 2013; Osburg 2013).

In the broadest sense – and this is the notion that this research project and this article build on – innovation can originate anywhere in the innovation system. That is to say that innovation can originate anywhere in the economy or society at large. It is obvious, as has been implied between the lines, that the overall target of the innovations assumed here challenges the notion that new processes, new goods, and novel services are crucially important for competitiveness, growth and wellbeing. These three concepts – 'competitiveness', 'growth' and 'wellbeing' – are usually seen as consecutive stages in a development, one building on the other. The broad sense of innovation challenges these three consecutive steps not by questioning their existence or their relevance but by questioning whether they are necessarily consecutive.

However, this challenge may be based on a rather trivial argument: not everything supporting competitiveness also supports growth. Not everything supporting growth also supports wellbeing. There are numerous examples of this. Yet the activities and decisions focusing on productivity and renewal, whether within the corporate strategic context or within the context of public economic policy-making, may shy away from the rather normative judgment required to assess whether or not capabilities, products and processes subsequently lead to an increased wellbeing. Sometimes innovations originating in domains other than the corporate world shortcut this rationale and target wellbeing directly without considering competitiveness or growth. All these types of innovation represent the target of innovation policy in a broad sense.

When innovation policy in general terms is understood as the purposeful action of governmental bodies or officials to influence the innovation process, i.e. to affect the development and diffusion of innovations (Kuhlmann, Shapira & Smits 2010; Chaminade & Edquist 2010), then the definition of innovation policy in a broad sense is to affect the development and diffusion of innovations regardless of where they originate. Given this, it is immediately obvious that the innovation system represents the context of these innovation policies. Hence, innovation systems affect the very rationale for innovation policy intervention, shape policymakers' options and determine their targets.

Two broad lines of arguments concerning the rationale for government intervention emanate from the literature.

Traditional rationale for governmental intervention

First, the market failure argumentation for governmental intervention narrows down the innovation process to corporate research and invention and thus reduces it to the activities of knowledge creation. Thereby it gains its principal insights from the very characteristics of knowledge: Knowledge-creation activities being uncertain and knowledge having public good characteristics, private (i.e. corporate) investment in knowledge creation and hence private investment in R&D is predicted to fall short of a social optimum (Nelson 1959; Arrow 1962). Under this rationale, the social optimum is defined by the maximisation of overall welfare in an economy, where welfare is defined in the rather strict and narrow neo-classical sense. It does not immediately translate to the wellbeing referred to in the previous section.

In the traditional rationale for governmental intervention, the gap between private returns and social returns reduces the incentives to invest. Generally this leads to under-investment in research, development and innovation. The stages of the innovation process are affected differently because, as Arrow (1962) argues, the more basic the research activities, the larger the under-investment. In addition to the lack of incentives, under-investment is also driven by a lack of resource mobilisation. Even with undistorted incentives, capital market imperfections might preclude firms from raising external funds for financing the investment in research, development and innovation (e.g. Hall 2002). Traditionally, innovation policy focuses on reducing this under-investment (e.g. Peneder 2008).

System failure as a rationale for governmental intervention

Secondly, the development of the systems perspective adds to the discourse on the rationale for government intervention. The system failure argument focuses on potential deficiencies of the innovation system (Carlsson & Jacobsson 1997; Teubal 1998; Klein Woolthuis, Lankhuizen & Gilsing 2005; Chaminade & Edquist 2010). These system imperfections occur when connections and linkages between the components of the innovation system are not sufficiently conducive to the generation and diffusion of knowledge. Summarising and consolidating previous contributions, Klein Woolthuis et al. (2005) distinguish between four distinct system failures that relate to the structural composition of the innovation system:

1. Infrastructural failures arise if the physical infrastructure, on which the components of the innovation system have to rely, does not adequately support the generation and diffusion of innovations.

2. Institutional failures relate to imperfections in the institutions, be they formal, written and consciously created or informal, implicit and rather more spontaneously formed.

3. Interaction failures highlight weaknesses in the innovation system concerning the structure and the composition of the actors' networks. This

leads to an insufficient composition of partners for the generation, application and exploitation of knowledge and reduces the potentially beneficial effects of collaboration such as positive spillovers, cost sharing or risk sharing.

4. Capability failures prevent change due to a lack of capabilities, learning potential, resources and flexibility.

These system failures can provide the rationale for government intervention (Metcalfe 2005; Klein Woolthuis et al. 2005). Innovation policy is thus about inducing and fostering linkages and interaction between the actors in the innovation system (Lundvall & Borras 2005) to support the overall functioning of the innovation system. Here it must be emphasised again that the above set of system failures does not explicitly relate to corporate innovation only. It also applies to innovation that might originate in various domains in an economy.

4.4 Informational requirement for innovation policy

While it has been argued that the assessment of system failures is crucial for the development and the evaluation of science, technology and innovation policy (e.g. Edquist 2001; Lundvall et al. 2002; Klein Woolthuis et al. 2005; Metcalfe 2005; Laranja, Uyarra & Flanagan 2008; Chaminade & Edquist 2010), it is questioned whether policy interventions can be designed, implemented and evaluated based on information about innovation system failures alone.

A priori, it is not obvious whether information that points towards weaknesses in the structural features of an innovation system necessarily leads to a negative or positive effect on the overall functioning of the system. Such an assessment requires an analysis of the effects of the structural features on the innovation process (Bergek et al. 2008; Bergek, Jacobsson, Hekkert & Smith 2010). Hence, innovation policy requires timely information for timely intervention and also a process perspective on the innovation system. The system's (sub)-functions (Johnson & Jacobsson 2001; Hekkert, Suurs, Negro, Kuhlmann & Smits 2007; Bergek et al. 2008; Bergek et al. 2010) or activities (Liu & White 2001; Edquist 2005; Chaminade & Edquist 2006) have to be defined and information has to be available for policy-makers to derive measures based on the assessment of system failures.

The functions of the system determine its overall performance with respect to its main function (Edquist 2005). In other words, functions are activities at the micro level (Hekkert et al. 2007) that affect the development, diffusion and utilisation of innovations. In addition, the functional analysis of innovation systems may alleviate the problems concerning the exact demarcation of the innovation system (Schienstock & Hämäläinen 2001), which might be crucial when innovations relevant for the policy intervention may originate in a variety of domains.

The literature is not always clear-cut in the distinction between functions, and the functions are occasionally mutually dependent. The following is an outline of three functions of the innovation system that I consider relevant for the question at hand.

1. *Resource mobilisation* as a function of the innovation system refers to the input side of the innovation processes. All activities in the innovation system require financial and human capital as a fundamental input. This system function provides an appropriate level of resources for the development and diffusion of innovations. It is essential for all subsequent functions (Johnson 1998; Bergek 2002; Rickne 2000; Johnson & Jacobsson 2001; Edquist 2005; Hekkert et al. 2007; Bergek et al. 2010).

2. The function of *knowledge development and learning* is often seen as the core of the innovation system. It comprises activities that are discussed separately in parts of the literature. In particular, it bundles the creation of knowledge and learning (Hekkert et al. 2007), the facilitation of knowledge exchange (Johnson 1998; Bergek 2002), the provision of internal R&D and innovation activities (Edquist 2005) and the maintenance of external interfaces (Liu & White 2001; Edquist 2005; Rickne 2000). Here it also includes the search for the direction of knowledge development (Johnson 1998; Johnson & Jacobsson 2001).

3. *(Entrepreneurial) experimentation* is a function of the innovation system that increases heterogeneity in knowledge, the product and the solution space and diversity in the firm population, and hence enables a more effective evolutionary selection among its actors (Carlsson & Jacobsson 2004; Edquist 2005; Bergek et al. 2008). Additionally, from the perspective of the system as a whole, a sufficient level of experimentation exerts portfolio effects on the overall risk (Bergek et al. 2010).

In addition to these three functions, the literature also discusses market formation (Johnson 1998; Bergek et al. 2008; Bergek et al. 2010) and legitimation (Johnson 1998; Hekkert et al. 2007; Bergek et al. 2008; Bergek et al. 2010). As I feel that these do not play a role for the purpose of this discussion, they are not summarised here.

For innovation policy-making, information on the functions of innovation system is usually generated using terminology such as ‘innovation input’, ‘innovation output’ and ‘innovation behaviour’. For assessment of innovation policies, related terminology has been devised: ‘input additionality’, ‘output additionality’ and ‘behavioral additionality’.

Input

As the *resource mobilisation* function addresses the input side of the innovation process, it most clearly relates to the potential under-investment induced by market failure and legitimises government intervention, which is typically carried out in

various ways targeting several components in the innovation system. The most prominent governmental interventions within industrialised countries to stimulate innovation activities are subsidies through tax credits or selective direct grants to companies. The discussion clearly refers to the governmental intervention through funding only (Viljamaa et al. 2013).

The R&D subsidy literature has primarily investigated the effectiveness of this instrument in targeting under-investment in R&D and innovation activities. The micro-level evaluation studies typically focus on the potential crowding-out effects on the level of the recipient firm. The fundamental question has been whether the firms targeted, i.e. subsidised firms, replace private investment in innovation with government funding. If such a crowding-out is found, public subsidies cannot effectively reduce under-investment. Thus, basic interest has focused on the effect of public subsidies on innovation input. In this sense, most of the studies focus on one dimension, typically referred to as *input-additionality*.

Analysing the effects of tax credits, Hall and van Reenen (2000) found that tax credits do not replace private expenditure in R&D; rather, one dollar in tax credits triggers additional private R&D spending of about the same amount. When estimating the effect of public funding in the form of government grants, David, Hall and Toole (2000) and Klette, Moen and Griliches (2000) point out that the methodology has to account for the selectivity of the granting process. With some exceptions (Wallsten 2000; Lach 2002), the majority of analyses that estimate the treatment effect on the subsidised firms reject full crowding-out at the level of the subsidised firm (Busom 2000; Almus & Czarnitzki 2003; Gonzalez, Jaumandreu & Pazo 2005; Aerts & Schmidt 2008).

Output

The innovation output clearly references the overall target of the innovation system or targets certain steps in the chain of ‘competitiveness’, ‘growth’ and ‘wellbeing’, where successful introduction and diffusion of innovation is seen as an antecedent.

Recently, the study of innovation policy effects, i.e. the analysis of public subsidies, has been extended to the analysis of their effect on innovation output. This highlights what is typically referred to as *output-additionality*. Positive effects on innovation output such as patent and innovation sales have been found (Czarnitzki & Hussinger 2004; Czarnitzki & Licht 2006; Hussinger 2008).

The output of innovation activities can also be measured by assessing the changes in productivity (Viljamaa et al. 2013), another antecedent of competitiveness. Productivity is a measure that relates the quantity of outputs to the quantity of inputs. It can be measured by TFP (estimated) or by any other partial productivity measure that relates the quantity of output to one single factor of input. For comparison, the latter obviously assumes that all the other factors of production do not change. Although productivity can be said to reflect the production behaviour of the firm, i.e. how it combines input factors to produce output, it is nevertheless

considered an output in the innovation process, which may be particularly relevant, as productivity increases can be driven by higher value creation in the firm through new products of higher quality or by the implementation of new processes. However, a more likely source of productivity is a combination of both.

Behaviour

The concept of innovation behaviour bears a strong relationship to the function of *knowledge generation and learning* and (*entrepreneurial*) *experimentation* introduced above. Georghiou (2002) explicitly points to the difference in persistence and clearly links *behavioral additionality* to the capabilities of the actors – in his discussion the actors are defined narrowly as firms – and in particular to their dynamic capabilities (Teece, Pisano & Shuen 1997). These are closely intertwined with knowledge generation, learning and entrepreneurial experimentation, which are crucial for renewable products, processes, routines and capabilities.

The knowledge development, experimentation and learning dimension of behavioural additionality can be investigated at various levels. For instance, Viljamaa et al. (2013) distinguished the project level, the firm level, the industry level and the societal level. The latter reflects a certain demarcation of the innovation system, the sectoral and potentially the national innovation system. Whether these demarcations are empirically helpful depends on the task at hand and on the interrelatedness of innovation activities across the sectoral and national boundaries.

Traditional generation of information about input, output and behaviour

Before sketching some characteristics of what might be called a traditional approach towards the generation of information about innovation input, innovation output and innovation behaviour, it must be emphasised that the following considerations are not intended to discredit any of the mentioned approaches and data sources. Rather to the contrary, one cannot imagine what knowledge we would have about the antecedents, about the determinants and about the effects of innovation without the information systematically generated by the surveys mentioned below. Additionally, the discussion of how to operationalise the once fuzzy notion of innovation in EU, Eurostat, OECD and national policy-maker circles certainly contributed to that common and more stable notion of innovation which can now be found in the OECD's Oslo Manual.

As the innovation system emphasises actor-level activities as an antecedent to innovation system behaviour, our focus here is on micro-level information. Traditionally, policy is informed through micro-data generated either through R&D Surveys or through Innovation Surveys, most notably through the Community Innovation Survey (CIS). For the present discussion, it suffices to focus on those primary surveys at the expense of data sources discussed elsewhere. The current CIS questionnaire is based on the definitions of innovation input, behaviour and output laid out in the third edition of the Oslo Manual (OECD 2005).

The CIS data are thoroughly reviewed and validated by the national surveying organisation prior to release. The primary purpose of the CIS is to inform national and European innovation and technology policy about the activities of corporate actors in the innovation system. Previous national editions of the Community Innovation Survey have been used extensively for analysis in economics (Cassiman & Veugelers 2002; Czarnitzki, Ebersberger & Fier 2007; Veugelers & Cassiman 2006), in management studies (Ebersberger & Herstad 2011; Frenz & Ietto-Gillies 2007; Grimpe & Sofka 2009; Laursen & Salter 2006) and in economic geography (Ebersberger & Herstad 2012; Laursen, Reichstein & Salter 2011; Simmie 2003, 2004). In addition to or preceding the history of innovation surveys, patent data have been used to capture innovation activities, patents being used as indicators for innovation output (Hagedoorn & Cloodt 2003). Using patent information as an innovation input indicator goes back to Schmookler (Griliches 1990) and usually captures competencies and expertise (Branstetter 2001; Jaffe 1986). However, with innovation indicators based on patent information the question always remains: "What aspects of economic activity do patent statistics actually capture?" (Griliches 1990, 1666), where we assume that the emphasis should be on the word 'economic'.

The host of items surveyed in the CIS, the plethora of measures that can be constructed from these items and the wealth of combinations that those measures give rise to (Hagedoorn & Cloodt 2003) generate a "non-trivial choice between innovation indicators" (Kleinknecht, Montfort & Brouwer 2002). Once this non-trivial choice has been made, the selected innovation indicators are used to characterise the innovation system, its strengths, its weaknesses and its performance. Based on those innovation indicators, innovation systems are compared and ranked internationally; this remains a driving force and guide line for policy intervention.

However, certain innate characteristics of those innovation indicators are mostly overlooked. Whether or not the indicators are still rendered useful after carefully contemplating these inherent characteristics is beyond the scope of the present discussion. Rather it must be put into the context of the use and application of these measures. After a brief discussion of those inherent characteristics, we sketch out an approach for utilising information sources that might address these characteristics in different ways.

Survey

With the exception of patent information, most of the indicators used to characterise the innovation system are generated through dedicated surveys. In some countries, particularly in the Nordic countries, this survey information can be combined with register information. However, to generate survey information the researcher or the statistician has to generate a survey questionnaire and phrase the questions accordingly. The continuous efforts to revise and update the Community Innovation Survey are a good example of this time-consuming process.

The main issue here is that the information is only gained from the actors who are actually sampled and polled. Also, the information only reflects the questions that are actually asked. In a survey, actors cannot contribute issues that are relevant to them if they are not covered in the questionnaire. Additionally, the actors have to decide on one of the predefined answers even if other answers might be more appropriate to them. All these properties of the data generated through surveys are not new (see e.g. Bryman & Bell 2011). Usually the survey process strives to reduce bias through extensive pre-testing of the questionnaire and through continuous updating of the questionnaire in case of repeated surveys as with the CIS.

Time

As surveys require time to be carefully planned, the units of observation need to be sampled representatively and the data have to be checked for validity, any survey necessarily involves a certain time lag. In the case of the Community Innovation Survey, this time lag often amounts to two years between the time the survey is in the field and the time the data are readily available to researchers or policy-makers. Considering that the time period covered in the innovation survey is usually three years, in an extreme case the temporal difference between innovation activities captured by the survey and their manifestation in the available data can be up to five years.

Granted, the upside of this time lag is the high reliability and strong validity of the data provided through this process. It may, however, may cause considerable challenges to policy-making in a dynamic environment, where change is a key characteristic of the phenomenon targeted by policy interventions.

Actors

Usually innovation surveys and R&D surveys focus on the activities of corporate actors. A notable exception may be the European public-sector innovation scoreboard (European Commission 2013) and the survey efforts documented therein. Overall, we feel that the focus on corporate actors does not do justice to the concept of innovation systems. The heterogeneity of actors involved in the innovation process and the diversity of origins of innovation suggest that a lot may have escaped our attention because of our focusing almost exclusively on firms.

4.5 Conclusion

Firstly, the concept of the innovation system has crucially influenced our understanding of innovation processes. Innovation is now considered a social and interactive process where firms play one role, but – and this is the most important

insight gained from innovation systems – firms are not the only players in the economy to influence innovation capabilities and innovation outcome. We have to bear this in mind when we find, secondly, that over approximately the same period of time the broad use and implementation of, innovation surveys, for instance, increased our knowledge about corporate innovation motives, activities, inputs and outputs. The data gathered across Europe and beyond helped us, researchers and policy-makers alike, to know more about corporate innovation.

However, and this is the rub, the concept of the innovation system suggests a multitude of heterogeneous actors that affect the innovation capability of economies. Yet the broad empirical evidence that is finally informing makers of innovation policy mostly focuses on corporate innovation. We thus know a lot about a small part of a multi-faceted system that we should know far better to inform a broad-based innovation policy.

In a sense, the insight in the previous paragraph clearly has some similarity with the overall problem of measuring an economy's performance. Purely relying on the traditional notion of GDP will not give a realistic image of an economy's capability. This fact has long been recognised, and progress has been made towards a broader measurement of an economy's performance (Stiglitz et al. 2013).

References

Aerts, K. & Schmidt, T. (2008) Two for the price of one? Additionality effects of R&D subsidies: A comparison between Flanders and Germany. Research Policy, 37(5), 806–822.

Ahrweiler, P. (2010) Innovation in complex social systems: An introduction. In: P. Ahrweiler (Ed.), Innovation in complex social systems (pp. 1–26). New York: Routledge.

Almus, M. & Czarnitzki, D. (2003) The effects of public R&D subsidies on firms' innovation activities: The case of Eastern Germany. Journal of Business and Economic Statistics, 21(2), 226–236.

Arrow, K. (1962) Economic welfare and the allocation of the resources for invention. In: R. R. Nelson (Ed.), The rate and direction of inventive activity (pp. 609–627). Princeton: Princeton University Press.

Asheim, B. T. & Coenen, L. (2005) Knowledge bases and regional innovation systems: Comparing Nordic clusters. Research Policy, 34(8), 1173–1190.

Bason, C. (2010) Leading Public Sector Innovation: Co-creating for a Better Society (p. 278). Policy Press.

Bekkers, V., Edelenbos, J. & Steijn, B. (2011) Innovation in the Public Sector: Linking Capacity and Leadership (Governance and Public Management). Palgrave Macmillan.

Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S. & Rickne, A. (2008) Analyzing the functional dynamics of technological innovation systems: A scheme of analysis. Research Policy, 37, 407–429.

Bergek, A., Jacobsson, S., Hekkert, M. P. & Smith, K. (2010) Functionality of innovation systems as a rational for and guide to innovation policy. In: R. E. Smits, S. Kuhlmann & P. Shapira (Eds.), The Theory and Practice of Innovation Policy (pp. 115-144). Cheltenham: Edward Elgar.

Blättel-Mink, B. & Ebner, A. (2009) Innovationssysteme im wissenschaftlichen und gesellschaftlichen Diskurs. In B. Blättel-Mink & A. Ebner (Eds.), Innovationssysteme: Technologie, Institutionen und die Dynamik der Wettbewerbsfähigkeit (pp. 11–23). Wiesbaden: VS Verlag für Sozialwissenschaften.

Branstetter, L. G. (2001) Are knowledge spillovers international or intranational in scope? Microeconometric evidence from the U.S. and Japan. Journal of

International Economics, 53(1), 53–79. doi:10.1016/S0022-1996(00)00068-4.

Breschi, S. & Malerba, F. (1997) Sectoral innovation systems: Technological regimes, Schumpeterian dynamics, and spatial boundaries. In: C. Edquist (Ed.), Systems of innovation: Technologies, institutions and organizations (pp. 130–156). London: Pinter.

Bryman, A. & Bell, E. (2011) Business Research Methods. Oxford University Press, USA. 720 p.

Busom, I. (2000) An empirical evaluation of the effects of R&D subsidies. Economics of Innovation and New Technology, 9(2), 111–148.

Callon, M. (1992) The dynamics of techno-economic networks. In: R. Coombs, P. P. Saviotti & V. Walsh (Eds.), Economic and social analysis of technology: Technological change and company strategies. Economic and sociological perspectives. London: Academic Press.

Carlsson, B. (Ed.). (1995) Technological systems and economic performance: The case of factory automation. Dordrecht: Kluwer.

Carlsson, B. & Jacobsson, S. (1997) In search of useful public policies: Key lessons and issues for policy makers. In: B. Carlsson (Ed.), Technological systems and industrial dynamics (pp. 299–316). Dordrecht: Kluwer Academic Publishers.

Carlsson, B. & Jacobsson, S. (2004) Dynamics of innovation systems: Policy-making in a complex and non-deterministic world. DRUID Summer Conference 2004: Industrial dynamics, innovation and development. Copenhagen.

Cassiman, B. & Veugelers, R. (2002) R&D Co-operation and Spillovers: Some Empirical Evidence from Belgium. American Economic Review, 92, 1169–1184.

Chaminade, C. & Edquist, C. (2010) Rationales for public policy intervention in the innovation process: Systems of innovation approach. In: R. E. Smits, S. Kuhlmann & P. Shapira (Eds.), The theory and practice of innovation policy: An international research handbook (pp. 95–114). Cheltenham: Edward Elgar.

Chesbrough, H. (2003) Open Innovation – The new imperative for creating and profiting from technology. Cambridge MA: Harvard Business School Press.

Christensen, J. F., Olesen, M. H. & Kjaer, J. S. (2005) The industrial dynamics of open innovation–Evidence from the transformation of consumer electronics. Research Policy, 34(10), 1533–1549.

Cooke, P., Gomez Uranga, M. & Etxebarria, G. (1997) Regional innovation systems: Institutional and organisational dimensions. Research Policy, 26(4/5), 475–491.

Coombs, R., Harvey, M. & Tether, B. S. (2003) Analysing distributed processes of provision and innovation. Industrial and Corporate Change, 12(6), 1125–1155.

Czarnitzki, D., Ebersberger, B. & Fier, A. (2007) The relationship between R&D collaboration, subsidies and R&D performance: Empirical evidence from Finland and Germany. Journal of Applied Econometrics, 22(7), 1347–1366. doi:10.1002/jae.

Czarnitzki, D. & Hussinger, K. (2004) The link between R&D subsidies, R&D spending and technological performance. ZEW Discussion Paper. Mannheim: ZEW.

Czarnitzki, D. & Licht, G. (2006) Additionality of public R&D grants in a transition economy: the case of Eastern Germany. Economics of Transition, 14(1), 101–131.

Danneels, E. (2002) The dynamics of product innovation and firm competences. Strategic Management Journal, 23(12), 1095–1121.

David, P. A., Hall, B. H. & Toole, A. A. (2000) Is public R&D a complement or substitute for private R&D? A review of the econometric evidence. Research Policy, 29(4–5), 497–529.

Ebersberger, B. & Herstad, S. J. (2011) Product innovation and the complementarities of external interfaces. European Management Review, 8(3), 117–135. doi:10.1111/j.1740-4762.2011.01014.x

Ebersberger, B. & Herstad, S. J. (2012) Go abroad or have strangers visit? On organizational search spaces and local linkages. Journal of Economic Geography, 12(1), 273–295.

Edquist, C. (2001) Innovation policy in the systems of innovation approach: some basic principles. In: M. M. Fischer & J. Fröhlich (Eds.), Knowledge, complexity, and innovation systems (pp. 46-57). Heidelberg: Springer Verlag.

Edquist, C. (2005) Systems of innovation – Perspectives and challenges. In: J. Fagerberg, D. C. Mowery & R. R. Nelson (Eds.), The Oxford handbook of innovation (pp. 181–208). Oxford: Oxford University Press.

European Commission. (2013) European public sector innovation scoreboard 2013 – A pilot exercise. Brussels: European Commission. doi:10.2769/72467

European Commission / DG Research. (2002) Benchmarking national research policies: The impact of RTD on competitiveness and employment (IRCE). Brussels. Retrieved from ftp://ftp.cordis.europa.eu/pub/era/docs/bench_irce_0802.pdf

Fagerberg, J., Mowery, D. C. & Nelson, R. R. (2005) Introduction to Part II. In: J. Fagerberg, D. C. Mowery & R. R. Nelson (Eds.), The Oxford Handbook of Innovation (p. 180). Oxford: Oxford University Press.

Fagerberg, J., Mowery, D. C. & Verspagen, B. (2009) The evolution of Norway's national innovation system. Science and Public Policy, 36(6), 431–444.

Fey, C. F. & Birkinshaw, J. (2005) External sources of knowledge, governance mode and R&D performance. Journal of Management, 31(4), 597–621.

Freeman, C. (1987) Technology policy and economic performance: Lessons from Japan. London: Pinter.

Freeman, C. (1988) Japan: a new national system of innovation. In: G. Dosi, C. Freeman, R. R. Nelson, G. Silverberg & L. Soete (Eds.), Technical change and economic theory (Vol. 331–348). London: Pinter.

Freeman, C. (1995) The national system of innovation in historical perspective. Cambridge Journal of Economics, 19, 5–24.

Frenz, M. & Ietto-Gillies, G. (2007) Does multinationality affect the propensity to be innovative? An analysis of the Third Community Innovation Survey. International Review of Applied Economics, 21(1), 99–117.

Giuliani, E. & Bell, M. (2005) The micro-determinants of meso-level learning and innovation: evidence from a Chilean wine cluster. Research Policy, 34(1), 47–68.

Gonzalez, X., Jaumandreu, J. & Pazo, C. (2005) Barriers to innovation and subsidy effectiveness. Rand Journal of Economics, 36(4), 930–950.

Graf, H. (2010) Gatekeepers in regional networks of innovators. Cambridge Journal of Economics, 35(1), 173–198.

Griliches, Z. (1990) Patent statistics as economic indicators: A survey. Journal of Economic Literature, 28, 1661–1707.

Grimpe, C. & Sofka, W. (2009) Search patterns and absorptive capacity: Low- and high-technology sectors in European countries. Research Policy, 38(3), 495–506. doi:10.1016/j.respol.2008.10.006

Habisch, A. & Loza Adaui, C. R. (2013) A social capital approach towards social innovation. In: T. Osburg & R. Schmidpeter (Eds.), Social innovation: solutions for a sustainable future (pp. 65–76). Heidelberg: Springer.

Hagedoorn, J. & Cloodt, M. (2003) Measuring innovative performance: is there an advantage in using multiple indicators? Research Policy, 32, 1365–1379.

Hall, B. H. (2002) The financing of research and development. Oxford Review of Economic Policy, 18(1), 35–51.

Hall, B. H. & Van Reenen, J. (2000) How effective are fiscal incentives for R&D? A review of the evidence. Research Policy, 29(4–5), 449–469.

Hargadon, A. & Sutton, R. I. (1997) Technology brokering and innovation in a product development firm. Administrative Science Quarterly, 42(4), 716–749

Hekkert, M., Suurs, R., Negro, S., Kuhlmann, S. & Smits, R. (2007) Functions of innovation systems: A new approach for analysing technological change. Technological Forecasting and Social Change, 74(4), 413–432.

Hussinger, K. (2008) R&D and subsidies at the firm level: an application of parametric and semiparametric two-step selection models. Journal of Applied Econometrics, 23(6), 729–747.

Jaffe, A. B. (1986) Technological opportunity and spillovers of R&D: evidence from firms' patents, profits, and market value. The American Economic Review, 76(5), 984–1001. doi:10.1111/1468-2370.00024

Jensen, M. B., Johnson, B., Lorenz, E. & Lundvall, B.-A. (2007) Forms of knowledge and modes of innovation. Research Policy, 36(5), 680–693.

Johnson, A. (1998) Functions in innovation system approaches. Working Paper. Göteborg: Chalmers University of Technology.

Johnson, A. & Jacobsson, S. (2001) Inducement and blocking mechanisms in the development of a new industry: The case of renewable energy technology in Sweden. In: R. Coombs, K. Green, A. Richards & V. Walsh (Eds.), Technology and the market: Demand, users and innovation (pp. 89–111). Cheltenham: Edward Elgar.

Katila, R. (2002) New product search over time: past ideas in their prime. Academy of Management Journal, 55(5), 995–1010.

Katila, R. & Ahuja, G. (2002) Something old, something new: a longitudinal study of search behaviour and new product introduction. Academy of Management Journal, 45(6), 1183–1194.

Kleinknecht, A., Montfort, K. Van & Brouwer, E. (2002) The non-trivial choice between innovation indicators. Economics of Innovation and New Technology, 11(2), 109–121.

Klein Woolthuis, R., Lankhuizen, M. & Gilsing, V. (2005) A system failure framework for innovation policy design. Technovation, 25(6), 609–619.

Klette, T. J., Moen, J. & Griliches, Z. (2000) Do subsidies to commercial R & D reduce market failures? Microeconometric evaluation studies. Research Policy, 29, 471–495.

Kline, S. J. & Rosenberg, N. (1986) An overview of innovation. In: R. Landau & N. Rosenberg (Eds.), The positive sum strategy: Harnessing technology for economic growth (pp. 275–305). Washington DC: National Academic Press.

Kogut, B. & Zander, U. (1996) What firms do? Coordination, identity, and learning. Organization science, 7(5), 502–518.

Kuhlmann, S. (2001) Future governance of innovation policy in Europe – three scenarios. Research Policy, 30(6), 953–976.

Kuhlmann, S., Shapira, P. & Smits, R. E. (2010) Introduction. A systematic perspective: The innovation policy dance. In: R. E. Smits, S. Kuhlmann & P. Shapira (Eds.), The theory and practice of innovation policy: An international research handbook (pp. 1–24). Cheltenham: Edward Elgar.

Lach, S. (2002) Do R&D subsidies stimulate or displace private R&D, Evidence from Israel. Journal of Industrial Economics, 50(4), 369–390.

Laranja, M., Uyarra, E. & Flanagan, K. (2008) Policies for science, technology and innovation: Translating rationales into regional policies in a multi-level setting. Research Policy, 37(5), 823–835

Laursen, K. & Salter, A. (2006) Open for innovation: the role of openness in explaining innovation performance among U.K. manufacturing firms. Strategic Management Journal, 27(March), 131–150.

Laursen, K., Reichstein, T. & Salter, A. (2011) Exploring the Effect of Geographical Proximity and University Quality on University–Industry Collaboration

in the United Kingdom. Regional Studies, 45(4), 507–523. doi:10.1080/00343400903401618

Lemola, T. (2002) Convergence of national science and technology policies: the case of Finland. Research Policy, 31, 1481–1490.

Liu, X. & White, S. (2001) Comparing innovation systems: a framework and application to China's transitional context. Research Policy, 30(7), 1091–1114.

Lundvall, B.-A. (1988) Innovation as an interactive process: from user-supplier interaction to the national system of innovation. In: G. Dosi, C. Freeman, R. R. Nelson, G. Silverberg & L. Soete (Eds.), Technical change and economic theory (pp. 349–369). London: Pinter.

Lundvall, B.-A. (1992) National systems of innovation: Towards a theory of innovation and interactive learning. London New York. Pinter.

Lundvall, B.-A. (2010) Post Script: Innovation System Research – Where It Came From and Where It Might Go. In: B.-A. Lundvall (Ed.), National systems of innovation: Toward a theory of innovation and interactive learning (pp. 317–350). London: Anthem Press.

Lundvall, B.-A. & Borras, S. (2005) Science, technology, and innovation policy. In: J. Fagerberg, D. C. Mowery & R. R. Nelson (Eds.), The Oxford Handbook of Innovation (pp. 599–631). Oxford: Oxford University Press.

Lundvall, B.-A., Johnson, B., Andersen, E. S. & Dalum, B. (2002) National systems of production, innovation and competence building. Research Policy, 31(2), 213–231.

Malerba, F. (2002) Sectoral systems of innovation and production. Research policy, 31(2), 247–264.

Markard, J. & Truffer, B. (2008) Technological innovation systems and the multi-level perspective: Towards an integrated framework. Research Policy, 37(4), 596–615.

Metcalfe, J. S. (1994) Evolutionary economics and technology policy. The Economic Journal, 104(425), 931–944.

Metcalfe, J. S. (2005) Systems failure and the case for innovation policy. In: P. Llerena & M. Matt (Eds.), Innovation policy in a knowledge-based economy: theory and practice (pp. 47–74). Heidelberg: Springer.

Miettinen, R. (2002) National innovation system. Scientific concept or political rhetoric? Helsinki: Edita.

Nelson, R. R. (1959) The simple economics of basic scientific research. Journal of Political Economy, 67(3), 297–306.

Nelson, R. R. (1988) National systems of innovation: preface and institutions supporting technical change in the United States. In: G. Dosi, C. Freeman, R. R. Nelson, G. Silverberg & L. Soete (Eds.), Technical change and economic theory (pp. 309–239). London: Pinter.

Nelson, R. R. (1993) National innovation systems: A comparative analysis. Oxford: Oxford University Press.

Nelson, R. R. & Winter, S. G. (1982) An evolutionary theory of economic change. Cambridge MA: Belknap Press of Harvard University Press.

Nicholls-Nixon, C. L. & Woo, C. Y. (2003) Technology sourcing and output of established firms in a regime of encompassing technological change. Strategic Management Journal, 24(7), 651–666.

Osburg, T. (2013) Social innovation to drive corporate sustainability. In: T. Osburg & R. Schmidpeter (Eds.), Social innovation: solutions for a sustainable future (pp. 13–22). Heidelberg: Springer.

Peneder, M. (2008) The problem of private under-investment in innovation: A policy mind map. Technovation, 28(8), 518–530.

Rickne, A. (2000) New technology-based firms and industrial dynamics. Göteborg: Chalmers University of Technology.

Salter, A. J. (2011) The pursuit of innovation, Inaugural Lecture, Imperial College Business School, March 10 2011.

Schienstock, G. & Hämäläinen, T. (2001) Transformation of the Finnish innovation system: A network approach. Helsinki: Sitra.

Sharif, N. (2006) Emergence and development of the national innovation systems concept. Research Policy, 35(5), 745–766.

Simmie, J. (2003) Innovation and Urban Regions as National and International Nodes for the Transfer and Sharing of Knowledge. Regional Studies, 37(6–7), 607–620. doi:10.1080/0034340032000108714

Simmie, J. (2004) Innovation and clustering in the globalised international economy. Urban Studies, 41(5–6), 1095–1112. doi:10.1080/00420980410001675823

Smits, R. E., Kuhlmann, S. & Shapira, P. (Eds.). (2010) The theory and practice of innovation policy: An international research handbook. Cheltenham: Edward Elgar.

Stiglitz, J., Sen, A. & Fitoussi, J.-P. (2013) Report by the Commission on the Measurement of Economic Performance and Social Progress, http://www.insee.fr/fr/publications-et-services/dossiers_web/stiglitz/doc-commission/RAPPORT_anglais.pdf.

Teece, D. J., Pisano, G. & Shuen, A. (1997) Dynamic capabilities and strategic management. Strategic Management Journal, 18(7), 509–533.

Teubal, M. (1998) Policies for promoting enterprise restructuring in national systems of innovation: triggering cumulative learning and generating system effects. OECD STI Review, 22, 137–170.

Van den Bosch, F. A. J., Volberda, H. W. & De Boer, M. (1999) Coevolution of firm absorptive capacity and knowledge environment: Organizational forms and combinative capabilities. Organization Science, 10(5), 551–568.

Veugelers, R. & Cassiman, B. (2006) In search of complementarity in innovation strategy: internal R&D and external knowledge acquisition. Management Science, 52(1), 68–82. doi:10.1287/mnsc.1050.0470

Viljamaa, K., Piirainen, K., Kotiranta, A., Karhunen, H. & Huovari, J. (2013) Impact of TEKES activities on productivity and renewal. Rambol, April 2013

Von Hippel, E. (1995) The Sources of Innovation. Oxford University Press, USA. 218 p.

Von Hippel, E. & Katz, R. (2002) Shifting Innovation to Users via Toolkits. Management Science, 48(7), 821–833. doi:10.1287/mnsc.48.7.821.2817

Wallsten, S. J. (2000) The effects of government-industry R&D programs on private R&D: The case of small business innovation research program. RAND Journal of Economics, 31(1), 82–100.

5. Are we measuring the right things?

Olavi Lehtoranta & Mika Nieminen

5.1 Introduction

In this chapter, we review existing statistical indicators on science, technology and innovation (STI) and argue that innovation statistics should concentrate on innovation activities in general rather than divide it into various artificial sub-categories (Sequeira 2012). We further recommend that activities used for major innovations such as new-to-market concepts, products and services should be given a higher role in the innovation surveys, and innovation surveys should try to differentiate real innovations from incremental adoptions, for instance. This relates specifically to organisational and marketing innovations and to process innovations in general.

We review existing indicators by beginning from what are known as framework conditions and then moving on to measurements and indicators relating to innovation inputs and activities and concluding with a discussion of innovation outputs and impacts. The chapter ends with our assessment of the possible gaps and flaws in the existing indicators.

5.2 Framework conditions

In the innovation systems approach, innovations are seen as embedded in the political, social, organisational and economic systems (Schubert, Neuhäusler, Frietsch, Rammer & Hollanders 2011, see also Edquist 2005, Grandstrand, Patel and Pavitt 1997), and the innovation system constitutes the conceptual (institutional) framework for innovation policy as well as for the measurement of innovation.

In general, it is seen that the public sector provides the framework conditions and infrastructure that support innovation. The public sector manages activities that provide goods and services to people or to other parts of the public sector. Examples of this are social and health care services, national security, the tax system and policy advice for legislation and regulation. Framework conditions can also result from culture and history (Gault 2010a, 3, 93).

Economic and legal framework conditions include areas such as taxes, governance, financing, open markets or laws that can be directly or indirectly steered by the political system (Milbergs 2007). Framework conditions also include competitive markets and regulations such as patents and copyright laws (Spence 1981)

that facilitate the creation of businesses. There are a number of economic policy factors that affect innovation, including a stable macroeconomic environment, sound public finances, well-functioning financial, labour and product markets, protection of intellectual property rights and effective tax, trade and regulatory policies (OECD 2011).

Examples of social framework conditions include flexibility and readiness for change on the level of both organisations and individuals. As recognised e.g. by Milbergs (2007), the mind-set of a nation may be a decisive innovation driver. Other framework conditions include health care and education and also science, technology and knowledge.

The generation, transmission and use of knowledge are keys to the functioning of innovation systems and to the effectiveness of innovation policies (Gault 2010a, 21). Similarly, the availability of skilled people for science, technology and innovation forms an important condition for knowledge investments and wellbeing. Related inputs can be directed for instance to the promotion of entrepreneurship and invention, increasing people's mobility and regeneration and encouraging risk-taking.

According to de Jong et al. (2008), framework conditions can be divided into human resources and employment conditions, science base, regulatory framework and fiscal environment. External conditions may be further analysed into networking and collaboration, entrepreneurial activities, IP-management, absorptive capacities and access to a high-quality, mobile labour force and finance. The borderline between framework conditions and external conditions is by no means clear-cut, however. In addition, the concept of infrastructure may overlap with the concept of framework conditions. For instance, Rotmans (2011) divides infrastructure into physical and economic infrastructure and institutions. Physical infrastructure includes transport and telecommunication systems and broadband access, whereas economic infrastructure includes markets, consumption and production, institutions, rules, regulations and collective actors.

