The Geography of Innovation

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Edward J. Malecki

Contents

Abstract

This chapter surveys the topic of the geography of innovation – not the economics of innovation – and asks several questions: What is innovation? Who innovates? Where do they learn to innovate? The research focus has shifted from innovation and technology to the broader issues of knowledge and innovative capability. The empirical literature has been much narrower in scope, previously focusing on research and development (R&D) and now rarely looking beyond patents.

E.J. Malecki
Department of Geography, Ohio State University 1036 Derby Hall, Columbus, OH, USA
e-mail: malecki.4@osu.edu

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The chapter surveys a broader set of innovation indicators – inputs, outputs, and hidden innovation, much of which is uncovered in large-scale surveys. Empirically, there is a global shift in innovative capability toward Asia, primarily in R&D (but less so in basic research) and in process innovation related to manufacturing. The overall pattern is one of persistent spatial concentration. As a result, a thriving business has emerged to craft policies to enhance innovation and to "construct advantage" in an uncertain competitive landscape. Finally, the actors in innovation include not only individual scientists and inventors but also the organizations that employ them, such as universities and firms. It is entrepreneurs who largely determine how innovation is exploited. The fruitful concept of the knowledge filter and the role of entrepreneurship and the geography of entrepreneurship provide clues to the patterns seen.

20.1 Introduction

Innovation is fundamental to economic growth and to variations in economic development across space. Innovation is a dynamic process – bringing about creative destruction and shifting the locus of innovation across industries and among locations. Innovation is a broader concept than technical (or technological) change alone; it includes ideas and knowledge that precede actual innovation, the learning that takes place through experience, and the synthesis of knowledge and complementary assets to utilize them profitably. Our understanding of the geography of innovation, however, has become too narrowly conceived as the topic has attracted a flurry of research attention from economists.

This chapter reviews what we know from the work of economists as well as from geographers. It begins with the simple world as grasped by patent data and models based on those data. Second, it examines what we know about innovation as a dynamic and complex – even messy – process. Third, this dynamic, complex messiness is seen in the location of innovation and of innovative capability: the geography of innovation at the global scale, which is itself the outcome of several distinct flows and forces. Fourth, the chapter reviews briefly the degree to which policy can influence the geography of innovation.

20.2 The Standard Model: Innovation as Knowledge Production

The standard economic view includes a knowledge production function, in which innovative output, typically measured as patents, results from innovative inputs, specifically research and development (R&D) by firms. Within regions, knowledge spills over from universities and industrial R&D, and these spillovers decline with distance. Griliches (1990: 1669) acknowledged "a whole host of problems" with patent data: "Not all inventions are patentable, not all inventions are patented, and the inventions that are patented differ greatly in 'quality,' in the magnitude of inventive output associated with them". However, most researchers have been persuaded by his conclusion that "[i]n spite of all the difficulties, patent statistics remain a unique resource for the analysis of the process of technical change. Nothing else even comes close in the quantity of available data, accessibility, and . . . detail" (p. 1702). Consequently, there has been a flood of research using patents as the principal – and often the only – measure of innovation and its geography.

Reviewing the literature since Griliches (1990), Nagaoka et al. (2010) conclude that patent data alone are not sufficient for understanding the mechanisms of either a knowledge production function or knowledge spillovers. Too many important flows are not captured by patents, including other means of appropriability, inventions not patented, and patented inventions not used. More common means of firms to protect their innovations include secrecy, lead time, and complementary capabilities (Nagaoka et al. 2010).

Notably, other knowledge – particularly tacit knowledge – is ignored or assumed to spread as seen in patent citations. The importance of tacit knowledge is that it is not readily transferred, and therefore, transfers are difficult unless the parties are colocated (permanently or temporarily) in a locality (Asheim and Gertler 2005). The growth of publications by firms also can be seen as an attempt both to find new access to external knowledge and to signal the existence of tacit knowledge and other unpublishable resources. Publishing allows a firm's researchers to become involved or take part in academic activities, with access to the epistemic communities of researchers. In return, the firm expects access to the tacit knowledge of academics in the field.

Not all industries are the same. High-technology, or high-tech, industries have received a great deal of attention, and they have informed our knowledge of how innovation occurs in those sectors. Innovation is managed differently across industries: fast-changing industries may be more creative but also less efficient, whereas slow-changing industries emphasize efficiency over creativity.

