1 Introduction

> The relation between what we see and what we know is never settled. Each evening we see the sun set. We know that the earth is turning away from it. Yet the knowledge, the explanation, never quite fits the sight.
>
> John Berger, *Ways of Seeing*

In this chapter we define the network perspective, and its role in understanding and managing innovation. We distinguish between the different ways in which the term network is understood in different contexts. We clarify the scope of social network theory and social network analysis, as well as the meaning of social networks, business networks, and knowledge networks. We describe an innovation network with the help of three dimensions that characterise it: the innovation stage (why do we carry out network analysis?), level of analysis (which networks do we analyse?), and social network metrics (which social network metrics should we use?). We distinguish between two kinds of managerial activities in which a network perspective is useful: direct network interventions and situation analysis.

At first glance, there is little in common between the Seven Bridges of Königsberg and the New York Training School for Girls. Yet they mark the beginnings of a particular way of seeing what is around us, which is today referred to as the network perspective. In 1736 Leonhard Euler found a mathematical solution to the problem of devising the most efficient way of negotiating the city of Königsberg on foot: the Seven Bridges of Königsberg is often quoted as the first study in graph theory.[1] Graph theory refers to the application of mathematical concepts and theories to a system that is composed of nodes and edges. Euler saw areas of land and bridges as a network of four nodes and seven links respectively (Figure 1.1). Two hundred years later, in a very different

[1] Euler's problem was that all the bridges could be crossed once only but all the pieces of land had to be visited. Euler showed that, for such a path to exist, the number of nodes with an odd number of ties must be either zero or two.

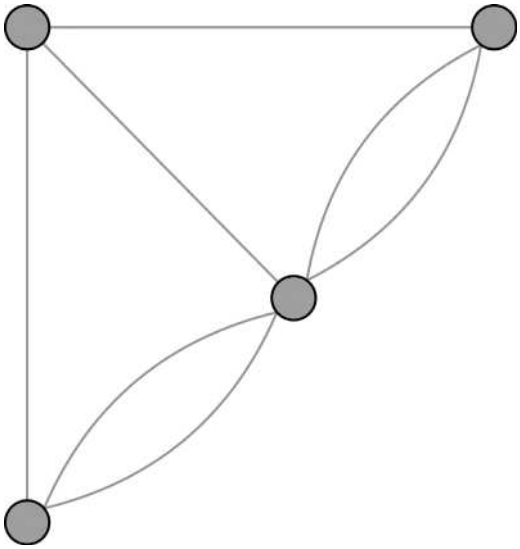

Figure 1.1 The Seven Bridges of Königsberg Represented as a Network
Note: Nodes are areas of land, and edges are the bridges between them.

context, a leading sociologist, Jacob Moreno, conceived a similar network for the New York Training School for Girls, which had a problem with runaway students. Moreno saw the girls as nodes and explained their runaway patterns by examining influence between them (Figure 1.2). His experimental work on this case is considered the leading study in sociometry today.[2]

These two contributions in strikingly different contexts reveal just how broad a range of phenomena can be regarded as networks. We are witnessing this vividly in our contemporary world where there seem to be networks everywhere: in scientific research, the popular media and in business. Aside from the interest in online communities like Twitter and Facebook, we have learned about organised crime networks in Sicily, social networks of characters in Homer's *Odyssey* and even the networks of common flavour compounds across ingredients in different parts of the world.[3]

[2] Moreno published his research in his book *Who Shall Survive* (1934). Also see the *New York Times* article, 'Emotions Mapped by New Geography: Charts Seem to Portray the Psychological Currents of Human Relationships' on 3 April 1934. For the history of social network analysis, see Freeman (2004). Cartwright and Harary's (1956) article about linking mathematical graph theory and sociology is now considered a classic.

[3] For the network of flavours, see Ahn et al. (2011); 'Social networks of Homer's Odyssey' is found in Miranda, Baptista and Pinto (2013); for the network study of businesses involved in organised crime in Sicily, see Gurciullo (2014).