In a global and rapidly changing world, innovation activities are also interconnected and are influenced by framework conditions in various countries. Global knowledge sourcing and collaborative networks drive innovation (FORA 2009). Unsatisfactory framework conditions, ranging from poor access to finance, high costs of doing business and high costs of IPR to slow standardisation and ineffective use of public procurement may become a disincentive for business and innovation.

Instead of the classifications given above, we sub-divide framework conditions (or enabling factors) as follows: education and culture; public goods and services; economic conditions; social conditions; and infrastructure. This division is often used in innovation measurement frameworks, and it has implications for how we understand broad-based innovation activities at the level of the organisation, the economy and society at large (Table 1). Table 2 shows examples of basic statistical indicators often used in the description of framework conditions for research and innovation.

Table 1. Examples of framework conditions.

Culture and education	1. A collective set of values, social norms 2. Perspective (shared orientation) and paradigm (defining problems and solutions) 3. Availability of skilled people; access to a high-quality, mobile labour force 4. Education and science, technology and knowledge 5. Generation, transmission and use of knowledge; absorptive capacities 6. Openness and attractiveness of the innovation system: Entrepreneurial activities Networking and collaboration including public-private collaboration Focus on user needs and market opportunities
Public goods and services	1. Regulation and administrative conditions such as patent and copyright laws; IP management 2. Competition policy; pro-competition regulation 3. Tax, trade and regulatory policies 4. Social and health care services
Economic conditions	1. Competitive markets for products, services and labour 2. Well-functioning financial markets; access to finance 3. Acceptable employment conditions; working conditions 4. A stable macroeconomic environment 5. Ensuring risk-taking
Social conditions	1. Mind-set of a nation 2. Flexibility and readiness for change
Infrastructure	1. Transport and telecommunication systems; ICT infrastructure; broadband access 2. Markets and institutions; institutional infrastructure 3. Rules, regulations, collective actors

Table 2. Indicators of framework conditions.

Indicators of framework conditions / Enablers for research and innovation	
Human resources	New doctorates (ISCED 6) per 1,000 population aged 25–34
	Percentage of population aged 30–34 having completed higher education
	Percentage of young people aged 20–24 having attained at least upper secondary level education
Open, excellent and attractive research systems	International scientific co-publications per million population
	Scientific publications among the top 10% most cited publications worldwide as % of total scientific publications in the country
	Non-EU doctorate students as a % of all doctorate students
Finance and support	R&D expenditure in the public sector as % of GDP
	Venture capital investment as % of GDP

Source: IUS (2013).

5.3 Innovation activities

Various frameworks have been developed to provide classifications for science and technology activities, linkages and the related outcomes. There is, however, no explicit framework to cover all innovation actors and activities included in broad-based innovation such as public institutions, governments, health care service providers, schools and libraries. Because the scope of innovation activities has broadened beyond the traditional R&D perspective, there are also several non-R&D activities, such as organisational or marketing activities, involved in the innovation process.

The Oslo Manual (2nd edition) provides a list of conventional innovation activities. They include research and development (R&D), training, knowledge acquisi-

tion, machinery, equipment and software acquisition for innovation[2] and patenting. R&D activities are understood to cover all activities from basic research, applied research, and development to piloting and demonstration of project results. In the third revision of the Oslo Manual (OECD 2005), innovation activities also include activities for developing and implementing new business practices, new knowledge management systems, new methods for workplace organisation and new methods of organising external relations, and developing and implementing significant changes to product design, new media or techniques for product promotion, new methods for product placement and new methods of pricing products (Gault 2010a, p. 56–57). The term 'new' is understood here to mean first-time use in an organisation.

Consequently, innovation activities are defined as including less novel innovations such as new-to-firm innovations, technology adoptions, minor modifications or incremental changes to products and processes, imitation including reverse engineering, combining existing knowledge in new ways or adopting solutions developed by users (Arundel, Bordoy & Kanerva 2008). Our critical assessment is that this broad definition can be justified from the perspective of the diffusion of technologies and practices, but it restricts the analytical usability of the information on innovativeness. Surveys on the use of advanced technologies and practices as well as surveys including open-ended questions on the firm's most important innovation such as those ones carried out by Statistics Canada (Gault 2010a, p. 61, http://www.statcan.gc.ca) could provide better or complementary views.

In addition to R&D, the activities used by the National Endowment for Science, Technology and the Arts (NESTA) in its Innovation Index are design, organisational improvement, training and skills development, software development, market research and advertising and other intangibles including copyright development and mineral exploration (NESTA 2009). Arundel et al. (2008) note that R&D is not the only method of innovating and that non-R&D activities compared to science-based research activities account for a remarkable percentage of innovation activities. Non-R&D methods include "technology adoption, incremental changes, imitation and combining existing knowledge in new way". Non-R&D innovators innovate primarily through customising or modifying products or processes obtained from other firms.[3] The higher prevalence of process innovation among non-R&D performers suggests that there are more options for developing process innovations without performing R&D. The European Public Services Innovation Scoreboard (EPSIS) (EU 2012b) reports that organisational innovations in

[2] Knowledge acquisition, machinery, equipment and software acquisition are already partly included in R&D. Except for research, R&D activities include experimental development which is defined by the Frascati Manual as systemic work that is directed to producing new materials, products and devices, to installing new processes, systems and services, or to improving substantially those already produced or installed (OECD 2002).

[3] "The definition of experimental development creates substantial problems, with many activities based on the use of existing knowledge, such as engineering and design, sometimes included as R&D and sometimes excluded. Many innovative activities based on new uses of existing knowledge are not R&D." (Arundel et al. 2008.)

the public sector are more likely than product innovations, as the former impact their core service functions. Gault (2010a) has made a list of activities contributing to innovation such as those identified by Lundvall (2007) in his DUI mode: learning by doing, using and interacting. In addition, Gault mentions capital investment, intellectual property protection, design, lifelong learning, immigration, healthcare and social safety nets.[4] Organisational activities may also cover practices, routines and ways of implementation at the individual level (Rotmans 2011).

There are also innovation activities undertaken by users (user organisations and individuals as consumers and citizens). In the user innovation and diffusion paradigm, lead users may innovate to solve their own needs at private expense and then freely reveal their innovations, followed by collaborative improvement and peer-to-peer diffusion. User ventures and existing firms commercialise some user innovations (von Hippel 2013, 7). There is, however, relatively little information on consumers or public-sector organisations as innovators.

To summarise, according to a broad statistical definition given by the OECD (2005) and further broadened for instance by von Hippel (2005), Edqvist (2005) and Gault (2010a), innovation activities entail investments aimed at producing and implementing new knowledge. It follows from this definition that innovation activities include a number of investments that relate to important aspects of hidden innovation, such as organisational innovation, investment in skills, investment in product design and investment in branding. Innovation activities also include knowledge investments by the public sector such as state-funded education or training. While there is an ongoing discussion of whether some aspects of intangible investment should be excluded from innovation investments, our critical assessment is that a large part of the innovation activities listed above, especially for broader innovation, should be understood as activities for increasing intangible assets rather than immediate activities for innovation.

5.4 Collaborative innovation activities

Innovation is by its very nature a systemic phenomenon. It results from continuing interaction between actors and organisations. To be able to turn an invention into an innovation, a firm normally needs to combine several different types of knowledge, capabilities, skills and resources. The firm may require production knowledge, skills and facilities, market knowledge, a well-functioning distribution system and sufficient financial resources (Fagerberg 2005). Furthermore, innovation happens when ideas come together. There are connections between new

[4] Firms do not engage in R&D only to develop new products but also to learn and enhance their ability to use existing information (Cohen and Levinthal 1990). Every innovation process uses existing information much more than it generates new information. The ability to use existing information depends, however, on the users' pre-existing level of information; this can be raised by own innovation activity, which Cohen and Levinthal call absorptive capacity.

ideas and methods and the organisational structure needed to implement them (OECD 2011).

Knowledge interactions or 'networks' are usually tracked as part of the existing innovation measurement frameworks. For instance, the Community Innovation Survey allows us to define indicators that describe the collaboration for product and process innovation, but not for organisational and marketing innovation. We can also distinguish collaboration by the type and location of the partnering organisation. Based on this information, we are able to construct indicators on the percentage of innovative companies and innovative SMEs co-operating for innovation with other firms and public organisations. Based on other information, the percentage of public and private organisations having collaborated in innovation projects may be obtained to some extent.[5]

The most frequently used indicators for overseas interactions are the percentage of high tech export in GDP, the percentage of foreign direct investments (FDI) in GDP, the percentage of international scientific co-publications and co-patents and the percentage of innovative firms engaged in co-operation with a foreign partner. The mobility of highly skilled persons is one indicator that implies knowledge flows across disciplines, sectors and borders, cross-fertilising between knowledge bases. Researcher mobility (inwards and outwards) measures the level of internationalisation of innovation activities, but usually only for R&D-based innovations.

5.5 Innovation inputs

Innovation indicators are typically used to monitor private and public spending on science, technology and innovation (STI) and to answer the following questions:

- How much do the private and government sectors spend on STI?
- Where do they spend it (geography and industry)?
- Why do they spend it (socio-economic objectives)?

According to Gault (2010a), "a fourth question: What does the government get for spending this money? requires a systems approach to get close to a meaningful response. If coupled with the policy objectives of government, it becomes a topic for evaluation." According to Bartelsman (2010), at the economy level, the focal question is how much should be spent on innovative activities, what the ability of innovation to explain productivity differences is, and further, whether policy can be used to steer innovative activity closer to an optimum. These questions drive and inform policies designed by ministers of finance.

Traditionally, the level of R&D inputs has been described by the percentage of business R&D expenditure (BERD) in business turnover or GDP, and by the per-

[5] For example, the databases on the technology programmes launched by the funding agencies include this type of information.

centage of government R&D expenditure (GERD) in GDP. These percentages do not describe the total spending on research, development and innovation (RDI) in GDP because not only spending on R&D but also spending on non-R&D such as training, marketing, aesthetic design and acquisition of machinery, equipment and software (except those included in R&D) and acquisition of intellectual property should be included. If spending on organisational and marketing innovations and improvements are also added to this figure, we may note that at the level of the economy RDI intensity is much higher than R&D intensity. According to NESTA (2009), in the UK investments in broad-based innovation represented 14% of private sector output in 2007.

In the CIS, innovation expenditure on all innovation activities defined by the Oslo Manual (3rd edition) is not polled for. Expenditure on marketing and organisational innovations (implementing new organisational concepts) as well as on public-sector innovations and user innovations belong to this group constituting a part of a broader group of intangible investments. Some investments in design activities (e.g. business model design, system design) also belong to this group and are not covered by either the Frascati or Oslo Manual and hence not measured as innovation investments. On the other hand, not all designs and design activities are related to innovation. Design as an activity is included in the R&D definition of the Frascati Manual, partly as research, partly as development.[6] The Oslo Manual treats design as marketing innovation (product or packaging design) or as part of other forms of innovation (EU 2009).

As mentioned above, there are no estimates for innovation investments by consumers in the Community Innovation Surveys, and there are also no estimates for investments used for public-sector innovation or innovative public procurements. However, modules for user engagement from the producer perspective have been introduced, and there are recommendations that a first step towards measuring public-sector innovation would be to measure the resources allocated to innovation activities and then to use the resulting indicators to support discussion on priorities for resource allocation. This raises the question of why innovation activities are undertaken and how the outcome is evaluated (Gault 2010a).

Table 3. Business sector innovation investments.

1. R&D expenditure in the business sector as % of GDP
2. Non-R&D innovation expenditure as % of turnover

Source: IUS (2013)

[6] The Frascati Manual includes some industrial design activities in the definition of R&D. Specifically, the Manual states that prototyping and industrial design required during R&D should be included in R&D for statistical purposes. Design for production processes and the less technical design activities are, however, not considered as R&D.

5.6 Innovation outputs

Studies of innovation have widely focused on two Schumpeterian definitions of innovation: the introduction of a new product and the introduction of a new production process. A similar approach to capturing innovation was suggested in the 2nd edition of the Oslo Manual with an emphasis on the technological component of such innovations:

> *"A technological product innovation is the implementation / commercialisation of a product with improved performance characteristics such as to deliver objectively new or improved services to the consumer. A technological process innovation is the implementation / adoption of new or significantly improved production or delivery method" (OECD 1996, 8, OECD 2009).*

With the introduction of the 3rd edition of the Oslo Manual in 2005, the above definition – now referred to as the narrow definition of innovation – was extended to encompass organisational and marketing methods and to include non-technological characteristics of product and process innovations. In this edition, used from the CIS3 onwards, the word 'technological' has been dropped from the questionnaire items measuring product and process innovation. Therefore, while the latest edition of the Oslo Manual does not distinguish between technological and non-technological innovation, it recognises the importance of organisational and marketing methods along with innovations in products and processes:

> *"An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations" (OECD 2005, 46, OECD 2009).*

As stated by the OECD (2009), these changes are reflected in theoretical and empirical studies on broader measures and/or modes of innovation. For example, a number of papers have discussed the determinants and effects of marketing and organisational innovations (e.g. Acha and Salter 2004) and innovation in services (e.g. Djellal and Gallouj 2001; Tether and Miles 2001).

A general distinction is made between technological and non-technological types of innovation. Generally, product and process innovations in manufacturing firms are considered technological, while organisational and marketing innovations and/or innovations in services are considered non-technology-based (e.g. Battisti and Stoneman 2007). Innovations in the hotel and catering industries, for example, are mostly considered to be non-technological (Djellal and Gallouj 2001). However, as highlighted by the OECD (2009), product and process innovations are also likely to have non-technological components, and technological knowledge often enters organisational and marketing innovation. Confining non-technological innovation to organisational and marketing innovation may just be a convenient simplification.

Analytical results suggest that both technological and non-technological innovation activities are relevant to corporate performance. Firms that engage in both product and process innovations and at the same time introduce organisational

changes outperform firms that do only one or the other (Geroski, Machin and van Reenen 1993). Battisti and Stoneman (2007) identify broad innovative activities (including marketing, organisational, management and strategic innovations) and traditional activities (including product, process and technological innovations). They link the two modes to corporate performance and find that broad innovative activities and traditional activities are complementary rather than mutually exclusive and that enterprises that engage in both perform better (OECD 2009). On the other hand, Jensen, Johnson, Lorenz and Lundvall (2007) cluster firms according to modes of knowledge: the science, technology and innovation (STI) mode (which may be seen as closer to technological types of activities) and the doing, using and interacting (DUI) mode (which may be closer to non-technological types of innovation). They find evidence that firms that engage in both types of knowledge generation and acquisition outperform in terms of product innovation.

There is a multitude of indicators drawn from the Community Innovation Surveys trying to describe the direct (immediate) products of various innovation activities. These include binary variables describing whether or not a firm has succeeded in introducing a "new or significantly improved product or service (good or service)" on the market, and whether or not it has implemented a "new or significantly improved production process". This information is classified by novelty: whether an innovation is new-to-firm only or new-to-market.[7] Based on this information, indicators describing the percentages of firms having introduced new-to-firm or new-to-market product or process innovations in different categories (branch, sector, size class) can be constructed.

Recently, binary variables for marketing as well as organisational innovations have also been used in the Community Innovation Surveys as well as in some other surveys.

> *Marketing innovations have been defined to include significant changes (first time use of new things) in aesthetic design and packaging, in sales and distribution methods, in product promotion and pricing. Organizational innovations have been defined to include the first use of new business practices like a new knowledge management system, a new way in organizing work responsibilities and management structures, and a new method for organizing external relations with other firms or public institutions, incl. partnerships, outsourcing and subcontracting etc.*

For innovation outputs, innovation surveys include information on product and process innovations, which may be based on technological and non-technological activities. Under the title "wider innovation outputs", the surveys include changes to management techniques and organisational structures, marketing strategies and the appearance of products. These activities are likely to incorporate a high percentage of non-technological activities.

The quantity, value and percentage of new products, patents and, increasingly commonly, the development of innovative business (added value, export) are typically used as indicators of the direct products (immediate outputs) of innovation activities.

[7] Not in all versions of CIS. The Finnish version of the CIS, for instance, does not include a question on the novelty of process innovations.

Table 4. Simple innovation indicators.

Technological innovation	1.	Percentage of firms that introduced a product innovation
	2.	Percentage of firms that introduced a process innovation
	3.	Percentage of firms that introduced either a product or a process innovation ("innovative firms")
	4.	Percentage of firms that developed in-house technological innovations (product or process)
	5.	Percentage of firms that introduced a new-to-market product innovation
Non-technological innovation	1.	Percentage of firms that introduced a marketing innovation
	2.	Percentage of firms that introduced an organisational innovation
	3.	Percentage of firms that introduced a non-technological innovation (marketing or organisational)
Outputs	1.	Percentage of turnover from product innovations in total turnover
	2.	Percentage of turnover from new-to-market product innovations in total turnover
	3.	Percentage of companies introducing new-to-the-world innovations
	4.	Sales of new-to-market innovative products and services in GDP
	5.	Sales of new-to-the-world innovations in GDP

Source: OECD (2009).

Table 5. Key policy-relevant characteristics.

Firms that were active on international markets (outside the home country)
Firms that collaborated with foreign partners on innovation
Firms that collaborated on innovation activities
Firms that collaborated with universities/higher education or government research institutes
Firms that received public financial support for innovation
Firms that applied for one or more patents (to protect innovations)

In the new version of the Innovation Union Scoreboard for research and innovation, the following structural indicators for innovation outputs have been proposed:

Table 6. Outputs.

Innovators	SMEs introducing product or process innovations as % of SMEs
	SMEs introducing marketing or organizational innovations as % of SMEs
	High-growth innovative firms as % of SMEs (N/A)

Source: IUS (2013).

Other examples of output indicators include SMEs innovating in-house and non-research based innovative companies. Output indicators can also describe returns on innovation such as the sales of new-to-market as well as new-to-firm products and services in total turnover, or earning most revenue from the sales of innovative products and services. These types of indicators will be considered in the next section. They could be understood as impact indicators rather than (immediate) innovation output indicators.

The output indicators described above can further be classified according to how they meet environmental and societal challenges. Broadly speaking, environmentally positive innovations may include technologies, services, products, processes and standards of activities, or environmentally friendly public procurements. At the moment, there is no systematic information covering all these activities.

5.7 Impact indicators

Innovation is not an objective in itself. Even companies innovate not just for profit but also to meet societal and ecological needs (Leitner 2012). It follows from this that innovation has to be placed in the broader context of its contribution to aggregate societal and economic performance. But what are the social impacts of innovation? As stated by the OECD in its measurement agenda for innovation, this raises difficult questions and calls for a rethinking of what constitutes an appropriate framework for measuring innovation (OECD 2010a, 12).

The framework developed by Statistics Canada in 1998 is an example of a wide measurement framework planned for an operational instrument for statistical information on the evolution of science, technology and innovation (STI) and its interactions with society at large, the economy and the political system. The structure of this framework is given by the systems approach of actors, activities, linkages, outcomes and impacts, but added to these are the knowledge flows in the system, the creation, transmission and use of knowledge, including the capacity to engage in the activities of creation, transmission and use (Gault 2010a, 25).

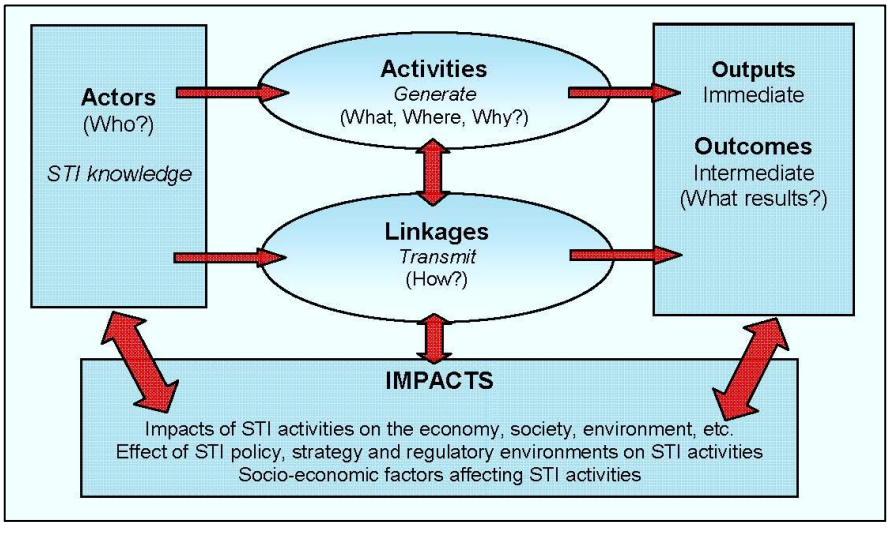

Figure 1. Measurement framework for STI. Source: OECD (2007).

As noted by Gault (2010a), this framework is rooted in the earlier systems work of Forrester (1971) and Simon (1996), and the knowledge component was adopted from the work of David (1993) and David and Foray (1995). “It provides a classification for science and technology activities, linkages and the related outcomes,

and makes explicit the description of the generation, the transmission and the use of scientific and technical knowledge." (Gault 2010a, 25.) It is complex, dynamic and non-linear in its response to policy intervention and based on a functional view of the territorial or global innovation systems, where recursive processes and effects are central attributes of a multitude of innovation processes.

The framework system developed by Statistics Canada is based on a wide understanding of innovation including tangible and intangible innovations and a wide group of actors and enabling factors (framework conditions) and their various roles and interactions in the innovation processes. Most of the activities in the system occur in the form of organisational, design and marketing innovation rather than R&D. And finally, the system acknowledges that innovation does not only take place in companies, but also in public research institutions, public authorities and agencies, or in the political system in general.

There is also the question of how well the system works. This raises politological questions about institutions, standards and interactions; sociological questions about communities of practice, learning capacity of groups, institutions and regions; and economic questions about growth, employment and priorities for resource allocation (Gault 2010a, 157). A complicated issue in the evaluation of the system functioning is the fact that innovation is not only overwhelmingly 'good'. An innovation may also have unanticipated consequences (Sveiby, Gripenberg and Segercrantz 2012). It follows that more investment in innovation may sometimes be the wrong way to go.

In the following, we briefly review some of the impact indicators of technology and innovation and divide them into social, economic and ecological impacts. Social impacts typically concern human wellbeing, cultural change or global influence, and economic impacts concern economic development, jobs, growth and wealth. Changes in the state of the environment are ecological impacts.

Science, technology, knowledge, education and culture

Earlier, indicators about firm renewal such as the entry and exit of SMEs, public-private co-publications and EPO patents per million populations were included in the Research and Innovation Union Scoreboard or in the previous European Innovation Scoreboard, but not in its most recent version. Similarly, the title *Throughputs* was replaced with the title *Intellectual assets*. This reflects changes in thinking: nowadays traditional innovation indicators such as patents and registered trademarks and designs as a percentage of the population of a country or group of countries are understood to describe intangible assets rather than outputs of innovation activities. On the other hand, traditional indicators based on patents and scientific publications are nowadays used to develop new indicators of science or innovation 'hot spots' in certain technologies or locations (OECD 2010a).

Despite this, the most frequently used indicators for describing a research system and its impacts are the percentage of the top 10% most cited scientific publications worldwide, and the percentage of public-private scientific co-publications. The openness and attractiveness of a research system may also be described by the percentage of international scientific co-publications and non-EU doctorate students.

Table 7. Science, technology, knowledge, education and culture.

Percentage of patent applications to the European Patent Office
Percentage of patents granted by the United States Patent and Trademark Office
Percentage of the top 10% most cited scientific publications worldwide
Percentage of public-private scientific co-publications
Percentage of international scientific co-publications and non-EU doctorate students

Other indicators of the level and state of science, innovation and research can be found in the list of the Structural Indicators describing the general economic background, employment, economic reform, research and innovation, social cohesion and environment for the Lisbon Agenda, such as: science and technology graduates by gender; persons of the age 20 to 24 having completed at least upper secondary education by gender; venture capital investments; e-government usage; and broadband penetration rate (European Commission, Search Database).

Economy, prosperity, growth and entrepreneurship

The present version of Innovation Union Scoreboard includes five indicators on the economic effects of innovation activities and captures the economic success of innovation in employment, exports and sales (IUS 2013). The traditional indicators are national prosperity described by GDP per capita, the overall productivity of the economy, productivity in the private and the public sectors, improvements in productivity, improvements in technological competitive advantage and the high growth (innovative) enterprises. Job creation and foreign direct investments have also seen as being indicative of innovation activities (Luoma et al. 2011).

The indicators proposed for the Economic Effects include employment in knowledge-intensive activities, exports of high-tech and medium-tech manufacturing, high tech trade, exports of knowledge-intensive service sectors, sales of new-to-market and new-to-firm innovations, percentage of new innovative products and services in business turnover, licence and patent revenues from abroad and increases in the number of patents filed and patents granted.

Table 8. Economic impacts.

1. Employment in knowledge-intensive activities (manufacturing and services) as % of total employment
2. Contribution of medium and high-tech product exports to the trade balance
3. Knowledge-intensive service exports as % total service exports
4. Sales of new-to-market and new-to-firm innovations as % of turnover
5. License and patent revenues from abroad as % of GDP

Source: IUS (2013).

The economic effects indicator *License and patent revenues from abroad* (% of GERD) has been indicated to ignore innovations in services. The percentage of high-tech trade is also often used as a key indicator for the innovation capacity of a country. However, this indicator focuses on technological innovations closely related to research indicators and does not account for non-R&D-based innovations. Therefore, the percentage of knowledge-intensive sectors, i.e. the percentage of sectors that employ a high percentage of employees with tertiary education might be a better indicator (EU 2010). Furthermore, an indicator on the percentage of high-growth enterprises (with more than 10 employees) out of all enterprises (or out of SMEs) in innovative, knowledge-based sectors included in the Innovation Union Scoreboard as an innovation output enables the measurement of economic impact of innovation closely related to structural change. This indicator is often seen as a good indicator of the dynamism and renewal of the economy.

Recently, the European Council has initiated developing of a single integrated innovation indicator (a composite indicator), the New Innovation Indicator, that would allow a better monitoring of progress in output-oriented innovation than R&D intensity. For this Europe 2020 innovation indicator, the following components have been proposed: number of patent applications (triadic patents) per billion GDP, number of persons employed in knowledge-intensive activities in business industries over total employment, a sub-indicator integrating the contribution of high-tech and medium-tech products to the trade balance and of the percentage of knowledge-intensive services exports in the total services exports, and the percentage of employment in fast-growing firms in innovative sectors out of the employment of all fast-growing firms. Sector-specific innovation coefficients, reflecting the level of innovativeness in each sector, serve here as a proxy for distinguishing innovative enterprises.

Environment and society

For monitoring the STI base of society, the following information is customarily used: scientific breakthroughs, new technologies, state of public research and percentage of licences and brands (e.g. registered trademarks). The educational level of the population is measured by using OECD education and immigration databases, data on human resources of science and technology (HRST), the OECD Main Science and Technology Indicators, and Science, Technology and Industry Scoreboard indicators, and the IMD World Competitiveness Yearbook. Indicators on Eco-innovation have also been proposed.

5.8 Gaps in existing indicators

In evaluating existing innovation-related indicators Veugelers (2009) raised a question: "Are we measuring the right indicators?" Veugelers then went on to make a list of missing or underdeveloped areas. These include structural change such as the entry and exit and growth of new innovative firms, incentives for innovation and framework conditions, (international) diffusion/absorption of new technologies and systems/linking Indicators. Furthermore, according to Veugelers, evaluation, data-collection and policy design phases should be built in the Statistical System.

According to the OECD, at least the following dimensions should be addressed in the measurement (OECD 2010b, 206–210):[8]

1. We should understand better why and how innovation happens, what are its impacts, and how it can be encouraged. The listing of the types of innovation and their frequency does not help to improve policy. The characteristics of various technologies and their varying impacts need to be taken better into account.

2. Innovation needs to be contextualized (to put into wider economic and social context by its outputs). Social goals of innovation and social impacts are currently inadequately covered by statistics. Innovations should also address major societal challenges like aging population or climate change as well as wellbeing in workplaces. In general, more information is needed on the outputs of innovation processes.

3. Current measures do not pay enough attention to the role of individuals, consumers and government in the innovation process. Public sector innovation would need a specific framework for measurement. In addition, new units of analysis with different geographical scope are likely required to better take into account the impact of location in the innovation process.

[8] Here, the ranking of these dimensions was made by the authors of this report.

4. Complementary intangible assets (e.g. software, human capital, organizational structures) should be taken better into account. There is a need to improve the use of administrative records for statistical purposes.

Furthermore, the OECD (2010b) states that science, technology and innovation (STI) surveys need to be redesigned to take a broader view of innovation. Therefore, the business, statistical and research communities are encouraged to work to:

1. Revisit the measurement framework for innovation to identify and prioritise areas for survey design and re-design.
2. Align survey and administrative data with economic aggregates to enable productivity analysis.
3. Measure and value intangible assets.

In the following, we discuss the measurement needs proposed by the OECD in more detail.

1. We should understand better why and how innovation happens, what are its impacts, and how it can be encouraged.

First, we should gain a better understanding of the type and nature of innovation. The pragmatic convention given by the Oslo Manual (OECD 2005) does not make any distinction between the invention and innovation process on the one hand and the adoption and diffusion process on the other, lumping them together as the 'innovation process'. This is done for practical reasons for getting more observations, but it does not help in providing a better understanding of whether an observation is a new innovation or an adoption or modification of an invention or innovation originally developed by someone else. Partly this problem can be circumvented by asking about the novelty and developer of the product and process innovation. However, in the Finnish questionnaire, for instance, nothing is asked about the novelty of the process innovation, or about the degree of novelty and developer of an organisational and marketing innovation. Furthermore, the pragmatic convention to call a new-to-firm (first time use) artefact or practice an innovation is not the best option for gaining an understanding of the societal significance of innovation.

This challenge could possibly be avoided by asking directly about innovation.[9] There are, however, psychological reasons to believe that respondents will tend to over-report innovativeness if no novelty estimations are requested. We could instead try to identify innovation by getting information 1) on current new artefacts and practices, 2) on their more or less recent introduction so that change can be identified, 3) on the perceived positive or negative impact of these changes by

[9] For example, it has been proposed that a survey on innovation in education should focus on asking about the implementation of specific practices at the school and classroom levels instead of asking directly about innovation (OECD 2010d).

evaluators as measured by specific objectives, and 4) whether there are any objective measures of the impact of these changes (OECD 2010d).

Contrary to the Community Innovation Survey approach, this measurement approach would allow identifying specific innovations, not just the broad category. It would also generate valuable information on tools and practices used, as well as possibly some information on the reasons why they are not utilised more. This approach would correspond to an object-based rather than a subject-based measurement approach (ibid.).

Finally, if a better understanding of the degree of novelty of specific innovations were attained, these innovations could be categorised into broader groups, into families of innovations. Information on the various technologies and practices involved is needed – the usual sector classification does not always indicate this.

2. *Innovation needs to be contextualised (to put into wider economic and social context by its outputs). More information is needed on the outputs of innovation processes.*

Contextual factors should be addressed in order to detect drivers and barriers for innovation in the sectors or innovation ecosystems in question. In particular, more attention should be paid to system innovations fostering transition towards sustainable patterns of production and consumption.

3. *Current statistics do not pay enough attention to the role of individuals, consumers and government in the innovation process.*

Conventionally, user innovation is not captured in official statistics. However, there has been a separate module on user-driven innovation in CIS 2010 (Finland). At the moment, it is not clear whether user innovation or public procurement and their significance can be measured in official statistics.

4. *Complementary intangible assets (e.g. software, human capital, organisational structures, and (service) trademarks) should be taken better into account. There is a need to improve the use of administrative records for statistical purposes.*

Innovation is the product of a range of complementary intangible assets – not only R&D but also software, human capital and new organisational structures. The role of markets as mediators between innovation supply and innovation demand is losing relevance, while communities (e.g. web-based co-design) within and external to companies are gaining importance. Companies have to initiate self-organisational processes that are more difficult to control (Leitner 2012).

As is well known, information is available on R&D expenditure in the private sector, universities and research centres, but not on innovation expenditure. Accordingly, we should have information on investments needed to implement or commercialise ideas, including product design, training, organisational methods, strategic design, developing new customer offerings, brands and copyright. There is a particular

need for information on service design and organisational innovation in services. New measures are also needed on skills and on the ways the workplace promotes and makes use of skills (OECD 2010b). Creativity may become a key aspect in all professional activities. However, the list above is probably not sufficient for the public sector, where a separate 'innovation index' could be constructed.

5.9 Conclusions

Built on the definitions of the Oslo Manual (OECD 2002, 2005), the statistical measurement of innovation focuses on innovation activities (subject approach) rather than on individual innovations (object approach). The list of conventional innovation activities given in the Oslo Manual (2nd edition) complies with the measurement tradition already embedded in the measurement of scientific R&D. It covers not only R&D aiming at developing new products, processes, systems and services but also R&D for developing those already produced or installed (OECD 2002). By following this tradition, innovation activities are broadened to encompass innovation adoption, incremental changes, imitation and combining existing knowledge in a new way.

The questions on innovation expenditure in the CIS questionnaire are, however, still restricted to innovation activities for product and (technological and delivery) process innovations. They do not sufficiently cover organisational and marketing innovations (broader process innovations). Reasonably, one survey can hardly cover all innovation expenditure, as it could ruin the existing vague understanding among respondents concerning innovations and innovation activities. This is a reason for not recommending that expenditure for broader innovation should be addressed in the same questionnaire as expenditure for product and process innovations.

Instead, activities for major innovations such as new-to-market concepts, products and services should be given a more extensive role in innovation surveys. The surveys should also try to differentiate between innovations and incremental adoptions. This especially concerns organisational and marketing innovations. Innovation surveys cannot be very useful unless there is a plausible differentiation between 'real' innovations on the one hand and adoptions and incremental improvements on the other. However, innovation surveys should also recognise innovation activities in service processes, where innovation is often incremental (new to the organisation) and results from intra- and extra-sector imitation (Hipp and Grupp 2005).

Finally, expenditure on research and innovation activities should be measured in a broad way, including all innovation actors and their innovation expenditure. This is because the focus has shifted gradually from science and technology (S&T) policies to more comprehensive innovation policies, which today form a key policy instrument for combining academic research, technical development and market-driven solution provision (Launonen and Viitanen 2011).

References

Acha, V., Salter, A. (2004), “Oslo Manual Revision 3 Workshop for a Chapter on the ‘Economics of Innovation’”, workshop report for the Department of Trade and Industry, November.

Arundel, A., Bordoy C., Kanerva, M. (2008), Neglected innovators: How do innovative firms that do not perform R&D innovate? Results of an analysis of the Innobarometer 2007 survey No. 215, INNO-Metrics Thematic Paper, MERIT

Arundel, A., Huber, D. (2013), From too little to too much innovation? Issues in measuring innovation in the public sector, University of Urbino 2013.

Arundel, A. Hollanders, H. (2005), EXIS: An Exploratory Approach to Innovation Scoreboards, MERIT, March 2005. http://arno.unimaas.nl/show.cgi?fid=15501 (Accessed 14.6.2013)

Battisti, G., Stoneman, P. (2007), "How Innovate are UK Firms? Evidence from the CIS4 on the Synergistic Effects of Innovations", Report for the Department of Trade and Industry.

Bartelsman, E. J. (2010), “Searching for the sources of productivity from macro to micro and back”, *Industrial and Corporate Change*, Volume 19, Number 6, pp. 1891–1917.

Cassiman, B. & Veugelers, R. (2006). In search of complementarity in innovation strategy: Internal R&D and external knowledge acquisition. *Management Science*, *52*(1), 68. Retrieved from http://webprofesores.iese.edu/bcassiman/complementarity10-04.pdf

Cohen, W. M., Levinthal, D. A. (1990) ‘Absorptive Capacity: A New Perspective on Learning and Innovation’, Administrative Science Quarterly, Vol. 35, No. 1, 128–52.

David, P.A. (1993), ‘Knowledge, Property and the System Dynamics of Technological Change’, in World Bank (ed.), Proceedings of the World Bank Annual Conference on Development Economics 1992, Washington, DC: World Bank, pp. 215–48.

David, P. A. and Foray, D. (1995), ‘Accessing and Expanding the Science and Technology Knowledge Base’, STI Review, 16, 13–68.

De Jong, P.J., Vanhaverbeke, W., Kalvet, T. and Chesbrough, H. (2008) ‘Policies for Open Innovation: Theory, Framework and Cases’, Research project funded by VISION Era-Net, Helsinki: Finland.

Djellal, F., Gallouj F. (2001), "Innovation Surveys for Service Industries: A Review" In Thurieaux B., Arnold, E., Couchot, C. (eds), Innovation and Enterprise Creation: Statistics and Indicators, European Commission, Luxemburg.

Dushnitsky, G. & Lenox, M. J. (2005). When do firms undertake R&D by investing in new ventures? *Strategic Management Journal*, *26*(10), 947–965. Retrieved from http://faculty.london.edu/gdushnitsky/assets/documents/Dushnitsky_Lenox_(2005_SMJ).pdf

Edquist, C. (2005), "Systems of innovation: Perspectives and challenges". The Oxford Handbook of Innovation. Chapter 7, pp. 181-208.

European Commission, Search Database, http://ec.europa.eu/economy_finance/db_indicators/index_en.htm.

EU (2009), Design as a driver of user-centred innovation, Commission staff working document, SEC(2009)501 final, 7.4.2009, Brussels.

EU (2010), Workshop of 21 June 2010 for national experts on Research and Innovation monitoring, RTD C.3 /PV D(2010), 381697.

EU (2012a), Innovation Futures: A Foresight Exercise on Emerging Patterns of Innovation Visions, Scenarios and Implications for Policy and Practice, Final report, http://www.innovation-futures.org (Accessed 23.5.2013).

EU (2012b), European Public Sector Innovation Scoreboard (EPSIS), Methodology Report, REVISED 8 May 2012. (MERIT, Technopolis), http//www.ec.europa.eu/enterprise/policies/innovation/files/epsis

Fagerberg, J. (2003), Innovation: A Guide to the Literature, Paper presented at the Workshop "The Many Guises of Innovation: What we have learnt and where we are heading", Ottawa, October 2003, organized by Statistics Canada.

Fagerberg,J. (2005), Innovation, A guide to the literature, in Fagerberg, Mowery, Nelson (eds.) The Oxford Handbook of Innovation, Oxford University Press.

FORA (2009), New Nature of Innovation, Copenhagen, September, www.newnatureofinnovation.org.

Forrester, J.W. (1971), World Dynamics, Cambridge, MA: Wright-Allen Press.

Gault, F. (2010a), Innovation Strategies for a Global Economy: Development, Implementation, Measurement and Management, Edward Elgar, Cheltenham, UK, Northampton, MA, USA.

Gault, F. (2010b), User Innovation in a Policy Context, Presentation given in Seminar on Measuring User Innovation, Tekes, September 26th 2010, Helsinki.

Geroski, P. A., Machin S., van Reenen, J. (1993), "The Profitability of Innovating Firms", *Rand Journal of Economics*, 24.

Grandstrand, O., Patel, P., Pavitt, K. (1997), Multi-technology corporations: why they have distinctive core competences, California Management Review, Vol. 39, 8-25.

Hipp, C., Grupp, H. (2005), Innovation in the service sector: The demand for service-specific innovation measurement concepts and typologies, *Research Policy* 34, pp. 517-535.

IUS (2013), http://bookshop.europa.eu/en/innovation-union-scoreboard-2013.

Jensen M. B. , Johnson, B., Lorenz, E., Lundvall, B. Å. (2007), "Forms of Knowledge and Modes of Innovation", *Research Policy*, Vol. 36, No. 5.