Patenting is not typical in all sectors; the pharmaceutical industry is particularly dependent on patent protection. The glamour of biotechnology and blockbuster drugs has led to an overemphasis on the importance of patenting. We know a great deal about biotechnology, in part, because the industry fits the R&D-based model of prevailing theory and, in part, because it is relatively small and localized in few locations. We know that patents generally are highly concentrated in large cities.

Those who study innovation at the scale of the firm, rather than the region, have noted the evolution from the development of something new to a process of creativity to a process dependent on knowledge. A similar evolution has taken place in the management of R&D within firms.

20.3 What Is Innovation?

As a result of the broadening of definitions and of ways to measure innovation, broader views of innovation have become more widespread. They have developed largely within Europe, particularly in the context of Organisation for Economic Co-operation and Development (OECD) and European Union (EU) policy documents

(Mytelka and Smith 2002). The OECD definition of an innovation includes more than merely a new or significantly improved product (good or service) or process, but also the implementation of a new marketing method, or a new organizational method in business practices, workplace organization, or external relations.

Products and processes – some of which are patented – have been the object of research on innovation for decades; services, marketing methods, and organizational methods are more recent. The series of Community Innovation Surveys conducted in (an expanding number of) EU member states have added to our knowledge of how firms innovate. Similar surveys are now conducted in several countries outside Europe, with the United States conspicuously not among them.

To this list can be added *soft innovation* – new products offering aesthetic rather than functional appeal as well as those goods and services with a distinctly intellectual appeal (including books, films, art, or computer games). Soft innovation builds on the increased importance of aesthetic content in products. Aesthetic improvements, the outcome of soft innovations, are a principal source of product differentiation but generally cannot be patented. "Whereas patents require novelty and copyright requires originality, the counterpart for a trademark is distinctiveness. . . . Whereas patents are not available for aesthetic innovations, such innovations may be trademarked" (Stoneman 2010: 262). In addition, copyright protects material such as literature, art, music, sound recordings, films, and broadcasts, and design rights (or design patents) protect the appearance or visual appeal of products (Stoneman 2010). Trademarks and copyrights remain underappreciated and understudied aspects of innovation.

Many have focused on tacit knowledge, implicitly in tune with the idea of technologies as recipes. However, a great deal of tacit knowledge is needed beyond the technological procedures in any codified recipe. Tacit knowledge flows through many channels, such as the multitude of interactions and knowledge flows between economic entities such as firms (customers, suppliers, competitors), research organizations (universities, other public and private research institutions), and public agencies (technology transfer centers, development agencies) (Asheim and Gertler 2005). Organizational means for absorbing, integrating, and transforming knowledge have been a major focus of research.

Just as inputs beyond R&D (and of outputs beyond patents) are important in innovation, more than a patent is necessary for a firm to appropriate and profit from the gains from an invention. Even an imitator can outperform an innovator if the imitator has assembled a better set of critical complementary assets. It also is the case that R&D has purposes beyond only patentable innovations, on which more below.

20.4 Two Faces: The Multidimensional Nature of Innovation

Binaries and dichotomies are simple solutions to complex problems. Dichotomies are found in studies of knowledge and innovation, shedding light but also obscuring the actual workings of knowledge production and innovation. Knowledge is more complex than merely codified and tacit.

One of the more useful binaries is the observation that R&D has two faces; that is, firms invest in R&D not only to generate innovations but also to learn from competitors and knowledge sources outside the industry, such as university and government labs (Cohen and Levinthal 1989). To a large degree, subsequent research has followed either one path or the other. The first flood of research has focused on patents and linkages between patents through citations.

A second body of research, largely unconnected, has focused on learning by people and firms and on types of knowledge. Not all knowledge is used (nor perhaps even useful) immediately and is retained and accumulated for future use. This store of knowledge is to the individual's – and the firm's – absorptive capacity. Firms differ widely in their knowledge search strategies, with impacts on their absorptive capacities.

Other motivations for R&D beyond the need to build an absorptive capacity include the following: an intention to maintain the firm on the technological frontier, the search for reputation, building and signaling its competences, and entrance to networks, which are among the main incentives for firms to invest in R&D.