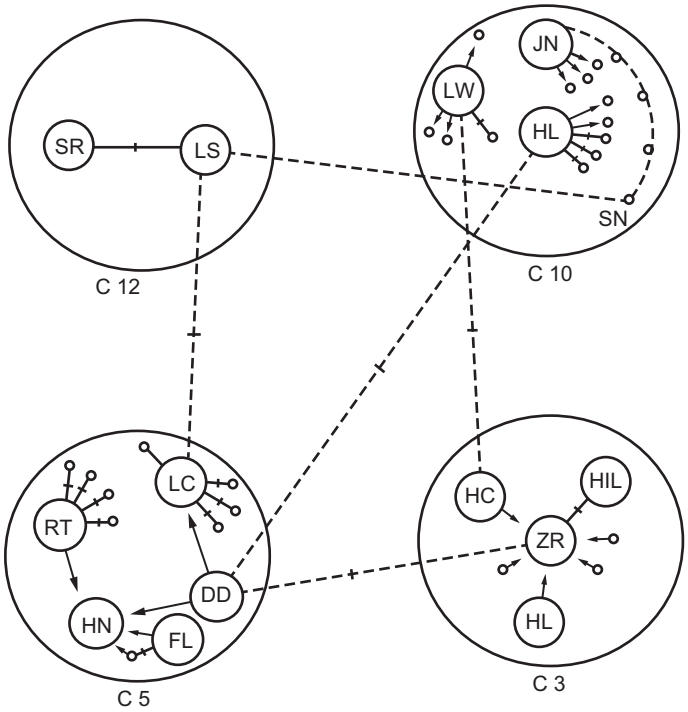

Figure 1.2 Possible Influence Patterns between Fourteen Individuals in Four Cottages are Shown as a Network
Source: Moreno (1934)

A network perspective is particularly valuable when applied to innovation, since innovation is mainly about the flow of knowledge and resources between a variety of actors. I use the term *flow of knowledge* in the general sense: it covers scientific or technical knowledge shared between inventors, experience using a technology shared among peers, 'who knows what' in an organisation or industrial district. A network perspective is an opportunity to take a bird's-eye view of knowledge flows between people, technologies and organisations.

The complex relations that drive the creation and diffusion of innovations can be better understood by taking a network perspective. Innovation is a multi-faceted activity encompassing creativity, learning, the diffusion of ideas and practices and social influence. There are significant interactions between a wide range of actors in all these diverse areas.

Partnerships between firms, collaboration among scientists, an integrated civil society and increased opportunities for users to participate in innovation are all developments that have been seen in recent years. Innovation has

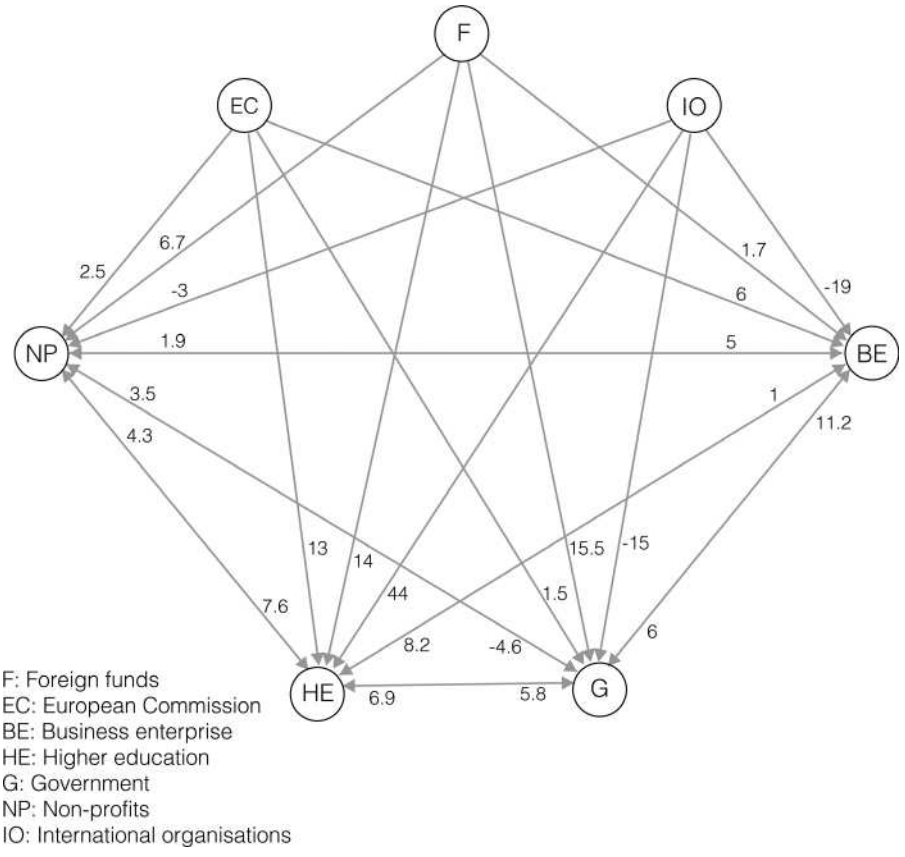

Figure 1.3 Average Annual Growth in the Flow of R&D Funds between Sectors in the Period 2000–12