Launonen, M., Viitanen, J. (2011) Hubconcepts, The global best practice for managing innovation ecosystems and hubs, Hubconcents Inc., Helsinki.

Leitner, K-H. (2012), Innovation Futures: How will we innovate in the future? Presentation given in the Hanken Focus Forum: The Future of Innovation, 16 April 2012, Helsinki.

Luoma, P., Raivio, T., Tommila. P., Lunabba, J., Halme, K., Viljamaa, K., Lahtinen, H. (2011), ”Better results, more value, A framework for analysing the societal impact of Research and Innovation”, Tekes Review 288/2011, Tekes.

Lundvall, B.-Å (2007), *Innovation System Research, Where it Came From and Where it Might Go*, Globelics Working Paper Series, No. 2007–01, Aalborg, Denmark: Globelics.

Milbergs, E. (2007), Innovation Vital Signs, Framework Report, An Update, Center for Accelerating Innovation, In collaboration with Kalweit, B., Boege, R. ASTRA – The Alliance for Science Technology Research in American. http://innovate.typepad.com/innovation/files/innovation_vital_signs_framework_report_v.2.8.pdf)

NESTA (2009), The Innovation Index, Measuring the UK’s investment in innovation and its effects, NESTA, November 2009.

OECD (1996), Oslo Manual (2nd edition), The Measurement of Scientific and Technological activities. Proposed guidelines for collecting and interpreting technological innovation data, OECD & Eurostat, Paris.

OECD (2002), Frascati Manual, Proposed standard practice for surveys on research and experimental development, Paris.

OECD (2005), Oslo Manual (3rd edition) : Guidelines for Collecting and Interpreting Innovation Data, OECD & Eurostat, Paris.

OECD (2007), Science, Technology and Innovation Indicators in a Changing World: Responding to Policy Needs, OECD.

OECD (2009), Innovation in Firms: A Microeconomic Perspective, Paris: OECD.

OECD (2010a), Measuring Innovation: A new Perspective, OECD, Paris.

OECD (2010b), The OECD Innovation Strategy: Getting A Head Start on Tomorrow. Innovation. OECD Publishing. doi:10.1787/9789264083479-en

OECD (2010c), Innovation to strengthen growth and address global and social challenges, Key Findings, Ministerial report on the OECD Innovation Strategy, OECD, Paris.

OECD (2010d), Measuring Innovation in Education: Discussion Paper, 2nd OECD/CERI Workshop, 11 June 2010, http://www.oecd.org/edu/ceri/46181130.pdf

OECD (2011), New Building Blocks for Jobs and Economic Growth, Intangible Assets as Sources of Increased Productivity and Enterprise Value, Report of a Conference May 16–17, 2011, OECD.

Rotmans, J. (2011), Sustainability Transitions & Transition Management, Presentation given in Tekes, Helsinki, 15.02.2011.

Schubert, T., Neuhäusler, P., Frietsch, R., Rammer, C., Hollanders, H. (2011), Innovation Indicator, Methodology Report. http://www.innovationsindikator.de/fileadmin/user_upload/Dokumente/Innovationsindikator_methodology_report.pdf (Accessed 28.5.2013)

Sequeira, K. (2012), Non-technological innovation and EU innovation policies, DG Enterprise and Industry, European Commission. Presentation given in

Simon, H. (1996), The Sciences of the Artificial, 3rd edition, Cambridge, MA: MIT Press.

Sveiby, K-E., Gripenberg, P., Segercrantz, B. (2012) (eds.), Challenging the Innovation Paradigm, Routledge Studies in Technology, Work and Organizations, Routledge.

Spence, A. M. (1981). The learning curve and competition. *The Bell Journal of Economics*, 49–70. Retrieved from http://www.jstor.org/stable/3003508

Tether, B., Miles, I. (2001), "Surveying Innovation in Services-Measurement and Policy Interpretation Issues:' in Thurieaux, Arnold, and Couchot (2001).

Veugelers, R. (2009), Indicators for a knowledge- based growth policy in the EU: tacking stock and moving forward, Presentation given ASIGO (Advancing the Study of Innovation and Globalization in Organizations) Conference, Nurnberg, May 29, 2009.

Veugelers, R. & others. (2009). Evaluation of the Finnish National Innovation System. Retrieved September 30, 2011, from http://www.tem.fi/files/24928/InnoEvalFi_POLICY_Report_28_Oct_2009.pdf

Witt, U., 1993.Evolutionary economics: some principles. In: Witt, U. (Ed.), Evolution in Markets and Institutions. Physica, Heidelberg, pp. 1–16.

Von Hippel, E. (2005), *Democratizing Innovation*, The MIT Press, Cambridge, Massachusetts.

Von Hippel, E. (2013), Update on understanding the new user innovation paradigm, Presentation given at the Statistical Indicator for User Innovation and Innovation Transfers in Finland (InFi) Workshop, March 11th 2013, Tekes.

6. An attempt to measure innovation differently – results of a pilot survey

Janne Huovari, Olavi Lehtoranta & Mika Nieminen

6.1 Introduction

Measuring innovation is challenging. Firstly, there is a definition problem: innovations are never well-defined (Kline & Rosenberg 1986). Even if the Oslo Manuals (OECD & Eurostat 2005) have done a great deal for defining innovation for measurement, in practice it is never clear-cut what an innovation is and what is not.

As the scope of the innovation and innovation policy has broadened, the definition problem has become increasingly complex. Difficult as it is to tell whether a product or process is innovative, it is even more complicated to judge an organisational change (method) as an innovative one. For broader concepts of innovations, there is much less research on measurement than for 'traditional' innovations (Armbruster, Bikfalvi, Kinkel & Lay 2008).

A measurement problem stems directly from the definition problem. Innovation measurement is always based on someone's subjective call on innovativeness. In a large survey, this would not be a problem if subjective calls were unbiased. But there is a substantial risk that this is not the case. For instance, respondents may interpret the concept of innovation differently from what was intended in the questionnaire. There is evidence of this for instance from Australia (Arundel, O'Brien & Torugsa 2010). Interpretations can also vary from one respondent to another due to cultural differences. There is significant national variation in the Community Innovation Surveys, for which it is difficult find an explanation other than different perceptions of innovation.

In this pilot survey, we tested whether it would be possible to transfer at least part of this subjectivity from respondents to researchers by not asking about innovations but about changes and their novelty value. The idea was to omit the abstract term 'innovation' from the questions. The innovativeness of a change was interpreted according its novelty value. We also used open-ended questions to reflect novelty value. Open-ended questions were also used to alleviate another measurement problem related to the questionnaires: closed surveys restrict and lead respondents to agreed definitions and might hide useful information of real innovation processes. This became evident in the survey: the most frequent

source of inspiration for a change mentioned in the open-ended answers was missing in the questionnaire because it was not explicitly listed as an alternative.

The survey

The survey was targeted at the same group of companies which participates in the Finnish CIS survey. The survey included all enterprises with at least 250 employees and a sample of enterprises with fewer than 250 but more than 10 employees. The sampling method was stratified simple random sampling. Subgroups in the sampling were based on personnel size groups and industrial classification. Statistics Finland conducted the sampling.

The questionnaire was sent to 2,860 enterprises by mail, and responses were collected via an online form between 18 February and 3 April 2013. The questionnaire was sent and the data collected by Statistics Finland. There were 819 accepted answers received by the deadline, giving a response rate of 28.6%.

The survey investigated changes that companies had made in the past three years. The questionnaire contained multiple-choice questions as well as open-ended questions. The questionnaire and detailed answers are presented in Huovari, Lehtoranta & Nieminen 2014 (in Finnish).

The response rate was higher than anticipated, probably partly due to the survey being carried out by Statistics Finland. That said, it seemed that a large part of the respondents were motivated to respond to the survey, judging by the quality of answers to the open-ended questions. The respondents appeared to be proud of their change and wanted to share their experience. Some also regarded the survey as an opportunity to voice their views, in particular to express their concerns of the future of manufacturing in Finland.

6.2 Who made changes?

According to the survey, the majority of companies, 75%, made changes during the past three years. That is a somewhat smaller number than reported by Nikulainen and Salmi (2012), who found that 94% of Finnish manufacturing firms made changes. The percentage in manufacturing in the current survey was 78%.The difference is probably explained by our filtering question of whether companies had implemented any changes at all. This question probably excluded respondents who did not think their changes where noteworthy or respondents who wanted an easy exit from the survey.

There are clear differences in the frequency of changes between industries (Figure 1). In manufacturing industries, the percentage of companies that made changes is slightly higher than in other industries. However, differences are wider on a more detailed industry classification.

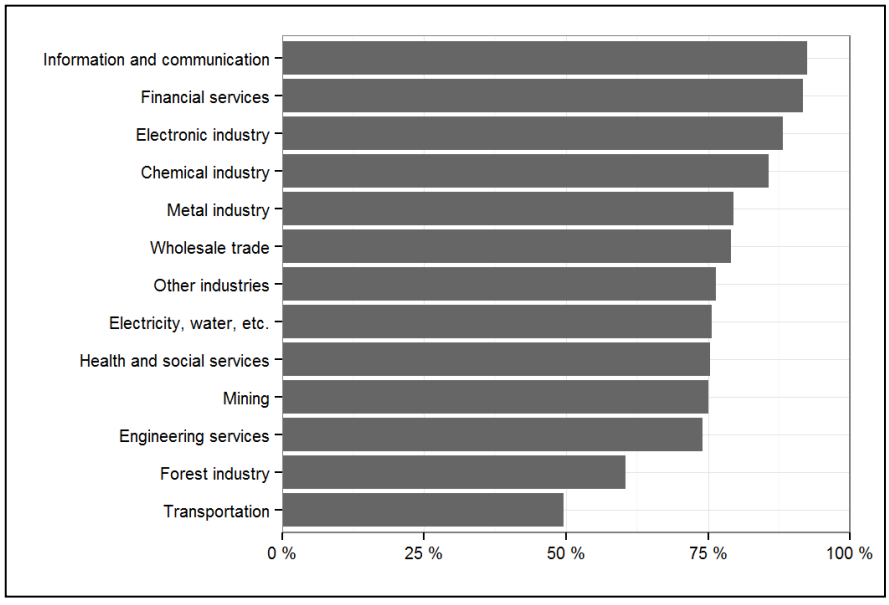

Figure 1. Percentage of companies that had made changes in the past three years.

The occurrence of changes was highest in information and communication services, together with financial services. More than 90% of companies in these sectors had implemented changes in the past three years. In manufacturing industries, the sectors with the highest rate of change were the electronics and chemical industries.

The least change-intensive industries were the transport and forest industries. The low change rate in the forest industries was due to the wood and wood product industries, where only 53% of companies had made changes in the past three years. In the paper industry, the figure was 88%, making it one of the most change-intensive industries.

The change rate was low in transport, where fewer than half of the companies made changes. The transport industry also stood out in the responses as to why companies had not made changes. It seems that there is such heavy competition in the industry that companies did not have the resources or the time to make any changes. Other industries on a more disaggregate level having low change rates were the manufacture of furniture and social work activities without accommodation.

The principal customers of companies also affect the frequency of changes. The most change-intensive companies were those whose principal customers were public-sector institutions internationally. Both the public sector and internationality seemed to correlate with the change rate. Also, companies whose princi-

pal customer was the domestic public sector implemented changes more often than those with domestic consumers or firms as their principal customers. Likewise, international principal customers increased the change rate in all customer categories: public sector, consumers and firms.

The high change rate in companies serving the public sector is mostly due to the computer programming, consultancy and related activities industry. It was the largest industry by number of respondents in the survey among those having the public sector internationally as their principal customer. It was also a significant supplier group for the domestic public sector in the survey. The clearly largest supply industry, by number of companies, was the residential care activities industry. Its change rate was more or less average.

After suppliers of the public sector internationally, the next highest change rate was among companies which had international consumers as their principal customers. Companies that catered to other companies had the lowest rate of change, domestically and internationally.

The portfolio of companies had some bearings on how often companies make changes. Companies that sold products were more change-prone (76%) than service companies (67%). However, the highest change rate was among companies that have a broad portfolio, including both goods and services. Some 87% of product companies with significant attached services made changes in the past three years, followed by service companies with attached products.

Between companies that implemented changes in the past three years and those that did not, there was only a slight difference in factors that companies regarded as important for their competitiveness. The most important factor, the quality of products/services, was equally important for both groups. Price was slightly more important for those that did not make changes. All other factors were slightly more important for those that made changes. The biggest differences were in the importance of the brand, marketing, technological advantage, user involvement, R&D collaboration, design and partnership in a broader product/service development environment.

Reasons not to make changes

A quarter of respondents reported that they had not implemented changes in the past three years. Of these 201 respondents, 133 responded to the question of why they had not made any changes. The majority (66%) of these said that there was no need for changes or that the business was in a stable environment. Some, however, said that they made gradual changes all the time or made only small changes. Some also said that they had recently finished changes or were going to initiate changes in the near future.

In addition, 11% reported that they had made some changes or that they had continuous changes under way even though they responded that they had not made any changes in the past three years. Thus, the principal conclusion drawn from the ‘why not’ question is probably that a lack of changes was, in most cases,

not a sign of passivity. Companies were making some changes, or their changes did not happen to fall within the time window of the survey.

For the rest, there were obstacles that prevented changes. One reason was economic difficulties, the enterprise having no money to make changes or seeing the situation in the economy as so uncertain that they did not think they could take a risk by making changes. For 11% of the respondents, the economy was the reason for the lack of changes. That seems to be a somewhat small percentage given that the survey period included difficult years after the financial crisis.

An equal percentage of respondents reported external factors as a reason for their absence of changes. The most notable among these were subcontractors and the transport industry. Very fierce competition and tight contractor control prevented changes. Some also listed regulation and uncertainty of regulatory changes as obstacles for change.

6.3 What kinds of changes were made?

As firms were quite active in making changes, what kind of changes were they making and how many innovations were involved in the changes? To answer these questions, respondents were asked to describe their changes in both open-ended questions and a questionnaire.

First there were three open-ended questions: What has been the most important change implemented in your company in the past three years? Please describe. Please describe other changes in your company related substantially to this most important change. Please tell why this change and changes related to it were implemented.

Then we probed the content and the novelty value (innovativeness) of the most important change described in the open-ended answers and related changes. Respondents were asked: How significantly were the changes given below related to the most important change you described? (see Figure 2 for change categories) And: Next we ask you to assess the novelty value of changes you reported in the previous question.

With the open-ended questions, we wanted to give respondents an opportunity to describe changes in their own words, without confining them to predetermined terminologies. There were two goals: firstly, to make it possible to find changes we had not thought of beforehand or new aspects of the changes, and secondly, to compare the answers of the open-ended questions to the questionnaire.

Content of changes

According to the questionnaire, management processes and strategy were the most frequent part of the most important (principal) change (Figure 2). Changes in organising internal work responsibilities or decision-making were part of this

change in 95% of changes. Changes in the business strategy or business model were almost as frequent. Those two change categories were most frequently a highly significant part of the principal change. Almost 70% of respondents to this set of questions assessed the change in the business strategy or business model to comprise a significant part (scores 4–5) of the principal change.

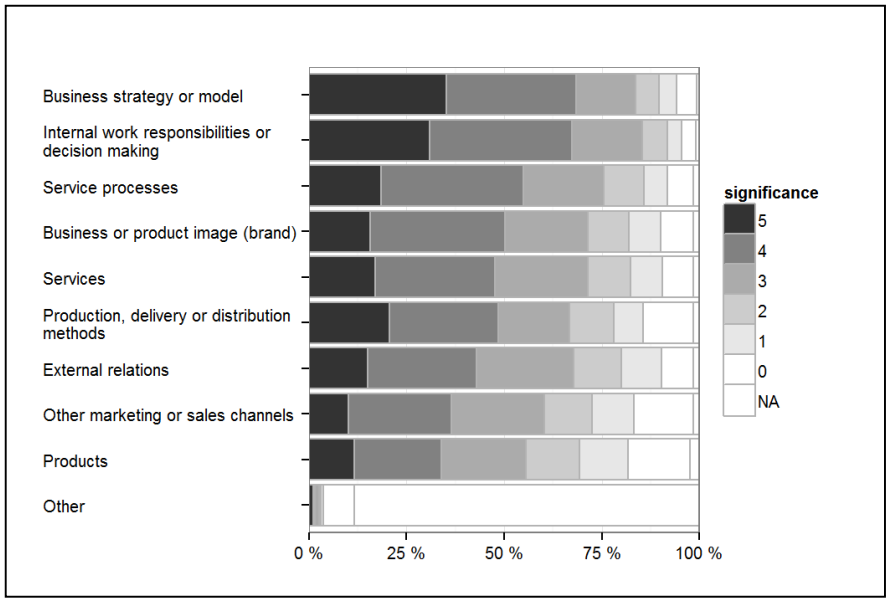

Figure 2. Content of the change. "*How significant were changes given below related to the most important change you described? (5 = highly important, 0 = not important at all).*"

Changes in strategy and organisational methods were also frequently mentioned in open-ended answers. The word 'organisation', with variations, was the most frequent word after 'new' and variations. Also, often the source of the whole change process was organisational thinking. However, changes in organisational methods and strategy were more common reasons for the change in the questionnaire than in the open-ended answers.

Respondents often ticked changes in strategy and organisational methods as highly significant even if there was not a word about them in the open-ended answers. It seemed that they were considered 'meta-changes', a significant part of all changes. Moreover, the perspective of the respondents may have had an influence on the dominance of strategic and organisational changes in the answers. The surveys were sent to CEOs, and the questions were probably answered by them or someone from the management team.

The open-ended answers did not reveal any uniformity in organisational changes: they involved all possible directions: centralisation – decentralisation of processes, outsourcing – insourcing of production, elimination of layers – adding layers to the organisation. With that high frequency of changes in organisational methods and strategy, one could ask whether there are too many organisational changes. One respondent stated that they had made changes to their organisation structure “several times during the past three years”.

The importance of changes in organisational methods and strategy is slightly overemphasised, as all companies were separately asked for their product/service changes together with the corresponding process changes. Obviously service companies do not engage in product changes, and vice versa.

Service companies considered changes in their service processes significant (scores 4–5) as often as they considered changes in organisational methods and strategy to be significant (Figure 3). In addition, a change in services was a significant element almost as often. Also, product companies often considered changes in their production, delivery or distribution processes and products significant. However, when all the companies were included in the analysis, product change emerged as the most infrequently included element.

In general, for service companies a change in services or service processes seemed to be a significant change more often than a change in products or production methods for product companies. The biggest difference between product and service companies was indeed in the service/product and service process / product process categories. Changes in service processes were significant among 67% of service companies, while 52% of product companies regarded changes in production processes as significant. For services and products, the respective percentages were 58% and 46%. At the same time, the differences between the service and product companies concerning the roles of organisational and strategy changes were very small.

With regard to other changes, a change in branding often comprised a significant part in the most important change described by the companies according to the questionnaire. However, this is not mirrored in the open-ended answers. A brand and its Finnish variants were mentioned only eight times, and some kind of change in brand was mentioned in fewer than 20 responses.

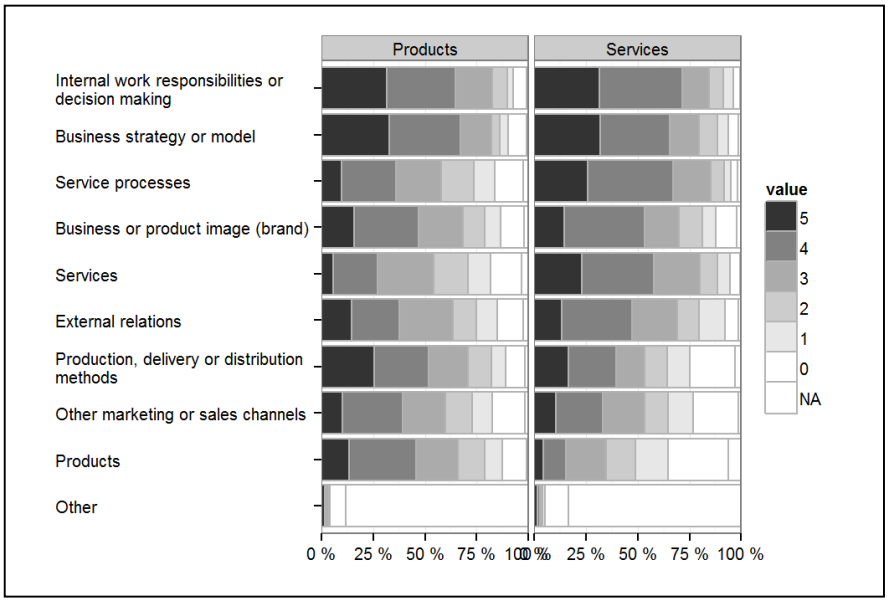

Figure 3. Content of the change for product and service producers separately. "*How significantly were the changes given below related to the most important change you described? (5 = highly important, 0 = not important at all).*"

The overall picture given both by the questionnaire and particularly by the open-ended answers was that the most important changes described by respondents comprise a complex combination of partial changes. As one respondent noted, "everything has changed". Nikulainen and Salmi (2012) reported the same result. This confirms that changes as well as innovations are complex and require many kinds of changes in companies.

Innovativeness of changes

To obtain information on the innovativeness of changes, we asked respondents to assess the novelty value of the changes they reported. This was to be assessed on a scale from 0 (others have undertaken similar changes earlier) to 5 (no one else has undertaken changes like this). In addition, the open-ended answers were classified based on whether they indicated that the change included innovative elements.

Assessing innovations on the basis of the open-ended answers was an ambiguous task. When describing changes in their own words, respondents did not usually state whether the changes were innovative or included new elements. The word 'innovation' and variations were mentioned only six times, and only one of these referred to the change itself. The other five referred to the target of the changes: the changes were supposed to make the companies more innovative.

However, the answers did indicate that innovations were included in changes. We judged all changes as innovative if it seemed possible that there were some elements in them that were somehow new. In other words, the threshold for a change to be classified as an innovation or innovative was fairly low. Possible innovations in the open-ended answers were recorded by the same classification that was used in the questionnaire.

As changes in strategy and organisational methods were the most frequent changes, they were also the most innovative ones (Figure 4). Over 50% of respondents who responded to this set of questions gave a novelty value of 4 or 5 for their strategy or business model change. For organisational change, the figure was 45%. Some support for the innovativeness of organisational changes was found in the open-ended answers, where organisational changes were seen as innovative in almost 30% of valid responses. This was the highest percentage in all change categories.

It was extremely hard to judge whether an organisational change just included novel elements or was truly innovative. On the basis of the descriptions of the respondents, a change was marked as innovative if it seemed non-trivial. In many cases, the changes seemed to be very profound and, at least for the company in question, something new. In the contrary cases, non-innovative organisational changes were seen to be simple modifications of existing organisational structures or implementations of existing methods or models (such as Lean Management, ERP, SAP).

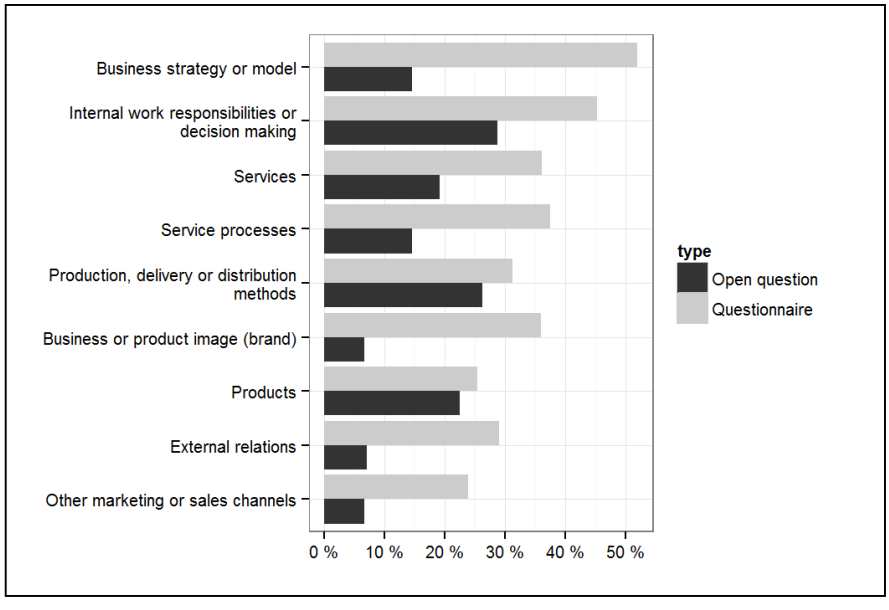

Figure 4. Percentage of novelty values 4–5 in the questionnaire and percentage of changes rated as innovative in the open-ended questions.

In the cases of strategy and business models, the open-ended answers did not lend support to the innovativeness suggested by the questionnaire. Assessment of the innovativeness of business models on the basis of the descriptions of respondents was even harder than that of organisational changes. What really contributed to the difference between the open-ended answers and the questionnaire was that respondents did not mention strategy changes in the open-ended answers nearly as often as they marked them as innovative in the questionnaire.

This was the problem with the other change categories as well. In all categories, the percentage of novel changes was higher in the questionnaire than in the open-ended answers. In most cases, the difference is substantial. Often the change marked as highly novel was not described at all. One would expect that if the change included really innovative elements, those would have been reported in the open-ended answers as well.

There were two exceptions to this pattern: products and production; and delivery and distribution methods. Product and process changes were almost as innovative in both the questionnaire and the open-ended answers. On the basis of both, the figure was about 25% for product changes and about 30% for process changes.

What is remarkable is the fact that these are approximately similar to the figures that can be found in the Finnish Innovation survey 2010 (Statistics Finland 2012) for product and process innovations. However, according to the Innovation surveys, the percentage of companies implementing business model or organisational innovations is slightly over 20%, which is inconsistent with our questionnaire and open-ended answers. This suggests that for product and process innovations the results are similar regardless of the survey method but that for other innovations the results are more mixed.

6.4 Reasons and inspirations

Why do companies make changes? This was probed with the open-ended question: “Please tell why this change and changes related to it were implemented.” Answers were classified on the basis of the principal reason to implement changes.

Usually the respondents gave one clear goal, but they also mentioned other benefits targeted or realised with the help of the change. Only the principal reasons were classified. However, notes were also made on other reasons, and the most noteworthy reasons are reported in the text.

The most important reason for the change was to seek growth, competitiveness or efficiency (Figure 5). Growth seeking was the main aim of the change in almost 40% of non-empty responses. The second most important reason for the change had a similar motive: to improve something that already existed. The difference between these two lay in how forward looking and dynamic the reasoning for the change was. Together, they accounted for almost 70% of all responses.

Customer needs and harsh competition or economic conditions were the third and fourth most important reasons. They were also the most important reasons

emerging explicitly outside of the company. However, the relatively low ranking of external factors underestimates their importance. Changes in the operating environment are seldom referred to as the principal reason for the change. They are, however, mentioned frequently as background information.

Savings were also seldom cited as the principal reason for the change. They are also mentioned as an additional motivation for or results of the change. General macroeconomic conditions were mentioned only a few times. This was somewhat unexpected, as the period within which changes were asked about included the recession following the 2009 financial crises.

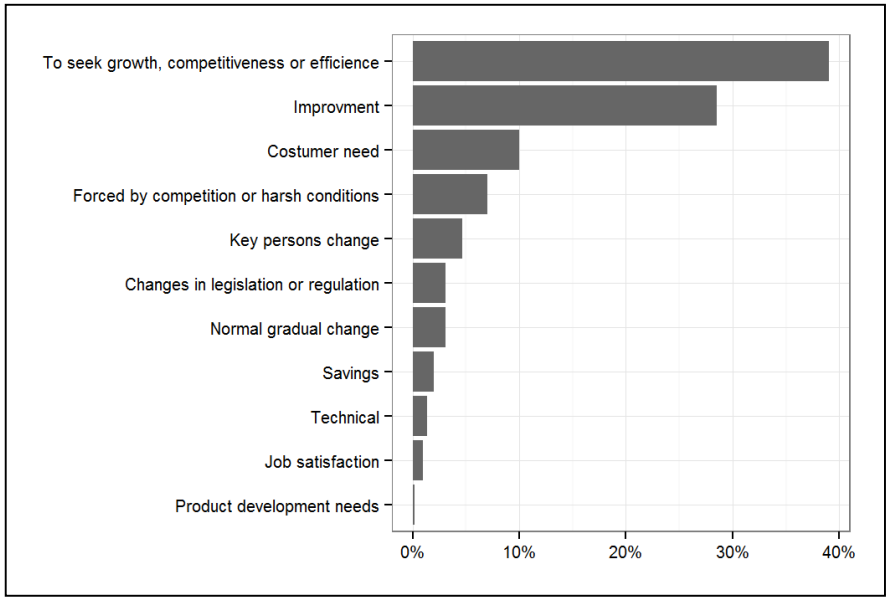

Figure 5. Inspirations for the change. Why the change was made, interpretation of open-ended questions. Percentage of interpretable answers (106 answers were empty or did not reveal any reason).

Descriptions of changes were also analysed from the perspective of what inspired the change or was the source of the idea for the change. Partly the same issue was asked also in the questionnaire.

The questionnaire questions and the classification of open-ended answers were inconsistent. That was most likely because when respondents described the reasons for the change with their own words, they did not think in terms of the questionnaire questions.

Broadly taken, the most important inspiration for the change according to the open-ended answers was internal organisational or strategic thinking (Figure 6). It seems that discussions in the management team inspired and steered the change.

This is something that cannot be deduced from the questionnaire replies (Figure 7) as there was no such option in the questionnaire.

The most frequently mentioned source of inspiration for changes in the questionnaire was the company's own R&D. This was not obvious from the open-ended answers. In fact, in-house R&D was mentioned only 33 times, and practically every time as a target of the change, not as a source.

In addition to in-house R&D, the company's marketing or sales were an important internal inspiration for change. This was also not obvious from the open-ended answers. Furthermore, it seems that the personnel were rarely referred to as a source of inspiration and ideas. This might be because there was no question explicitly to this effect. However, in the open-ended answers the absence of personnel as an active agent of change was striking.

'A technology new to the company' was an important inspiration for change. In fact, it was the most important factor if technology, new products and production methods – all of them technology-related inspirations – are taken together. Investment in new machinery or software, digitisation, etc. requires a profound change. Responses to the open-ended questions described actions such as putting the business online, changing the logistics systems that involved a real-time tracking and routing of vehicles, and electricity meter e-reading.

It was evident, however, that usually even pure technical changes were accompanied by and required a wider change in the company.

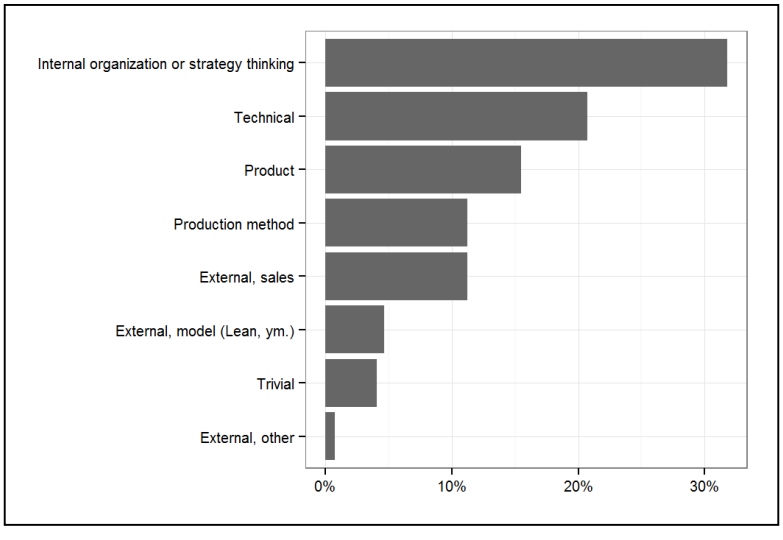

Figure 6. The source of inspiration for the change process, interpreted from open-ended questions. Percentage of interpretable answers (102 answers were empty or did not reveal any source of inspiration).

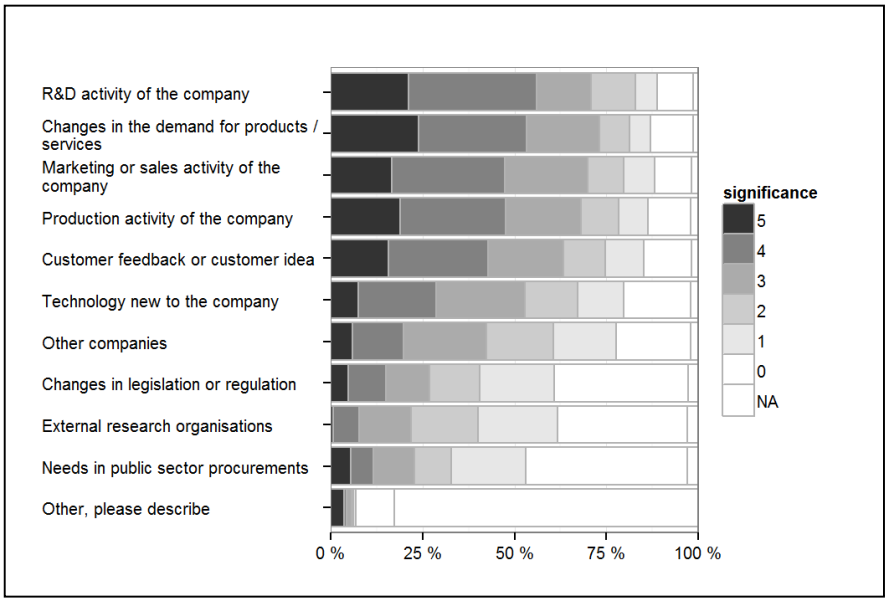

Figure 7. Importance of sources of inspiration.

6.5 User involvement in changes

The role of customers appeared in previous questions, but user involvement in the change process was also asked about explicitly. Users were involved in 38% of the changes (Figure 8). The majority of these were cases where other companies were involved in the change. Consumers and public-sector organisations played a minor role. Consumers and the public sector participated in 8% and 7% of the changes, respectively.

User involvement was usually traditional and relatively passive (Figure 9). In most cases, companies utilised existing information on user needs. Most of the companies also received opinions and feedback from users during the change process and surveyed user needs for this purpose.

Active involvement was less frequent. However, almost 50% of the companies that reported user involvement agreed strongly (scores of 4–5) that they had an active user community which was utilised in the change. More than one in four agreed strongly that the change was based mainly on the needs of a few key users or that they utilised solutions from users in the change. Active user involvement was mostly the result of business-to-business contacts. Especially subcontractors have a strong user involvement in their change processes.

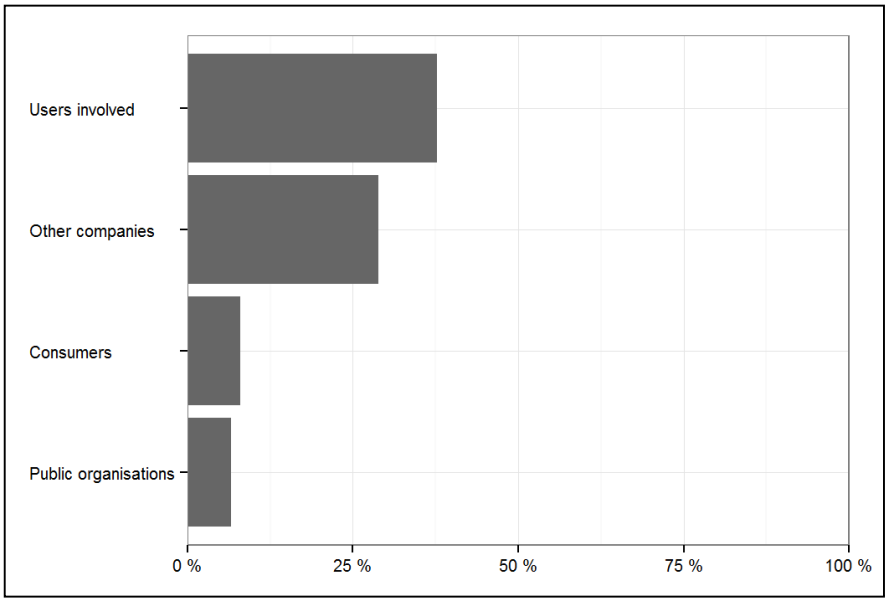

Figure 8. The percentage of changes with customers or end-users involved in the change, overall and by type of user.

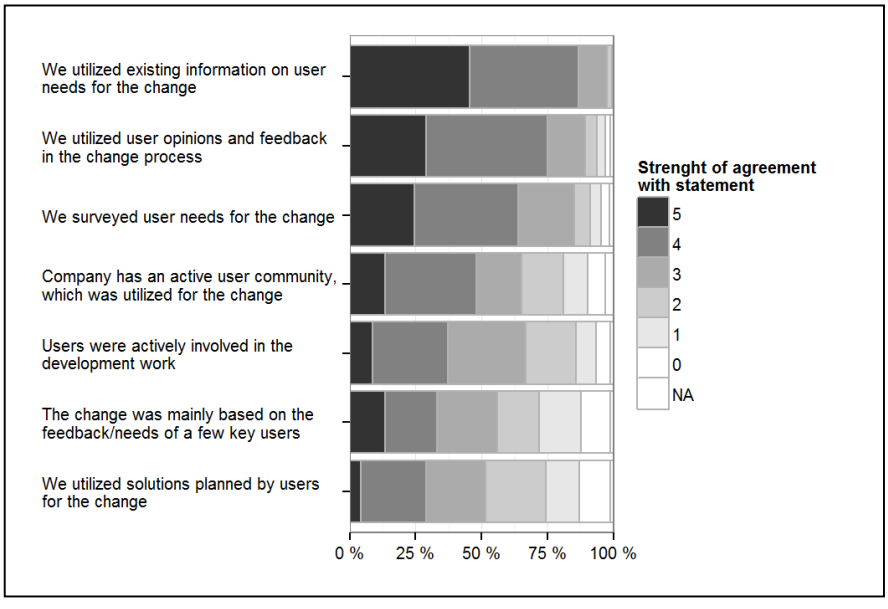

Figure 9. User involvement in the change. *"What is your opinion on the following statements related to the involvement of your customers or end-users of your products / services in the change?"* Only companies that had users involved in the change.

6.6 Conclusions

The general impression on the basis of the survey is that companies are very active in making changes. In the past three years, 75% of the respondents had implemented changes. For the rest, the main reason for the absence of changes was that they had had no need for a change in the past three years or that they thought that the changes implemented were not noteworthy enough.

The changes described in the survey were mostly complex and comprised concurrent changes in the strategy, organisation, processes, products, etc. It is also obvious that it is unfeasible to change only one aspect. Indeed, when something is changed, it is usually accompanied by other changes. Changes in the strategy and organisation were involved in almost all the changes. They were most frequently a significant part in the principal change. In service companies, a change in the service process was also a significant part in the change.

The main reason for companies to make changes was a forward-looking desire to grow, to be more competitive and efficient. Accordingly, the inspiration for changes seemed to come mainly from internal discussions within the management team. The goal was set in the management team and then the required changes were planned and implemented. However, there were also technology-related inspirations for change. These were related to the requirements and possibilities of new technologies.

While the survey revealed the complex nature of changes, it also revealed the difficulty of assessing the innovativeness of changes. This, in particular, is the case for a broader concept of innovation. It is very difficult to assess the innovativeness of anything other than product and production process changes. For these 'traditional' innovations, the results given by the questionnaire and answers drawn from the open-ended questions were in accordance. In addition, results from the survey are broadly in accordance with the results of the CIS.

The same cannot be said about the wider set of innovations. In the questionnaire, changes in the strategy and organisational methods (organisational processes) were most frequently described as novelties. Instead, in the open-ended answers their innovativeness did not seem to be equally common. This indicates that it is difficult to assess innovativeness on the basis of open-ended answers. This also raises a question as to whether a change really was a significant and novel one if there was no mention of it in the open-ended answer. This suggests that assessment of innovativeness is difficult for companies. Companies are not used to consider their processes from the perspective of the world or sector-wide novelty value. It might be also doubtful how often organisational changes or changes in business models really are innovative. At the very least, it is difficult to measure their innovativeness reliably.