Systems integration, like R&D, also has two faces: the internal activities of firms as they develop and integrate the inputs they need to produce new products and services and the external activities of firms as they integrate components, skills, and knowledge from other organizations to produce ever more complex products and services. Complex systems of technologies (e.g., automobiles, aerospace systems, iPhones) require the integration of knowledge from many sources – technological as well as geographical. Systems integration and the skills required to translate and interpret across disciplines, jargon, language, and technologies – and to synthesize these into forms and routines usable within the organization – are neither easy nor straightforward.

Knowledge as created and used is not identical but differentiated. Three types of knowledge bases have been outlined by Asheim et al. (2011): *analytical* (science based), *synthetic* (engineering based), and *symbolic* (arts based). Alternative typologies are based on whether knowledge is codified or poorly articulated, spillovers are intentional or unintentional, and incentives to reveal and to capture knowledge are strong or weak. Once again, biotechnology (with few other industries) stands out as unusual.

A key debate in the literature concerns whether specialization or diversity within an agglomeration is most beneficial for spillovers. The consensus had begun to shift toward diversity, but the current consensus is swayed by research which shows that *related variety* is best (Asheim et al. 2011; Boschma and Frenken in Cooke et al. 2011; Iammarino in Cooke et al. 2011).

A recent addition to the roster of binaries is the distinction between local and nonlocal (or extralocal) knowledge sources. The impact of local "buzz" is particularly important in the creative and cultural industries, where symbolic knowledge, performance, and events perhaps outweigh the importance of codified, cumulative knowledge. A useful literature has grown on types of proximity – not only geographical, but also organizational, cultural, technological, cognitive, institutional, and social (▶ Chap. 26, "Networks in the Innovation Process" by Tranos). The summary by Moodysson and Jonsson (2007: 15) concerning Swedish biotechnology firms is appropriate more widely: "The convenience of local collaboration can never replace the extreme requirements of specialized knowledge, which forces them to seek collaborators on a global arena."

Nuanced views deconstruct the meaning of proximity to an even greater extent: However, proximity has a different influence depending on the size of the city. The concept of *temporary clusters* also reflects the complexity of proximity: it need not be fixed in place or permanent to be beneficial. Crevoisier and Jeannerat (2009) develop a richer framework to understand the simultaneous need for both local and nonlocal sources. “The concept of ‘from elsewhere’ is now differentiated: the places are clearly identified, as are complementary and/or competing ones” (p. 1235). In other words, the globalization of knowledge does not reflect an amorphous “elsewhere.” It reflects known places where specialized knowledge is as great, or greater, than in a given locality.

Clusters do not necessarily have links to knowledge pools elsewhere (Vale 2011). Even when a region’s knowledge networks include pipelines to distant knowledge, that knowledge needs to be “anchored” and integrated with the regional knowledge base (Crevoisier and Jeannerat 2009; Vale 2011).

20.5 How Innovation Works: Linear or Complex?

The bottom line is that innovation flows from knowledge and ideas, broadly viewed, rather than from R&D, even if broadly defined. This point is implicit in the new growth theory, which results in positive-sum growth based on ideas. The recent criticism by Steinmueller (2010: 1190) is that “unlike the old growth theory which produced a central result, the ‘golden rule’ of accumulation, the new growth theory is still evolving” with considerable variety in its outcomes. The broader conception of knowledge and innovation is more explicit in the recent shift seen from innovation systems to knowledge systems.

Early work was based, explicitly or implicitly, on the *linear model*, which postulates that innovation begins with basic research, adding applied research and development (all still under the umbrella of R&D), followed by production and diffusion. A standard of innovation studies for decades, the linear model captures the temporal sequence of activities in innovation, is easily monitored in data gathering and appeals to policymakers because of its simplicity and logic. The linear model fits biotech and other science-based industries because of a key feature of the linear model – linearity – the fact that not everything occurs simultaneously. Regional analyses based on the linear model and on patent data are still common.

20.5.1 Entrepreneurship as Innovation

The linear model has been extended to encompass entrepreneurship. Ideas lead not only to new products and services but also to new firms and, in some cases, to clusters of new firms in new industries. Indeed, research and policy interest in entrepreneurship grew largely out of interest in technology-based clusters (Mason 2008).

The entrepreneurial process within the innovation process is captured best by the *knowledge filter*, a key element in the knowledge spillover theory of entrepreneurship (Audretsch and Keilbach 2007; Acs et al. 2009). The knowledge filter is the set of barriers to converting research into commercialized knowledge.