become increasingly receptive to all sorts of collaboration: with suppliers, customers, competitors, universities and research labs. Through networks, innovators access complementary resources, inform themselves about others' roles and identity and achieve timeliness in accomplishing their goals by combining resources. The resources, knowledge and capabilities of different stakeholders are increasingly integrated and shared through networks. The network in Figure 1.3 shows the average annual growth in the flow of R&D funds between sectors in the period 2000–12. The increasingly collective nature of the R&D is evident in the growth of funding among nearly all stakeholders.

With these developments in mind, using a lens through which we can see the interdependences between technologies, people and organisations, and how they change over time is increasingly relevant for better innovation

performance. In an increasingly interconnected world what managers and entrepreneurs need is less about what to do, and more about how to see. But what do we mean by a network perspective?

1.1 The Network Perspective

In the most common use of the term, a network links an actor (which can be an individual, a group or a firm) with other actors in a certain context. Some network positions confer advantages while others actively prevent people from accessing opportunities. This is nothing new; as long ago as the seventeenth century, Shakespeare was writing in *Othello*, 'Preferment goes by letter and affection,/And not by old gradation'.[4]

Social network theory deals with how social structure constrains and enables the behaviour and performance of actors, as well as the behavioural and social psychological factors that influence the formation and dissolution of ties between them.[5] Social networks are made up of ties that signify affection (or the lack of it) between human beings. The field of social networks is a sub-field of sociology and social psychology is a proximate field.[6]

Social network analysis (SNA) was originally developed in the field of sociology and draws upon graph theory, offering a range of mathematical tools to analyse the structure of networks. SNA can be used to analyse any kind of network as long as relations are mapped in the form of nodes and edges. For example, a network whose nodes are patents and whose links are citations can be analysed with SNA, although a patent network is not a social network.

The four core concepts of the network research programme highlighted by Kilduff, Tsai and Hanke (2006) can be used to clarify the meaning of a network perspective. These are:

- **Primacy of relations:** the social network research programme takes relations as the main force behind change and economic action. This is

[4] *Othello*, Act I, Scene I.

[5] For a collection of early articles, see Leinhardt (1977) and Holland and Leinhardt (1979). See Barnes (1979) for a discussion of social network theory and methodology. Also see Cross, Parker and Sasson (2003) for a collection of more recent and classic articles (especially from the 1980s and 1990s).

[6] See Kilduff and Tsai (2003) for organisational social networks, in which they explore theories imported from the social psychology and 'home-grown' theories within the social network discipline. An exploration of the most recent issues in organisational social research can be found in Brass et al. (2014).

different from the individualistic and atomistic approaches in mainstream economic theories, where the subject of analysis is the individual (Borgatti and Foster, 2003).

- **Ubiquity of embeddedness:** economic action is embedded in inter-personal relationships (Granovetter, 1985).
- **Social utility of network connections:** network relations confer opportunities and constraints on actors.
- **Structural patterning of social life:** the apparent complexity of social life can be explained in terms of the architecture of relationships, represented by networks. In this sense, a group is not a social network as it connotes the whole rather than showing who is connected to whom.

The network perspective used in this book is both narrower and broader than the scope expressed in these four points. It is narrower, because the focus of the book is on innovation; broader, because it is not only on social networks that connote affection or the lack of it. This book examines a wide range of other networks that are important to understanding innovation. To Kilduff, Tsai and Hanke's (2006) four core concepts, this book adds:

- **Focus on innovation:** innovation includes search processes, where a knowledge base expands and becomes more diverse and new opportunities are recognised and turned into products, and selection processes through which novelties diffuse and are accepted or rejected in the market or among users. Networks play an important role in both search and selection.
- **Not confined to a particular sector:** we tend to think of private enterprise as the main sector that produces innovations. While this is accurate according to the formal R&D data, many other sectors generate innovations. Non-governmental organisations (NGOs), governments, public research labs and users also innovate.[7] This is happening more and more, as the impact of communities, crowds and participatory open source projects demonstrates.
- **All types of network that are relevant to innovation:** social network metrics can be applied to all networks, regardless of how we define a node. For example, centralisation of a network, which measures the extent to which a network has a dense core and a sparse periphery, can be calculated for an inter-personal, patent or strategic alliance network. However, the implications of centralisation depend on the context of investigation and

[7] The earliest investigation of user innovation, now a classic, is by Von Hippel (1978).

node type, whether this concerns innovation diffusion, finding a creative solution to a problem or indeed something else entirely.

- **Governance:** different governance mechanisms can be viewed as networks. This book is not concerned with 'orchestrated' networks formed on the initiative of an authority.[8] Rather, it focuses on self-organising networks, which are governed by the independent and autonomous decisions of a wide range of actors and form from the bottom up.

1.2 The Changing Meaning of Networks and Innovation

Words often acquire new interpretations that reflect their economic, technological or institutional context. This is the case with 'innovation' and 'network'. Since the beginning of the twentieth century innovation has been understood to be a major driver of economic growth in many economies. This understanding was accompanied by dissatisfaction with the way it was viewed in mainstream economics theory, where it was considered a 'black box' (Rosenberg, 1983). While mainstream economists left this black box to be studied by other technical disciplines, evolutionary economics gave innovation a central role, contributing significantly to our understanding of its sources and its effects in the economy (Nelson and Winter, 1982). For a long time, positive efficiency effects of innovation were studied as a major criterion in defining economic performance. However, this pro-innovation perspective has been slowly changing over recent years, giving rise to discourses that emphasise the quality of innovation in terms of its impact on welfare, equality and the environment. This is evident in new terms like 'pro-poor approaches' and 'social', 'frugal', 'eco' and 'inclusive' innovation. Leaving aside the conceptual ambiguities of the everyday use of the word, and taking innovation as *diffused novelty in a certain context*, one of the persistent aspects of innovation is that relations between people, ideas, knowledge and artefacts are an essential part of it. This is particularly the case today, when better innovation requires diverse stakeholders, from sometimes distant societies, who interact through networks.

Interpretation of the word network has also changed over time. Scientific progress, inventions and innovation have *always* been driven by relations

[8] This specific governance mechanism, where the network is coordinated by a central actor, is referred to as 'orchestration' in the literature (see Dhanaraj and Parkhe, 2006).

between people.[9] Yet in the course of just a few decades, the term 'network' started to take a central position in the agendas of business, policy, academia and the population at large. There are some explanations for the relatively recent popularity of networks that particularly stand out. The first reflects a change in the scientific paradigm, with an increasing interest in open systems in many fields of science during the last fifty years. Open systems emphasise interrelations between parts of a system, rather than focusing on the individual elements that constitute them (Scott and Davis, 2007). The second is the development during the second half of the twentieth century of sophisticated computational tools that allow these interrelations to be analysed. A third reason is appealingly expressed by Ronald Burt, and applies to a specific use of the term: 'One of the opening acts of the 21st century was venture capital discovering social networks' (Burt, 2005: 1). In other words, social networks and the analysis of them are no longer confined to the realms of research and policy; with the rising popularity of online websites, they have become the means of communication for the masses.

Like innovation, the development of network research has also been accompanied by an increasingly 'pro-network' approach in business and policy debates. Today, networks are seen as the remedy for many problems, and collaboration is largely perceived to be a *sine qua non* of innovation. Throughout this book we will uncover the cases in which this is so, but also highlight that the effect of collaboration on innovation depends on a myriad of factors that should also be taken into account.

1.3 What is an Innovation Network?

It is not easy to define an innovation network. This is because innovation is not just the result of systematic efforts to innovate; it is also the result of serendipitous events that occur in daily life (see Box 1.1) and spark an unexpected idea that may produce a radical turnaround. If innovation were only the result of systematic efforts, an innovation network would include only activities *aimed* at innovation, and R&D departments would be the main network actors. However, the fact that there is always scope for learning and novelty creation during, or as a result of, human interactions broadens the conceptualisation of an innovation network significantly. Human interactions can ignite ideas, novelties and ultimately innovations.

[9] See Moon (2014) on the history of inventions and social networks.