References

Armbruster, H., Bikfalvi, A., Kinkel, S. & Lay, G. (2008). Organizational innovation: The challenge of measuring non-technical innovation in large-scale surveys. *Technovation*, *28*(10), 644–657. Retrieved from http://www.sciencedirect.com/science/article/pii/S0166497208000394

Arundel, A., O'Brien, K. R. & Torugsa, A. (2010). Errors in the interpretation of 'innovation': preliminary results from a 2007 innovation survey in Australia. Retrieved from http://eprints.utas.edu.au/10813/

Huovari, J., Lehtoranta, O. & Nieminen, M. (2015). Yritysten uudistukset 2010–2012. Kyselyn tulokset. *PTT työpapereita 157*.

Kline, S. J. & Rosenberg, N. (1986). An overview of innovation. *The positive sum strategy: Harnessing technology for economic growth*, *14*, 640. Retrieved from http://books.google.com/books?hl=fi&lr=&id=N9a6tqRr3ikC&oi=fnd&pg=PA275&dq=An+Overview+of+Innovation&ots=6YhOckdRB-&sig=IU9pSeYJo5nteBQOo_wwfh7xBG4

Nikulainen, T. & Salmi, J. (2012). Uudistaminen ja yhteistyöverkostot Suomen teollisuudessa – Havaintoja yrityskyselystä. *ETLA, Discussion Papers, No. 1285*. Retrieved from http://ideas.repec.org/p/rif/dpaper/1285.html

OECD & Eurostat. (2005). *Oslo Manual. Communities*. OECD.

Statistics Finland. (2012). *Innovation 2010*.

7. Measuring public-sector innovation – a critical assessment based on the Finnish MEPIN survey

Carter Bloch

7.1 Introduction

Focus on the functioning of the public sector and the importance of innovation to improve the quality and efficiency of public services have generated increasing interest in our ability to measure public-sector innovation. This interest has prompted a number of large scale pilot surveys of public-sector innovation, such as the MEPIN (Measuring Public Innovation in the Nordic Countries) study (Bloch 2011, Bugge et al. 2011), the NESTA Public Sector Innovation Index for the UK (Hughes and Baker 2011), the EU 2010 Innobarometer survey (Gallup Organisation 2011) and most recently the survey conducted as part of the Australian Public Sector Innovation Indicators (APSII) Project[10]. While public-sector innovation measurement is still in the early stages of development, these studies have provided a valuable first look at public-sector innovation on a broad scale across public-sector organisations and at how innovation can be measured in these institutions. There are, however, a number of remaining questions concerning measurement, in terms of choice of overall approach, individual definitions and indicators and also the general quality of these preliminary results[11].

Among the most central of these issues is defining innovation in the public sector and how public-sector organisations themselves conceptualise innovations. While there are some minor differences across surveys, each of the recent pilot studies defined innovations in much the same way as the approach taken in the Oslo Manual for innovation measurement in the business sector. The key elements of the Oslo Manual definition are that innovations should comprise new or significant improvements in activities, that the innovation concept spans products, processes, organisational and marketing activities, and that innovations must be new to the firm, but do not necessarily need to be novel compared to others. A number of issues have been debated concerning the Oslo Manual definition, including the element of novelty, the inclusion of 'non-technological' activities, and even the use of the term 'innovation' itself. These issues may have similar relevance for the public sector. In addition to questions concerning the chosen ap-

[10] See http://innovation.govspace.gov.au/?s=APSII+Project.

[11] For a review of recent work and issues on public-sector innovation measurement, see Bloch (2013).

proach, an important issue is the results of the surveys, how respondents understand the definition and whether the conceptualisation is similar across respondents. A common result across the various pilot surveys of public-sector innovation is that a very high percentage of organisations reported having introduced an innovation in the last 2 to 3 years, which motivates the question of what factors lie behind these results and whether respondents understand questions on innovations correctly.

The objective of the Nordic research project "Measuring innovation in the public sector in the Nordic countries (MEPIN)" was to develop a measurement framework for collecting internationally comparable data on innovation in the public sector, which both would contribute to our understanding of what public-sector innovation is and how public-sector organisations innovate and to develop metrics for use in promoting public-sector innovation (Bloch 2011).[12] A key element of the project was a large scale pilot survey conducted in all five Nordic countries (Denmark, Finland, Iceland, Norway and Sweden).

The purpose of this paper is to conduct a critical assessment of the MEPIN framework through an analysis of the pilot study results for Finland. The analysis will focus in particular on the examples of innovations provided by respondents, examining them both on their own and in combination with other indicators from the survey. The main questions that will be examined in this paper are: "What kind of changes or innovations does a measurement exercise like the MEPIN capture? How can we use this data to characterise innovation in the Finnish public sector? And to what extent is this data useful for policy?"

The first section will briefly review recent work on public-sector innovation measurement in general and the MEPIN project in particular. This first section will also review basic results from the Finnish survey. The following sections will use the examples to examine a number of aspects concerning public-sector innovations. This includes the use of the word 'innovation' itself in survey questions, and close examination of the how individual types of innovations are understood and what kinds of examples have been given. This part will focus on communication and organisational innovations. In addition to reflecting on individual types of innovations, examples may be able to help characterise public-sector innovation in more depth, for example, what kinds of broader processes appear to be driving the implementation of changes in public-sector organisations. Finally, the analysis will also explore the issue of innovative novelty, in particular drawing on the concept of 'major innovators'. The final section will summarise the main results and potential implications for further measurement work.

[12] See also Bloch and Bugge (2013).

7.2 Measuring public-sector innovation – a review of recent work

In the recent wave of pilot surveys (over the period 2010–11), the approach generally followed has been to adapt the measurement framework used for firms (*i.e.* based on the *Oslo Manual* – OECD/Eurostat 2005) and attempt to extend it to public-sector organisations. Although the specificities of the public sector (and innovation within it) are acknowledged in such efforts, it is argued that many elements from the *Oslo* framework can be adapted reasonably well to a public-sector context. Therefore these studies adopt a similar conceptual basis (*i.e.* considering the organisation as the locus of innovation, mapping its interactions with other agents, analysing the innovation process in terms of inputs, activities and outputs, etc.) and the surveys themselves are modelled after Oslo-type surveys, in particular the European Community Innovation Survey (CIS).[13]

Three studies were conducted over the period 2010–2011: the MEPIN study, the NESTA Public Sector Innovation Index and the EU 2010 Innobarometer. The EU's Innobarometer 2010 was devoted to "Innovation in Public Administration" (Gallup Organization 2011). A survey was conducted among 4,063 public-administration organisations in 29 countries across Europe using a questionnaire that draws partly on the MEPIN survey. As part of the Public Sector Innovation Index developed on behalf of the UK Government, NESTA commissioned a pilot survey of innovation across two parts of the public sector: the National Health Service (NHS) and Local Government (Hughes and Baker 2011). The survey draws both on NESTA's Private Sector Index survey questionnaire, the MEPIN survey and the EU Community Innovation Survey (CIS) for businesses. The main purpose of the NESTA survey was to provide input for the development of a pilot version of the Public Sector Innovation Index.

A fourth study is an Australian survey of federal agencies. The Australian Public Sector Innovation Indicators (APSII) Project aims to "equip public sector agencies with the information they need to assess their innovation performance and capabilities, and to benchmark Australia's performance against other international public sector, especially in OECD countries" (DIISR 2011). The project includes the development of a data collection tool (survey) as well as a measurement tool (set of indicators). The survey was conducted at the level of branches within federal agencies.

- All four studies asked about the introduction of innovations within products, processes, organisational methods and communication or marketing. The MEPIN survey, which was either web-based or postal, utilised detailed definitions that partly draw on definitions from the *Oslo Manual* (OECD/Eurostat 2005). As the EU Innobarometer and NESTA surveys

[13] See Bloch (2013) for a review of recent work on the measurement of public-sector innovation.

were telephone-based, formal definitions of individual types of innovations were not used.[14] In fact, neither of these two studies explicitly uses the word 'innovation' in specific questions on types of innovation. Otherwise, the wording of the types of innovation was quite similar in all cases. However, both the Innobarometer and the APSII combined process and organisational changes. The Australian survey also included an additional type of innovation, policy innovations.

This paper focuses more specifically on the Nordic MEPIN study, in particular the study for Finland. During the initial phase of the project, a number of interviews were conducted with representatives of public-sector organisations and policy users (Annerstedt and Björkbacka 2010). Both users and respondents were asked how they understood innovation and also how they viewed the four types of innovations in the Oslo Manual (i.e. product, process, organisational and market innovation); whether each type was relevant and whether they thought other types of innovations should also be included. In general terms, the four types of innovations were viewed by respondents as relevant for the public sector, though definitions required modification to better suit the public sector. This thus motivates the definitions developed in the MEPIN study, which are included in the appendix. Principal changes here were changing marketing innovations to communication innovations and modifying all four definitions to better reflect the nature of public-sector services and processes. The definitions of product and process innovations are similar to those in the Oslo Manual; though, with a less technical focus to better reflect public services. Organisational innovations include: new management systems, new methods of organising work responsibilities and decision making, new ways of organising external relations, and new systems for gathering knowledge and building innovative capacity. Communication innovations attempt to take account of the fact that most public-sector organisations do not operate on a market, but where promotion is nevertheless important for their operations. In addition, public-sector organisations may make a number of campaigns or promotions that essentially do not provide a service to users. Three types of communications innovations are identified: new methods of promoting the organisation or its services, new methods to influence the behaviour of user, and first time commercialisation of goods or services.

A common Nordic questionnaire was developed based on a preparatory study of user needs as well as an introductory feasibility study among potential respondents (see Bugge et al. 2011). The questionnaire was also partly based on the Community Innovation Survey (CIS) for the business sector, though adjusted to fit public-sector contexts. Following the basic structure of the CIS survey, the questionnaire sought to cover the following topics dealing with innovation in public-sector organisations:

- Innovations
- Innovation activities and expenditure

[14] However, an overall definition of innovation was provided to respondents at the beginning of the survey.

- Objectives of innovations
- Information channels for innovation activities
- Innovation cooperation
- External funding for innovation
- Innovative procurement practices
- Driving forces of innovation
- Innovation strategy, management and competences
- Barriers to innovation

However, there were some variations among the national questionnaire versions regarding some of the questions. The approach used was to take the basic framework from the Community Innovation Survey (CIS) for the business sector as a point of departure, but to use modifications or different approaches where needed in order to fit public-sector contexts. The Finnish questionnaire included questions on types of innovations, who developed the innovations, new to sector product innovations, innovation activities and expenditure, objectives, information channels, cooperation, barriers and innovative procurement. The Finnish survey did not include questions on innovation drivers and innovation strategy. Concerning examples, the Finnish survey asked for examples for each individual type of innovation, whereas the common questionnaire included a single question that asked for 1–2 examples of innovations without specifying type. This latter aspect makes the Finnish survey well-suited for evaluating respondent understanding of innovation, as it contains a large number of examples for each of the four types of innovations.

The survey was targeted at public-sector institutions at the central, regional and local levels. The central level includes government institutions such as ministries and agencies, whereas the regional and local level comprises public-sector actors such as municipalities, schools and hospitals. In most cases the questionnaire was answered by the top management of the institutions.

A major challenge in conducting the pilot studies was selection of the survey frame. The starting point for all countries was the populations of enterprise (or legal) units within the general government sector. Selected units in a number of countries were excluded after an evaluation of their relevance for this pilot study. In Finland, 90 units within central government were selected for the study out of 503 units. In particular, organisations such as district courts, execution authorities, various approving authorities and regional prisons were excluded from the sample. Universities and units within national defence were typically excluded from all countries.

In both the MEPIN and NESTA studies, and the EU Innobarometer study that covered public administration in all EU27 countries, percentages of public-sector organisations with innovations are very high, both in relation to prior expectations and in relation to percentages of innovative firms typically found in business sector innovation surveys. For example, in the MEPIN study, percentages with product innovations ranged from 44% in Sweden to 72% in Denmark, and the EU27 aver-

age (for service innovations) in the Innobarometer study was around 66%. Percentages in the NESTA survey are even higher at around 90%.

The Finnish sample included a total of 334 units within central, municipal and regional (associations of municipalities) government. Of these, 150 organisations (45%) responded to the survey. In total, around 55% of the organisations had implemented a product innovation over the two year survey observation period (2008–2009), while 72% had implemented either a product or a process innovation. Of these product innovators, just over half (30% out of 55%) had implemented a product innovation that was new to their sector. For both product and process innovations, around half of respondents with innovations stated that they had developed the innovation together with private businesses. About 62% of organisations had implemented an organisational innovation, while only 34% had introduced a communication innovation.

7.3 Innovation examples – data and method

Respondents in the Finnish survey were also asked to provide examples of each of the four types of innovations, and many respondents provided more than one example of an innovation. Of the 118 respondents with an innovation, 101 provided at least one example of an innovation. In all provided these 101 respondents a total of 471 examples of innovations: 163 examples of product innovations, 133 process innovations, 115 organisational innovations, and 60 communication innovations. Of the 101 respondents, 66 were municipal or regional organisations while 35 were in central government. The box below shows a list of selected innovation examples from the Finnish MEPIN survey.

Box 1. Examples of innovations from the Finnish MEPIN survey.

Product innovations	**Organisational innovations**
Implementation of online services (e.g. building permits, tax declarations)	Implementation of contact centre
Various portals	Increasing the responsibility of immediate supervisor
Group therapy and training for depressed people at home using video	New method for regional co-operation
Surgery robots	First use of team work
Art pharmacy	Implementation of Customer Relationship Management (CRM) system
	The establishment of a new administrative unit in a research centre
Process innovations	New methods of organising work (integration or de-integration)
Online procurement processes	
Results of medical checks given online from health centre to service homes	**Communications innovations**
Planning of hospitals using virtual environment	Email free of charge to all inhabitants in a municipality
New type of co-operation between various organisations (e.g. special health services, social services from the same place, home health care together with other home services)	Collecting the opinions of citizens in the strategic and programme work
	First use of social media
	Campaign against false drugs
Service concepts for various customer categories	Transfer from product marketing to imago marketing

Source: Statistics Finland, Survey of innovation in the public sector 2008–2009.

The analysis consists of three parts. The first part examines whether the examples given can in fact be considered innovations based on the definitions used in the survey. The second part examines individual types of innovations in more detail, while the third part uses examples to identify and classify underlying processes driving innovations. We describe the methods behind each of these below.

7.4 Examining the interpretation of 'innovation'

The main goal of this first part of the analysis is to assess whether respondents interpret the innovation concept correctly. The design of this exercise draws to a large degree on analysis conducted by Arundel et al. (2013), though there are a number of differences in the data and hence also the analysis. The analysis by Arundel et al. uses business innovation data (the 2007 Tasmanian Innovation Census, TIC) in which respondents were asked to describe their most important innovation. Importantly, the question on most important innovations was asked of both firms that replied elsewhere in the questionnaire that they had introduced an innovation and of firms that did not report an innovation. The MEPIN survey of

public-sector organisations did not ask for the most important innovation, but instead for the respondent to provide an example of an innovation.[15] In the case of Finland, respondents were asked to provide examples for each of the four types of innovation. And in contrast to the TIC, only organisations that reported an innovation were instructed to answer the question.

The approach used in the analysis was modelled after the approach used in Arundel et al. (2013), though taking into account these differences in data and survey structure. Two experts examined and classified each example independently of each other and without viewing any other responses to the survey. Thereafter, the two classifications were compared and any differences discussed until a consensus was reached. Thereafter, the examples were analysed based on these classifications and also in comparison with other survey data concerning types of innovations and novelty.

Table 1 shows the main results of the assessment of examples. We find that a fairly sizeable percentage of examples do not meet the criteria given in the definitions. Of the 471 examples of innovations given by in all 101 respondents, only 77% were assessed to actually fall within the definition of an innovation used in the survey. Percentages vary across types of innovations. For examples of product innovations, 86% were viewed as innovations, while the percentage for examples of process innovations was 81%. Percentages are substantially lower for examples of organisational and communication innovations – 73% and 50%, respectively. These results for Finland are comparable to what has been found for other Nordic countries and for the UK (see OECD 2013). Percentages of examples that are innovations range from 62% in Iceland to 69% and 71% in Denmark and Norway, respectively, to 77% in Sweden and a high of 87% in the UK. Based on the results, it appears that a sizable percentage of respondents have not understood the definition of innovations correctly, suggesting a need for better clarification of the borderline between what is and what is not an innovation.

While 23% of examples were not assessed to be innovations, this does not appear to have had a large influence on the actual percentage of innovative organisations. Most respondents provided more than one example and it was much less likely that all examples given by a single respondent were not innovations. In fact, only 5 out of 101 respondents did not provide at least one example that was assessed to meet the criteria for an innovation.

Of those examples that were considered innovations, 12% out of the 77% were viewed to be 'borderline innovations' that just barely meet criteria for an innovation. This result does not indicate additional difficulties with the definitions, but it helps in interpreting the pilot survey results, suggesting that a large percentage of innovative organisations are in fact innovative, but these innovations are fairly minor. Given this, there may be a need to better distinguish these from more significant innovations.

[15] Our expectation is, however, that respondents have typically provided examples that are among their most important innovations.

Table 1. Percentages of examples assessed to be innovations.

	Number of examples	Meet criteria for innovation	Of which: borderline innovation	Multiple innovation types
Example of product innovation	163	86%	7%	29%
Example of process innovation	133	81%	13%	25%
Example of organisational innovation	115	73%	16%	11%
Example of communication innovation	60	50%	17%	20%
Non-major innovator	275	73%	16%	24%
Major innovator	196	81%	7%	20%
Local and regional govt.	315	76%	15%	23%
Central govt.	156	78%	6%	22%
Total	471	77%	12%	23%

Source: Own calculations based on data from the Survey of innovation in the public sector 2008–2009, Statistics Finland.

We consider also the possible role of using the word 'innovation' in definitions or questions on innovations. Arguments against using the word 'innovation' in surveys are that it may contribute to misinterpretation of the innovation concept, leading respondents to rely on their own conceptualisation of what an innovation is, which may both be more restrictive than the actual definition and diverge from others' views. On the other hand, the main purpose of including the term 'innovation' and defining it is precisely to develop a common understanding of what an innovation is. While we are unable to conduct a proper test of the effect of using the word 'innovation', our general impression from results and the design of the questionnaires is that it has not had a significant effect. Firstly, both the EU Innobarometer 2010 and the UK NESTA surveys did not use the word 'innovation' in specific survey questions on types of innovations, but experienced similar results in terms of high percentages of innovators. For example, the EU Innobarometer 2010 questionnaire asks "Since January 2008, did your organisation introduce any new or significantly improved services?" Secondly, it is typically expected that use of the word 'innovation' would lead to a reduction in the percentage of innovative organisations (that many respond that they do not have any innovations, even though they do), which does not appear to be the case here. However, it is hard to

determine whether use of the term 'innovation' can have led to greater divergence in understanding of the innovation concept, without more formal testing.[16]

7.5 Further examination of innovation examples

Discussions of how innovation should be defined typically revolve around three elements: degree of novelty, degree of impact and breadth in terms of different types of innovations. In terms of novelty, the main question is whether innovation should also include changes that are only new to the organisation itself (as is the case for the Oslo Manual definition) or if innovation should be restricted to truly novel changes. In terms of impact, there appears to be widespread agreement that innovations differ from inventions and must have been implemented or taken into use. However, some would argue that innovations should go even further than this and have had diffused to others or have resulted in some form of socio-economic impact. The final element concerns what kinds of activities the innovation concept should include, only technological elements or also non-technological aspects. In more practical terms and drawing from the Oslo Manual definition, this discussion has centred on whether innovation should only include changes in products and processes, or whether it also should include organisational and marketing changes.

This analysis will attempt to contribute to this discussion by examining examples from these perspectives, first through the concept of 'major innovations' and thereafter by taking a closer look at examples of organisational and communication innovations.

The concept of 'major innovations', which draws in part on the model of Utterback and Abernathy (1975), focuses on the notions of both novelty and impact. Major innovations are defined through three dimensions: technological novelty, market attractiveness and their ability to solve societal problems. Major innovations are thus viewed as both being novel and having socio-economic impact. Typically, most examples were not detailed enough to allow assessment of whether they were major innovations, so we instead created a measure for 'major innovators' based on other variables from the survey and thereafter examined what types of examples of innovations these organisations provided. Major innovators were defined as organisations having a new to sector product innovation and a broad range of highly important objectives.[17] The measure thus attempts to model both novelty and potential impacts through responses concerning innovation objectives. Using this definition, 33 out of 101 respondents with innovation

[16] For example, by using a split ballot approach where the word 'innovation' is used in questions for half of the sample and excluded for the other half.

[17] The latter was defined as either having cited four out the following five objectives (develop online services, improve quality of goods and services, customer satisfaction, improve efficiency, and fulfill regulations) as highly important, or having cited both customer satisfaction and either improving quality or efficiency as highly important.

examples were classified as major innovators. Our objective with this exercise is twofold; both to examine whether major innovators can be reasonably measured in this way and to examine through the examples what types of innovations these 'major innovators' have implemented.

Given that major innovators are identified on an organisation level (and not for individual innovation examples), we examine here the full sets of examples for each organisation. In general, these major innovators have a larger number of examples than other respondents with examples. The 33 major innovators account for 196 of the examples, and a higher percentage of these examples were viewed to be innovations. For major innovators, 81% of examples were viewed to be innovations, of which only 7% were borderline innovations. For the remaining organisations, 73% were innovations, of which 16% were borderline innovations. As we mentioned earlier, for most examples it is not possible to assess whether they are major innovations or not, but we can make a rough assessment of whether they have the potential to be a truly novel innovation with socio-economic impact. Many of these 'major innovators' appear to have an innovation example that fits this characterisation, though not all, and none of the examples could be considered to be true, path-breaking innovations. Of the 33 organisations, 8 had provided examples that could be considered novel, technological innovations with large potential for diffusion and broader socio-economic impact. An additional 5 organisations had IT-based innovations that might also fit this characterisation, though it is more difficult to discern the degree of novelty for these examples. Another 6 organisations did not have technological innovations but had introduced new, novel services that could be diffused to other organisations and thereby have important impacts. The remaining 14 organisations did not appear to be major innovators based on the examples provided. Nine of these had a number of examples and appear to be very innovative across a wide range of their activities, but these innovations were typically less novel and mainly directed at improving their own performance, with less potential for diffusion to others. The final 5 did not appear novel at all, and their examples appeared to be more minor than for the other organisations.

Somewhat related to the question of novelty is the breadth of the innovation concept in terms of types of innovations. The third edition of the Oslo Manual (OECD/Eurostat 2005) included organisational and marketing innovations based on the argument that changes to organisational and marketing processes can be important components of firms' innovation activities and can also be crucial in terms of effects of innovation on performance. On the other hand, organisational and marketing changes are less likely to be novel innovations with broader impacts.

In order to investigate this question, the further analysis of organisational and communication innovations takes a more general look at these examples, where we examine what types of examples of changes are given, how important they appear to be for the organisation and whether there appears to be potential for diffusion and broader impacts. This further assessment is much less systematic than the analysis of whether the examples are innovations or not.

The analysis of examples of communication innovations indicates that examples are generally quite basic in nature, reflecting standard activities to promote the organisation or improve contact with users. Examples include newsletters, use of social media, changes to websites and customer feedback surveys. In fact, only half of these examples were assessed to be innovations. There are however a number of examples of communication innovations that appear to be important parts of broader innovations, and which act to improve customer service processes and service responsiveness. However, these were typically classified by respondents as product or process innovations, and not communication innovations.

Examples of organisational innovations typically involve restructuring and reorganisation, including the centralisation of activities, outsourcing and collaborations. A number of examples also cited the introduction of new management systems. In many cases these organisational innovation were part of a larger innovation, involving either a product or a process innovation.

7.6 Classifying public-sector innovations

In examining the examples of public-sector innovations, a goal was to utilise the data to identify common trends and driving forces in public-sector innovation. Drawing on both key focus areas in the public sector and on preliminary examination of the examples, we have identified six trends in public-sector innovation: consolidation, digitisation, user experience, innovative procurement, new technologies and societal impacts. Each of the respondents with examples was then classified according to these trends based on their examples of innovations. These trends are not mutually exclusive and may in some cases be complementary. Hence, innovations in a single organisation may be driven by more than one of these trends (or by none of them). We discuss each of them in turn.

Consolidation

Demands for greater efficiency can motivate the reorganisation of public-sector activities at a number of levels. There are a number of examples that included the merging of functions or services with those of other public-sector organisations. These appear to reflect a broad trend among public-sector organisation to consolidate services, processes or administration in larger units, presumably to reduce costs. This includes joint services or functions among municipalities or a single municipality that ‘pools’ different types of services that are related to specific customers, new collaborative partnerships, and organisations taking on additional service responsibilities from other units.

Digitisation of processes and services

ICT offers a broad range of new opportunities for public-sector organisations to innovate and improve their operations. This includes IT innovations related to service provision and processes and other IT related innovation in equipment or other technologies.

New technologies

While the public sector in general has often been associated with minor incremental change, the public sector has also in many cases been the source of large, technological innovations that are designed for widespread diffusion and, when successful, have substantial impacts. Focus on the process of developing new technologies either for own use or for adoption by other public-sector organisations or businesses seeks to examine what percentage of organisations appear to be active in technological innovation.

Procurement

Public procurement is becoming an important issue for innovation policies, based on the idea that public procurement can be used to promote innovation in businesses. In terms of measurement, procurement can potentially impact innovation in two directions: contributions to innovation in the organisation itself and promoting innovation in other organisations. This includes different types of changes that are related to organisations' procurement activities, such as new ways of procurement, joint procurement with others and outsourcing of activities to contractors.

User experience

A key goal of public-sector innovation is to improve the quality of public services and citizen satisfaction. As a result, citizens have increasingly been viewed as customers in the provision of public services. This trend relates to innovation targeted at the consumer – better communication, improving user satisfaction, better understanding users, etc.

Societal impacts

An increasing policy focus is on social innovation and using innovation as a tool to help meet societal challenges. This attempts to capture innovations that have societal impacts, or address societal challenges. This can be either intentional or unintentional on behalf of the innovators (i.e. the main objective could be to reduce costs). This includes environmental related innovations, new methods in health, social or elderly care, energy related innovations, etc.

Table 2 shows the results of the classifications for the 101 organisations with innovation examples. Digitisation is the most prevalent of the trends, with 47% having cited an example involving the digitisation of either services or internal processes. The next most prevalent is user experience, where around 40% had given examples of changes implemented to improve contact with users and/or user satisfaction. Percentages for implementing technological innovations or renewing procurement processes are much lower, around 17% for technology and 13% for procurement.

Table 2. Classifications of organisations based on innovation examples.

	Number of organisations	Percentage of total	Central govt.	Local and regional govt.	Product innovators	Process innovators	Organisational innovators	Communication innovators	Major innovator
New technologies	17	17%	23%	14%	88%	82%	82%	41%	59%
Consolidation	32	32%	17%	39%	72%	91%	91%	47%	25%
Digitisation	47	47%	54%	42%	75%	87%	79%	60%	38%
Procurement	13	13%	14%	12%	69%	92%	100%	54%	46%
User experience	40	40%	43%	38%	83%	98%	95%	80%	43%
Societal impacts	29	29%	20%	33%	83%	79%	69%	48%	38%
Total	101	100%	100%	100%	70%	81%	79%	43%	33%

Source: Own calculations based on data from the Survey of innovation in the public sector 2008–2009, Statistics Finland.

The table also indicates fairly large differences between central government on the one hand and local and regional government on the other. This is particularly the case for consolidation, where percentages are 39% for local and regional government and only 17% for central government. This reflects the fairly extensive activity to create joint services or consolidate functions across municipalities but also across areas or services. An example of the latter is the consolidation of different types of service to a specific group, such as young people or the elderly. Both

digitisation and technological innovation are almost 10 percentage points higher for central government, while societal impacts are higher for non-central government. The latter may in part reflect that local government is often closer to citizens and thus more oriented towards societal impacts of public services.

As would be expected, there is a much higher percentage of major innovators within new technologies. The next highest percentages of major innovators are within procurement and user experience. The latter is perhaps less expected, but may suggest that novel innovation is also linked to the user or takes user impacts into account. The lowest percentage for major innovators is within consolidation. This may reflect that non-major innovators are more focused on improving their existing operations, of which consolidation may be an important element.

These classifications of organisations are not mutually exclusive; a single example can fall within more than one classification, and many organisations have multiple examples. Among the classifications, overlap is greatest for the two most prevalent, digitisation and user experience. For example, among organisations with digitisation, between one third and two thirds also have one of the other classifications. Table 2 also shows percentages with each of the four types of innovations. As can be seen, the majority of innovative organisations have more than one type, as the percentages with each of the types of innovations are quite high. Around 70% have product innovations (note that this is among organisations with at least one innovation and not among all organisations), 80% each have process and organisational innovations and just over 40% have communication innovations. Organisations with technological innovation examples have a higher percentage with product innovations. Consolidation, procurement and user experience have a higher percentage with process and organisational innovations, and user experience also has a substantially higher percentage with communication innovations.

A simple factor analysis gives a better idea of how these classifications and types of innovations are connected. The analysis produced four factors. The first links user experience with digitisation of processes and services, involving process and communication innovations in particular, but also to a lesser extent product innovations. The second factor involves societal impacts, which are linked to product innovations and strongly negatively correlated with process innovations and digitisation. The third factor involves consolidation which is highly connected with organisational innovations, with the fourth factor linking technological and product innovations.

In the following, we examine many of the indicators from the public-sector innovation survey, both on their own and in relation to the classifications of organisations based on examples. The first concerns whether innovations were developed in-house, with the collaboration of others or entirely externally. Given that organisations can have more than one innovation, they may have chosen more than one of these categories. And, while this question was asked separately for product and process innovations, in order to increase the number of observations for which data are available (for example, 70% of innovative organisations have a product innovation, while 92% have either a product or a process innovation), a composite indicator was created for product and process innovations combined.

Table 3. Results of factor analysis for classifications of organisations and types of innovation.

Variable	Factor1	Factor2	Factor3	Factor4
New technologies	-0.108	-0.055	0.022	0.712
Consolidation	-0.011	0.131	0.516	-0.133
Digitisation	0.347	-0.240	-0.430	-0.024
Procurement	0.002	-0.406	0.165	0.216
User experience	0.345	0.051	0.133	-0.049
Societal impacts	0.024	0.563	0.029	0.062
Product innovation	0.095	0.347	0.045	0.499
Process innovation	0.279	0.000	-0.010	-0.069
Organisational innovation	-0.034	-0.156	0.574	0.097
Communication innovation	0.406	0.041	-0.066	-0.052

Principal component analysis, varimax rotation. Based on the 101 innovative organisations with at least one innovation example. Number factors chosen based on eigenvalues greater than 1. Source: Own calculations based on data from the Survey of innovation in the public sector 2008–2009, Statistics Finland.

Within new technologies and user experience, percentages are higher in all cases, which may indicate that these organisations have developed multiple innovations and that they are reliant on both in-house know-how and external expertise for their innovations. Compared to averages, organisations within consolidation have higher percentages where innovations were developed in cooperation with others, both businesses and other public-sector organisations. The same pattern was found for digitisation and societal impacts, but only for businesses concerning digitisation and other public-sector organisations for societal impacts. Within procurement, emphasis was actually on in-house development, which suggests that focus for these organisations was on improving their internal procurement processes as opposed to improving the quality of what they receive from suppliers.

The Finnish MEPIN survey both asked for an estimate (among intervals) of total innovation expenditure and whether innovation activities included in-house R&D, external R&D and other purchases of knowledge and services, and training related to innovations. A general result of all pilot surveys of public-sector innovation was that respondents found it very difficult to provide an estimate of how much they had spent on their innovation work. Furthermore, it is not clear whether public-sector respondents are familiar with the R&D concept. Around 74% of innovative organisations answered that they had conducted in-house R&D, and 61% stated that they had contracted R&D services from others. Both these percentages are much higher than anticipated and also after examination of the innovation examples, which in most cases do not appear to have required R&D.

Table 4 shows results concerning the importance of a range of objectives for innovation. Each objective can be rated from highly important to somewhat im-

portant to not relevant, and thus values can range from 0 (not important) to 2 (highly important). Overall, the most important objective was user satisfaction, followed by efficiency, quality and developing online services. The different classes show some differences in priority of objectives. For new technologies, all objectives are rated higher than overall averages, suggesting that these organisations have a greater focus on innovation to achieve performance goals. On the other hand, consolidation is close to overall averages on all types of objectives, thus not providing an indication that consolidation efforts have a particular goal that is more highly targeted, such as improving efficiency. Digitisation has less focus on quality of services and more on efficiency and increasing internal communication. User experience also has extra emphasis on these two factors. User satisfaction is important here, but only slightly more so than for other organisations.

Table 4. Importance of objectives for innovation.

	Obs.	Online	Quality	User satisfaction	Internal communication	Efficiency	Health and safety	Environment	Regulations
New technologies	17	1.53	1.65	1.71	1.44	1.53	1.27	0.87	1.12
Consolidation	32	1.41	1.31	1.47	1.37	1.38	1.00	0.57	0.91
Digitisation	47	1.68	1.30	1.51	1.51	1.49	1.00	0.76	1.00
Procurement	13	1.39	1.31	1.46	1.22	1.54	0.89	0.56	0.77
User experience	40	1.58	1.35	1.60	1.44	1.50	1.09	0.71	1.15
Societal impacts	29	1.59	1.55	1.62	1.18	1.48	1.21	0.70	1.24
Total	101	1.36	1.37	1.52	1.27	1.38	1.09	0.65	1.00

Average values for importance for innovation objectives, where highly important=2, somewhat important=1 and not important=0. Based on the 101 innovative organisations with at least one innovation example.

Source: Own calculations based on data from the Survey of innovation in the public sector 2008–2009, Statistics Finland.

Two questions in the Finnish MEPIN survey seek to capture knowledge transfer. Information channels measure the importance of different types of channels for obtaining knowledge that may be useful for their innovation, while cooperation measures the importance of different types of collaborative partners. Overall and for individual classes, informal networks are by far the most important information channel. Organisations within new technologies tend to attach greater importance to all channels, suggesting that they are larger users of various types of external knowledge for their innovations than other organisations. For other organisations, generally all other types than informal networks are given much less importance. One exception here though is evaluations, which are given relatively greater importance within digitisation, procurement and user experience.

On average, other public-sector organisations are most important as collaboration partners for innovation, followed by businesses. Surprisingly, there is relatively little variation in the importance of businesses across the different classes of innovative organisations. There is somewhat greater variation for other types of cooperation partners. Collaboration with citizens is the least important type of partner, though in relative terms, consolidation and user experience give higher than average importance to citizens, while it is given extremely low importance within new technologies. For new technologies, public research institutions are actually the most important partners, and public research is also given relatively high importance for societal effects.

Table 5. Importance of information channels for innovation.

	Obs.	Internet	Informal networks	Conferences, etc.	Scientific and trade journals	Hiring personnel	Evaluations
New technologies	17	1.18	1.77	1.29	1.38	1.12	1.31
Consolidation	32	1.00	1.53	1.00	0.87	0.73	1.13
Digitisation	47	1.12	1.56	0.93	0.90	0.89	1.28
Procurement	13	1.10	1.60	1.11	1.11	0.82	1.27
User experience	40	1.11	1.56	1.03	0.91	0.97	1.37
Societal impacts	29	1.07	1.54	0.93	1.03	0.93	1.14
Total	101	0.94	1.54	0.95	0.92	0.85	1.12

Average values for importance for information channels for innovation, where highly important=2, somewhat important=1 and not important=0. Based on the 101 innovative organisations with at least one innovation example.

Source: Own calculations based on data from the Survey of innovation in the public sector 2008–2009, Statistics Finland.

Table 6. Importance of collaborative partners for innovation.

	Obs.	Other public-sector organi-sations	Public research inst.	Citizens	Businesses
New technologies	17	1.47	1.65	0.07	1.19
Consolidation	32	1.63	1.13	0.61	1.17
Digitisation	47	1.46	1.04	0.37	1.15
Procurement	13	1.33	0.92	0.27	1.11
User experience	40	1.53	1.13	0.55	1.23
Societal impacts	29	1.56	1.28	0.48	1.04
Total	101	1.45	1.00	0.39	1.15

Average values for importance for cooperation partners, where highly important=2, somewhat important=1 and not important=0. Based on the 101 innovative organisations with at least one innovation example.

Source: Own calculations based on data from the Survey of innovation in the public sector 2008–2009, Statistics Finland.

The survey also asked about a range of factors that may hinder innovation in public-sector organisations. Lack of resources was by far given greatest importance as a barrier – both lack of funds and lack of time devoted to innovation. Bureaucracy (rigidity of laws and other regulations) and risk of failure are two factors that are often argued to be significant barriers to public-sector innovation. However, both are given low importance among these innovative organisations. Lack of incentives to innovate (either for personnel or for the organisation as a whole) is given slightly higher importance, but still appears to be fairly low as a barrier to innovation. Lack of knowledge, skills or qualified personnel are also generally low, but are more important as a factor for technological organisations.

Table 7. Importance of barriers to innovation activities.

	Obs.	Rigidity of laws and regulations	Risk of failure	Lack of coop. between organisations	Lack of funding	Lack of time allocated to innovation	Lack of personnel incentives to innovate	Lack of incentives for organisation to innovate	User resistance to change	Lack of knowledge, skills or qualified personnel
New technologies	17	0.69	0.60	0.87	1.25	1.31	0.93	0.73	0.57	1.13
Consolidation	32	0.63	0.47	0.72	1.13	1.44	0.91	0.84	0.55	0.74
Digitisation	47	0.72	0.50	0.73	1.36	1.48	0.96	0.88	0.47	0.91
Procurement	13	0.67	0.55	0.78	1.08	1.33	0.82	0.50	0.36	0.80
User experience	40	0.61	0.50	0.69	1.31	1.40	1.00	0.92	0.51	0.78
Societal impacts	29	0.83	0.57	0.66	1.41	1.35	1.00	0.82	0.54	0.71
Total	101	0.71	0.48	0.73	1.26	1.30	0.92	0.81	0.47	0.81

Average values for importance obstacles to innovation, where highly important=2, somewhat important=1 and not important=0. Based on the 101 innovative organisations with at least one innovation example.

Source: Own calculations based on data from the Survey of innovation in the public sector 2008–2009, Statistics Finland.

7.7 Discussion

This paper has analysed the data and results for Finland of the recent MEPIN pilot study of innovation in public-sector organisations. We have both utilised examples of innovations provided by respondents and responses to the other survey questions to assess the validity and usefulness of the data and to gain a better understanding of innovation in the public sector. This final section discusses the main results of the analysis.

A key issue we have considered here is the measurement framework's ability to capture the development of major or novel innovations that both represent the development of new technologies or methods and also have a potentially large socio-economic impact through diffusion to other public-sector organisations and

to businesses. There are diverging views concerning what degrees of novelty should be measured. A narrow viewpoint is that only major, novel innovations are important and measurement should thus focus on these. A broader view sees less novel innovation activities, including adoption and moderate improvements, as also being relevant for measurement in order to understand innovation and diffusion in a broader context. Arguably, incremental change may be of particular importance to the public sector. Innovations are often seen as the result of intentional actions and the requirement that innovations must be implemented generally implies that at least part of the innovation process must be planned. However, the service innovation literature (e.g. Gallouj and Weinstein 1997) has argued that many service innovations are at least partly developed through work with a particular customer and thus can be more of an ad hoc nature. Ad hoc innovations that are developed indirectly through the resolution of some problem as opposed to being the result of a planned process have been argued to be of particular importance in the public sector (Fuglsang 2010).