The knowledge filter for academic research is (besides the challenge of converting basic science into applied knowledge) largely an institutional filter. It consists of organizational barriers, university policies, attitudes among faculty and university administrators against commercialization of research, and lack of incentives to pursue commercialization. Additional barriers within the academic knowledge filter reflect an inability to convert inventions into intellectual property (primarily in the form of patents) and to commercialize that intellectual property through licenses and start-ups.

Similar filters for industrial R&D reflect the difficulty in business organizations to convert research into intellectual property and to commercialize new products. Entrepreneurs are able to see a path and to assemble the networks necessary for commercialization. Many types of interfirm networks are needed, ranging from global to local and from formal links to informal networking (Lawton Smith 2008; Giuliani in Cooke et al. 2011).

20.5.2 Innovation as a Complex Process

What is missing from the dominant flow of the linear model are the feedbacks and interactions that are so crucial to innovation. Many interactions are contained within national boundaries or within regions (Asheim and Gertler 2005). These national and regional innovation systems are thought to largely define the institutions, cultures, and path-dependent strengths (and weaknesses) that vary from place to place. The idea of innovation as – and within – systems recognizes innovation as a complex and systemic phenomenon. Research on innovation systems also reflects this broad synthetic perspective (Fischer et al. 2001; Mytelka and Smith 2002; Soete et al. 2010; Wolfe in Cooke et al. 2011; ▶ Chap. 24, "Systems of Innovation and the Learning Region" by Cooke).

The spatial complexity of RISs and the operational complexity of learning have already pushed the linear model into the background. Caraça et al. (2009) suggest a multichannel interactive learning model that captures the complex flows and interactions among actors.

Work on innovation systems was at first national and technological. Subsequent research added sectoral systems and regional systems (Tödtling and Trippl in Cooke et al. 2011). Research has begun to recognize the overlap and boundary relations between national, sectoral, and technology-specific innovation systems and between technological systems and sectoral systems of innovation. Crossing international boundaries highlights the distinctiveness of each national innovation system as nations compete to stay innovative and thereby wealthy. Regional systems link to those in other national systems, thereby forming international innovation systems (Crevoisier and Jeannerat 2009; Soete et al. 2010).

Regional innovation systems (RISs) have attracted the research attention of economic geographers and regional scientists (Asheim and Gertler 2005). The actual workings, activities, and policies, as well as measurements of contacts and linkages, are sometimes easier to grasp within a regional or local context than at the scale of the nation. Several terms are used to describe such local territorial innovation systems, such as clusters, territorial production complexes, productive systems, territorial systems, milieus, and local systems (De Propris and Crevoisier in Cooke et al. 2011).

The significance of RISs is that they represent "spatial knowledge monopolies" that attract investment and participation by transnational corporations (TNCs) (Cooke 2005). The central feature of the national and regional innovation systems is that while R&D activity still matters greatly, it is only one part of a larger system that includes education, training, government support, and linkages among sectors. Recent research suggests that regional clustering and networking (such as those found in innovative milieus) are less important than localized capacities to build global connections.

Intermediaries also can bring external knowledge to potential users. Knowledge-intensive business services (KIBS) are a particularly important source of innovative knowledge. Geographically, KIBS are highly concentrated at the top of the urban hierarchy.

Feldman and Kogler's (2010) eight stylized facts in the geography of innovation focus on the importance of proximity and location to innovative activity. Although the geography of innovation comprises agglomeration and spillovers (Feldman and Kogler 2010; ▶ Chap. 22, "Knowledge Flows, Knowledge Externalities, and Regional Economic Development" by Karlsson and Gråsjö), it is also much more. Agglomeration or clustering alone does not provide the ingredients within RISs necessary for collective learning – institutions, social capital, and entrepreneurs (Capello in Cooke et al. 2011). The advantages of agglomeration are well established, providing opportunities for sharing, matching, and learning. In general, large urban areas are expected, ceteris paribus, to have higher proportions of skilled workers, higher rates of innovation, and more rapid adoption of innovations, smaller places. However, all large and/or dense cities are not alike; they vary widely in culture and in institutional infrastructure.

What is left out, of course, is the complex of social dynamics, captured in part by the concept of social capital, which is fundamental to the cohesion (or lack of it) in a community. Power – especially the power exerted by TNCs – is key to the actual dynamics in many regions, but is omitted from most analyses of RISs.

