

## 2. Innovation systems

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### 2.1 INTRODUCTION

This chapter starts with a basic review of systems<sup>1</sup> as a means of classification of actors in the system, their activities and their linkages with other actors. Activities can change with time. Linkages, and what they transfer, can go in one or two directions and can also take time to make the transfer. Linkages may act as feedback loops and they can interact with one another, as well as with the actors, to alter the change anticipated when an activity is implemented. The system is bounded, which means that there are boundary or framework conditions which influence the activities of the actors and what flows through the linkages. A system can be complex.<sup>2</sup>

After a general description of systems, ‘innovation’ and ‘innovation policy’ are introduced, also at a basic level. Later, a connection is made to national, regional and sectoral innovation systems.

The reason for this approach is to encourage the reader to reflect first on what systems are and how they can be used to describe complex phenomena. That understanding is a first step towards asking what could be done to cause the system to behave differently and to learn from that.

Language is an issue throughout the book and the term ‘eco-systems’ is an example. With one exception, ‘systems’ will not have the preface ‘eco’. The exception is found in Chapter 9 when green innovation is discussed, and ecological systems are relevant.<sup>3</sup>

### 2.2 SYSTEM COMPONENTS

In this book, the focus is on innovation everywhere in the economy. As a consequence, the actors are ‘institutional units’, as defined in the *System of National Accounts Manual, 2008* (EC et al. 2009: 4.24).<sup>4</sup> These include firms in the business sector,<sup>5</sup> government departments in the general government sector, households, or individuals in the household sector, and lobby groups, political parties, or other such groups, in the

non-profit institutions serving households (NPISH) sector. The public sector is the general government sector plus public institutions, such as government-controlled businesses, education institutions or hospitals. The SNA sectors are reviewed in Chapter 7.

The institutional units engage in activities, interact with other institutional units and produce outcomes in the short term that may lead to economic or social impacts in the longer term.

A point relevant to systems analysis, and especially to innovation systems, is that the actors do not act in isolation. It is the connection (linkage) with other actors that constitutes the system and allows some actors to influence the behaviour of others. This influence can result from new products made available to other actors (smart phones) or the response of regulators (actors) to services provided by other actors (e.g., germline gene editing). The term ‘linkage’ here covers any exchange, in any direction, between institutional units. Some examples are money, skilled people, property ownership, knowledge or services.

A system can be viewed as a set of actors engaged in activities, linked in various ways and producing outcomes, bounded by what have been called ‘institutions’ or ‘rules of the game’ (North 1990) or framework conditions, the term used here.

## 2.3 INTERVENTION, COMPLEXITY AND NON-LINEARITY

In an economic system, there are at least two kinds of interventions. The first acts directly on an actor to change its behaviour. For example, a government procurement office asks for tenders that require innovation to be part of the response. The behaviour of the successful bidder(s) changes as a result. The example used is the promotion of innovation in a firm. The change in behaviour could also include training of staff in the use of critical technologies (artificial intelligence), developing digital competence or meeting government requirements for an inclusive labour force.

The second type of intervention deals with the framework conditions which influence what the actors do. They could include policy to promote research in higher education, resulting in more highly qualified people who could be employed in the business sector or in public sector research establishments. Such a policy can influence innovation but not directly.

Policy intervention can be a mix of direct intervention and indirect intervention and this will be discussed in Part II.

Innovation systems are complex, non-linear and are difficult, if not impossible, to model. This is largely because of human behaviour which changes in response to interventions, direct or indirect, but not necessarily in the way expected. Non-linearity happens when interventions interact with one another or with links between actors. As a result, the desired output, more innovation perhaps, may not change in proportion to the intervention.

## 2.4 INNOVATION SYSTEMS

So far, systems have been introduced, but not innovation systems. That requires definitions of innovation and of innovation activities which may or may not lead to innovation. Once there is a definition of innovation (Chapter 6) the distinction can be made between institutional units that are ‘innovative’ and those that are not. Further distinctions can be made if the innovation is restricted (inclusive or sustainable innovation are examples).

The study of innovation, and innovation systems, has many approaches and one of the objectives of this book is to suggest a direction which can bring some, if not all, of these together.

One approach has been the measurement of innovation, and related activities, through internationally agreed surveys such as the EU Community Innovation Survey (CIS), using internationally agreed definitions. The evolution of the definition of innovation in four editions of the *Oslo Manual* is reviewed in Chapter 6, as well as the application of the definition in the series Community Innovation Surveys, starting with reference year 1992 and continuing to the present. The *Oslo Manual* provides definitions, the CIS provides data and the data are used to populate statistics which may be used as they are, or in combination with other statistics, as indicators. The principal use is the monitoring of the innovation system – the rate of innovation in the sector being studied, the allocation of resources to activities that support innovation and, perhaps, evidence of activities that support or inhibit innovation. These indicators may be used in ‘scoreboards’ which report on the innovation system in countries, supporting comparisons that may be used to influence policy (Chapter 4).

The indicators from the measurement approach to observing innovation can be used to monitor and to evaluate (Chapter 4) implemented innovation policy,<sup>6</sup> which may lead to policy learning and the further development of policy (Chapter 5). Part II reviews some current innovation policies, looks at the role of scoreboards in monitoring and eval-

uation, and at developing new policies or improving existing ones. With exceptions that will be noted, existing innovation policy is focused on the business sector. The discussion in Part II leads to the broader discussion in Part III on measuring innovation in other economic sectors.