An examination of the examples here also suggests that a broader view may be more appropriate and makes best use of the data. While there are a number of examples of innovation that show innovation activities which may have importance for public-sector organisations, there are few examples of truly novel innovations. However, even if one accepts that a broader view of innovation is most appropriate for public-sector innovation measurement, it is still important to be able to distinguish between major innovations and more moderate or incremental changes. Our analysis here shows that this was difficult. We attempted to use the data to identify major innovators using indicators of novel product innovation and objectives as a proxy for potential impact, but analysis of examples showed that this was too inclusive. More work needs to be done both to facilitate the identification of truly novel innovations and to ensure that minor changes that do not qualify as innovations are excluded. Possible avenues here are to strengthen the concept of innovative novelty and to include additional questions on the novelty of innovation, for example whether it has been diffused to others.

We have also examined organisational and communication innovations more closely. In general, we found that examples of communication innovations were very minor (though some more substantial innovations were given as product innovations that also involved significant changes in communication methods). Examples of organisational innovations were more varied, with some including significant restructuring of activities. Our overall impression is that organisational and communication innovations in general perhaps do not merit the same status as product and process innovations, but that in many cases, they include important components of organisations' overall innovation activities. For example, many communication innovations appear to be part of broader objectives to improve communication and service quality for users, while organisational innovations are often made to facilitate service or process innovations. In general, there were few respondents with only communication or organisational innovations. Of the 101 respondents with examples, only 7% had only organisational innovations and none had only communication innovations.

Investment in innovation is an important measure for tracking innovation activities, focus on innovation compared to other activities and towards measuring the impact related to these investments. Unfortunately, this has proved to be one of the most difficult questions to answer, with a large percentage of respondents stating that they were unable to estimate innovation expenditure for their organisation. In addition, results for qualitative questions on different types of innovation expenditure suggest that the R&D concept may not be correctly understood by public-sector respondents.

Questions on innovation objectives appear useful as an overall measure, showing the relative importance of customer satisfaction related to service quality and efficiency. However, variation across organisations is fairly minor, which reduces the usefulness of these indicators. One possible factor here is that many organisations have a number of innovations, which may have different (and in some cases opposing) objectives. Hence, one gets a broad average assessment of objectives as opposed to those linked to a specific innovation. An alternative here would be to link this question to a single innovation that the organisation has implemented.

Questions on information channels and cooperation provide information on the overall importance of different channels and collaboration partners and indicate that the most innovative organisations obtain information from a broad range of sources and types of partners. Data on interaction with public research is also useful as an indicator of R&D based innovation. However, while these questions provide information on the linkages that public-sector organisation have with others, they tell us less about specific diffusion processes, e.g. what types of new technologies and methods organisations have adopted and the diffusion of own innovations to others. In some respects, innovation surveys are not the most appropriate tool to measure specific diffusion processes; this would likely be better done by directly tracking the development and uptake of specific technologies. Though, more could be done to measure diffusion in public-sector innovation surveys. For example, questions could be constructed to ask if any of the organisations' own innovations have been adopted by others, and how.

In this paper we have conducted a fairly extensive analysis of examples of innovations provided by respondents. A very high percentage of organisations that reported having implemented innovations also provided examples, which helped facilitate the development of indicators based on coding of examples. The descriptions of examples are typically very brief, which creates limitations to what types of analysis can be done; however we still find the analysis of examples useful in a number of respects. First, as is described in detail above, the examples are a valuable tool for the validation of survey data, in particular concerning responses on innovations. The examples also give us a much better picture of what public-sector innovations are than would otherwise be possible only on the basis of 'closed' survey questions.

As a first attempt at coding innovations, we have identified a number of classifications, based in part on relevant trends in public-sector innovation. These are consolidation, digitisation, user experience, procurement, technological and societal impacts. These classifications were then merged with other data. Technological

organisations are typically more innovative, based on a variety of measures. They have a higher and broader range of objectives for their innovation activities, draw on a wide range of information channels and are in greatest need for additional technology, skills and personnel for their innovation.

User experience is closely connected with digitisation, indicating that IT-based solutions are heavily relied on to improve user communication, access and quality. These are often connected with a number of different types of innovations, communication, process and product. Consolidation involves both the merging of activities or services internal to the organisation and establishing joint activities with other organisations. Consolidation is thus closely linked with organisational innovations, and these organisations have a greater tendency to work with both businesses and other public-sector organisations in the development of product and process innovations.

Procurement was the least prevalent of the classifications, and the examples given typically involved improving internal procurement processes and had little to do with interaction with suppliers. A very high percentage of organisations had own in-house development of product or process innovations, and the greatest focus concerning objectives was on efficiency. Societal impacts involve innovations that focus on improving societal impacts and thus are mainly linked with product innovations and objectives of quality and user satisfaction. These organisations also have a greater tendency to develop product and process innovations in cooperation with public research and other public-sector organisations.

References

Annerstedt, P. and Björkbacka, R. (2010), Feasibility study of public sector organisations: MEPIN (Measuring Public Innovation in the Nordic Countries) project. Copenhagen: Danish Agency for Science, Technology and Innovation.

Arundel, A., O'Brien, K. and Torugsa, A. (2013), How firm managers understand innovation: implications for the design of innovation surveys. Chapter 4 in: F. Gault (ed.) *Handbook of Innovation Indicators and Measurement*. Cheltenham, UK: Edward Elgar.

Bloch, C. (2011), Measuring Public Innovation in the Nordic Countries – Final Report. Nordic project 'Measuring innovation in the public sector in the Nordic countries: Toward a common statistical approach' ("Copenhagen Manual").

Bloch, C. (2013), Measuring innovation in the public sector. Chapter 17 in: F. Gault (ed.) *Handbook of Innovation Indicators and Measurement*. Cheltenham, UK: Edward Elgar.

Bloch, C. and Bugge, M. (2013), Public Sector Innovation – From Theory to Measurement. *Structural Change and Economic Dynamics* 27:133–145.

Bugge, M., Mortensen, P.S. and Bloch, C. (2011), Report of the Nordic Pilot Studies – Analyses of methodology and results. Nordic project 'Measuring innovation in the public sector in the Nordic countries: Toward a common statistical approach' ("Copenhagen Manual").

DIISR (Department of Innovation, Industry, Science and Research, Australia) (2011), *Australian Innovation System Report 2011*.

Fuglsang, L. (2010), Bricolage and invisible innovation in public service innovation. *Journal of Innovation Economics* 1:67–87.

Gallouj, F. and Weinstein, O. (1997), Innovation in services. *Research Policy* 26:537–556.

Gallup Organization (2011), Analytical Report – Innovation in Public Administration. Report commissioned by the DG Enterprise and Industry of the European Commission.

Hughes, A. and Baker, C. (2011), Public Sector Innovation Index – The findings from our pilot project measuring innovation in the public sector using a survey approach. Report produced by Ernst & Young for NESTA.

OECD (2013), Key elements for a measurement framework for public sector innovation. DSTI/EAS/STP/NESTI(2013)10. Paris: OECD.

OECD/Eurostat (2005), Oslo Manual – Guidelines for Collecting and Interpreting Innovation Data. Third Edition. Paris: OECD.

Utterback, J.M. and Abernathy, W.J. (1975), A dynamic model of process and product innovation. *Omega* 3(6):639–656.

Appendix A: Definitions of innovation in the public sector

An **innovation** is the implementation of a significant change in the way your organisation operates or in the products it provides. Innovations comprise new or significant changes to services and goods, operational processes, organisational methods, or the way your organisation communicates with users.

Innovations must be new to your organisation, although they can have been developed by others. They can either be the result of decisions within your organisation or in response to new regulations or policy measures.

A **product innovation** is the introduction of a service or good that is new or significantly improved compared to existing services or goods in your organisation. This includes significant improvements in the service or good's characteristics, in customer access or in how it is used.

A **process innovation** is the implementation of a method for the production and provision of services and goods, that is new or significantly improved compared to existing processes in your organisation. This may involve significant improvements in for example, equipment and/or skills. This also includes significant improvements in support functions such as IT, accounting and purchasing.

An **organisational innovation** is the implementation of a new method for organising or managing work that differs significantly from existing methods in your organisation. This includes new or significant improvements to management systems or workplace organisation.

A **communication innovation** is the implementation of a new method of promoting the organisation or its services and goods, or new methods to influence the behaviour of individuals or others. These must differ significantly from existing communication methods in your organisation.

8. New indicators for measuring user innovation by Finnish firms and consumers

Mervi Niemi & Jari Kuusisto

8.1 Introduction

Innovation is seen as a key to achieving progress, economic growth and prosperity in business and for the entire national economy. Beyond economic benefits, governments increasingly see innovation as a key to solving major societal challenges such as climate change, the ageing of society and renewal of public-sector services. At the same time, there is an increasing realisation of the growing significance of open and user innovation activities and, more broadly, a need to understand how innovations are created. In the innovation policy context, it is important to address and measure all sources of innovation in order to be at the forefront of nations in benefitting from these new opportunities. This paper contributes to the debate by reporting user innovation indicator development for consumer innovation and for businesses in the Community Innovation Survey (CIS) context. The paper will also present the results of measured user innovation activities in Finland.

New innovation landscape and the rise of open- and user innovation

The dominant view of innovation is the producer-firm perspective, the assumption being that such firms are the most important innovators and their efforts are rewarded as others adopt their innovations (Kuusisto, de Jong, Gault, Raasch & von Hippel 2013). Schumpeter (1934), for instance, suggested that it is entrepreneurs who create the most important and game-changing innovations. These innovations are also introduced to the markets by small and start-up enterprises. Later on, Schumpeter changed his argument and claimed that innovation mainly takes place in R&D laboratories within large firms (Schumpeter 1942). In both scenarios, innovations clearly originate with producers who introduce their novel goods and services to the markets. While start-ups and research laboratories remain important innovators, the growing realisation is that they are not the sole source of innovations.

Recent research in Finland and elsewhere has accumulated evidence on the increasingly active role that users have as innovators. User innovation by firms is based on the need to develop and tailor their own production tools and processes

to remain competitive and to meet the requirement for environmental sustainability, among other things (Kuusisto, de Jong, Gault, Raasch & von Hippel 2013). Besides skills, user innovation among consumers is driven by improved connectivity, i.e. lowering of communication and coordination costs. Also, an increasing number of consumers now have access to inexpensive, user-friendly technologies such as powerful CAD-CAM design tools, 3D-printing, laser cutting, apps development kits and others (see e.g. Baldwin and von Hippel 2011). Such technologies, the Internet in particular, have created a situation where global low cost access, sharing and development of knowledge and ideas are possible. For instance, with the help of dedicated innovation platforms and social media18 tools (e.g. YouTube, Facebook, Twitter, Instagram, Whatsup), user and developer groups can organise and publish themselves very effectively. All this has great potential to drive innovation at the individual, organisational and community levels.

Different types of open innovation and user innovation activity

The following sections first address certain conceptual issues, followed by user innovation indicator development in the case of user innovator firms and consumer innovators. Secondly, survey results on user innovation intensity and diffusion among Finnish businesses and consumers are presented. Figure 1 illustrates how user innovation can be divided into innovation by consumers and by businesses. In terms of the value chain, user innovation can happen at any point in the process through actions by consumers or by production firms.

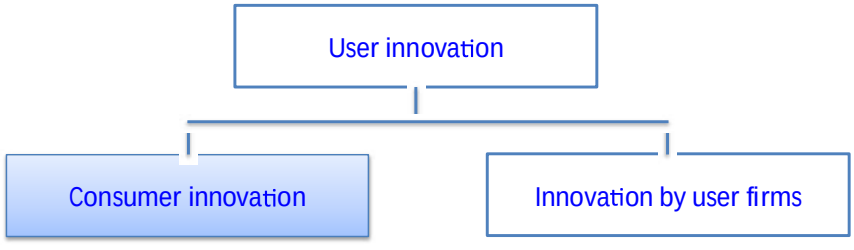

Figure 1. User innovation by businesses and consumers.

Evolving innovation theories suggest that goods and service development in firms is becoming a more open activity. For instance, the open innovation paradigm is based on the idea that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as firms look to advance their

[18] Social media can be defined as “a group of Internet-based applications that build on the ideological and technological foundations of Web 2.0, and mobile and web-based technologies to create highly interactive platforms through which individuals and communities share, co-create, discuss, and modify user-generated content.” Kaplan Andreas M., Haenlein Michael (2010). "Users of the world, unite! The challenges and opportunities of social media". *Business Horizons* 53 (1), p. 61.

technology and services (see Chesbrough 2006). The idea of the distributed nature of knowledge and innovation activities is shared by the user innovation paradigm (von Hippel 2005). Open and user innovation paradigms highlight a clear difference from previously dominant thinking that centred on firms and their internal R&D. Now it is recognised that innovations can originate in many sources often outside enterprises. Thus, it is important that firms have capability to effectively mobilise outside actors and utilise their contributions in their R&D&I processes. Such capability is increasingly seen as a way to succeed in innovation-driven competition.

In this new landscape characterised by distributed innovation, consumers are also active innovators. Recent research indicates that Finnish consumers do play a significant role in the development and modification of goods (Kuusisto, de Jong, Gault, Raasch & von Hippel 2013), not only for their own personal use but also as an important source of innovations for consumer goods companies (summarised in von Hippel 2005). Users who develop consumer goods for their own use have also been found to be an important source of new start-up firms (Shah and Tripsas 2007). Thus, consumer innovation diffusion can work in three ways; peer-to-peer sharing, adoption by a producer firm or new venture creation (Gault 2012).

For the purposes of this paper, user innovation is defined as follows. *'Users' are firms or individual consumers that expect to benefit from using a good or a service (von Hippel 2005:3). 'User innovation' happens when users invent novel goods or services or significantly modify existing ones.*

More specifically, the three main features that distinguish user innovation from traditional, producer-centred innovation are:

- *How the innovator benefits from the innovation*. User innovators expect to benefit from using an innovative good or service they have developed, while producer innovators benefit from selling innovative goods and services

- *Type of knowledge involved and resulting innovations*. User innovators have the advantage of knowing precisely what they want, as they possess superior information regarding their own needs. Producers rely on market research and cooperation with users to get information on unsatisfied user needs. In practice, this task is very difficult. Estimates of the failure rate of product innovations range from 75% to 90% (Cooper 2003).

- *Diffusion mechanisms and motivations are different*. While producers expect to benefit from their innovations by selling or licensing them, user innovations are primarily developed for personal use, so broad diffusion is not an objective as such.

In a review of users as innovators, Bogers et al. (2010: 866) suggest that there is "significant scope to develop a theory of why users innovate". This applies to consumer innovators as well as firms that act as user innovators, and both of these will be addressed in the following sections discussing the two surveys that were

carried out in Finland (Kuusisto, de Jong, Gault, Raasch & von Hippel 2013; Niemi and Kuusisto 2013).

8.2 Policy responses to evolving innovation activities

The importance of open innovation and user innovation is increasingly recognised and has implications for innovation management and innovation policy-making as well. In 2010, the Finnish Ministry of Employment and the Economy launched a specific policy programme to analyse and stimulate demand and user-driven innovation (Ministry of Employment and the Economy 2010). Measuring and statistical evidence are particularly important for such an emerging policy area. This article contributes to this Finnish policy initiative by exploring the scope, intensity and diffusion of user innovation among Finnish businesses and consumers.

Demand and the user-driven innovation policy framework in Finland

The core of the Finnish demand and user-driven policy thinking is summarised in Figure 2, which presents the various roles and functions that users play in innovation activities (Kuusisto, de Jong, Gault, Raasch & von Hippel 2013).

The right side of Figure 2 depicts user innovations and their commercialisation by producer businesses or via new start-up ventures. Diffusion of user innovation can also take place through an increasing number of intermediaries or through free sharing within user communities. The strength of user innovations lies in the fact that users create solutions to meet own specific needs. They can thus be creative without the limitations that commercial producers face in their innovation activities, such as the small size of the existing market. As a result, users often create entirely new functionalities and pioneering solutions that are unavailable on the markets. They may also modify products and services in ways that sometimes can lead into radical innovations or find new uses for existing products. Typically, user innovators have a varying degree of interest in commercialising their innovations. Still, user-created innovations represent significant potential due to their sheer volume and the specific characteristics described above.

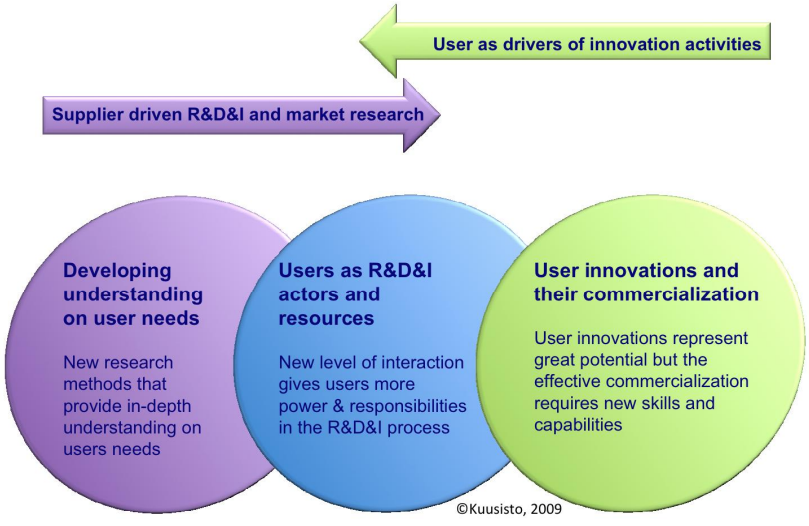

Figure 2. Manifestations of user-driven and user innovation.
Source: Kuusisto et al. (2013).

Users can be an extremely important resource and co-creators in the development of products and services for both businesses and the public sector. This is highlighted in the middle section of Figure 2, which depicts *users as dynamic actors and/or a resource in innovation processes*. Such a situation reflects increasingly open innovation activities among producer businesses. The users' role in the development process very much depends on the producer's goals, expertise and the type of innovation pursued. Innovation activities characterised by strong user interaction are commonly called *co-creation*. Genuine co-creation is quite different from a situation where the users' role is limited to offering 'free' resources to the producer. In the content producer role, users may have a more or less active role as innovators. In many social media based business models, the users' role is limited to content production only, with very limited room for innovation activities.

The circle on the left in Figure 2 points to utilisation of user information and rapidly increasing user data, aimed at achieving a more in-depth understanding of user needs. This approach is closest to traditional market research and closely connected with new product and service development. The number of affordable tools and methods in this area is proliferating due to new technologies. The Internet and mobile technologies provide global access to micro level data on individual behaviour patterns. This vastly improved access to detailed data is creating unprecedented new opportunities for marketing and business intelligence.

Moreover, it has created opportunities to pursue data-driven innovation that is now emerging largely because of new affordable data capture and processing technologies. These have made it easier and cheaper to collect, store, analyse,

use and disseminate data. Yet many organisations have been slow to adopt these technologies, even if the vast potential for data-driven innovation is increasingly understood. Innovation policy has the task of spurring data-driven innovation in both the public and private sectors, including supporting the development of human capital, encouraging the advancement of innovative technology and promoting the availability of data for users to use and reuse (Castro and Korte 2013).

In summary, all the three aforementioned types of user-centred innovation are making an increasing impact on business, communities and the public sector. It is evident that these fundamental changes will require new thinking in the innovation policy context and measuring of innovation activities, which we will address next.

8.3 Importance of new user innovation indicators

Until recently, user innovation by consumers and businesses remained almost unknown territory, as indicators and measuring have focused on more traditional forms of innovation. Typical measurement includes innovation inputs such as R&D expenditure, and output indicators such as patents obtained and levels of sales of new products developed. In this section, we discuss the measurement of consumer innovation, including indicator development for innovation inputs and outputs. Since individual consumers develop and modify products that they use in their daily lives, indicators used for measuring firms' innovation activities are not suitable for consumer innovation. For instance, consumers hardly keep a record of 'R&D expenditure', and in most cases they do not apply for patents or report sales of new or improved products / services. Most consumers do not seek any income from the products they have developed, and they may have limited motivation to share their knowledge with peers, intermediary organisations or producers. All this implies that there is a need to develop new indicators and measurement methodologies that can capture the nature, intensity and diffusion of consumer innovations (Kuusisto, de Jong, Gault, Raasch & von Hippel 2013).

Nature and importance of consumer innovation

Innovation by consumers represents a significant but almost unknown element of innovation that exists everywhere in society. While innovation by consumers concerning goods and services has existed in various forms for very long time, new technologies such as the Internet have given a significant boost to consumer innovation and increased its diffusion potential. Consumer innovation is a highly distributed and democratic activity, closely linked to our everyday lives. Increasing innovation activities by consumers are changing the traditional view where only few genius individuals and firms innovate.

Due to the lack of research on the subject, the scope and nature of consumer innovation is not well known. However, researchers and policy-makers in the USA,

the UK, Netherlands, Japan and Denmark (see von Hippel et al. 2010), among others, have begun to take an interest in finding out about the scope, intensity and diffusion of consumer innovation. In 2010, the Finnish Ministry of Employment and the Economy launched a dedicated policy program to analyse and stimulate demand and user-driven innovation (Ministry of Employment and the Economy 2010).

8.4 Measuring of consumer innovation in Finland

The Finnish survey on consumer innovation supports the Ministry's policy programme and builds on recent work in the UK (von Hippel et al. 2012), the Netherlands (de Jong 2011a), Japan and the USA (Ogawa & Pongtalenert 2011). Besides measuring the frequency of innovation by Finnish consumers, the survey explored the diffusion of innovations for the benefit of society at large. This is critical from the social welfare perspective, because it is diffusion that enables society to benefit from consumer innovations.

Definition of consumer innovator

Earlier, 'user' and 'user innovation' were defined as follows. 'Users' are firms or individual consumers that expect to benefit from using a good or a service (von Hippel 2005:3). 'User innovation' happens when users invent novel goods or services, or modify significantly the existing ones. In the case of consumer innovation, the above definition is further elaborated. In order to qualify as consumer innovation, new or improved goods / services need to be developed during the respondent's leisure time. As with any other innovations, consumer innovations need to have sufficient novelty value. In other words, home-built versions of existing products and services – unless they involve significant improvement – do not qualify as consumer innovation.

Methodology of the Finnish consumer innovation survey

As reported by Kuusisto, de Jong, Gault, Raasch & von Hippel (2013), in Finland consumer innovation research was carried out in two iterative cycles of data collection and reporting. The first cycle (December 2010 – November 2011) was mainly aimed at improving the consumer innovation measurement methodology. This pilot cycle built on previous consumer surveys (UK, Netherlands, Japan, USA) and further developed indicators and survey scripts aimed to identify innovators in broad consumer samples. At the next stage, these scripts were tested in a range of telephone and Internet surveys of Finnish citizens. The resulting refined screening procedure was then utilised in the second cycle in tracing innovating consumers. The aim was to test how well an online survey works in comparison to

telephone surveying. The comparative analysis indicated that the procedure developed works best with telephone surveys but may also be applied in an electronic format.

The second cycle (December 2011 – March 2013) was the main phase of the consumer innovation measurement project where three electronic surveys of Finnish citizens were conducted:

1. Survey 1 includes a representative sample of 993 Finnish consumers in the age group 18 to 65. It utilised the screening procedure developed to identify respondents who had realised at least one qualified user innovation within the past three years.
2. Survey 2 targeted 1,055 Finnish consumers who were considered potential user innovators. The past research results accumulated a profiling of potential consumer innovators, who are more likely to be highly-educated males with a technical background. Open invitations were sent to the members of several relevant professional unions (engineers, architects, highly educated, manufacturing/blue collar workers) to take part in the electronic survey. The survey script was nearly identical with the one in the first survey. In both, the analysis focused on specific innovation cases that respondents had identified and described. Combining both surveys, complete responses were obtained for 176 validated consumer innovations.

New consumer innovation indicators

Consumer innovation activities are not only distributed across the population but also cover a huge range of goods and services. Based on findings from earlier surveys (Flowers et al. 2010; de Jong et al. 2011b; Ogawa & Pongtanalert 2011), the questions focused on seven key areas in the recent survey. To start with, the respondents were asked: *'In the past three years, did you ever use your leisure time to create something of your own' (yes/no).* If the response was yes, the survey focused on the following seven areas.

1. Household fixtures and furnishing, such as kitchenware and cooking utensils, cleaning devices, lighting, furniture, etc.
2. Transport or vehicle-related products, such as cars, bicycles, scooters or anything related
3. Tools and equipment, such as utensils, moulds, gardening tools, mechanical or electrical devices, etc.
4. Sports, hobby and entertainment products, such as sports devices or games.
5. Children's and education-related products, such as toys and tutorials
6. Help, care or medical products
7. Any other products or applications?

The questions that followed probed the respondent's motives for developing novel solutions, collaboration in the development work, investment in the development in

terms of time and money, IPR protection, revealing of the invention, actions taken to diffuse the invention, and various paths for the diffusion (see Table 1).

Table 1. Consumer innovation survey key questions and indicators.

Indicator	Description	Values
(population level - indicators on the share of innovators in a broad population)		
Innovator	Respondent created a user innovation in past three years	0 (no); 1 (yes)
Innovation object	Innovation was concerned with…	
	…computer software	0 (no); 1 (yes)
	…household fixtures or furnishing	0 (no); 1 (yes)
	…transport or vehicles	0 (no); 1 (yes)
	…tools or equipment	0 (no); 1 (yes)
	…sports, hobby or entertainment	0 (no); 1 (yes)
	…children or education	0 (no); 1 (yes)
	…help, care or medical products	0 (no); 1 (yes)
	…other products or applications	0 (no); 1 (yes)
(innovation level - indicators related to specific reported innovations)		
Motives	Innovation was created for…	
	…personal need	0-100 points
	…to sell or make money	0-100 points
	…to learn or develop own skills	0-100 points
	…to help other people	0-100 points
	…the fun of doing it	0-100 points
Collaboration	Innovation was developed in collaboration with others	0 (no); 1 (yes)
	Average number of collaborators	No. of collaborators
Investment	Estimated time investment to develop the innovation	No. of person-days
	Estimated money investment to develop the innovation	Amount of money
Protection	Innovation was protected with any intellectual property right	0 (no); 1 (yes)
Revealing	Respondent willing to freely reveal the innovation…	
	…to all	0 (no); 1 (yes)
	…selectively	0 (no); 1 (yes)
	Respondent willing to reveal for compensation…	
	…to all	0 (no); 1 (yes)
	…selectively	0 (no); 1 (yes)
	Respondent employed activities to inform others about the innovation	0 (no); 1 (yes)
Diffusion	Innovation commercialized via new venture creation	0 (no); 1 (yes)
	Innovation transferred to commercial producer	0 (no); 1 (yes)
	Innovation adopted by others via peer-to-peer sharing	0 (no); 1 (yes)
	No diffusion of the innovation	0 (no); 1 (yes)
Diffusion intentions	Respondent has intentions to…	
	…commercialize the innovation via new venture creation	0 (no); 1 (yes)
	…transfer the innovation to a commercial producer	0 (no); 1 (yes)
	…have others adopt the innovation via peer-to-peer sharing	0 (no); 1 (yes)
	…not diffuse the innovation	0 (no); 1 (yes)

The following sections mainly focus on the survey results describing the consumer innovation incidence level and diffusion rate in Finland. Other survey themes and questions presented in Table 1 are discussed in detail in the recent report 'Consumer Innovation in Finland – Incidence, Diffusion and Policy Implications' by Kuusisto, de Jong, Gault, Raasch & von Hippel (2013).

Consumer innovation survey analysis and key results

The survey analysis indicates that *5.4%* of Finnish consumers aged 18 to 65 had engaged in innovation for personal need during the past three years (2009–2012). More precisely, these citizens had created at least one new item for their personal use to fix an everyday problem or to improve an existing good or service. With a population of 3,197,037 citizens aged 18 to 65 (source: Statistics Finland), the estimated total number of consumer innovators in the Finnish population is around 172,640 individuals. Arguably, such a number of active consumer innovators represents a significant level of innovation activities not recorded in official surveys. Moreover, this estimate of the number of consumer innovators does not include elderly citizens and those who were aged under 18 at the time of the survey. Until recently, such consumer innovation could be considered dark matter, unmeasured and impossible to include in economic or policy-making analyses.

Table 2 presents an international comparison of the percentage of consumer innovators in Finland, the UK, Netherlands, the USA and Japan. It shows that Finland is more or less on a par with other countries – the 95% confidence interval ranges from 4.0% to 6.8% (representing 127,900 to 217,800 individuals).[19] Thus, as in other countries, design and development of applications by consumers themselves is fairly widespread and independent of producer involvement.

Table 2. Frequency of user innovation in broad samples of consumers.

Source	Country	Year	Sample	Frequency
von Hippel et al. (2012)	United Kingdom	2009	1,173 consumers ≥ 18 years	6.1%
de Jong (2011a)	Netherlands	2010	533 consumers ≥ 18 years	6.2%
Ogawa & Pongtanalert (2011)	USA	2010	1,992 consumers ≥ 18 years	5.2%
Ogawa & Pongtanalert (2011)	Japan	2011	2,000 consumers ≥ 18 years	3.7%
Kuusisto et al. (2013b)	Finland	2012	993 consumers of 18-65 years	5.4%

In terms of the nature of innovations, Finnish consumer innovators report a wide variety of novel solutions ranging from tools and equipment to household fixtures and furnishing, to sports, hobby and entertainment (see Table 3). These three categories represent the most common types of consumer innovations, each covering close to 20% of all qualified innovations in the survey.

[19] Note that surveys in other countries also included individuals aged over 65. In Finland, we only sampled persons aged 18 to 65. If we re-estimate the percentage of consumer innovators in the UK and the Netherlands for the same age group, the figures are 6.3% and 6.8%, respectively. Again, these numbers are not significantly different from the Finnish estimate.

Table 3. Categories of consumer innovation in Finland.

Object	Freq.
tools & equipment	20,00%
household fixtures & furnishing	20,00%
sports, hobby & entertainment	17,00%
food and clothes	12,00%
transport & vehicle	11,00%
help, care & medical	7,00%
computer software	6,00%
children & education	4,00%
other	3,00%
total	100%

Innovations related to food and clothes, transport and vehicles were reported in just over 10% of the responses. Consumer innovators are also active in areas such as help and medical care, computer software, children and education.

Cross-country comparison of the demographic profiles of consumer innovators shows some variation, but there are also common themes. For instance, the frequency of innovation by consumers is higher for males, for those with a high educational attainment and for those with a technical training or job (von Hippel, Ogawa & de Jong 2011). These general patterns in consumer innovation demographics are also found in Finland.

Table 4. Demographic profiles of consumer innovators.

Incidence rate	UK (n=1173)	USA (n=1992)	Japan (n=2000)	Finland (n=993)
General	6.1%	5.2%	3.7%	5.4%
Highly educated (master's or bachelor's degree)	8.7%	8.9%	3.7%	7.7%
Technical job or business	12.0%	8.0%	4.2%	8.8%
Male	8.6%	5.9%	4.9%	6.3%

In the Finnish survey, consumers were also asked to indicate the importance of their motives to innovate. In the case of their most recent innovation, respondents were asked to score these on a 100-point scale (Table 5). Given the nature of consumer innovations where people essentially develop solutions for themselves, it was no surprise that personal need was most important motive. Fun, helping and learning were also significant motivators. Very few respondents reported an interest in commercialising their innovation at the time they developed it.

Table 5. Motivation to innovate among Finnish consumer innovators.

Motive	Importance
Personal need	51
Enjoyment	20
Helping other people	13
Learning/develop skills	12
Sell/make money	3
	100

Notes: Numbers based on 176 validated consumer innovations.

There are also cases where consumers innovate for other reasons than their personal need. While solving their own problem, they may realise that there is an opportunity to commercialise their innovation. While commercialisation is not a primary driver, it may create an additional spur for a consumer innovator (Shah & Tripsas 2007). For some consumers, the motivation to innovate is partly based on their willingness to learn or develop their skills or to help other people who are facing similar problems (usually people to whom they have strong ties, such as relatives and friends). Furthermore, there are consumers who engage in innovation for the sheer joy of tinkering and creation of new things (Lakhani & Wolf 2005; Raasch & von Hippel 2013).

Percentage of consumer innovations developed in collaboration with other people

There are several reasons why consumers may need help or collaborative efforts to realise an innovation. Usually collaboration involves relatives and friends, but consumer innovators may also seek help from their business network or rely on a club or community they belong to. The survey at hand indicates that innovation-related collaboration is more common in Finland than in other countries (Table 6). Almost 29% of the validated innovation cases in Finland were developed with others, while in the UK, the USA and Japan the figure was around 10%.

Table 6. Consumer innovators who collaborated in realising their innovation.

Source	Country	Year	Sample	Frequency
von Hippel et al. (2012)	United Kingdom	2009	104 consumer innovations	10.3%
Ogawa & Pongtanalert (2011)	USA	2010	114 consumer innovations	11.0%
Ogawa & Pongtanalert (2011)	Japan	2011	83 consumer innovations	8.0%
Kuusisto et al. (2013b)	Finland	2013	176 consumer innovations	28.3%

Further on, respondents were asked how many other people had made a contribution and what kinds of people were involved in the innovation process. On average, 0.6 persons in addition to the respondent were involved in consumer innovations. In cases where the innovation resulted from collaborative efforts, the aver-

age number of contributors (beyond the respondent him/herself) was 2.0. Overall, the number of collaborators ranged between 1 to 6 persons.

Of all collaborators, 78% were personal friends and/or relatives of the respondent. In 16% of the cases, help was received from business contacts or commercial producers. It was interesting to find contributions from producers in the case of innovations developed by consumers in their leisure time. These cases clearly indicate that producer innovators can, at least occasionally, provide effective support for the development of consumer innovations. Finally, a further 16% of the external contributors were members of a club or web community that the respondent belonged to. In this case, the club/community was usually concerned with developing similar innovations as its main pursuit (88%).

The findings suggest that in Finland consumer innovators are more engaged in collaborative activities than in the countries compared. Overall, the open collaborative mode of innovation is becoming increasingly important, compared to the more classic case of individual user innovators (Baldwin & von Hippel 2011). In the Finnish case, there are several possible explanations for this. For instance, Finnish culture may be less individualistic than that of the other countries. It may also be that Finnish respondents are more inclined to give credit for their innovation to other people. The Finnish population is also relatively well-educated and may be more inclined to mobilise others in joint innovation efforts.

Diffusion of consumer innovations

This section presents the survey results concerning the diffusion of consumer innovations in Finland. Diffusion is one of the key concepts of the innovation debate. From the societal point of view, diffusion of innovations is critical as it is necessary in delivering the innovation-related welfare gains to society at large. Conceptually, diffusion is the process by which an innovation is communicated through certain channels among the members of a social system over time (Rogers 2003).

As indicated earlier in this article, novel goods and services invented by consumers can be considered innovations once they become available to the markets and for the benefit of society at large. This is the baseline argument that the following survey results build on. There are three main ways by which diffusion of consumer innovations can happen:

- From peer to peer: Users may reveal their innovations to others for inspection, copying and adoption without charge, so that innovations are diffused peer to peer.
- Through new venture creation: Innovating consumers may start a new business to introduce a commercial version of their innovation to the market.
- By producer adoption: Commercial producers may adopt users' innovations to further improve and sell them as commercial products.

Table 7 shows that 19% of the validated innovation cases did spread to other economic actors, whereas 81% did not diffuse at all. In other words, vast majority of innovations developed by the Finnish consumers did not bring benefit for the wider society.

Table 7. Diffusion of consumer innovations in Finland.

Type of diffusion	Percentage
Of any kind	19.0%
Commercially	6.0%
- New venture creation	1.8%
- Adoption by commercial producers	5.5%
To peers	15.7%

In Finland, peer-to-peer sharing represents the major diffusion route, applying to 16% of consumer innovations. Typically, such sharing involves relatives and friends of the innovator. In addition, sharing may take place between members of a club or community to which the innovator belongs. Commercial producers adopted consumer innovation in about 5% of the cases; fewer than 2% of consumer innovations were realised through new ventures.

International comparison between Finland, the UK, the USA and Japan shows that sharing of consumer innovations varied between 5% to 19% of reported innovations. In the UK (17.1%) and Finland (18.8%) sharing is on roughly same level, while in the USA (6.1%) and Japan (5.0%) the level of shared innovations is considerably lower (see Table 8).

Table 8. Diffusion of consumer innovations in various countries.

Source	Country	Year	Sample	Frequency
von Hippel et al. (2012)	United Kingdom	2009	104 consumer innovations	17.1%
Ogawa & Pongtanalert (2011)	USA	2010	114 consumer innovations	6.1%
Ogawa & Pongtanalert (2011)	Japan	2011	83 consumer innovations	5.0%
Kuusisto et al. (2013b)	Finland	2012	176 consumer innovations	18.8%

Notes: Percentages indicate what fraction of innovations has been diffused to peers or commercial producers. New venture creation as a diffusion mechanism is not included as benchmark data for other countries are not available.

The results show that more than 80% of all consumer innovations do not become available to society at large, indicating a potential welfare loss. However, the amount of welfare loss is debatable, because not all consumer innovations have potential value beyond the inventor himself/herself.

Table 9. Perceived value of consumer innovations.

	The innovation worked for me, it solved my personal need	The innovation was valuable to me
barely or not	3%	10%
somewhat	12%	34%
highly	43%	37%
perfectly	41%	20%
	100%	100%

In the sample of 176 validated Finnish consumer innovations, most innovators indicated that their creations had some personal value (Table 9). Only 3% of the innovators indicated that the innovation did not solve their personal need, while 10% denied it being valuable to them. From the social welfare point of view, the key issue is whether consumer innovation holds value for the inventor or for a much wider group of people. The four indicators in the survey were used in determining the value of consumer innovations for society at large. They include the following self-assessing statements by the consumer innovators. This innovation:

- ...helps other people to save money
- ...enables people to do new things
- ...would be valuable to others (many or nearly all)
- ...can become a valuable commercial product (to a reasonable/ substantial market)

In terms of the broader value of consumer innovations, the analysis shows that around 5% (5.4%) of Finnish consumers are engaging in innovation. This group includes those 2% (2.1%) of consumers who are developing innovations that are likely to be valuable only for themselves. About 2.5% (2.4%) of consumer innovators consider that their novel solution might be valuable to some other people. Finally, about 1% (0.9%) think that their innovation might be of value to many other people.

The third condition for the diffusion of innovation is the consumer innovators' willingness to share their novel solution with others (Table 10). A total of 85% to 90% of the respondents were willing to share their innovation for free or against some compensation.

Table 10. Finnish consumers' willingness to share their innovation.

Variable/value	Percentage
Willingness to share for free	
No	16%
yes, selectively	40%
yes, with everyone	44%
Willingness to share for compensation	
No	9%
yes, selectively	23%
yes, with everyone	68%

The Finnish consumer innovation survey analysis supports earlier research-based assertions that user innovators tend to share their innovations for free. Free revealing implies that user innovators voluntarily give up their potential intellectual property rights and share the details of their innovation with anyone interested so that the information becomes a public good (Harhoff et al. 2003). Practices in open-source software development were important in bringing this phenomenon to general awareness.

Table 11. Efforts to diffuse consumer innovations.

Source	Country	Year	Sample	Frequency
von Hippel et al. (2012)	United Kingdom	2009	104 consumer innovations	28.9%
Ogawa & Pongtanalert (2011)	USA	2010	114 consumer innovations	18.4%
Ogawa & Pongtanalert (2011)	Japan	2011	83 consumer innovations	10.8%
Kuusisto et al. (2013b)	Finland	2012	176 consumer innovations	26.7%

Notes: Percentages indicate what fraction of innovators has done any effort to inform others about their innovation

In addition to general value and willingness to reveal discussed above, diffusion only occurs if consumers actually make the effort to inform others about their innovation (Table 12). In comparison to other countries, Finland is on a par with the UK and actually doing better than the USA or Japan in terms of consumers' active efforts to diffuse innovations. Nevertheless, only about one out of four validated innovation cases were reported as being revealed to others.