The ground-up, largely local view of how the geography of innovation is constructed is primarily an economic view rather than a bird's-eye look at the changing geography of innovation. The following proceeds from the opposite direction: from the global to the local.

20.6 Global R&D

That R&D is global has been evident for over two decades. Through the 1990s, however, global R&D was largely triadic – distributed among (western) Europe, Japan, and North America. Since 2000, the "global landscape" of R&D has changed dramatically, reflecting major innovative effort in Asia outside Japan. The current situation is a *global innovation system*, in which India, China, and the United States have leveraged the growing internationalization of innovation to offset weaknesses in their own national innovation systems.

The following focuses on two central shifts at the global scale: the location of innovative activity and the competition for talent. These shifts and the measures of them are tracked by a bewildering array of scoreboards of indicators.

20.6.1 Fact 1: Innovation Is Dispersing Globally

The geography of innovation used to follow the product cycle in a predictable manner, flowing from R&D, conducted only in high-income countries. The activities of TNCs and their global production networks have altered but not eliminated product cycle as an important concept at the global scale (Tichy in Cooke et al. 2011). The benefits of agglomeration economies appear to be greatest at the "birth" of new firms and diminish during the later stages of the industry life cycle.

During the 1970s – that is, before the rise of China – R&D had begun to globalize, becoming much more so during the 1990s to exploit sources of knowledge at the locations of customers and competitors. However, in-house R&D alone is no longer sufficient for a firm to be technologically competitive. In-house R&D must be complemented by external sources of innovation, which then need to be integrated into the firm's structures and competences. These trends are captured in firms' utilization of open innovation and the phenomenon of the double network.

The global innovative activities of TNCs are one force behind the shift from R&D being located only (or primarily) in rich countries. Another force is active efforts by firms – many state owned – in emerging economies to serve their own growing consumer markets. This means that in any industry, the number of pipelines a firm must maintain is increasing. As Crevoisier and Jeannerat (2009) stress, there are many knowledge sources, and links to them require effort to maintain rapport and productive contact. In short, research has increasingly become a borderless activity.

20.6.2 Fact 2: Places Are Competing for Talent and Brains

The global geography of innovation has been transformed primarily by the globalization of scientific and engineering talent, which Freeman (2010) suggests has proceeded rapidly along five related tracks. These are:

- Expansion of mass higher education worldwide
- Growth in number of international students
- Migration
- Non-immigration trips by academic visitors and conference attendees
- A rapid rise in international coauthorship and co-patenting

As these five changes have occurred, changes in national capabilities have taken place.

Migration is an important channel for the movement and spread of knowledge. Migration need not be considered a brain drain, but can be a *brain recirculation* as migration is less frequently permanent and as people construct multilocational careers and professional and personal lives. The term brain drain has been replaced by global competition for talent. In this ongoing competition or race for talent – and for highly skilled migrants – countries have implemented *competitive immigration regimes* as a new form of interjurisdictional competition.

There are benefits from such policies, seen the movement of the world's productive researchers toward nations with research infrastructure and strong R&D support.

At the level of policy, as opposed to theory, the geography of innovation primarily means the visible shifts in innovative capability, inputs, and outputs on the ground – the changing landscape of innovation. The new, more global pattern reflects the growing role of knowledge in the global economy, seen primarily in investments in tertiary education and R&D outside the OECD countries. Scientific publications are the result of creative efforts of people working in universities, government research institutes, and the R&D labs of private firms. The map of such knowledge-producing places is increasingly global, with prominent new nodes in China. Despite the diffusion of knowledge – and indicative of the peculiar nature of patents as an indicator of innovation – patents tend to be the most unequally distributed dimension of knowledge creation at the global level.

The dispersion of R&D has been a response to the location of both markets and talent, both of which have improved throughout much of the world as economic growth has taken place, particularly in Asia. As scientific and technological talent has improved in many places, the result on the ground is a range of capabilities, typically measured at the national level. Fagerberg et al. (2010) provide the most comprehensive review of how capabilities have been measured, incorporating one or more of several dimensions: science, research, and innovation; openness; production quality/standards; information and communication technology (ICT) infrastructure; finance; skills; quality of governance; and social values.