The measurement approach to understanding innovation is used in statistical offices and in research institutes with a mandate to produce official statistics. The indicators resulting from the measurement are published by countries that produce reports on the state of their innovation system and by international and supranational organisations that produce scoreboards (Chapter 4). The definitions and guidelines for measurement, in the case of innovation, are developed and agreed by the OECD Working Party of National Experts on Science and Technology Indicators (NESTI) in collaboration with the EU statistical office, Eurostat. The membership of NESTI is a mix of statisticians who produce the innovation statistics and people from government policy departments of participating countries which use them. Staff from research institutes and academics are, in some cases, invited to join the country delegation to provide expertise on a specific topic.

Outside of the OECD/Eurostat community are academics who work on understanding innovation with a view to finding a theory of innovation. Some of this work is reviewed in the next section.

## 2.5 INNOVATION SYSTEMS LITERATURE

There is a large literature on innovation systems and on national innovation systems. In this section, both are considered briefly. The objective is to provide a background to the discussion of current innovation policy in Part II leading to questions to be considered in Part III when innovation in any economic sector is discussed.

An ongoing discussion is the theoretical basis for innovation policy. Borrás and Edquist (2019: 5) assert that ‘the theoretical foundations for innovation policy design from the innovation systems approach remain underdeveloped today’. This is compatible with the approach of this book which focuses on statistical measurement guided by internationally agreed definitions indicating the outcome of implemented innovation policy.

*Table 2.1 Key activities in innovation systems in Borrás and Edquist (2019: 25)*

<b>1. Provision of knowledge inputs into the innovation process</b>
1.1 Provision of R&D results
1.2 Competence building
<b>2. Demand-side activities</b>
2.1 Formation of new product markets
2.2 Articulation of new product quality requirements
<b>3. Provision of constituents for innovation systems</b>
3.1 Creation and change of organisations
3.2 Interactive learning, networking and knowledge integration
3.3 Creation and change of institutions
<b>4. Support services for innovating firms</b>
4.1 Financing of innovation processes
4.2 Incubating activities
4.3 Provision of consultancy services

*Source:* An abbreviated version of Box 2.2 in Borrás and Edquist (2019: 25).

### 2.5.1 Innovation Systems

Edquist (2005) presents a chapter in the *Oxford Handbook of Innovation* (Fagerberg et al. 2005) which is an accessible discussion of innovation systems, their components and their purpose, which has had considerable influence over the last 15 years on innovation policy. It discusses functions or activities that are important for the analysis of innovation systems. This leads to a list of ten activities, or functions, that are important to the innovation system. The chapter reflects earlier work (Edquist 1997; Edquist and Hommen 2008). The most recent version of the list appears in Borrás and Edquist (2019: 25). It has the same content as that in Edquist (2005), but the activities are grouped under explanatory headings as shown in Table 2.1. These will be discussed in Chapter 6 when the definition of innovation and of innovation activities for measurement purposes (OECD/Eurostat 2018) are introduced.

For comparison, innovation activities were presented in the third edition of the *Oslo Manual* (OECD/Eurostat 2005: para. 40–43). In both cases, innovation, and innovation activities, took place in the business sector.

### **2.5.2 National Innovation Systems**

Much of the literature in the last 30 years has addressed national innovation systems and Chaminade et al. (2018: 49) have provided a comprehensive review of the subject, noting that ‘analysing the system is very complex and there is a tendency to reduce complexity by looking at particular aspects of the system ...’. The key point is that an innovation system is very complex which is a recurring theme in this book.

### **2.5.3 The Digital Economy and Innovation**

The digital economy is growing rapidly and changing the way innovation happens. This does not affect the innovation system, but it does influence the speed at which it can happen and the means of providing digital product innovations and digital process innovations. Some of this is discussed in Gault (2019) and in Paunov and Planes-Satorra (2019).

## **2.6 CONCLUSION**

Innovation systems are complex and that is why there is no headline indicator for the activity of innovation comparable to the ratio of gross domestic expenditure on R&D (GERD) to gross domestic product (GDP). To analyse what is going on in an innovation system may require simplification of its description (Chaminade et al. 2018). It could also be modelled, which is considered in Chapter 10.

In the following chapters, the systems approach is used to describe the innovation system, its components and its outcomes. In Part II, the chapters deal with innovation in the business sector. Part III introduces the general definition of innovation and the definition of the economic sectors used by the SNA so that sector-specific innovation can be discussed. Chapter 8 considers types of innovation that can occur in any sector. Part IV looks at what happens next, in this subject, in the 2020s.

## **NOTES**

1. See Meadows and Wright (2008) for more on systems from a basic perspective.
2. See Mitchell (2009) for more on complexity.
3. The view is that, in most cases, ‘eco-’ adds nothing to the discussion of innovation systems. For further discussion, see Borrás and Edquist (2019: 26), Chaminade et al. (2018: 95) and Gault (2010: 32).

4. This is developed in Chapter 7.
5. In Chapter 8 the non-financial corporations sector and the financial corporations sector are combined to be the business sector. This aligns this book with the usage in the *Oslo Manual*.
6. The use of 'implemented' is important. Policies can be announced in various ways: the manifesto of a political party; the news media; or in the legislature. There is some distance between an announced policy and an implemented policy which can be monitored and evaluated.