Looking at the survey results from innovation policy point of view, the slow diffusion rate is an interesting finding. Even if the majority of innovations have value to (at least some) others and attitudes towards revealing are positive, only few innovating consumers actually did something to initiate the diffusion process. From the policy point of view, such insufficient diffusion of innovations might require interventions. From the user innovators' point of view, a low level of diffusion efforts is only logical, since they primarily innovate to satisfy their personal needs.

A producer innovator's motivation to diffuse innovations is based on earning potential through selling or licensing. The motivation to diffuse innovation is not so clear in the case of user innovators. Once the innovation has solved their own problems, all benefits from diffusion-related activities tend be an externality. Since many consumer innovators have little to gain from wider adoption of their innovation, they tend to lack motivation for diffusion efforts. As a result, many innovations with potential broad use value remain available only the innovators themselves. Consequently, in the case of consumer innovation, insufficient diffusion forms a major bottleneck.

Table 12. Consumer innovators' actions to inform other about their innovation.

Type of activity	Percentage
Revealed the innovation to relatives/friends, showing it off	69%
Posted its design on the Web	26%
Showed the innovation to a business/entrepreneur	24%
Spend time/money to help others adopt it	5%
Developed a manual	7%
Other	2%

Notes: Percentages indicate the percentage of innovators undertaking any diffusion efforts at all (48 innovators out of 176).

The survey included specific questions on what the consumer innovators had done to inform others about their novel solution. The most common activity was to show the innovation to relatives or friends. However, some innovators undertook efforts for broader diffusion of their innovation. They might publish the design on the Internet or demonstrate its benefits to a commercial supplier in the hope that they would take it up for further improvements and make it available for a wider market. Hardly any of the surveyed consumer innovators invested money in the diffusion process or made any significant effort to further the diffusion of their innovation.

8.5 Measuring user innovation activities by Finnish business enterprises

While consumer innovation measurement is still in its infancy, the Community Innovation Survey (CIS) is a well-established and Eurostat-managed survey on innovation activities by businesses. However, even with the CIS, measurement of user innovation activities is only just beginning to take shape. These early encouraging steps are reported in the following sections.

Piloting of a new module in Community Innovation Survey

User innovations or user innovators are not explicitly targeted in the core part of the CIS. However, some of the CIS core questions and variables provide useful proxy information that allows us to learn about the users' role in the innovation process. The CIS includes questions on information sources and co-operation in innovation activities covering possible users as options, and results have indicated that clients, for instance – as possible users as well – are principal sources of information for innovation activities, and they are also leading collaborators in the innovation activities of enterprises. However, CIS questions on the developers of

product and process innovations do not cover private consumers as potential developers of innovations.

It is increasingly being realised that users represent significant innovative potential. This applies to all users, whether private consumers or enterprises. However, existing innovation surveys provide very limited information on user innovation activities and their potential.

The potential and increasing importance of user innovation is now recognised as relevant in the innovation policy context. As a result, there is also increasing pressure to generate measuring-based evidence showing to what extent enterprises are making use of user information and user innovations in their innovation activities and in the production of their innovative products.

In order to generate user innovation data, Statistics Finland integrated new questions on users and user innovations into the CIS 2010 innovation survey. As a result, the CIS for the first time explicitly mapped user innovation as a part of the innovation activities of enterprises over the three-year period 2008–2010. The new question addressed the frequency and the importance of user information, co-creation of innovations with users and commercialisation of user innovations by enterprises. The objective was to gather information on how enterprises are incorporating users, user information and user innovations into their innovation activities. The second aim was to find out how important these activities were for respondent firms.

The research on user innovations is still in its early stages, and one important area for further research – possibly an issue for policy measure as well – is understanding the dynamics of the transfer of user information and especially user innovations from the developer to wider use and utilisation. One of the diffusion channels for user innovations is through commercialisation by established enterprises.

The enterprise innovation survey may prove a useful and necessary tool for surveying the importance of user innovations. For instance, in their review of users as innovators, Bogers et al. (2010; 866) suggest that there is "significant scope to develop a theory of why users innovate". In order to do this, it is necessary to measure and collect data on users' innovation activities by firms and by consumer innovators. Although it is not the main research focus with consumer innovations, an enterprise survey might be used for tracing to what extent enterprises utilise information from users and play a role in diffusing consumer innovations and related information to a wider community.

Current coverage of CIS questions

The European Community Innovation Survey has been running in two-year cycles since the 1990s.[20] The survey is carried out within the EU Member States and also

[20] http://epp.eurostat.ec.europa.eu/portal/page/portal/science_technology_innovation/data/main_tables
http://epp.eurostat.ec.europa.eu/cache/ITY_SDDS/en/inn_esms.htm

in some EFTA countries and EU candidate countries. The implementation of the CIS is based on a standardised core questionnaire developed by Eurostat in close cooperation with the Member States. The survey follows harmonised methodology, and an EU regulation specifies the CIS as mandatory for the Member States.[21] The concepts and underlying methodology are based on the Oslo Manual.[22]

The objective of the CIS is to provide information on the frequency of innovation activities and to find out the main characteristics of this activity. The results describe the percentage of surveyed enterprises that have carried out innovation activities, i.e. introduced or implemented innovations or engaged in activities with the aim to implement innovations. The survey further explores what types of activity or what measures enterprises have adopted in order to carry out innovation activities, i.e. what elements the activities consist of.

During a given three-year period under consideration in the CIS, three kinds of innovation activity may be identified:

- successful, having resulted in the implementation of an innovation (although the innovation need not have been commercially successful);
- on-going, with work in progress that has not yet resulted in the implementation of an innovation;
- abandoned before the implementation of an innovation.

The survey comprises mandatory core questions and rotating questions responding to which is partly voluntary. Since CIS 2008, the survey has included an ad-hoc module – a set of questions focusing on a topical special theme.[23]

The EU has defined the mandatory core industries to be covered by the CIS, but Member States may also cover other industries in their surveys. The core industries include mining and quarrying, manufacturing, electricity, gas and air conditioning supply, water supply and waste management and the following service industries: wholesale trade (except of motor vehicles and motorcycles), transportation and storage, industries within information and communication, financial and insurance activities, technical testing and analysis, scientific research and development and advertising and market research.

The aggregated results can be found in Eurobase, and the survey results are used as a material for compiling several publications such as the European Innovation Scoreboard and Regional Innovation Scoreboard as well as OECD publications, to name but a few.

The Finnish CIS complies to a great extent with the EU standard questionnaire and its methodological recommendations. In addition, some national special fea-

---

http://epp.eurostat.ec.europa.eu/portal/page/portal/statistics/search_database

[21] Commission Implementing Regulation (EU) No 995/2012.

[22] Oslo Manual, Guidelines for collecting and interpreting innovation data, 3rd edition, OECD/Eurostat 200 5.

[23] Eco innovations in CIS 2008, Skills and Creativity in CIS 2010 and Strategies and Obstacles in CIS 2012.

tures and additions are included, albeit they tend to be minor ones. Overall, the survey is heavily regulated due to its mandatory status.[24]

The content of the Finnish CIS 2010, which also included a new question on user aspect, covered the following items:

- implementation of innovations;
- developers of product and process innovations;
- novelty of product innovations introduced to market and turnover from innovations;
- engaging in different innovation activities;
- innovation expenditure and public financial support;
- information sources and co-operation in innovation activities;
- hampering factors in innovation activities; and
- creativity.

Piloted new user innovation question

Based on the EU guidelines and model questionnaire, the content of the Finnish CIS 2010 was prepared during spring 2011. The question on user orientation was also developed at that time. It came to be well in line with the typology adopted in the Finnish Innovation Policy Programme by the Ministry of Employment and the Economy (2010) and draws on the research by Kuusisto & Kuusisto & Yli-Viitala (2013).

The phrasing of the question was extensive, because the question was asked for the first time and the intention was to cover the phenomenon broadly. The question was placed as the last one in the survey questionnaire and it was intended only for those enterprises that in earlier questions reported innovation activities. This was considered the most relevant target population for the inquiry of user innovation activities.

The pilot question, with three sub-questions on the user aspect, was as follows:

During the three years 2008 to 2010, which means and measures did your enterprise use to include customer and user orientation in your enterprise's innovation activities and in the production of your innovative products, and how significant were the means and measures used?

These questions on user innovation are shown in Table 12 in the format that was applied in the 2010 Finnish CIS survey. The first part focuses on the methods by which businesses seek to develop a better understanding of users and their needs. These include customer feedback systems, market studies, consumer panels, focus groups, interviews and various other alternative ways to research user needs, such as ethnography.

The second part of the question explores *the role of users as co-creators of innovations and new content*. Here, possible tools include development forums, platforms facilitating user ideas capture and other types of contributions, innova-

[24] Statistics Act (280/2004).

tive user communities, software and content production with users, and crowdsourcing activities. Such co-creation also refers to the idea of open innovation, as does the commercialisation of user innovations addressed in the third question.

The third question focuses on the core of user innovations by asking businesses about the adopting and commercialisation of user innovations. Here, 'user innovations' are assumed to include new and modified products developed by users. More specifically, the question includes cases where:

- Customers and users modified existing products, and the enterprise was responsible for further development, production and market introduction of the product.
- Customers and users developed a new product that the enterprise took into its production and introduced it in the markets.

The third user-innovation question in particular focuses on products rather than process and marketing innovations. This may somewhat limit the scope of user innovations captured by the survey. It is also possible that some respondents may not report service innovations by users. However, within the available limited space it was considered better to keep the focus on product innovations only.

Table 13. User innovation questions in the 2010 Finnish CIS survey.

Ways and modes of including customers and users in innovation activities and production of innovative products		Degree of importance			
		High	Medium	Low	Not used
Consideration of customer and user needs and of user information	Use of customer feedback systems	ρ	ρ	ρ	ρ
	Use of market studies, consumer panels, focus groups and interviews, etc.	ρ	ρ	ρ	ρ
	Surveying of user needs by research methods; examination of unconscious needs and other user observation by means of ethnographical, anthropological, need and use analyses, and interviews of use situations	ρ	ρ	ρ	ρ
Users as a resource of innovation activities; joint brainstorming, development and content production	Development forums and e.g. development platforms provided by the enterprise to collect ideas from users and user communities; software and content production, crowdsourcing, etc.	ρ	ρ	ρ	ρ
Products modified and developed by users and their commercialisation	Customers and users modified existing products, and your enterprise was responsible for the actual development, production and market introduction of the product	ρ	ρ	ρ	ρ
	Customers and users developed a new product that your enterprise took into production and introduced on the market	ρ	ρ	ρ	ρ

CIS pilot question results and key conclusions

Based on the results from the Finnish CIS 2010 altogether 56% of all enterprises in surveyed population reported innovation activities during 2008–2010.[25]

As regards the user orientation, altogether 80% of the enterprises with innovation activities reported having incorporated user information or engaging users – in a way or another and with at least some importance – in their innovation activities during the survey period. The majority of them estimated that the procedure was significantly or moderately important.

The survey results indicated that businesses use a variety of methods in acquiring user information for innovation purposes. Seven out of ten with innovation activities had utilised information received from customer feedback systems, and 50% of those that practised innovation activities reported that they had made use of information obtained from market surveys, consumer panels or similar means. More than one-third of enterprises had also used more scientific methods in ascertaining user needs.

In terms of the business population, exploitation of user information was slightly more common among service enterprises than manufacturing enterprises.

As with innovation activities in general, the exploitation of user information increases as the enterprise size grows.

The results indicated that users are an important innovation source and that a significant number of businesses were already involved in co-creation activities with users. One-third of the innovating enterprises had done so together with users by involving them directly in the search for ideas, in the development process itself and, say, in content production. Joint development activities with users may be realised by the use of development platforms, for instance. More than 17% of the enterprises with innovation activities considered co-development activities with users to be of high importance or medium importance. Joint innovation activities with users were somewhat more common among service businesses (38%) than manufacturing enterprises (28%). Joint development also increases as the enterprise size grows.

Utilisation of user innovations was well recognised among the surveyed businesses. About half (47%) of the enterprises with innovation activities reported that products modified by customers had been utilised in their innovation activities. Furthermore, around 30% of the innovating enterprises reported that they had made use of products developed by users. The results indicated that businesses recognised user innovations, and such innovations may represent important inputs in enterprises' innovation processes.

[25] A total of 46% of all enterprises engaged in innovation activities related to products and processes, and, for example, 33% of enterprises reported the market introduction of product innovations.

Table 14. Incorporation of users and user information in enterprises' innovation activities, methods and their importance, 2008–2010, percentage of enterprises with innovation activities.

Industry		Degree of importance			
		High	Medium	Low	Not used
		%	%	%	%
All NACE -	User needs and user information; customer feedback systems	20.1	31.3	17.1	31.5
Total	User needs and user information; market surveys, consumer panels, etc.	9.9	20.9	19.4	49.8
	User needs and user information; ascertaining unconscious needs and other user observation	6.2	16.7	14.4	62.7
	Joint development; e.g. development platforms for collecting ideas and producing contents	4.2	13.3	14.9	67.6
	Products modified by users, enterprise responsible for the production and market launch	8.0	21.7	17.2	53.1
	Products developed by users, enterprise responsible for the production and market launch	3.8	9.1	16.6	70.5
Manufacturing	User needs and user information; customer feedback systems	17.0	32.0	18.1	32.9
	User needs and user information; market surveys, consumer panels, etc.	7.4	19.2	19.7	53.7
	User needs and user information; ascertaining unconscious needs and other user observation	6.3	13.8	14.3	65.6
	Joint development; e.g. development platforms for collecting ideas and producing contents	3.6	10.2	13.7	72.5
	Products modified by users, enterprise responsible for the production and market launch	8.9	25.0	15.0	51.1
	Products developed by users, enterprise responsible for the production and market launch	4.9	10.3	17.7	67.1
Services	User needs and user information; customer feedback systems	23.3	30.5	16.1	30.1
	User needs and user information; market surveys, consumer panels, etc.	12.5	22.7	19.1	45.7
	User needs and user information; ascertaining unconscious needs and other user observation	6.1	19.7	14.4	59.8
	Joint development; e.g. development platforms for collecting ideas and producing contents	4.7	16.6	16.1	62.6
	Products modified by users, enterprise responsible for the production and market launch	7.1	18.3	19.5	55.1
	Products developed by users, enterprise responsible for the production and market launch	2.7	7.8	15.6	73.9

The results indicate that enterprises in manufacturing seem to be slightly more active in making use of user innovations than enterprises in surveyed service industries. Analysis of differences between industries would possibly reveal industry specific dynamics in innovation activities.

The results from innovation surveys indicate that, in general, innovation activities are more common in larger enterprises than in smaller ones. As regards the exploitation of user innovation among enterprises with innovation activities, the size of enterprise has relatively limited influence on the frequency of this measure.

Table 15. Incorporation of user innovations in enterprises' innovation activities, methods and their importance by industry, 2008–2010, percentage of enterprises with innovation activities.

	Products modified by users			Products developed by users		
	High importance	Medium importance	Low importance	High importance	Medium importance	Low importance
Manufacturing	8.9	25	15	4.9	10.3	17.7
Services	7.1	18.3	19.5	2.7	7.8	15.6

Table 16. Incorporation of user innovations in enterprises' innovation activities, methods and their importance by size category of personnel, 2008–2010, percentage of enterprises with innovation activities.

	Products modified by users			Products developed by users		
	High importance	Medium importance	Low importance	High importance	Medium importance	Low importance
10-49	8.1	22.5	15.7	3.7	9.1	16.1
50-249	6.8	21.1	19.2	3.9	9.4	16.9
250+	10.4	15.3	26.2	4.3	7.7	21.2

Table 17 illustrates that enterprises active in product and process innovation activities, especially in in-house R&D activities, are also making increasing use of user innovations. Enterprises with in-house R&D reported both products modified by users and products developed by users more commonly than enterprises with no in-house R&D.

Table 18 describes results indicating that the enterprises that reported product innovations also reported inclusion of user orientation much more often than enterprises that innovated without product novelties between 2008 and 2010. This is a logical result. The important observation was that the inclusion of user orientation was most common among enterprises that reported having launched new products on the market during the period under review.

Table 17. Incorporation of user innovations in enterprises' innovation activities, methods and their importance by type of innovation activities and conducting R&D, 2008–2010, percentage of enterprises with innovation activities.

	Products modified by users			Products developed by users		
	High importance	Medium importance	Low importance	High importance	Medium importance	Low importance
Innovation activities relating to products and processes, and in-house R&D	10.2	24.8	19.3	5	11.8	20.3
Innovation activities relating to products and processes, and no in-house R&D	4.6	19.8	12.6	1.5	5.3	12.8
No innovation activities relating to products and processes, and no in-house R&D	3.1	11.9	13.9	1.7	2.7	6.9

Table 18. Incorporation of user innovations in enterprises' innovation activities, methods and their importance by introduction of product innovations, 2008–2010, percentage of enterprises with innovation activities.

	Products modified by users			Products developed by users		
	High importance	Medium importance	Low importance	High importance	Medium importance	Low importance
Product innovations, new to the enterprise's market	13.7	27.4	19.1	7	11.5	21.1
Product innovations, only new to the firm	7.1	22.8	18.3	2.3	10.3	18.7
No product innovations	4	16.4	15	2.2	6.4	11.8

Conclusions on user innovation in Finnish enterprises

User innovation is a novel research topic especially in the statistical context, and this was the first time it was mapped in the CIS enterprise survey and in the context of innovation activities in enterprises. This was done particularly from the product-innovation point of view.

The phrasing of the new question was kept quite comprehensive, covering various types of approach from integration of user information and customer feedback to utilisation of products modified or developed by users. The terminology used was also intentionally broad, because the issue might be new to many respondents and not all are necessarily familiar with this new perspective or framework.

The aim was to provide information on the importance of user aspect, and possibly also identify measures that should be surveyed further and could increase our understanding of innovation dynamics. How are innovations – preferably successful ones – created? How are they developed? Which kinds of mechanism exist behind new stories?

User aspect may increase potential in this area

Based on common knowledge but also on the results from the Finnish CIS 2010, the role of user information seems to be important for enterprises in their innovation activities. In the light of the results we may summarise that co-creation and user innovations are also important resources for plenty of enterprises.

Some of the main findings from the survey can be described as follows:

- Utilisation and commercialisation of products modified or developed by users was more common in manufacturing than in surveyed service sectors;
- Integration of products modified or developed by users into production occurs with almost the same frequency among small and large innovating enterprises;
- Incorporation of user innovations was more common among enterprises with product innovations new to the market than among enterprises with

other innovation activities and innovations, and more common among enterprises with in-house R&D for product and process innovations than among other enterprises with innovation activities.

The findings of the CIS survey prompted a number of further questions such as:

- Are there cases where radical innovations are based on user innovations?
- Are actively innovating firms more capable of utilising user innovations?
- What characteristics are typical of the firms willing and capable to make use of user innovations?
- Can user innovations stimulate other innovation activities within the firm?

Another outcome of the Finnish CIS pilot was that Portugal and Switzerland also decided to add the same questions to their CIS 2012, along with two additional questions:

"During the three years 2010–2012, did your enterprise introduce new or significantly improved products (goods or services) that were partly or entirely developed by customers and users of the product? Y/N

"If yes, what per cent of the total corresponds to new or significantly improved products (goods or services) put on the market by your enterprise during the three years 2010–2012?"

Once further analysis of the statistical materials has been conducted, a more comprehensive view of the user's role in enterprise innovation will emerge.

Furthermore, it is worth considering whether it would be possible to modify some core elements of the CIS so that the questions would be better able to capture user innovation activities within firms. Referring back to the beginning of the chapter, the question probing the developers of product innovations does not include private consumers as an option. In this example, *own enterprise, other enterprises and institutions* are given as potential developers. It may be argued that the option 'Other enterprises or institutions' also includes private consumers. However, the first initial analysis of the Finnish data does not support this argument. When the linkage between the questions on user orientation and developers of innovations was tested, the result was negative.

In the case of product innovations, private consumers create an essential link towards what we call user innovations. Hence, adding a private consumer category in the innovation developer question is an option worth considering. The need for other, separate and specific questions on user innovations also has to be analysed. As with the innovation system itself, modes of innovation as well as sources of innovations are constantly evolving; it is only natural that innovation indicators and measuring should evolve along with the surrounding world.

8.6 Concluding comments on consumer innovation and user innovation in Finnish enterprises

The two surveys described above provided the first comprehensive and nationwide surveys of user innovation activities. While earlier studies on consumer innovation activities exist, these two Finnish surveys cover innovation activities among consumers as well as user innovation by Finnish businesses. Both studies made use of state-of-the-art survey methodologies and indicators drawing on the knowledge of the leading experts on the field – Professor Eric von Hippel, Professorial Fellow Fred Gault and Professor Jeroen de Jong in the case of consumer survey. At the same time, the business survey on user innovation was conducted in connection with the Finnish Community Innovation Survey 2010. Hence, it was able to utilise the expertise of Statistics Finland and the proven methodology of this major innovation survey.

The research results show that user innovation is a widespread phenomenon among businesses and consumers in Finland. On the population level, 5.4% of Finnish consumers aged 18 to 65 had engaged in innovation for a personal need during the past three years. These citizens created at least one new item for personal use to fix an everyday problem. The percentage of consumer innovators in Finland is not significantly different from comparable figures in other surveyed countries. The estimated total number of consumer innovators in the Finnish population is around 172,640. Such a group of active consumer innovators represents a significant volume of distributed innovation activities that until now has not been recorded in statistics at all. A particular feature of Finnish consumer innovation behaviour is the high level of collaborative activities. Almost 29% of validated innovation cases in Finland were developed in collaboration with others, while in the UK, the USA, and Japan this figure was around 10%.

User innovations and users' inputs into innovation process play a significant role in the business community. About half of the enterprises with innovation activities utilise products (goods or services) *modified by users* in their innovation activities. Furthermore, around 30% of the innovating enterprises reported that they had made use of products *developed by users*. One out of three innovating enterprises are involved in co-creation activities with users. Finally, 80% of the innovating enterprises have incorporated user information or users in their innovation activities – and consider that it is of some importance for them.

Taken together, the combined volume of user innovation activities in business and consumer sectors clearly indicates that these distributed innovation activities have implications for policy. It can also be argued that such a volume of distributed innovation activities represents a fundamental and rapidly evolving feature of the Finnish innovation ecosystem. However, knowledge in the area is still very limited, and the dynamics of the user innovation activities remain largely unknown territory for policy-making.

While consumer innovation intensity does not seem to pose a problem in Finland, the bottleneck seems to be in the area of diffusion. According to the analysis, only 19% of consumer innovations were diffused to the benefit of society at large, despite the fact that 61% of consumer innovators perceived that their innovation could deliver value also for society at large. The low diffusion rate is related to the fact that only a minority of consumer innovators made an effort to inform others about their innovation (27%). In this light, consumer innovation diffusion is a key area for further research. For instance, it is important better to understand consumer innovators' motivation to share their innovations and any bottlenecks that may hamper such diffusion. At the same time, it is important to understand the fundamentally distributed nature of consumer innovation and the implications that this has for the diffusion debate. In terms of indicator development, clear progress has been achieved. Still, it is clear that the characteristics and nature of consumer innovation require further development of indicators and measurement tools.

The CIS survey raises further questions relevant for the academic community as well as policy-makers. In the light of the initial analysis, innovations modified or developed by users may indeed deliver some value also for enterprises.

However, these results need to be analysed and interpreted carefully, as in the case of novel phenomena there is always a high risk of measurement errors. However, the results indicate that users may play a worthwhile role as innovators and that user innovations can be one type of source for innovative market production. In order to understand the dynamics of innovation activities and all aspects of the innovation creation process, it is very important to understand the various roles that users may take in the process. This requires much more work, further research on indicators and related new data collection, clear definitions and a number of other issues necessary in building up robust knowledge on this topic. Again, diffusion is a pivotal issue also in the case of user innovation in the business context. It is essential to develop knowledge on the issues that can catalyse or hamper diffusion, keeping in mind the full range of issues that are related to the diffused nature of user innovation in the business community.

References

Baldwin, C. & von Hippel, E. (2011). Modeling a paradigm shift: From producer innovation to user and open collaborative innovation. *Organization Science* 22: 6, 1399–1417.

Bogers, M., Afuah, A. & Bastian, B. (2010). Users as Innovators: A Review, Critique, and Future Research Directions. *Journal of Management*, Vol. 36, No. 4, July 2010, 857–875.

Castro, D. & Korte, T. (2013). Data Innovation 101: An Introduction to the Technologies and Policies Supporting Data-Driven Innovation. Washington DC: Center for Data Innovation.

Chesbrough, H. (2006). *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Boston: Harvard Business School Publishing.

Cooper, R. (2003). Profitable product innovation: the critical success factors. In: L. V. Shavinina (Ed.). *The International Handbook on Innovation*. Amsterdam, Boston: Elsevier Science. Pp. 139–157.

de Jong, J. P. J. (2011a). *Uitvinders in Nederland* (Inventors in the Netherlands). Research Report A201105. Zoetermeer: EIM.

de Jong, J. P. J. (2011b*). Identifying Consumer Innovators: A Five-step Survey Procedure.* Working Paper. Rotterdam: RSM Erasmus University.

Flowers, S., von Hippel, E., de Jong, J. & Sinozic, T. (2010). *Measuring User Innovation in the UK: The Importance of Product Creation by Users*. London: NESTA.

Gault, F. (2012). User innovation and the market. *Science and Public Policy* 39: 1, 118–128.

Harhoff, D., Henkel, J. & von Hippel, E. (2003). Profiting from voluntary information spillovers: How users benefit by freely revealing their innovations. *Research Policy* 32: 10, 1753–1769.

Kuusisto, J., de Jong, J., Gault, F., Raasch, C. & von Hippel, E. (2013). *Consumer Innovation in Finland: Incidence, diffusion and policy implications, Report of Development of Statistical Indicators of User Innovation in Finland (InFi) Project*. Proceedings of the University of Vaasa, Reports 189. Vaasa, Finland. http://www.uva.fi/fi/research/publications/orders/database/?sarja=8

Kuusisto, A., Kuusisto, J. & Yli-Viitala, P. (2013). Service development tools in action. *The Service Industries Journal*, Vol. 33, Nos. 3–4, 352–365.

Lakhani, K. R. & Wolf, B. (2005). Why hackers do what they do: Understanding motivation and effort in free/open source software projects. In: J. Feller, B. Fitzgerald, S. Hissam & K. R. Lakhani (Eds.). P*erspectives on Free and Open Source Software*. Cambridge: MIT Press. Pp. 3–22.

Ministry of Employment and the Economy (2010). *Demand and User-driven Innovation Policy – Framework (Part I) and Action Plan (Part II)*. Helsinki: Edita.

Niemi, M. & Kuusisto, J. (2013). The Role of the User in Innovation: Results from the Finnish Community Innovation Survey (CIS 2010) (May 23, 2013). Available at SSRN: http://ssrn.com/abstract=2269388

Ogawa, S. & Pongtanalert, K. (2011). *Visualizing Invisible Innovation Content: Evidence from Global Consumer Innovation Surveys* [Web document]. Available at: http://ssrn.com/abstract=1876186 or http://dx.doi.org/10.2139/ssrn.1876186.

Raasch, C. & von Hippel, E. (2013). Innovation process benefits: The journey as reward. *MIT Sloan Management Review* 55: 1, 33–39.

Rogers, E. M. (2003). *Diffusion of Innovations*. 5th ed. New York: Free Press.

Schumpeter, J. A. (1934). *The Theory of Economic Development*. New York: Oxford University Press.

Schumpeter, J. A. (1942). *Capitalism, Socialism and Democracy*. New York: Harper & Row.

Shah, S. K. & Tripsas, M. (2007). The accidental entrepreneur: the emergent and collective process of user entrepreneurship. *Strategic Entrepreneurship Journal* 1: 1–2, 123–140.

von Hippel, E. (2005). *Democratizing Innovation*. Cambridge: MIT Press.

von Hippel, E., de Jong, J. P. J. & Flowers, S. (2010). *Comparing Business and Household Sector Innovation in Consumer Products: Findings from a Representative Study in the UK* [Web document]. Available at: http://ssrn.com/abstract=1683503 or http://dx.doi.org/10.2139/ssrn.1683503.

von Hippel, E., Ogawa, S. & de Jong, J. P. J. (2011). The age of the consumer-innovator. *MIT Sloan Management Review* 53: 1, 27–35.

von Hippel, E., de Jong, J. P. J. & Flowers, S. (2012). Comparing business and household sector innovation in consumer products: Findings from a representative study in the United Kingdom. *Management Science* 58: 9, 1669–1681.

9. Investments in broader innovation

Olavi Lehtoranta

9.1 Introduction

One of the starting points for this project was the need for broader input indicators for innovation. This means input indicators for non-technological (non-R&D) innovation activities,[26] public-sector innovation activities and user and consumer innovation activities, just to mention the most important spheres of broader innovation. Impact indicators are also needed, and reference has been made to new indicators developed by the OECD, Eurostat and NESTA in the UK. If there are no indicators available in these new spheres of innovation, our perspective on innovation may remain too narrow. Surveys on user and consumer innovation have already been conducted, in Finland too, and also pilot surveys on public-sector innovation.

Our statement is that before sufficient knowledge is acquired for developing and implementing new input indicators for non-technological innovations, the existing measurements frames and surveys should be critically assessed. This is the essence of the present publication. Otherwise, respondents in companies and public organisations would not be able to follow the scheme of things, nor to understand why questions are being asked about long-term administrative expenses for business and organisation development. Existing accounting systems do not readily allow this information to be found.

In this chapter, we discuss long-term expenses for broader innovation conceptually. In this, we rely on the framework for intangible investment rather than on a weak understanding of what the innovation expenditure in the case of non-technological innovations should encompass. Even if we can define them conceptually, it is not clear how their measurement could be operationalised, i.e. implemented. It is not even clear enough what the existing statistical measurement of non-technological innovations might include.

[26] Non-R&D innovation activities include technology adoption, incremental changes, imitation and combining existing knowledge in new ways.

9.2 Intangible investments

Intangible investments mean investments in all the intellectual (knowledge-based) resources which a nation or an organisation utilises for its governance or management, (technological) innovation, the skills base of its people or personnel, and marketing and interaction with other nations and organisations and which affect its future prosperity and development. Usually investments in these resources are measured by the number of people involved (such as R&D personnel) or their long-term expenditure. Often these resources are not acquired from markets but created inside a nation or an organisation, and they may be embodied in people and organisations.

In terms of money, intangible investments include research and development (R&D) expenditure, other long-term expenses on design, marketing and branding (advertising), long-term expenses on human capital such as personnel training paid by firms, long-term expenses on intellectual property such as patents, copyrights and trademarks, and long-term expenses on organisational and interaction activities such as new operating practices and new business models.

In an intangibles questionnaire circulated in the UK, the following information on investment is enquired: R&D, design, organisational or business process improvement, training and skills development, software development, market research and advertising and other intangibles including copyright development and mineral exploration (NESTA 2009). Following the classification proposed by Corrado, Hulten and Sichel (2005), the OECD distinguishes between three types of activity underlying intangible assets: 1) computerised information (software, databases); 2) innovative properties (patents, copyrights, trademarks, designs, etc.) and 3) economic competencies (brand equity, organisation-specific human capital (training), networks joining people and institutions, and organisational know-how (OECD 2011, 2012a).

The cumulative sum (minus depreciation) of intangible investments constitutes 'intangible assets' or 'intangible capital'. Based on the model developed by Edvinsson and Malone (1997), intangible assets are divided into human capital, structural capital and relational capital (market or customer capital). Innovation capital has been placed under structural capital.[27] However, these categories are not clear-cut, truly hierarchical and exclusive. Based on the guidelines given by the Oslo Manual 3rd edition (OECD 2005), innovation capital may be defined to include traditional innovation expenditure such as R&D expenditure, expenditure for the acquisition of machinery, equipment and software for innovation, expenditure for the acquisition of external knowledge for innovation (such as patents),

[27] Edvinsson and Malone (1997) divide intellectual capital (IC) into human, organisational and relational capital. In this classification, innovation capital belongs to organisational capital. Here, we take a somewhat broader view and discuss structural or organisational capital, depending on the context (Andriessen and Stam 2004), and (industrial) innovation capital as a fourth category, realising that this innovation capital does not encompass the concept of broad-based innovation.

training expenditure for innovative activities, expenditure for product design, and other expenditure to implement innovations such as expenditure used for feasibility studies, testing, software development and industrial engineering.

Usually, innovation capital has *not* been defined to include all broad-based innovation expenditure, such as expenditure on marketing and organisational innovations including their implementation, or expenditure on user innovations. For statistical purposes, marketing innovations are defined in the Oslo Manual as covering significant changes in product or packaging, product placement, product promotion and pricing. Organisational innovations are defined to include new business practices such as the introduction of knowledge or quality management, new methods of organising work responsibilities and decision making such as *the first use* of a new organisation or training system or team work and new methods of organising external relations with other organisations such as *the first use* of partnerships, alliances, outsourcing or sub-contracting. Organisational activities also cover practices such as routines, behaviour, ways of handling and implementation (Rotmans 2011).

Human capital is often discussed at the society level, where it stands for the creativity, capabilities, health and competencies of individuals, skills and experience, tacit knowledge, education and training, and lifelong learning. Demographics and migration can also be included in human capital. At the organisation level, it includes the knowledge, skills, experiences and abilities of employees.

Structural or organisational capital has been defined to include computerised information such as software and databases; codified knowledge; innovative property such as scientific and non-scientific R&D, intellectual property rights, designs, and trademarks. It also includes aspects of advertising and marketing (OECD 2011). Structural capital is clearly an 'in-house' (i.e. organisation-specific or more generally system-specific) combination of the innovation capital and human capital defined above. It also includes governmental and political practices and institutions if the system under consideration is a nation.

As an outward oriented concept, we can discuss relational capital. Relational capital is defined as including all resources linked to the external relationships of an organisation (or of a nation) with customers, suppliers and partners. It includes networks joining people and institutions, customers and users. It enables and utilises the tacit and codified knowledge of development collaborators and subcontractors providing intermediate inputs and the knowledge of customers utilising the brand equity and features of products[28] or services sold (OECD 2011).

The broad perspective of intangibles provides thus a view on worker skills and know-how, reputation, business models (business plans and practices, brand names), organisational structures and relations with suppliers and customers. Furthermore, it provides a view on software and databases and the traditional

[28] In this report, we prefer to use the dichotomy *products and services* rather than *goods and services* to highlight the fact that services should not be treated as a synonym for intangibles. The traditional dichotomy between goods and services should be replaced by a breakdown between tangible goods, intangible goods and services (see Hill 1999, 427). Tangible and intangible goods may be collectively referred to as products.

intellectual property of patents, copyrights, and trademarks. These are said to be the new keys to competitive advantage, and they drive the innovation process and produce the productivity gains needed to maintain prosperity (OECD 2011).

9.3 Intangible investments as proxies for innovation expenditure

The Community Innovation Surveys do not ask about innovation expenditure for all innovations, only for product and process innovations. Expenditure on marketing and organisational innovations as well as on public-sector and user innovations belongs to this group, constituting a part of a broader group of intangible investments. In the next section, we will consider whether fragmentary data on intangible investments can be used as proxies for broad-based innovation expenditure, but before that we wish to clarify the distinction between traditional (scientific) R&D expenditure and other long-term expenses on design, marketing, branding, education and training, IPR, and organisational and interaction activities, sometimes also referred to as 'non-scientific R&D' or 'innovation activities beyond (scientific) R&D'.

R&D expenditure

According to the Frascati Manual (OECD 2002), R&D activities are understood to cover all activities from *basic research*, *applied research*, and *experimental development* to piloting and demonstration of project results. R&D also covers research in social sciences and humanities.[29] Basic research is defined as work undertaken to acquire new knowledge, without any particular application in view, and applied research as work undertaken to acquire new knowledge directed primarily towards a specific practical application. Product and process development (*experimental development*) is systematic work that draws on existing knowledge gained from research and/or practical experience with the aim of producing new materials, products, processes, methods and systems or of substantially improving existing ones. R&D should encompass an appreciable element of novelty.[30]

The statistics on research and development are based on data obtained from enterprises, universities, central university hospitals, universities of applied sci-

[29] R&D in social sciences and humanities conducted by higher education institutions or other public-sector organisations is usually not taken into account in R&D for industrial innovations.

[30] According to Arundel et al. (2008) "the definition of *experimental development* creates substantial problems, with many activities based on the use of existing knowledge, such as engineering and design, sometimes included in R&D and sometimes excluded. Many innovative activities based on new uses of existing knowledge are not R&D."

ences and public-sector organisations. The statistics on enterprise R&D include data on R&D expenditure, their funding, research personnel and person-years in research. R&D statistics describe the resources used for research and for product, service and process development. *Education and training, health care, after-sales services, patenting and licensing not connected with R&D projects, routine tests, routine software development, general purpose data collection as well as enforcement of standards and regulations, and policy related studies are excluded* (OECD 2002).

R&D expenditure consist of the labour costs of R&D personnel including actual wages, fringe benefits counted under current costs, holiday pay and holiday bonuses. They also include social security payments, contributions to unemployment insurance, compulsory and voluntary pension contributions, and contributions to mutual benefit funds. In addition, R&D expenditure includes a percentage of intermediate expenditure such as heating, electricity, water, rents, maintenance of premises, cleaning and insurance, and also intermediate expenditure on materials, equipment and software needed for R&D.

R&D expenditure also includes outsourced services (*extramural R&D*). These are defined as purchases of services relevant to the organisation's own R&D (*intramural R&D*): construction work, software development or other services not generally considered R&D activities from the point of view of the service provider. This rule is followed to avoid duplication. However, entire R&D projects that are outsourced are not included. R&D expenditure may also include administrative costs including labour costs of the administrative and maintenance personnel who are not counted as research personnel. Personnel responsible only for R&D-related administrative tasks or for providing other kinds of support for R&D projects (e.g. laboratory technicians, computer programmers) are classified as other R&D personnel.

Capital expenditure for R&D includes the acquisition of and major improvements to buildings such as laboratories, production plants used for R&D (or a percentage of such expenditure if the building is also used for other purposes) and the acquisition of machinery and equipment for R&D estimated according to their use. Expenditure incurred during the statistical year is reported exclusive of VAT and depreciation.[31] R&D statistics provide information on in-house R&D expenditure and services outsourced by industry, sector, region and field of science. Sectors cover business enterprises, the public sector and the higher education sector.

For intangible R&D investments, balance sheet values on activated R&D expenses and R&D services acquired from external enterprises have sometimes been used. These are not fully equivalent with the actual R&D expenditure asked for in the R&D Surveys. Instead of using balance sheet values for in-house R&D expenditure and outsourced R&D services, the industry estimates based on the annual R&D Surveys should be used.

[31] http://www.tilastokeskus.fi/til/tkke/kas_en.html, accessed 20 Aug 2013. In the National Accounts, capital expenditure for R&D is replaced with capital services provided by tangible investments. In addition, for the National Account concept of R&D investment, the imported R&D expenditure is included and the exported R&D expenditure excluded.

Software development

> *According to the Oslo Manual (3rd edition) substantial improvements in technical specifications, components and materials including incorporated software should be included in product innovations. On the other hand, significant changes in techniques, equipment and/or software in production or distribution processes should be classified as process innovations. Software acquisition or development directly related to innovation is, therefore, a part of the innovation process.*

There may be a remarkable risk of double counting if software expenditure in R&D Surveys, Innovation Surveys, Business Services Statistics and Financial Statements are used together without considering the overlap. Service statistics include data on the production and the use of IT services, advertising services, legal services, accounting, bookkeeping and auditing services, management consultancy services, architectural and engineering services, technical testing and analysis, and market research services. IT services consist of development, designing and management of information systems and customised software. They include development and production of applications, their maintenance and installation services, maintenance and repair of computers and peripheral equipment, hardware consulting, consulting and training services relating to IT, and other data processing services such as data entry, tabulation and sales of server space for a customer's website.