20.6.3 Keeping Track

A number of distinct efforts have been made to measure the technological capabilities of national economies, some for more academic interest and others for policymakers. Fagerberg et al. (2010) and Archibugi et al. (2009) compare many of these. Policymakers like such scoreboards for three reasons. First, they provide an "early warning system" for potential problems at a national level. Second, when used over time, national strengths and weaknesses can be monitored. Third, they help to focus firms, institutions, and government bodies on the same issues (Arundel and Hollanders 2008). Fagerberg et al. (2010) distinguish between several types of capabilities that indicate in various ways the capacity of the firms of a country to compete through creation of new technologies and to exploit existing knowledge from elsewhere.

It has become common for benchmarking and scoreboard reports to track the technological progress of national (and sometimes regional) economies. Indeed, there are so many scoreboards and sets of cross-national indicators that the EU produced its *Global Innovation Scoreboard* only in 2006 and 2008, now being content to publish only its *Innovation Union Competitiveness Report* and *Innovation Union Scoreboard* on an annual basis. All these measures are highly correlated – with one another and with gross domestic product (GDP) per capita (Fagerberg et al. 2010).

All of these address real – or imminent – technology gaps envisaged by the rise of China and other Asian competitors. All indicators and rankings are imperfect. Archibugi et al. (2009: 929) conclude, however, that “R&D intensity is less capable of explaining differences in innovative performance because *non-R&D factors* play an important role in differentiating national paths of innovation and performances”. However, there is a real risk that policymakers will drown in the flood of numbers from so many, especially annual, scoreboards.

20.7 Policy: Changing and Reacting to Changes in the Geography of Innovation

Here, policy refers to efforts at the national, regional, and local level to respond to – and to shape – the geography of innovation. Innovation policy has evolved from R&D alone to systemic – appreciating innovation as a systemic process. The OECD and, later, the EU have attempted to gather knowledge on the state of the art in policy and its empirical evaluation (Mytelka and Smith 2002). Policy continues to run ahead of theory (Steinmueller 2010).

20.7.1 Regional Innovation Policy: Constructing Advantage

Martin et al. (2011:566) provide convincing evidence that regional strategies based on one “best practice” model do not meet the very industry-specific needs of firms. In fact, these best-practice models . . . seem to be most well suited to industries that draw primarily on an analytical knowledge base”. Such sector-specific needs remind us of the importance of the nonspatial sectoral innovation systems. Any useful policy must include gatekeepers and other actors within a regional system who can interpret across sectoral and technological boundaries. These interactions work best when they are informal, untraded interdependencies rather than formal, contractual links. It is plainly difficult to create policy structures that must be at the same time formal (enacted in laws, personnel hired and evaluated, accounted for to taxpaying citizens) and informal (flexible and adaptable to new circumstances and knowledge).

Regions compete and, more than in the past, they work to create advantage in a world where the ability to attract and keep capital and people requires attention to infrastructure, institutions, policies, and innumerable details (Asheim et al. 2011; Cooke in Cooke et al. 2011). At a minimum, regional advantage should be constructed more on the basis of the unique capabilities of firms and regions and not primarily on the basis of corporate or regional R&D efforts. What is needed is "smart specialization" (Lagendijk in Cooke et al. 2011). At worst, regions that fail to be attentive to these demands can become, or be perceived as, systemically innovation averse.

Constructed regional advantage, the current state-of-the-art regional innovation policy approach, takes into account three lessons from policy experience. First, *platform policies* represent "tailor-made policy strategies geared towards specific potentials and focused on tackling specific bottlenecks in regions that occur over time. As a result, regional policy needs to evolve, capitalizing on region-specific assets, rather than selecting from a portfolio of policy recipes that owed their success in different environments" (Asheim et al. 2011: 900; Cooke in Cooke et al. 2011; Harmaakorpi et al. in Cooke et al. 2011). Second, such a strategy must be based on *related variety*, rather than specialization or broad-based differentiation, to reflect shared and complementary knowledge bases and competences. The third element of this policy approach reflects that knowledge is distributed across traditionally defined sectors in distributed knowledge networks, and these knowledge bases are distinct and often incompatible with one another. Tura et al. (2008) illustrate several dimensions (structural, social, cultural, and intellectual) of *innovation platforms*, which reflect network-based innovative capability.

