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1 Innovation systems and policy in a global economy

DANIELE ARCHIBUGI, JEREMY HOWELLS
AND JONATHAN MICHIE

New technologies are a fundamental part of modern economic life. Economists and engineers, no less than politicians and public opinion, are devoting increasing attention to understanding why, how and where technological innovations are generated. This book is devoted to discussing two separate, but closely connected bodies of literature on the sources and nature of new technologies. The first set is focused on the similarities and differences in the organisation of innovative activities at the national level, whilst the second group is centred on the role of globalisation in shaping technological change.

The first body of literature stresses that a proper understanding of technological developments, and their dissemination throughout the economy and society, requires us to also understand the social fabric that shapes these developments. Over the last decade, the notion of systems of innovation, either local, regional, sectoral or national, has been widely used to map and explain the interactions between agents that generate and use technology.

The second body of literature has studied how innovation interacts with economic and social globalisation. The debate on globalisation has flourished over the last decade and a large number of themes connected to it have been investigated. Trade, production, finance, culture, media and many other fields have been scrutinised from the viewpoint of globalisation. The issue of technological change has been at the core of these debates on globalisation, and rightly so. On the one hand, technology is a vehicle for the diffusion of information and knowledge across borders; on the other hand, technological developments have themselves been stimulated by the globalisation of markets.

This book is devoted to studying the interplay between these national and global forces shaping technological change; it builds on three previous books that have analysed related issues (Archibugi and Michie eds., 1997;

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Howells and Michie eds., 1997; Archibugi and Michie eds., 1998). This introductory chapter sets out the key concepts addressed in more detail in the subsequent chapters. The first part is devoted to outlining the origin of, and latest developments in, the systems of innovation approach; we then turn to consider more specifically the implications of globalisation for systems of innovation.

The origin of the ‘system of innovation’ approach

The ‘systems of innovation’ approach has developed and evolved since its initial appearance in the form of the ‘national systems of innovation’ (NSI) studies presented by Freeman (1987, 1988, 1995), Lundvall (1988), Lundvall ed., (1992) and Nelson ed. (1993). Chris Freeman (1987) was among the first to use the concept to help describe and interpret the performance of Japan over the post-war period. He identified a number of vital and distinctive elements in its national system of innovation to which could be attributed its success in terms of innovation and economic growth (Freeman, 1988, p. 338). It has subsequently been applied in a number of different contexts, many of which have been outside the original focus of a national setting. Thus, although the national focus remains strong, and rightly so, it has been accompanied by studies seeking to analyse the notion of systems of innovation at an international (or pan-national) level and at a sub-national scale.

Studies have also examined the systems of innovation approach within the context of a sectoral or technology perspective. Thus Bo Carlsson has developed what has become termed the ‘technological systems’ approach, indicating that systems can be specific to particular technology fields or sectors (Carlsson ed., 1995). Sectors and technologies do matter and have their own dynamic. But as argued by Nelson, it is also the case that ‘nationhood matters and has a pervasive influence’ (Nelson, 1993, p. 518). Sectors and technological systems within a nation have a powerful shaping influence on the structure and dynamic of a national innovation system, whilst national contexts have important influences on sectoral conditioning and performance. Thus, prior institutional endowments of a national system may help or hinder innovative activity and performance within particular sectors of a national economy (Howells and Neary, 1995, p. 245). The concepts of national (or spatially bounded) systems of innovation and technology systems (or sectoral innovation systems) should not be seen as mutually exclusive. Indeed, establishing the interrelationships between the two can yield valuable insights into the wider systems of innovation approach (Archibugi and Michie, 1997, p. 13).

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Some definitions and concepts

Much of the literature on systems of innovation, and more especially on national systems of innovation, has been covered in an excellent review by Edquist (1997), which draws on earlier valuable discussion and reviews by Lundvall (1992a), Nelson and Rosenberg (1993) and Freeman (1995). However, certain preliminaries in terms of definitions and concepts are useful here for two reasons. Firstly, they form the basis of the subsequent discussion within this chapter and in the rest of the book, and, secondly, such a discussion highlights areas that may prove particularly profitable in terms of future work within the 'systems of innovation' research area.

Chris Freeman (1987, p. 1) defined the concept as 'the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies'. Lundvall (1992a, p. 12) makes a distinction between a narrow and broad definition of a system of innovation. His narrow definition would include 'organisations and institutions involved in searching and exploring – such as R&D departments, technological institutes and universities'. His broader definition would include 'all parts and aspects of the economic structure and the institutional set-up affecting learning as well as searching and exploring – the production system, the marketing system and the system of finance present themselves as sub-systems in which learning takes place'.

In respect of the 'national' element, Lundvall (1992a, pp. 2–3) stresses that this is not as clear-cut as is often assumed. The concept of 'national systems of innovation' has two dimensions: the national-cultural and the *Étatist*-political. The ideal, abstract nation state where these two dimensions coincide controlled by one central state authority is difficult, if not impossible, to find in the real world. Moreover, this nationally bounded view, at least in geographical terms, has been loosened over time. The approach has now been widened and developed to include systems of innovation that are sectoral in dimension and those that are at a different geographical scale, both above in terms of what Freeman (1995) coined 'upper' regions ('triad' and continental regions), and below in relation to regional¹ and local systems.