Software development is partly included in own R&D activities (*in-house R&D*), outsourced services (*external R&D*) and other in-house or external innovation activities such as market research and other preparatory work for innovation, training and education of staff for innovation, other consultancy services for innovation, acquisition of external know-how (patents, licenses) and acquisition of machinery, equipment and software for innovation. In the harmonised CIS questionnaire, expenditure for software is a separate item, but this is not followed in the Finnish questionnaire, because it is difficult to separate this from other items.

In the financial statements questionnaire, there is a question about the expenditure of ICT services divided into *computer programming services* and *software and database services*. Outsourced ICT services partly overlap with R&D expenditure, but the exact extent is unknown. Computer software includes bought and customised computer software. Software included in the acquisition price of machinery and equipment (incl. one-off license fees) is included not here but under *computers, servers, data network equipment and peripheral equipment.* Annual licence fees related to acquisition of software are not considered investments but as expenses from patents and licenses.

Expenses on outsourced ICT services[32] are included in the Financial Statements Statistics, but there is no question on how much of the R&D expenditure is

[32] In categories of equipment and programming consulting, design and programming of software, activities related to computer operations and database hosting, and telecommunication, audio, video and other ICT devices.

used for ICT investments. In the Statistics on the Use of Information Technology in Enterprises, there is a question on the number of person-years used for developing and preparing of own-account software. This, together with the average costs of a person-year, can be used to estimate own-account software expenditure. In the national accounts, the issues of double counting of R&D and ICT investments are addressed and estimated by using employee compensation in the relevant occupations. Computerised databases (both purchased and own-account) are also supposed to be captured by the national account software measures.

To sum up, resources invested in developing software and databases create a valuable asset, but the distinction of software developing expenses from other R&D expenditure may be difficult.

Design

As expressed by NESTA (2009), "investment in design has been described by some macroeconomists as non-scientific R&D. These designs may be critical in the innovation process, as they play an important role in new product and service development." Furthermore, as stated by the EU (2009), "design as a tool for innovation has developed rapidly in recent years, resulting notably in concepts such as strategic design, design management and design thinking".

The Frascati Manual (OECD 2002) includes some industrial design activities in the definition of R&D. Specifically, the Manual states that scientific prototyping and industrial design required during R&D should be included in R&D. *Design for production processes and the less technical design activities such as business model design and system (organisational) design are, however, not considered as R&D or covered by either the Frascati or Oslo Manual and hence not measured as innovation activities.* The Oslo Manual treats aesthetic product or packaging design as marketing innovation. Functional and user characteristics design belongs to product innovation, while design of software in the production or distribution processes belongs to process innovations. On the other hand, not all designs and design activities are related to innovation activities the target of which is to produce novel products, services or processes with characteristics substantially diverging from earlier ones, or novel marketing and organisational methods, or substantial improvements to these.[33] In other words, *some designs are incremental changes rather than substantial improvements or strategic designs.*

According to the Design Ladder of the Danish Design Center, companies climb up the ladder where in the beginning companies do not use design, then companies use design for styling or appearance, then they integrate design into the development process, and finally they consider design a key strategic element, as the terms *user-centred design* and *concept design* manifest. Developing individual experiences and co-creation of values with the consumer are the key strategies

[33] In this respect, the architectural design of a building, for example, may be an intangible innovation activity.

that more than 70% of companies rely on in the Danish Firms' Evaluation of the Importance of Design in 2006 (FORA 2008).

At the moment, *there are no statistical surveys in Finland covering the whole range of product, service and strategic design including design of systems and business processes*. There is a particular need for information on the design of service processes. There is, however, information on registered industrial designs and trademarks (copyrights claimed),[34] their names and numbers, but not on expenditure used for design activities. For example, a study carried out by NESTA (2009) in the UK suggests that design spending might be more than twice as large as business spending on R&D (OECD 2012a, 6). In the NESTA questionnaire, design spending includes outsourced design services.

In principle, the resources used for business model and organisational design – being part of design activities – can be estimated on the basis of investments in organisational and interface design. These will be considered in the section of organisational innovation and improvements. Brand design, by contrast, is often included under branding expenditure.

Market research and branding

Market research is at the front end of innovation: to identify the market potential for new products, companies must at the outset anticipate future demand. The category of market research often captures investments made to develop brands and trademarks in order to take products to market. Market research and branding (advertising) are strategic elements of the innovation process.

The term *brand* is often used as a synonym for trademark, but brand may also include many other legal rights such as trade names or registration of designs. A brand does not have a legal or registered character, and if protection is required, a registration application for a trademark or trade name should be filed. The registration of trademarks and designs is less expensive than the patent protection of industrial innovations. Also, SMEs and service companies can benefit from registration. Registration can also be used for minor technical solutions which may not fulfil patentability requirements. These legal rights to protect incremental inventions are called utility models. On the other hand, creating and developing new trademarks or aesthetic designs is an innovative activity related to marketing.

Because of the shortage of information on strategic and system design, *product design is often lumped together with marketing (market research) and branding (product promotion)*, as in the Oslo Manual (3rd edition). In the Community Innovation Surveys,[35] however, only total expenditure for product design, training for

[34] The Office for Harmonization in the Internal Market (OHIM), which is the European Union agency responsible for registering trademarks (RTM) and designs (RCD) that are valid in all 28 countries of the EU, has information on the registered Community designs. These are exclusive rights for the outward appearance of a product or part of it, resulting from the features of the product itself and/or its ornamentation. (figures until 06/08/2013). http://oami.europa.eu/ (Accessed 22 Aug 2013).

[35] The Finnish version.

innovation, and market introduction of innovation including market research, a new brand image and launch advertising, as well as other expenditure for innovation *not elsewhere classified* is requested, only concerning product and process innovations.

In principle, the expenditure for marketing and organisational innovations and improvements mainly includes strategic management expenditure discussed in the following section, but it is good to notice that a new marketing method, aesthetic product design or new brand image can be implemented for both new and existing products. On the other hand, the broad categories of marketing and organisational innovations defined in the Oslo Manual quite often encompass product and process innovations, and it is sometimes difficult to distinguish between product, service, process, marketing and organisational innovation. An innovation can simultaneously belong to different categories. If follows that a certain amount of double counting occurs, if the aim is to distinguish between different types of innovation and innovation expenditure.

A common practice is to measure intangible investments in broad categories such as design, marketing and branding including trademarks, copyrights and reputation ('goodwill'). Sometimes investments used for patents and licensing are added to this total figure. It is also usual to exclude other strategic and system design.

In-house marketing expenditure as well as outsourced marketing and advertising services are included in the Business Services Statistics and also in the Financial Statements, but there is not a single piece of information on innovation expenditure related to the market introduction of innovation in the Community Innovation Surveys. Consequently, there is no information on expenditure used for brand and trademark designs and their economic value.[36]

The number of registered trademarks and designs in the EU Member States (country reports) can be found in The Office for Harmonisation in the Internal Market (OHIM) as described above. Marketing expenses activated in the financial year can be found in the Financial Statements Statistics, as well as the expenses for marketing, advertising and sales purchased from outside the enterprise. Outsourced services include expenses from the marketing and sales of products, advertising and sales exhibitions, services provided by advertising agencies, marketing, communications and public relations consulting, market research and opinion polls, setting up and maintenance of outdoor and traffic advertising, decoration and design of display premises, and fairs and other product demonstration events. There are, however, no separate data on long-term marketing or branding expenses. The definition and boundary of brand investment is not clear. According to Corrado, Hulten and Sichel (2006), about 60% of marketing and advertising expenses have an investment character (such as brand development), and this

[36] The economic value of a brand (valuation of brand equity) has sometimes been estimated by using the market value of a trade name or the cash flow of a company. According to Wikipedia, brand equity is created through strategic investments in communication channels and market education and appreciates through economic growth in profit margins, market share, prestige value and critical associations (accessed on 14 Oct 2013).

percentage has been used for instance by Maliranta and Rouvinen (2007) for their estimates of investments in advertising and marketing.

Other intellectual property

As mentioned above, other long-term expenses on intellectual property except registered designs, utility models and trademarks (copyrights) and trade names include expenditure on patenting and licensing. Under Business Services Statistics and Financial Statements, there is information on the *patenting and licensing costs paid by firms*. On the other hand, the purchase or licensing of patents and non-patented innovations are included in the category of acquisition of external knowledge for product and process innovations, and are covered in the CIS. All national-level patenting and licensing costs are included in the total figure of intangible investments. Royalties, i.e. returns from external parties for patents and licenses owned by the companies, are requested in the Business Services Statistics, but they do not belong to intangible investments.

Organisational innovation and improvement

Investments in organisational innovation and improvements such as improved knowledge or quality management, a new organisation or training system and organising external relations are not covered in the Community Innovation Surveys. The main part of the expenses for organisational improvement goes to the group of non-R&D expenditure. As highlighted by Arundel et al. (2008), non-R&D innovators innovate primarily through customising or modifying products or processes obtained from other firms. Non-R&D innovation activities include technology adoption, incremental changes, imitation and combining existing knowledge in new ways. As reported by the European Public Services Innovation Scoreboard (EPSIS), organisational innovations in the public sector are more likely than product innovations, as the former impact their core service function (EU 2013). There is a particular need for information on marketing and organisational innovation in services. The (non-scientific) R&D in the services sector is closely related to marketing and organisational activities.[37]

Some proxy time series for sector, industry, region and unit-level expenditure on organisational improvement can be extracted from register data related to persons, for instance from the Employment Statistics and Statistics on the Structure of Earnings. Structural statistics on wages and salaries describe the numbers, hourly and monthly gross earnings and the formation and distribution of employees' wages and salaries in all employer sectors. In these statistics, we may find data on the annual payrolls and monthly earnings of personnel in a position (based on their relative wage level or occupation) that enables their paid contribu-

[37] As stated in Piekkola (ed.) (2011), proper measurement of R&D activity should include a broader scope of activities that may better capture R&D in the services sector compared to current measures.

tion to business models and system designs. For each employee, there are data on his or her occupation, status in occupation, workplace, education and income. Data on occupation and socio-economic group have been produced annually since 2004, whenever possible drawn from administrative registers. Monthly and annual earnings are inclusive of additional items, such as overtime pay, working hour supplements, benefits in kind, performance-based bonuses and other one-off items.[38] Data on the prevalence of significant organisational improvements can be drawn from the Community Innovation Surveys.

The administrative and management personnel working in a position enabling their contribution to business models and organisational design include executive managers (CEOs), design managers, heads of production and production lines, directors of small businesses, other specialists in education, businesses and other organisations, legal specialists, security and currency traders, consultancy service buyers, business service providers and administrative officers. Long-term expenses on organisational and interaction activities can be estimated on the economy level on the basis of this administrative and management personnel minus personnel included in R&D as defined earlier. The employee compensation of administrative and management personnel could be estimated for enterprises that have implemented significant organisational improvements.

The expenditure-based approach of Corrado, Hulten and Sichel (2006), which estimated investment in organisational capital as 20% of managerial compensation, has been widely adopted across OECD countries (OECD 2012b). Maliranta and Rouvinen (2007) also used this assumption for their estimates.

Management consultancy services and other external expenses for strategic design should also be covered. In principle, if we had a coefficient based on Time Use Surveys describing the working hours of managers and specialists for organisational improvements and organising external relations, this coefficient could be used to estimate the average payroll percentages used for strategic designs compared to other tasks. This percentage is smaller than the percentage used for organisational and interaction activities in general.

Occupations included in the estimation of expenses for organisational improvement (investments in organisational capital), including directors and specialists in management and marketing, are as follows (Görzig, Piekkola & Riley 2010).

Directors General, chief executive officers (CEOs)
Heads of production and production lines
Expert directors
Directors of small businesses
Specialists in education
Specialists in businesses and other organisations
Legal specialists
Economists
Security and currency leaders
Consultancy service buyers

[38] www.tilastokeskus.fi, Accessed 19 Aug 2013.

Business service providers
Administrative officers

In Görzig et al. (2010), the organisational capital is calculated as the sum of payroll expenses times a multiplier, which for organisational work is 0.35.

According to the results of the Innodrive project (www.innodrive.org), 9% of employees in companies belong to R&D personnel (70% of working time) and 8% are in occupations included under organisational capital (20% of working time). The percentage of workers engaged in intangible capital type work was around 18%. [39]

Training and skills development

Investment in training and skills development is critical to the innovative capacity of firms; it is particularly important for service innovation. According to the OECD, "the skills and competencies required for innovation are broad. Incremental innovation and the improvement of organisational efficiency and routines, for example, can come from a range of workers, not just managers, researchers or external consultants, and can rely on different skills and competencies. Moreover, new organisational methods or marketing innovations require specialised skill sets well beyond traditional science and engineering training." (OECD 2010, 56) Training for innovation is defined by the OECD as internal or external training specifically for the development and/or introduction of new or significantly improved products or processes. Furthermore, the OECD suggests that better measures are needed of the skills required in innovative workplaces and of ways in which the workplace promotes such skills. In addition, crafting policy especially in a new ecosystem framework would require a better understanding of the flows of knowledge, including the tacit knowledge of workers (OECD 2011).

In principle, long-term human relation expenses can be estimated on the basis of employer funded staff training by using data on payrolls of the trainees and other education expenditure during the training period. Approximately every five years, Statistics Finland conducts the *Continuing Vocational Training Survey* (CVTS) on personnel training funded by enterprises. This survey includes data on wage costs during the training period and other training expenditure, but due to relative low response rates the coverage of this data is not the best possible. In 2010, the percentage of education expenditure out of total employee compensation was 1.4% on average.

Information on participation in adult education and training can be drawn from the person-based Adult Education Survey (AES) that is conducted by Statistics Finland approximately every five years, like the CVTS. According to this survey, a

[39] The INNODRIVE Company Intangibles Database provides information on the percentage and wages of workers in intangible capital related occupations in six countries (Finland, Germany, Norway, UK, Slovenia, Czech Republic). INNODRIVE applied a broad definition of R&D occupations in the firm-level approach, leading to a higher percentage of R&D employees in the UK in particular.

bit more than 2/3 of persons who have completed tertiary education participated in adult education and training in 2006. The training expenditure for these persons cannot be estimated reliably from these person-based surveys.

Other intangibles

Other intangibles include items such as mineral exploration and artistic originals. Originals created by authors, composers, scientists, architects, engineers, designers, software writers, film studios, orchestras and so on are intangibles that have no physical dimensions or spatial co-ordinates of their own and have to be recorded and stored on physical media such as paper, films, tapes or disks. They can be transmitted electronically. Originals may be used to produce copies which in turn may be used in further processes of production or directly for final consumption. When they are repeatedly used to produce other goods and services they must be fixed assets in the national accounting sense (Hill 1999).

9.4 Conclusions

According to NESTA (2009) we should have information on investments needed to commercialise ideas, including product design, training in new skills, organisational innovation, developing new customer offerings and brands, and copyright. For many of these categories we already have information, but they are lumped together with other items. For example, investments needed to commercialise ideas are included in the other expenditure for innovation *not elsewhere classified* together with expenditure for product design (i.e. designing its functional and user characteristics), training for innovation and other expenditure for implementing innovations. However, investments in organisational improvements and aesthetic and strategic design and possibly in branding are partly missing; they are partly included under investments in products, services and production and distribution processes due to difficulties to separate different investment items. The main items not covered may include long-term non-R&D expenses[40] for innovation in a full range of services, in the public sector and among households and consumers.

In the case of industrial innovation, investment in intangible capital is typically seen as a broader concept than investment in innovation, but if we consider broader innovation − as we do in this book – and allow that all actors and organisations can carry out innovation activities and introduce and implement innovations, innovation capital as a concept approaches the concept of intangible capital. However, with the definitions of R&D and innovation activities given in the Frascati and Oslo Manuals, broad-based innovation capital is not equal to intangible capi-

[40] Such as expenses on design, marketing, branding, staff training, IPR and organizational and interaction activities.

tal. It also includes some tangible investment and excludes mineral exploration and some incremental changes, for example.

As mentioned earlier, an innovation can simultaneously belong to different types of innovation, and double counting may occur if attempts are made to treat different types of innovation and innovation expenditure separately. In the national accounting system, the issues of double counting of scientific R&D and ICT investments are addressed and estimated by using employee compensation in the relevant occupations. But other innovation investment items, such as investments in *organisational improvements and branding,* are not included in the accounting system. In principle, innovation expenses could be roughly distinguished from each other by using existing micro data together with employee compensation in relevant occupations and a number of extra questions placed in various questionnaires. However, in the short term asking about these items may not lead to any valid and comparable figures. Generally speaking, respondents may not be able to answer the questions, given the state of their own accounting systems.

References

Andriessen, D. and Stam, C. (2004). The Intellectual Capital of the European Union, Measuring the Lisbon Agenda. Available at http://www.intellectualcapital.nl/artikelen/ICofEU 2004.pdf

Arundel, A., Bordoy, C. & Kanerva, M. (2008). Neglected innovators: How do innovative firms that do not perform R&D innovate? Results of an analysis of the Innobarometer 2007 Survey No. 215, INNO-Metrics Thematic Paper, MERIT.

Corrado, C., Hulten, C. & Sichel, D. (2005). Measuring Capital and Technology: An Expanded Framework. In: C. Corrado, J. Haltiwanger & D. Sichel (eds.), Measuring Capital in the New Economy, National Bureau of Economic Research, Studies in Income and Wealth, Vol. 65. Chicago: University Chicago Press, pp. 11–45.

Corrado, C., Hulten, C. & Sichel, D. (2006). Intangible Capital and Economic Growth. NBER Working Paper 11948.

Edvinsson, L. & Malone, M. (1997). Intellectual Capital: Realising Your Company's True Value by Finding its Hidden Brainpower. New York: Harper Collins.

EU (2009). Design as a driver of user-centred innovation, Commission staff working document, SEC(2009)501 final, 7.4.2009. Brussels.

EU (2013). European Commission, European public sector innovation scoreboard 2013 – A pilot exercise. Brussels: European Commission. http://ec.europa.eu/enterprise/policies/innovation/files/epsis-2013_en.pdf

FORA (2008). Design and innovation, Presentation given by Jorgen Rosted at Marseille, France in June 2008.

Görzig, B., Piekkola, H. & Riley, R. (2010). Production of intangible investment and growth: Methodology in INNODRIVE. Innodrive Working Paper No. 1.

Hill, P. (1999). Tangibles, intangibles and services: a new taxonomy for the classification of output. Economic Commission for Europe, The Canadian Journal of Economics, Vol. 32, No. 2, 426–446. Special Issue on Service Sector Productivity and Productivity Paradox, Wiley-Blackwell.

Maliranta, M. & Rouvinen, P. (2007). Aineettomat investoinnit Suomen yrityksissä vuonna 2004: Kokeilu yritysaineistoilla. Working Papers N:o 104. Helsinki: Pellervo Economic Research Institute.

NESTA (2009). The Innovation Index. Measuring the UK's investment in innovation and its effects. NESTA, November 2009.

OECD (2002). Frascati Manual. Proposed standard practice for surveys on research and experimental development. Paris: OECD.

OECD (2005). Oslo Manual (3rd edition): Guidelines for Collecting and Interpreting Innovation Data. Paris: OECD & Eurostat.

OECD (2010). Measuring Innovation: A new Perspective. Paris: OECD.

OECD (2011). New Building Blocks for Jobs and Economic Growth: Intangible Assets as Sources of Increased Productivity and Enterprise Value Intangibles. Conference Report September 2011, Athena Alliance. www.athenaalliance.org/new/Intangibles.

OECD (2012a). New Sources of Growth: Knowledge-based capital – Interim project findings. Paper C(2012)59. Paris: OECD.

OECD (2012b). Defining and measuring investment in organizational capital: using US micro data to develop a task-based approach. STI Working Paper 2012/5. Paris: OECD.

Piekkola, H. (ed.) (2011). Intangible Capital – Driver of Growth in Europe. Proceedings of the University of Vaasa, Reports 167.

Rotmans, J. (2011). Sustainability Transitions & Transition Management. Presentation given in Tekes, Helsinki, 15.02.2011.

10. Measuring and visualising networked innovation

Kaisa Still, Jukka Huhtamäki, Martha Russell & Neil Rubens

10.1 Need to understand networked innovation

It used to be the case that the perception of innovation was limited to new products or technologies that were a result of in-firm R&D activities. Now, innovation is seen as a wider concept including service and process innovation and going well beyond R&D units and even beyond the borders of individual companies (Crossan & Apaydin 2010). New theoretical approaches have emerged, including: (a) user-driven and demand-driven innovation as well as user innovation (Karat 1997, Holmqvist 2004, von Hippel 1976, Franke et al. 2006); (b) open innovation (Chesbrough 2003) and co-creation (Ramaswamy & Gouillart 2010); (c) innovation networks and emphasis on multiple, independent actors (Kogut & Zander 1996), as well as innovation ecosystems (Russell et al. 2011); and (d) service dominant logic for resource integration of actors (Vargo & Lusch 2004, Vargo 2009). We observe that the locus of innovation activities has changed, and many actors, most significantly users and consumers, are seen to be involved in it. The process of innovation is seen as less linear, less waterfall-like, and approaches of agile methods and lean start-up (Ries 2011) are often applied.

The third version of the Oslo Manual (2005, 20) addresses the systemic dimension of innovation focusing on innovation linkages:

> "*The innovative activities of a firm partly depend on the variety and structure of its links to sources of information, knowledge, technologies, practices and human and financial resources. Each linkage connects the innovating firm to other actors in the innovation system: to government laboratories, universities, policy departments, regulators, competitors, suppliers and customers.*"

As the notion of networked innovation gains more traction, the need to develop new tools and methods for measurement for innovation becomes an imperative, also due many of the existing indicators are seen to be lacking in detail and timeliness (Perani et al. 2006). For example, Milbergs (2007) concluded that "currently available indicators and measurement methods do not adequately describe in a timely manner the dynamics of innovation today"; Oslo Manual (2005) calls for

dynamic models; NESTA has called for reliable data for evidence-based policy (NESTA 2008); and the OECD has called for "blue-sky indicators" (OECD 2010).

Highlighting linkages and relationships

Our conceptualisation of innovation ecosystems includes human networks (Hwang & Horowitt 2012; Powell et al. 1996) and firm-level networks (Basole and Rouse 2008) as well as "inter-organizational, political, economic, environmental and technological systems of innovation through which a milieu conducive to business growth is catalyzed, sustained and supported" (Russell et al. 2011, 3). We hence share the belief that linkages act as sources of knowledge and technology for an enterprise's innovation activities, and that the variety and structure of such relationships is crucial (Oslo Manual 2005, 76), which places highlighting the importance of linkages or relationships at the core of our indicator development.

As we address innovation ecosystems with human networks and interdependent firms that form symbiotic relationships, it allows us to study them from the systems perspective, using social network analysis SNA (Wellman 1988) to reveal the relationship-based structures of individuals, firms and their relationships (Halinen et al. 2012). The basic idea of a social network is very simple (Hanneman & Riddle 2005):

> *A social network is a set of actors (or points, or nodes, or agents) that may have relationships (or edges, or ties) with one another. Networks can have few or many actors, and one or more kinds of relations between pairs of actors. To build a useful understanding of a social network, a complete and rigorous description of a pattern of social relationships is a necessary starting point for analysis. That is, ideally we will know about all of the relationships between each pair of actors in the population.*

SNA assists in communicating the findings about networks to others (Freeman 1999). It has been used to study the sociological relationships of people and organisations (Wasserman & Faust 1994) and to analyse communication structures, content and virality in social media (Welser et al. 2007). Furthermore, it is understood that one of the roles played by networks is to inspire insights on how simple processes at the level of individual nodes and links can have complex effects that ripple through the network as a whole (Easley & Kleinberg 2010) – giving promise to actions targeted at individual nodes and links, which could be conducted by policy-makers, regional development agencies, business executives, venture capitalists, etc.

Using big data-type relational information

It has been estimated that the global shift from analogue to digital data had nearly been completed in 2011 (Leontiou 2011). Certainly the amount of global digital information is vastly increasing and is being measured in zetabytes (1 trillion giga-

bytes). Overall, the transition from analogue to digital is touching most facets of modern life, and it has been proposed that this paradigm shift addresses the major transition from analogue to digital innovation (Moody 2011). Could digital data, therefore, be used to explore innovation indicators?

If shortage of real-time innovation data was previously a challenge, this is no longer an issue. The vast ocean of available data is oftentimes referred to as information overload or *big data* "as the next frontier for innovation, competition and productivity" (McKinsey 2011). Our everyday actions in the digital world, from posting messages on Facebook to checking a bank account balance, create digital exhaust or a digital footprint – trails conveying information about behaviour, preferences and interactions (Deloitte 2012), contributing to innovation data as a natural by-product of innovation activities by various actors, often in an unstructured format: innovation actors, such as company founders, entrepreneurs, knowledge and financial investors, journalists, policy-makers, and customers share information, discuss and communicate their needs, experiences and opinions related to innovation using social media (Still et al. 2012b): a company writes and shares a press-release when it receives major funding, or a new board member; board members discuss their career paths; the same individual may write a scientific paper that gets cited and could lead to patent filing; companies are written about in Wikipedia, on Twitter and on Facebook.

Hence, we see that innovations occur in the context of co-creation relationships, where innovation actors willingly and voluntarily share information. Social media provide access to volumes of global, multipurpose, real-time digital data related to innovation activities in a cost-efficient manner. We see that there are large amounts of relational innovation data in digital formats (Figure 1):

- Open data about financing – linking financing organisations to companies
- Open data about projects – linking companies to companies, linking companies to universities and research institutions, linking individuals to their respective organisations
- Patent data – linking individuals to companies and to technologies
- Scientific publication data – linking individuals to other individuals, linking individuals to organisations as well as to technologies
- Websites – linking companies to companies, individuals to companies, financing to companies
- Socially constructed datasets, or crowd-sourced datasets, (such as TechCrunch CrunchBase, Arctic StartUp, AngelList) – linking individuals to companies, companies to companies, companies to technologies
- Wikipedia – linking individuals to companies, companies to companies, companies to technologies
- Facebook – linking individuals to individuals and to companies
- Twitter – linking individuals to individuals and to companies

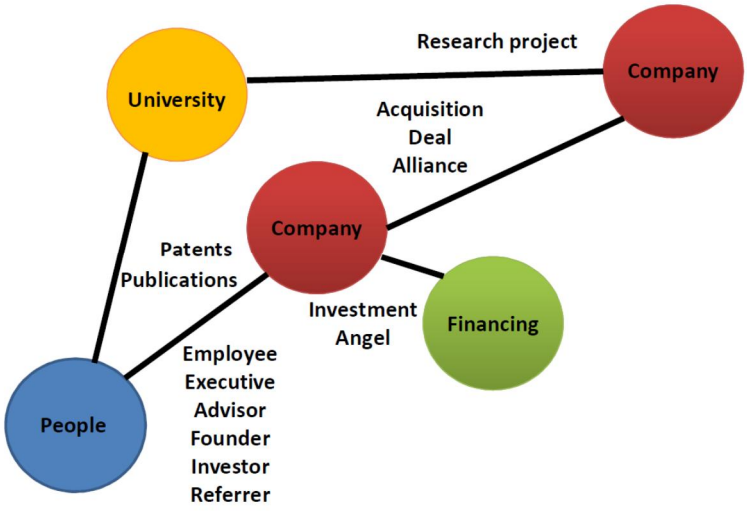

Figure 1. Innovation data as relational data, with emphasis on linkages and relationships.

With powerful analysis towards network visualisations

Previously, large amounts of data have presented challenges for data handling, data analysis and data representation as well as the related organisational processes. Even with computers available, much of the data processing was conducted by people. Collecting data from different sources with surveys or even from secondary, already digital sources, cleaning, aggregating and analysing data with spreadsheet processors and tools alike is laborious, thus making the work cycles long, from weeks to months to years. Now, the advances in computing capabilities have made storing, analysing, presenting and even interacting with large amounts of data possible, fast (almost in real time) and economical.

Traditionally, innovation information is presented in table formats, with some Excel-supported graphs, yet with few dynamic and interactive features. The process of turning data into a dynamic graph or visual model was previously expensive, technically tricky and regarded as the end product of an experiment rather than an everyday tool (Hadhazy 2011). New data and new tools now afford new possibilities for innovation indicators.

Visualisations can help us “see through the forest of data”; they are more than pretty pictures, as they allow for exploration of complex interacting variables in real time and can reveal when analytical tools and policy programs are not performing as intended (Hadnazy 2011). Hence, for in-depth understanding, the power of visualisations comes from combining human strengths with computational capabilities.

Visual analytics addresses this, with the definition of "the formation of abstract visual metaphors in combination with a human information discourse (interaction) that enables detection of the expected and discovery of the unexpected within massive, dynamically changing information spaces." (Wong and Thomas 2004, 20). More generally, visual network analytics provide the means for modelling the skeleton of an ecosystem, bringing transparency to something that might otherwise remain tacit (McKinsey 2011). Thus, we wish to stress the fact that the person looking at a visualisation is able to observe many other metrics: the number of connections per node, the size, diameter, and density of the network (Wasserman & Faust 1994) and so on. Additional information can be inferred from the actors in the network: items such as the financial results of companies, the volume of the possible liquidity events, the size of venture capital fund, change in the number of people working for a company and so on can be projected on top of the network through node size, colour or other visual properties.

- Visual analytics can provide an intuitive approach toward the goal of exploring ecosystems: showing innovation ecosystems as networked systems is seen to provide evidence of the complexity of innovation activities. Network visualisations furthermore show (a) the skeleton/structure of the ecosystem, and (b) the roles of individual actors within the network.

10.2 An approach to measuring and visualising networked innovation

Our proposed novel indicators for measuring networked innovation are indicators that exhibit the social network metrics in a visual, intuitive, user-friendly way. Indeed, we use network analysis more as a qualitative than quantitative means of showing and describing the different aspects of ecosystemic innovation, toward supporting human decision-making for example for policy-making and regional development purposes.

For bringing out these novel indicators that allow for insights on the networked innovation, we have developed a data-driven approach for measuring and visualising networked innovation. We see it as an iterative five-stage process for analysing a business ecosystem, consisting of (Still et al. 2013):

1. Boundary specification — determining the boundaries of the system: which nodes (actors of the innovation ecosystem) and which connections (linkages) as well as the time-line of the analysis;

2. Metrics identification for selecting the appropriate social network and graph theoretic metrics for understanding the dynamics of an ecosystem;

3. Computation, analysis and visualisation toward measuring and visualising temporal, relational ecosystem data; and

4. Sense-making and storytelling, describing the processes from data to understanding as well as the visual narratives for telling the story.

Technical description

Our approach to measuring networked innovation is based on the data-driven visualisation approach to information visualisation (Nykänen et al. 2007), which aims at automating the visualisation process with pipelines through which the data flows from raw data to multivariate, interactive dynamic representations, in the best case in real time. Our data-driven innovation ecosystem analytics approach also follows the information visualisation reference model (Card et al. 1999, see Figure 2). The digital raw data are first collected and then managed and curated locally to speed up the further steps of the analysis. The relevant case-specific and questions-specific projections of the data are created on basis of case-specific filtering options, e.g. the home office of a company. The resulting projections in data table formats are transformed to various visual representations such as networks, timelines and value distribution diagrams. Finally, the visualisations are operationalised with the help of tools and widgets, in our case e.g. with Gephi, NodeXL, Gexf-js and Highcharts, creating snapshots of network visualisations, animation and videos, and timelines.

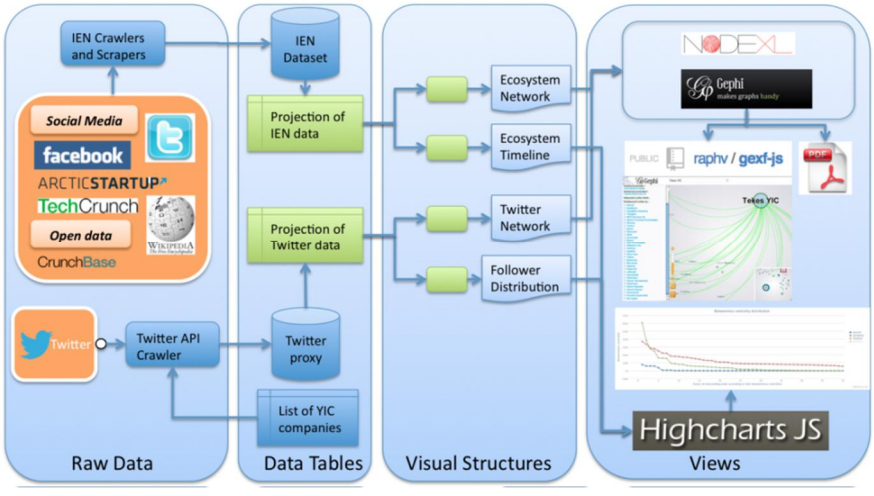

Figure 2. Illustration of the process of data-driven innovation ecosystem analytics.

Source data

As source data, we concentrate on digital data that are rather easily available. These data may be considered almost free and available in real time, often the

quickest way to find out about companies, especially start-ups, and their innovation activities (Still et al. 2012b).

Socially curated data has the inherent characteristic of social bias. The correcting mechanisms that many socially curated datasets have help in minimising this; also, as there are many “bits of information”, the biases of individual bits are reduced. Still, social data are messy, incomplete and unstructured, which poses challenges for collecting and scraping it, as well as for managing the data (Still et al. 2012b)

When looking at business ecosystems, we often use our key dataset, called IEN data, which is based on socially constructed data that people have chosen to openly communicate about, share and modify, related to businesses and start-ups. It is largely based on data from English-language news, press releases and social media. IEN data includes two datasets that are updated quarterly: (1) the IEN Start-up dataset, including data on firms, investors and individuals, with time stamps on individuals and strong emphasis on data from 2010 on, and (2) the IEN Growth dataset, including firms, investors and individuals. In summer 2013, both datasets contained data on more than 100,000 individuals and companies.

In some cases, we complement the IEN datasets with SDC platinum data (by Thomson Reuters), a commercial database about global interfirm relationships across multiple sectors that includes data based on SEC filings about alliances, joint ventures, R&D agreements and licencing and distribution data (Shilling 2009). In addition, for exploring the user ecosystem, we use Twitter, collecting specific data on follower relationships.

Most of the time, we limit the source data to single datasets, as those have been seen to provide valuable insights for case contexts. However, we recognise that the real power comes from going beyond individual digital datasets and from combining the data sources. Our approach has also been used for creating an aggregated dataset based on multiple separate datasets.

Network metrics

The metrics for understanding the dynamics of an ecosystem introduce the concepts of centrality, density, connectivity and clustering within the network — allowing for quantitative analysis of the network, its structure and the roles of its individual nodes (actors). Accordingly, the most common metrics are categorised based on the distinct but related levels of analysis: the network as a whole (ecosystem) and the node level (a single actor such as a firm, financing organisation or individual). This differentiation is important, because network dynamics at each level, although related, are also distinct (Zaheer et al. 2010).

The traditional network metrics that consider the network as the whole include (a) size (total number of nodes), (b) density (percentage of ties that are realised in the network relative to the hypothetical maximum) and (c) number of components (a component is a subgraph in which any two nodes are connected to each other by paths, and which is connected to no additional nodes in the supergraph). At the

node level, the metrics include (a) degree (the number of direct connections), (b) betweenness centrality (the number of times a given node appears in the shortest path from all nodes in the network to all others) and (c) clustering co-efficiency (Ahuja et al. 2011).

In many of our studies, we have used betweenness centrality and degree as metrics for continued visualisations. Node degree is the simplest metric for node centrality: a high node degree shows that an actor has many connections. However, it does not take into account what types of actor are these connections to. A high betweenness centrality better includes the structure of the overall network: it shows that an actor has a connecting role as bridge between various parts of the overall network — hence highlighting key actors in the network.

We see that network metrics as such provide a somewhat quantitative approach to networks and actors. However, these individual numbers are 'just numbers' that can be compared within a context; their comparisons between different contexts becomes challenging, however. Hence, the changes in metrics become more interesting and may be extended to allow for comparisons between different contexts, which is considered important in innovation measurement (Oslo Manual 2005).

Resulting visualisations

As our data include multiple types of actors (individuals, companies, educational institutes, financing organisations) these networks represent multimode networks. Nodes (circles) represent actors of the innovation ecosystem and the edges (lines) connecting the nodes represent relationships between nodes.

The resulting visual innovation indicators are constructed using social network analysis presented in forms of visualisation with tools such as gephi. Using data in relational format, the tool creates an initial network visualisation, which can be a 'hairball' type of visualisation, especially with large numbers of nodes. This is then subjected to better organisation, using network layout algorithms. To bring further clarity to the roles of individual actors, node representation is changed based on the network metrics so that the size of the node changes (see Figure 3). As explained earlier, most often we use betweenness centrality as the defining network metric for creating the visualisation (the higher the betweenness centrality, the bigger the node). The tools allow for colour-coding the nodes and the edges. In our visualisations, we have attempted to be consistent — also allowing for better understanding and comparisons — and used green for investor nodes, red for company nodes and blue for individual actors. The edge (line) colouring follows the colour of the source node: for example, green edges show links from investors to companies.

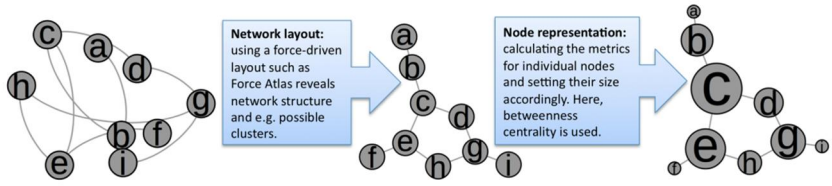

Figure 3. Illustration of the process of applying social network analysis toward visualisations.

Example 1: Case EIT ICT Labs

EIT ICT Labs is a major initiative intended to turn Europe into the global leader in ICT innovation. Since 2010, EIT ICT Labs has consistently brought together researchers, academics and business people. By linking education, research and business, EIT ICT Labs empowers ICT top talents for the future and brings ICT innovations to life. EIT ICT Labs' partners represent global companies, leading research centres and top ranked universities in the field of ICT (http://www.eitictlabs.eu/about-us/).

The objective of visualising the ecosystem of EIT ICT Labs was to make the existing relationships and interactions visible and to explore possibilities of creating novel innovation metrics showing the impact of EIT ICT Labs activities. The case studies looked at its interconnections in three consecutive years (Still et al. 2011; Still et al. 2012a; Still et al. 2013).

Boundary specification and data:

- EIT ICT Labs co-location cities (in 2011: Paris, Berlin, Eindhoven, Stockholm and Helsinki; in 2012 Trento was added) and their connections;
- Companies having their home office in one of the EIT ICT Labs cities were pulled from the IEN Growth dataset and connected to a city;
- Individuals and investors connected to companies were then added to the network, and individuals were connected to the educational institutions they are affiliated with:
    - In 2011: 1,634 key individuals, 1,056 companies, and 280 financial firms,
    - In 2012: 2,817 key individuals, 1,665 companies, and 425 financial firms,
    - In 2013: 3,660 key individuals, 2,041 companies, and 480 financial firms;
- For exploring the question "what if San Francisco Bay Area were a node in the EIT ICT Labs ecosystem", also data about actors in that region were added:
    - With EIT ICT Labs co-locations, the total number of nodes was 6,186, total number of links 7,050;

- With the addition of SF Bay area, the total number of nodes was 35,389 and the total number of links was 51,106.

Metrics selection toward visualisations:

- The nodes of the resulting network are sized according to their betweenness centrality;
- The network is laid out with a force-driven algorithm to reveal the clusters in the network.