Policymakers, like firms, also face massive information overload. It appears that their ability to compete is made more difficult unless they use gatekeepers, such as consultants and service intermediaries who can help gather and synthesize knowledge from elsewhere. As with firms, the number of knowledge inputs to policy and the number of sources are increasing, and demands for data and synthesis – for example, for benchmarking – are common. Regional and national innovation policies now typically include university R&D, technology transfer, entrepreneurship, and spinoffs.

Regional absorptive capacity must be built and maintained, and it includes the absorptive capacities of firms located in the region, institutional features that promote knowledge exchange and learning in the region, and links to organizations elsewhere (Abreu in Cooke et al. 2011).

Vale (2011) dissects the standard policies related to clusters, which often downplay informal and untraded interaction among firms in an agglomeration. Further, he emphasizes that spatial localized learning processes are necessary but not sufficient for a successful cluster in a world where relevant knowledge is located in several – known and perhaps unknown – nonlocal and perhaps distant locations.

The complexity of innovation, not surprisingly, leads to complex frameworks for regional policy. Innovation policy generally is seen as messy and complex, with multiple levels and multiple actors including, in the European Union (EU), supranational policy. In this sense, innovation systems – like clusters – may be too difficult for policymakers to grasp fully and to coordinate adequately. Numerous intermediaries are involved at several levels (Nauwelaers 2011). As policy continues to run ahead of theory, specific programs are evaluated, but it is uncommon for technology policy to undergo evaluation (Steinmueller 2010).

Recent proposals for policy focus on the *cognitive* dimension of territories (Camagni 2009, Capello in Cooke et al. 2011), whereby territories act as learning regions (Simmie in Cooke et al. 2011). Knowledge-oriented policies (KOP) for regions as well as for firms can help to build competencies and to participate in the codevelopment of knowledge at a global scale. This involves several types of networks (Lawton Smith 2008).

Uyarra and Flanagan (2010) believe that the regional innovation system has become a fuzzy concept – attractive to policymakers and a useful "boundary object" linking but at the same time preserving the integrity of academic and policy discourses. The use of the term "system" encourages a view of regional economies as more-or-less closed systems and allows for inclusion of emergent, functioning, and dysfunctional systems. It also focuses attention on structure at the expense of agency.

20.7.2 Policy in a World of Global Production Networks and Global Value Chains

Manufacturing, long derided as a blue-collar sector staffed by uncreative people, of course includes engineers and other innovative personnel. The now-distant capabilities related to manufacturing leave many firms as "head-and-tail" companies with no body – the only activities remaining in-house are research and branding. Dankbaar (2007: 272) asks two pertinent questions: "Is there any reason to assume that research can be maintained as an in-house activity in the long run, if development and manufacturing have been outsourced? What happens to research if knowledge and experience coming from manufacturing and development are no longer immediately available?" TNCs make location decisions with a short-term perspective, but ultimately weaken the knowledge base of their home economies as suppliers of advanced materials, tools, production equipment, and components – collective capabilities – are no longer utilized as they also move or are replaced abroad.

Within global production networks, there has been a "geographic dispersion of *cross-functional, knowledge-intensive support services* that are intrinsically linked to production". As flagship firms have moved to global sourcing, an "*erosion* of the *collective knowledge* which used to be a characteristic feature of the flagship's home location . . . may have migrated for good to the supplier's overseas cluster(s)" (Ernst 2002: 51, emphasis in original). In response to the new global situation, current advice for innovation policy is to frame such policy as a knowledge-based economy strategy, within a complex framework that includes the whole of government.

20.8 Conclusions

This brief survey has emphasized the systemic, learning-based model of innovation favored by many geographers and evolutionary economists. This view of innovation is able to embrace what we know about how innovation actually works – as a messy and highly varied process that defies model builders. The standard model has not provided adequate guidance for policy, and this is why policy runs ahead of theory: it must do so but the result is that we have little systematic knowledge about how and why policies actually work. Policymaking often takes its cues from politics and political pressures rather than from empirical knowledge. Changes in the geography of innovation at the global scale affect regions and localities, both through the changing location of R&D and flows among nodes in the global system of knowledge. However, global forces are much more difficult for regional – and even national – policies to influence, as they are the outcome of independent choices by TNCs and by national policymakers. Innovative capability also is more difficult for any actor to assemble as technology grows more complex, and the necessary knowledge is found in ever more places.

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