Visualisations and sense-making

- Figure 4: Distribution of network metric of betweenness centrality (Still et al. 2011):
  - Very few actors have high betweenness centrality,
  - The actors with the highest betweenness centrality were venture capital investors,
  - The actor with highest betweenness centrality was Intel Capital.
- Figure 5: The visualisation of the network — with the San Francisco Bay Area as an additional node (Still et al. 2012a):
  - Venture capital is abundant around the node representing San Francisco Bay.;
  - The two hubs in the top left part in blue represent Google and Yahoo! ;
  - The EIT ICT Labs nodes circle on the perimeter.
- Figure 6. Change between 2011 and 2013 in network metrics for co-location cities (Still et al. 2013):
  - Paris and Berlin have the greatest number of connections, roughly twice that of Eindhoven, Helsinki and Stockholm and more than five times that of Trento;
  - Paris and Berlin also have the greatest betweenness values;
  - The largest changes in betweenness values were observed in Eindhoven and Berlin.

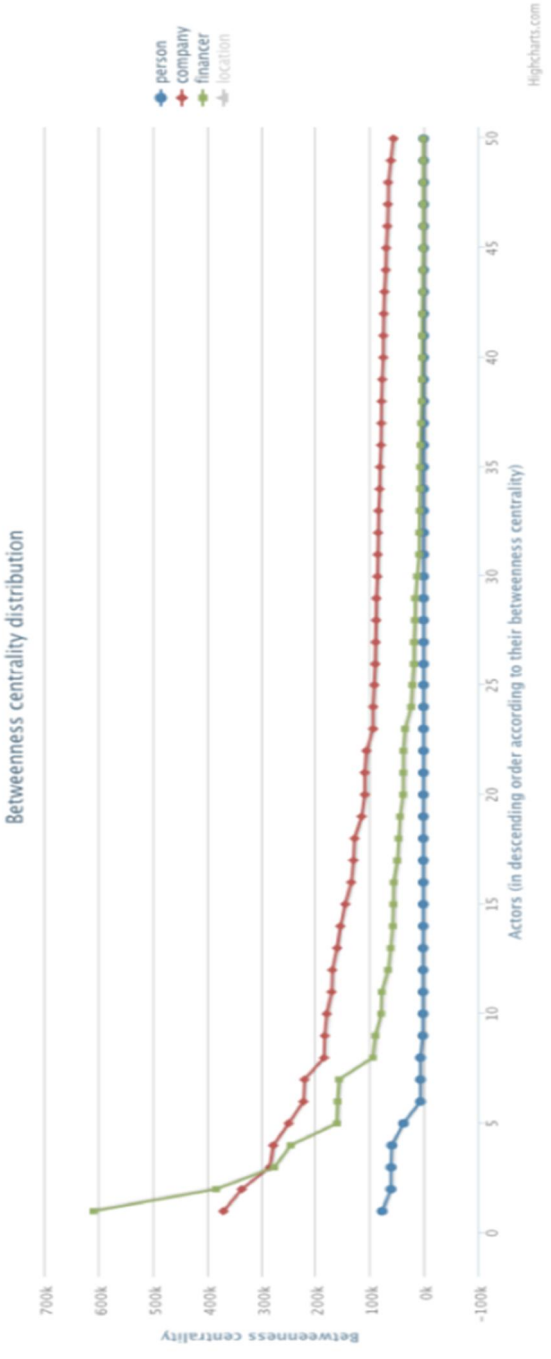

Figure 4. Distribution of betweenness centrality values for financial organisations, companies and individuals (Still et al. 2011).

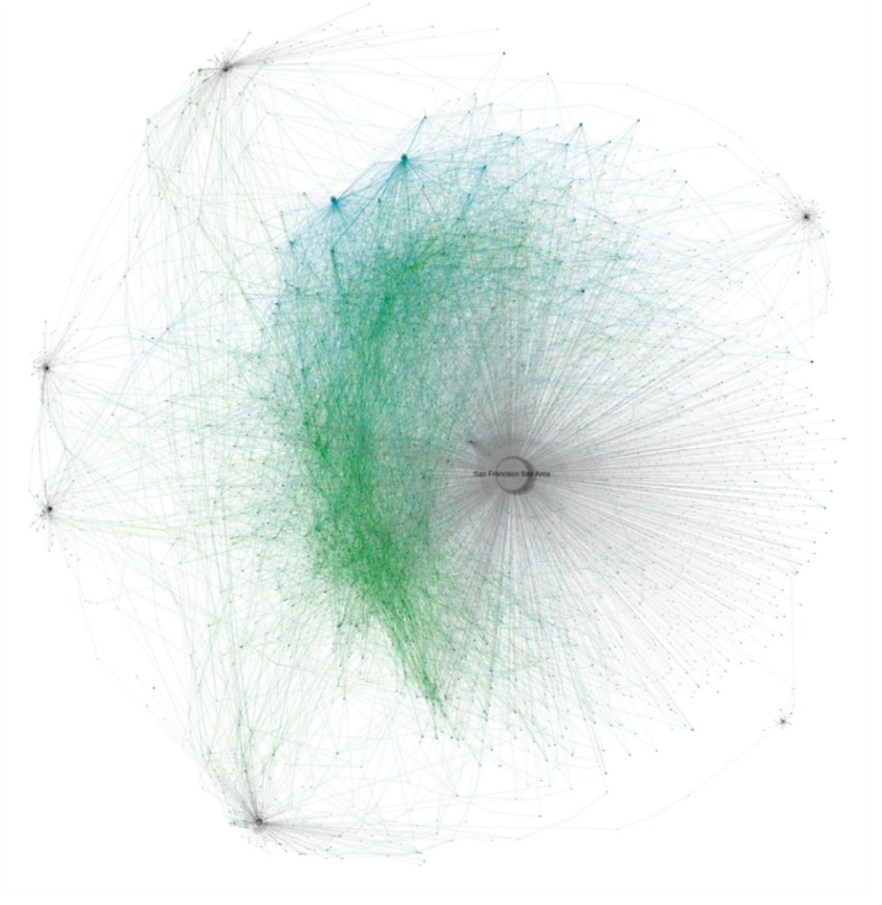

Figure 5. What if San Francisco Bay area were the seventh node of EIT ICT Labs? (Still et al. 2012a).

Table 1. Change over time in relationship metrics for co-location cities.

	Betweenness			Degree		
Co-location cities	2012	2013	Change	2012	2013	Change
Paris	6,950,362	9,762,717	40%	505	589	17%
Berlin	5,284,815	8,159,381	54%	389	507	30%
Eindhoven	2,802,845	4,445,841	59%	202	257	27%
Stockholm	2,695,012	3,978,408	48%	230	273	19%
Helsinki	2,741,119	3,914,762	43%	230	264	15%
Trento	820,993	1,246,415	52%	56	71	27%

Example 2: Case Young Innovative Companies program

The Young Innovative Companies program (YIC) in Finland supports international growth, with funding from Tekes – the Finnish Funding Agency for Innovation. The aim of the funding is to substantially accelerate the growth and internationalisation of small companies (http://www.tekes.fi/en/funding/companies/young-innovative-growth-enterprises-/).

The goal of this case study was to look at growth companies and their connections and to see what kinds of resource are available through these existing connections, hence creating transparency in the existing relationships within the YIC ecosystem. Also, a big picture of the actors and their linkages was seen important for Tekes, as it funds individual companies and wants to see the network surrounding those (Huhtamäki et al. 2012).

Boundary specification and data:

- A list of 94 YIC companies was collected from the Tekes home page of the program;
- Each company was matched to the IEN Growth dataset, resulting in 33 companies found;
- Twitter followers (direct followers) of all YIC company Twitter accounts were collected:
    - More than 70,000 followers.

Metrics selection toward visualisations:

- A three-step network was created;
- First, the direct connections, both individuals and investors, were connected to YIC companies (that were all connected to a node representing the YIC program);
- Additional companies and related individuals that were related to those direct connections were included ;
- Finally, investors who have invested in the second-step companies were included;
- The nodes of the resulting network are sized according to their betweenness centrality;
- The network was laid out with a force-driven algorithm to reveal the clusters in the network;
- For the Twitter analysis: as only direct followers were included, the difference between the values of degree and betweenness was not likely to be significant:
    - The nodes were sized according to their indegree, i.e. the number of connections coming in to the node,
    - In a Twitter follower network, the indegree value is equal to the number of followers for a node.

Visualisations and sense-making

- Figure 6: The 3-step network of Tekes Young Innovative Companies program participants (Huhtamäki et al. 2012):
    - Shows their directly connected individuals and investors as well as investors and individuals that can be reached through the direct connections of companies in the YIC program,
    - Highlights the role of an individual that has worked both at Nokia and Google; a more detailed scrutiny showed that the individual sold a company to Google and has been involved in funding or advising many other start-ups;
- Figure 8: A snapshot of an interactive version of the YIC network:
    - Allows for experimentation and first-hand experiences with playing with the visualisation;
- Figure 7: A network of Twitter followers of the YIC companies:
    - A large number of followers; companies with web-related technologies rather active on Twitter,
    - Showing the follower-based connections between companies, most likely giving some insights into the behaviour of users and customers of the products of these companies.

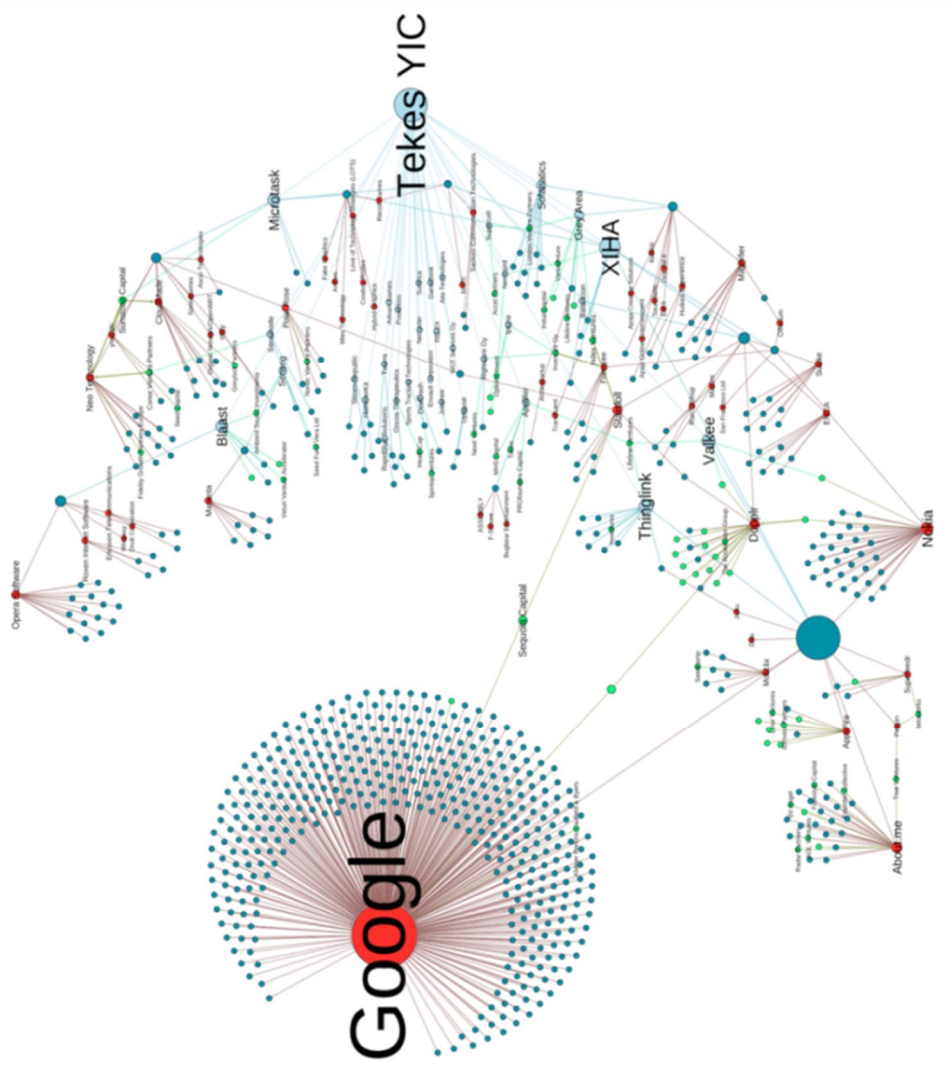

Figure 6. The 3-step network of Tekes Young Innovative Companies program participants (Huhtamäki et al. 2012).

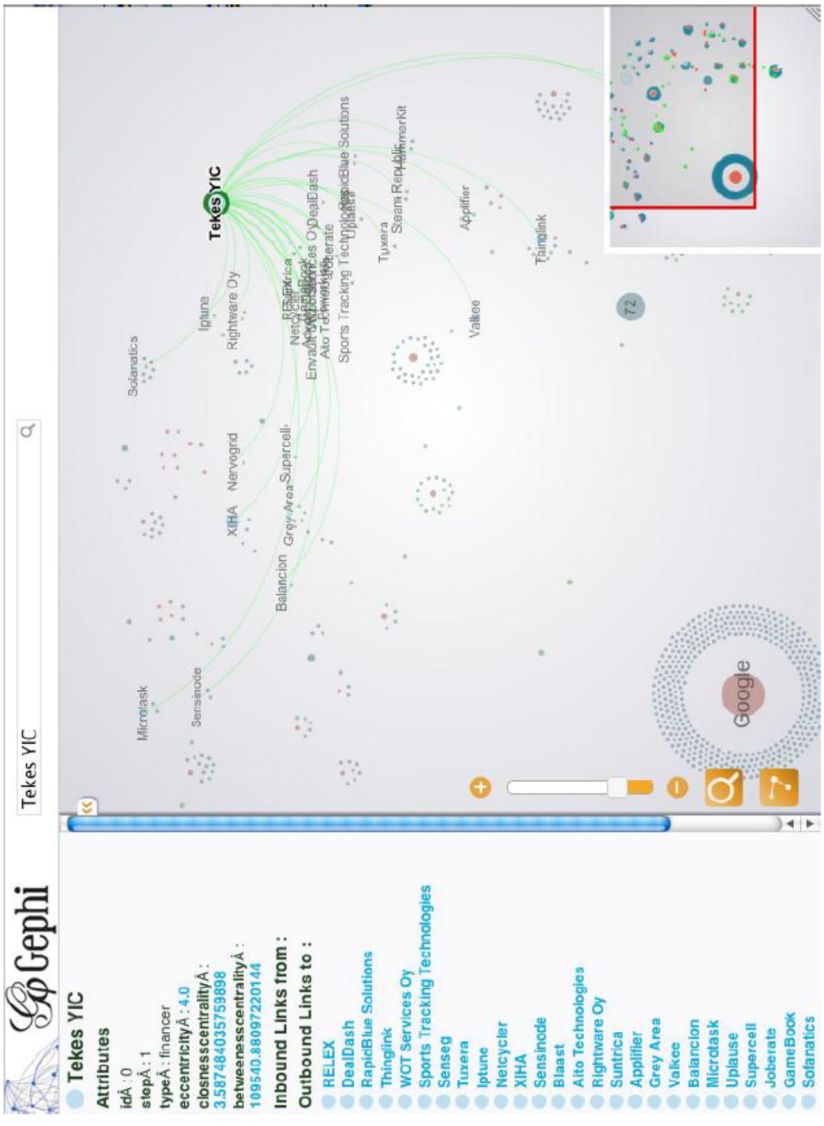

Figure 7. The interactive version of the Tekes YIC network (Huhtamäki et al. 2012).

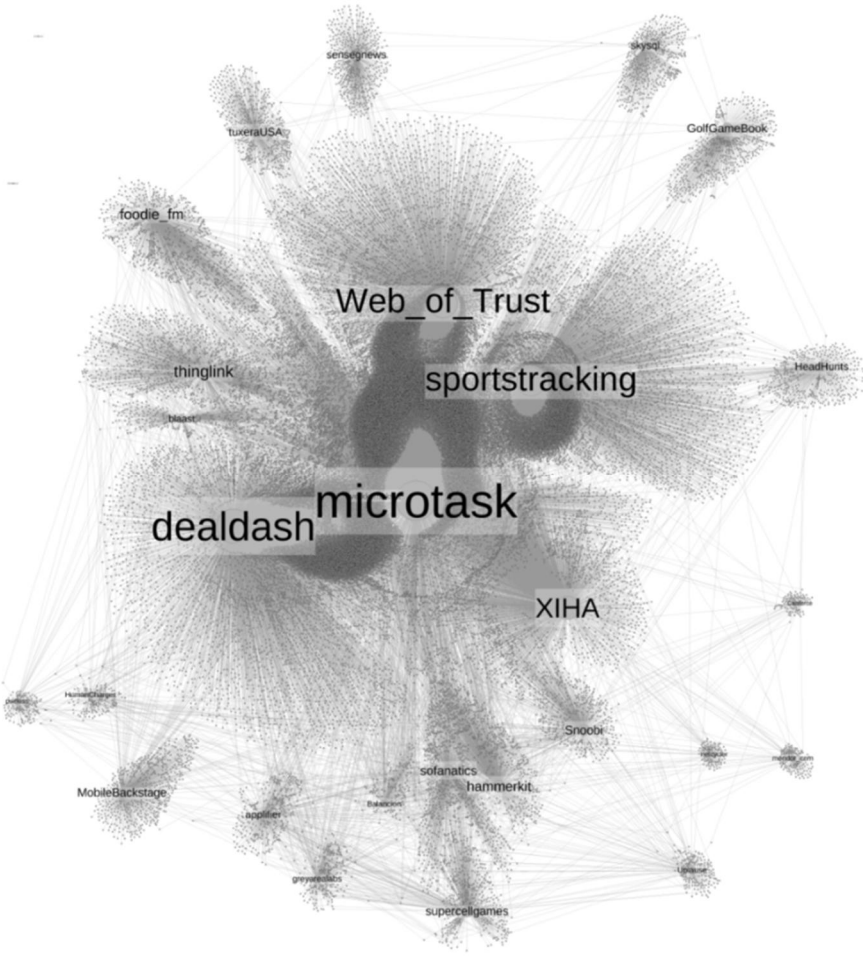

Figure 8. A network of Twitter-followers of YIC companies (Huhtamäki et al. 2012).

10.3 So what? Evaluating the novel indicators

Our innovation indicator development highlights the linkages or relationships in innovation ecosystems, hence addressing the calls for novel approaches to measuring networked innovation. We do not assume linearity in the process of collaboration and co-creation but instead wish to provide a systemic view of the (complex) innovation system, simultaneously addressing individual actors and their relationships within that system. Our research experiments have aimed at making these

intangible resources of value-creation more concrete and more tangible by (1) using digital data as innovation data, and (2) treating this digital data as relational data, which can be measured and visualised with social network analytics. Both are rather novel approaches in the arena of innovation measurement, and both have presented challenges for the process as well as for communicating about it.

First, the issue of digital data. Traditionally, innovation indicators are very strongly based on surveys (conducted every two years) and focus on company activities. Our data are obviously derived from the Internet and do not come directly from representatives of organisations (although they may do). As we already mentioned, we see that the sheer amount of the digital innovation data and its almost-real-time quality introduce novel possibilities for innovation measurement. Coupled with the possibilities afforded by new technologies in data analysis and visualisation, even these messy, unstructured, complex and biased data can be curated in a consistent manner – which is addressed with our data-driven approach.

With the methodologies based on social network analysis, the data can be formed into novel indicators. The resulting indicators can be presented in many forms. We have used network metric distributions, top 10 lists, tables showing changes in metrics and showing networks as networks. Feedback has been favourable, but it is also clear that the results need to be communicated in a way that is easy to understand, and currently network metrics are difficult to comprehend. However, we see that the popularity of LinkedIn has helped people to understand the overall concept of a network. Hence, our network visualisations have received positive feedback. The stakeholders have appreciated the 'big picture' of the innovation ecosystem skeleton as well as the possibility to 'drill down' to look at individual actors and their connections. Furthermore, the visualisations can show us where innovation activities are taking place and what the hotspots are – both are questions that cannot be answered with traditional measurement methods. In particular, our experience shows that a straightforward way to allow interactive network exploration is appreciated in the case environments. Using network visualisation widgets based on Web technologies has exposed variability and enabled experimentation (McKinsey 2011).

We see that showing a rough sketch of the phenomenon of networked innovation is an important first step toward its modelling. The eventual objective in modelling is to enable simulation and prediction – which is a goal that stakeholders in our case environments have also mentioned. However, to create a model at this level of detail, we need to first make sure that the various stakeholders see the model as valid: policy-makers, entrepreneurs, serial entrepreneurs, business angels, venture capital investors and education developers all have very different perspectives, yet in the best case the efficacy of the network visualisations is increased if they all accept the models created. We continue to strive toward this.

Though we suggest that these novel indicators can bring novel insights into innovation activities at the ecosystem level while allowing for zooming in to look at individual actors and their networked innovation activities, we recommend their complementary use together with other existing or emerging indicators. Further-

more, challenges remain at three levels: (1) managing the data-driven process toward these new indicators calls for seamless integration of its phases, often requiring special competences and tailored software components; (2) interpreting and comparing these new indicators requires new kinds of processes, as they might be context specific and in visual format; and (3) acknowledging the fact that even the novel big data based indicators tell us more about the history than about the future, which posits demands for even more advanced tools and methods to simulate or predict the future for support, taking the what-if approach (Haas et al. 2011).

Overall, with this initial research toward measuring and visualising networked innovation, we agree with Kohlhammer et al. (2012) that “visualisation and visual analytics are vital for informed decision-making and policy modelling in a highly complex information environment overloaded with data and information”. The visual representations based on these vast datasets are not intended to replace other traditional or emerging innovation indicators but rather bring added value to understanding, managing and improving innovation activities, both at the ecosystem level as well as zooming in to individual actors and their networked innovation activities. We see this adding to innovation management with possibilities of (adapted from McKinsey 2011): (1) Creating transparency, for example by making tacit information related to connections and relationships very explicit, or visible, through network visualisations; (2) Exposing variability and enabling experimentation and simulation; (3) Segmenting populations, or networked individuals, to tailored actions; (4) Supporting human decision-making with automated algorithms; toward innovating new business models, products and services.

References

Ahuja, G., Soda, G. and Zaheer, A. (2011). The genesis and dynamics of organizational networks, Organization Science, 23 (2): 443-448.

Basole, R.C. and Rouse, W.B. (2008). Complexity of service value networks: Conceptualization and empirical investigation. IBM Systems Journal 47, 1 (2008), 53–70.

Card, S.K., Mackinlay, J. and Shneiderman, B. (1999). *Readings in Information Visualization: Using Vision to Think (1st ed.).* San Francisco, CA: Morgan Kaufmann.

Chesbrough, H. (2003). Open Innovation: The New Imperative for Creating and Profiting from Technology. Boston: Harvard Business School Press.

Crossan, M. and Apaydin, M. (2010). "A Multi-Dimensional Framework of Organizational Innovation: A Systemic Review of the Literature." *Journal of Management Studies*, Vol. 27, No. 6, pp. 1054–1191.

Deloitte (2012). Disruptive Innovation: Case study – Intelligence Open-Source Data Analytics. Deloitte reports, 2012, http://www.deloitte.com/assets/Dcom-Australia/Local%20Assets/Documents/Industries/Government%20Services/Public%20Sector/Deloitte_IntelligenceDI_CaseStudy_2Apr2012.pdf

Easley, D. and Kleinberg, J. (2010). Networks, Crowds, and Markets: Reasoning about a Highly Connected World. Cambridge University Press.

Franke, N., von Hippel, E. and Schreier, M. (2006). "Finding Commercially Attractive User Innovations: A Test of Lead-User Theory." *Journal of Product Innovation Management*, Vol. 23, No. 4, pp. 301–315.

Freeman, L.C. (1999). "Methods of Social Network Visualization." In: R. A. Meyers (ed.). *Encyclopedia of Complexity and Systems Science*. Berlin: Springer.

Haas, P.J. and Maglio, P.P. (2011). "Data is Dead... Without What-If Models." *PVLDB*, Vol. 4, No. 12, pp. 1486–1489.

Hadhazy, A. (2011). "Visualization Tools Can 'See' Through a Forest of Data." *TechNewsDaily*, February 10, 2011, http://www.technewsdaily.com/2053-visualization-tools-can-see-through-a-forest-of-data.html

Halinen, A., Medlin, C. and Tornroos, J.-A. (2012). Time and process in business network research. *Industrial Marketing Management*, Vol. 41, Issue 2, pp. 215–223.

Hanneman, R.A. and Riddle, H. (2005). Introduction to Social Network Method. Online text, http://faculty.ucr.edu/~hanneman/nettext/C2_Formal_Methods.html

Holmqvist, L. (2004). User-driven innovation in the future applications lab. *Proceedings of the International Conference for Human-Computer Interaction, CHI 2004*. Vienna, Austria, 2004, pp. 1091–1092.

Huhtamäki, J., Still, K., Isomursu, M., Russell, M.G. and Rubens, N. (2012). "Networks of Growth: Case Young Innovative Companies in Finland." *Proceedings of the 7th European Conference on Innovation and Entrepreneurship.* Santarém, Portugal, September 20–21, 2012.

Hwang, V.W. and Horowitt, G. (2012). The Rainforest: The Secret to Building the Next Silicon Valley. Regenwald.

Karat, J. 1997. Evolving the scope of user-centred design. *Communications of the ACM*, Vol. 40, No. 7, pp. 33–38.

Kogut, B. and Zander, U. (1996). "What firms do? Coordination, Identity and Learning." *Organization Science*, Vol. 7, No. 5, pp. 502–518.

Kohlhammer, J., Nazemi, K., Ruppert, T. and Burkhardt, D. (2012). "Toward Visualization in Policy Making." *IEEE Computer Graphics and Applications*, Vol. 32, No. 5, September–October, pp. 84–89.

Leontiou, A. (2011). "The world's shift from analog to digital is nearly complete." *Tech News Daily*, October 2, 2011. http://www.msnbc.msn.com/id/41516959/ns/technology_and_science-innovation/t/worlds-shift-analog-digital-nearly-complete/#.UJdhY2cdwuc

McKinsey (2011). "Big Data: The next frontier for innovation, competition and productivity." McKinsey Global Institute, Overall Presentation, October, 2011, http://www.jegi.com/sites/default/files/McKinsey_Presentation.pdf

Milbergs, E. (2007). "Innovation Vital Signs: Framework Report, An Update." In collaboration with ASTRA – The Alliance for Science Technology Research in America.

Moody, G. (2011). "Open source, open data, open innovation." Presentation given at South Tyrol Free Software Conference, November 18, 2011, http://www.slideshare.net/glynmoody/glyn-moody-open-data-open-innovation

NESTA (2008). “Measuring Innovation.” Policy Briefing, July, 2008. http://www.nesta.org.uk/library/documents/Measuring-Innovation-v3.pdf

Nykänen, O., Mannio, M., Huhtamäki, J. and Salonen, J. (2007). “A Socio-Technical Framework for Visualising an Open Knowledge Space.” *Proceedings of the International IADIS WWW/Internet 2007 Conference*, edited by Isaías, P., Baptista Nunes, M. and Barroso, J. Vila Real, Portugal, October 5–8, 2007, pp. 137–144.

OECD (2010). “Measuring Innovation: A New Perspective.” Paris: OECD. http://www.oecd.org/site/innovationstrategy/45362740.pps

Oslo Manual (2005). “Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data (3rd edition).” Paris: OECD.

Perani, G., Rosario, M. and Sirilli, G. (2006). “Innovation at regional level: CIS4 two-tiered survey in Italy.” Blue Sky Forum on “What Indicators for Science, Technology and Innovation Policies in the 21st Century”. Ottawa September 25–26, 2006. http://www.oecd.org/sti/innovationinscience technologyandindustry/37443591.pdf

Powell, W.W., Koput, K.W. and Smith-Doerr, L. (1996). Interorganizational Collaboration and the Locus of Innovation: Networks of Learning in Biotechnology. *Administrative Science Quarterly*, Vol. 41, No. 1 (Mar., 1996), pp. 116–145.

Ramaswamy, V. and Gouillart, F. (2010). “Building the Co-Creative Enterprise.” *Harvard Business Review*, Vol. 88, No. 10, October, 2010.

Ries, E. (2011). *The Lean Startup.* USA: Crown Business.

Russell, M.G., Still, K., Huhtamäki, J., Yu, C. and Rubens, N. (2011). “Transforming Innovation Ecosystems through Shared Vision and Network Orchestration.” *Proceedings of Triple Helix IX International Conference: “Silicon Valley: Global Model or Unique Anomaly?"* Stanford, California, USA, July 11–14, 2011.

Schilling, M.A. (2009). Understanding the alliance data. *Strategic Management Journal*, Vol. 30, No. 3, pp. 233–260.

Still, K., Russell, M.G., Huhtamäki, J., Turpeinen, M. and Rubens, N. (2011). “Explaining Innovation with Indicators of Mobility and Networks: Insights into Central Innovation Nodes in Europe.” *Proceedings of Triple Helix IX International Conference: “Silicon Valley: Global Model or Unique Anomaly?"* Stanford, California, USA, July 11–14, 2011.

Still, K., Huhtamäki, J., Russell, M.G. and Rubens, N. (2012a). “Transforming Innovation Ecosystems Through Network Orchestration: Case EIT ICT Labs.” *Proceedings of the XXIII ISPIM Conference – Action for Innovation: Innovating from Experience*. Barcelona, Spain, June 17–20, 2012.

Still, K., Huhtamäki, J., Russell, M., Koskela-Huotari, K., Isomursu, M. and Pohjolainen, S. (2012b). Sosiaalisesta mediasta dataa innovaatiotoiminnan mittaamiseen. Tekes Policy Brief 2/2012: Kysyntä- ja käyttäjälähtöinen innovaatiotoiminta.

Still, K., Koskela-Huotari, K., Isomursu, M., Huhtamäki, J., Pohjolainen, S. and Russell, M.G. (2013). Social media supported innovation indicators. VTT Research Report. Espoo: VTT. http://www.vtt.fi/inf/julkaisut/muut/2013/VTT-R-01113-13.pdf

Vargo, S. (2009). “Toward a transcending conceptualization of relationship: a service-dominant logic perspective.” *Journal of Business and Industrial Marketing*, 2009, pp. 373–379.

Vargo, S. and Lusch, R.F. (2004). “Evolving to a New Dominant Logic for Marketing.” *Journal of Marketing*, Vol. 68, No. 1, January 2004, pp. 1–17.

von Hippel, E. (1976). The Dominant Role of Users in the Scientific Instrument Innovation Process. *Research Policy*, Vol. 5, No. 3, pp. 212–39.

Wasserman, S. and Faust, K. (1994). *Social Network Analysis: Methods and Applications*. New York, NY, USA: Cambridge University Press.

Wellman, B. (1988). “Structural Analysis: From Method and Metaphor to Theory and Substance.” In: Wellman, B. and Berkowitz, S.D. (Eds.). *Social Structures: A Network Approach.* New York, NY: Cambridge University Press, pp. 19–61.

Welser, H.T., Gleave, E., Fisher, D. and Smith, M. (2007). Visualizing the Signatures of Social Roles in Online Discussion Groups. *Journal of Social Structure*; 2007; 8 (2).

Wong, P.C. and Thomas, J. (2004). “Visual Analytics.” *IEEE Computer Graphics and Applications*, Vol. 24, No. 5, pp. 20–21.

Zaheer, A., Gözübüyük, R. and Milanov, H. (2010). It’s the connections: The network perspective in interorganizational research. *Academy of Management Perspectives*, Vol. 24, No. 1, pp. 62–77.

11. Conclusions

Olavi Lehtoranta & Mika Nieminen

This book contains discussions and investigations of many aspects of measurement, logic of measurement, challenges encountered in measurement, possible solutions, and complementary measurement frameworks. In the following, we would like to pick up on some issues from these discussions that we consider important. We also put forward some ideas for further development.

As we know, statistics usually do not follow definitions adopted in in-depth qualitative research. Instead, they follow what can be surveyed repetitively and with relative ease. This is also because only simple basic questions can be asked routinely. On the other hand, there are constant attempts to develop and broaden the scope of innovation measurement. As our understanding of innovation processes is becoming more detailed and broad, the concept of innovation may also become blurred. Thus, currently, as practically any and all changes to products, services, methods and practices are considered innovations, the ability to make distinctions between innovations and non-innovations has declined. Furthermore, it seems that a remarkable percentage of activities included in broad-based innovation activities (such as development of operations, brand and marketing) are such that we may ask whether these activities should rather be understood as activities complementing innovation activities than as innovation activities *per se*.

Paradoxically, current standard definitions and measurements, while very broad, can also be seen as somewhat restrictive. For instance, in the current literature, the innovation process is usually seen as a long-standing process comprising several interlinked events and processes intertwined with other actors. This systemic nature of innovation is usually poorly covered by existing standard measurements. Likewise, it is not standard to include individual consumers as producers of innovation or wide social impacts of innovations in measurements. It is also common for innovation activities to remain a shapeless, aggregate phenomenon in statistical measurement. This happens for instance when companies performing innovation activities are not classified by the nature of innovations or by their potential impact on society at large.

The measurement of innovations and innovation activities becomes increasingly challenging when considering non-technological innovations. Technological innovation is usually seen and measured as an activity related to R&D. By contrast, a non-technological innovation can be generated without R&D. Non-technological innovations may include new management and business processes or services. Thus, by the definitions of the Oslo Manual (ed. 3) a somewhat fuzzy figure on the frequency of non-technological innovations in various countries can be reached. For example, according to the CIS, the percentage of SMEs that have implemented organisational and marketing innovations varies between 10% and 70% of all

SMEs in the surveyed countries. One possible interpretation for such high variation is that it is interpreted by respondents as broad-based development activity, thus not being actually an indicator of innovation activities. Because the CIS does not make any distinction between innovations according to their societal novelty value or impact, it is very difficult to assess, without innovation descriptions, how many actual innovations there are among this development. Interestingly, in the pilot questionnaire reported in this book, one of the main findings was that quite a small number of non-technological changes can be interpreted as significant innovations.

Actually, in many cases it might be more feasible to talk conceptually about the measurement of intangible investments rather than the measurement of broad-based innovation expenditure. This is because it is not clear in principle (or to the respondents) what changes actually are innovations. Such measuring of intangible investments is challenging enough, as their changes cannot be easily extracted from any accounting system. For example, the long-term expenditure for design is partly included under traditional research and development (R&D) expenditure (functional design) and partly under expenditure for marketing innovations (aesthetic product or packaging design). In the CIS, respondents are requested by contrast to report companies' marketing, education and product design expenditure. These are included under the aggregate innovation expenditure. There are no questions about expenditure for developing new business models and organisational methods. A more detailed breakdown of these investment items would possibly require a revision of the Frascati Manual and a definition of non-scientific R&D.

Interestingly, the challenge of the concept of innovation is also indicated in the analysis of the Finnish MEPIN survey of public-sector organisations. In the survey, respondents were asked to give examples of innovations. Respondents typically provided a long list of development activities. These renewals, being mainly adoptions and implementations of innovations developed by others, involved technological products, services, data and other management systems and processes.

While these perspectives can be considered relatively critical on extending innovation measurement, we naturally also need new, improved measurements and indicators. For instance, public-sector innovation and other organisations and service innovations should be more widely included in innovation surveys. There is also no doubt that the measurement of user and consumer innovation should be further developed. One of the challenges of current measurement practices is that we should be able to extend the traditional producer and technology-centred perspectives to other areas and also find new methodologies to better catch the networked and systemic character of innovation. We are just beginning to use Internet-based sources and 'big data' in the monitoring of innovations and innovation activities.

Measurement and indicators should also better support policy-making purposes and target setting. In this sense, the rationale of measurement should come closer to that of impact assessment and evaluation. We need more information on the nature of innovations, on their interconnections (innovation families) and impacts.

This would provide a richer view of innovation processes and the diffusion of innovations.

While acknowledging the limited possibilities of the statistical systems to provide this kind of information, we believe that innovation surveys could be directed more towards:

- New technologies, practices, materials and their implementations;
- New-to-market/society innovations in broader categories of innovation;
- Innovations in service processes;
- Conceptual and intangible innovations;
- Systemic innovations, including administrative-organisational innovations;
- Socially and environmentally sustainable innovations;
- Social, economic and environmental impacts of innovations.

We also believe that innovation statistics should make a clearer distinction between an invention, the innovation process and the diffusion process. At the moment, these are considered practically to be the same thing. The different character of innovations should also be better taken into account (e.g. service innovations, which are usually incremental improvements). Furthermore, the factors promoting and hampering innovations should be included more clearly than at present. For example, statistics should include the measurement of demand-based innovation policy instruments (e.g. innovative public procurements) and their impacts in order to better catch the role of the public sector in innovation. In addition, as indicated earlier, we need better information on investments in commercialisation and marketing as well as on investments in planning, education, brand building, development of organisation, etc., which are related to the innovation process. Also, the links between the main innovation and other renewals in the organisation should be better highlighted.

The strategic topics in recent innovation policy discussions reflect these viewpoints. The topics have emphasised *inter alia* the significance of demand and user orientation, service innovations, the development of innovation environments and co-operation, and intangible value creation and investments. Although our understanding of the nature of innovation activities and our innovation policy have undergone a major development, our monitoring systems still largely reflect technology-centred innovation activities. Thus, in recent years several indicator development projects have been launched to meet this challenge. We hope that the present book may also contribute to that work. The main message of the book is, however, that there can scarcely be one correct way to measure innovation; different views and approaches should complement each other.

Series title and number

VTT Technology 242

Title	**Measuring broad-based innovation**
Author(s)	Mika Nieminen & Olavi Lehtoranta (eds.)
Abstract	The book contributes to the discussion of monitoring and measuring broad-based innovation. The major questions are: are available indicators working properly, and can we find new perspectives on or indicators for innovation processes? The study discusses and investigates many aspects of measurement, logic of measurement, challenges encountered in measurement, possible solutions, and complementary measurement frameworks. While the study provides critical perspectives on extending innovation measurement and is sceptical whether current statistics serve in best possible way policy-making, it suggests also new, improved measurements and indicators. For instance, public-sector innovation and other organisations and service innovations should be more widely included in innovation surveys. Also the measurement of user and consumer innovation should be further developed. We should also find new methodologies to better catch the networked and systemic character of innovation like ones that utilize internet-based sources and 'big data'. Some of the conclusions of the study are that innovation statistics should make a clearer distinction between an invention, the innovation process and the diffusion process, the different character of innovations should be better taken into account, and the factors promoting and hampering innovations should be included more clearly in the measurements than at present.
ISBN, ISSN, URN	ISBN 978-951-38-8385-0 (Soft back ed.) ISBN 978-951-38-8386-7 (URL: http://www.vttresearch.com/impact/publications) ISSN-L 2242-1211 ISSN 2242-1211 (Print) ISSN 2242-122X (Online) http://urn.fi/URN:ISBN:978-951-38-8386-7
Date	December 2015
Language	English
Pages	195 p.
Name of the project	
Commissioned by	
Keywords	Innovation statistics, broad-based innovation, innovation measurement, innovation indicators
Publisher	VTT Technical Research Centre of Finland Ltd P.O. Box 1000, FI-02044 VTT, Finland, Tel. 020 722 111

VTT TECHNOLOGY 242

Measuring broad-based innovation

Measuring broad-based innovation

Measuring innovation and impacts of STI has become an increasingly important issue in policy-making during the last few decades. This book contributes to the on-going discussion of monitoring and measuring innovation. Are available indicators working properly, and can we find new perspectives on or indicators for innovation processes?

The book introduces a number of various complementary perspectives on measuring and indicators. The basic assumption behind the book is that we need multifarious indicators and measurement methods in order to describe such a complex and systemic phenomenon as innovation. There is no single truth about innovation indicators and there is room for various different – and sometimes even conflicting – ways of understanding and measuring of innovation.

ISBN 978-951-38-8385-0 (Soft back ed.)
ISBN 978-951-38-8386-7 (URL: http://www.vttresearch.com/impact/publications)
ISSN-L 2242-1211
ISSN 2242-1211 (Print)
ISSN 2242-122X (Online)
http://urn.fi/URN:ISBN:978-951-38-8386-7