Regarding the term 'innovation', Edquist (1997, p. 10) has stressed the ambiguity and wide variation in its use. Thus, Nelson and Rosenberg (1993) and Carlsson and Stankiewicz (1995) have tended to adopt narrower definitions, mainly (though not wholly) centred on technological innovations, whilst Lundvall (1992a) seeks to include non-technological innovations, in particular institutional innovations (this point is further developed in his chapter in this volume). In his analysis of the Japanese

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innovation system, Freeman (1988, pp. 339–41) also emphasised the role of social and educational innovations, whilst Carlsson and Stankiewicz (1995, p. 28), in adopting Dosi's (1988) definition of innovation would also seem to include the emergence and development of new organisational set-ups.

Lastly, discussion of the term 'system' has been strangely limited. Lundvall (1992a, p. 2) is the most specific here although still brief. Thus he makes a short reference to Boulding's (1985) definition of a system as 'anything not in chaos' as well as noting that a system 'is constituted by a number of elements and by the relationships between these elements' (p. 2). Little reference is made to earlier work on systems theory, or to how this literature originally defined, or perceived, a system (see, for example, Hall and Fagen, 1956).

The evolution and development of the concept

Edquist (1997) reviewed the different elements and perspectives of the systems of innovation literature, in particular concentrating on the commonalities of the different approaches. More specifically, he outlines nine common characteristics of the systems of innovation approach and their advantages and problems. These core characteristics of systems of innovation approaches are: innovation and learning; their holistic and interdisciplinary nature; the natural inclusion of a historical perspective; differences between systems and non-optimality; their emphasis on interdependence and non-linearity; the incorporation of product technologies and organisational innovations; the central role of institutions in the systems of innovation approach; their conceptually diffuse nature; and the focus of the systems of innovation literature on conceptual constructs rather than on a more deeply rooted theoretical framework (Edquist, 1997, pp. 16–29).

Edquist's contribution is important because it seeks to determine common foundations of a 'systems of innovation' approach and seeks to build common frames of reference. It also highlights the high degree of diversity of approaches. While at one level this diversity is problematic, it might also explain why the approach has provoked such interest and produced such a rich vein of inter-disciplinary work. Seeking to harmonise and more closely delimit definitions and concepts may now be necessary if the research programme is to develop further; on the other hand, it is important to avoid the danger of foreclosing on ideas too early on. The following sections focus on a number of these ideas and key issues in current systems of innovation thinking.

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The role of learning in an innovation system

Although Lundvall noted the role that learning played in binding together production and innovation in a national system of innovation (Lundvall, 1988, p. 362) and sought to further emphasise the importance of learning in his 1992 discourse on the notion of national systems of innovation (Lundvall, 1992a, pp. 9–11), it has been only recently that he has sought to develop the role of learning and to put it at the core of the national systems of innovation construct (Lundvall, 1995; Lundvall and Johnson, 1995; see also his chapter in this volume). In these latter works he has stressed the role of learning in new and competitive national systems of innovation and especially the process of interactive learning (Lundvall, 1995, p. 39).

Learning is important in Lundvall's conception of systems of innovation because it is a key element in both the *dynamic* of the system and as a key agent in *binding* the whole system together. Thus, 'many different sectors and segments of the economy contribute to the overall process of interactive learning and the specificity of the elements, as well as the linkages and modes of interaction between them, are crucial for the rate and direction of technical change' Lundvall (1995, p. 40).

Learning thus plays a major role in the development of the system, whilst forming the key element in its connectivity. In this framework learning takes place at all levels from the individual, through to the firm and organisation, on to inter-firm and inter-organisational learning, institutional learning (Johnson, 1992), cross institutional learning, and on through to the whole system – the 'learning economy'. Obviously the learning process involves a clear interactive and collective dimension. There are also inter-firm and more general institutional routines that can be set up through this interactive learning process (Hodgson, 1988). However, it is much harder to ascribe collections of firms, organisations and institutions as having a single, clear cognitive process, involving both a decision-making and memory function. The notion that what is learnt will be exactly the same for each individual, firm, organisation and institution is difficult to accept (see Antonelli, 1994).

The evolutionary nature of systems of innovation

There have been important attempts recently to develop the latent evolutionary aspects of the national systems of innovation concept. This has been done by outlining the value of evolutionary concepts in providing a stronger theoretical underpinning to the national systems of innovation model (Saviotti, 1997) and also by highlighting the utility of evolutionary

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concepts in helping to define what is meant by a national system of innovation (McKelvey, 1997).

Although such evolutionary approaches have, a posteriori, helped to explain the dynamic aspects of systems of innovation they have provided very little, if any, predictive insights into how national systems of innovation might develop in the future. While Galli and Teubal (1997, pp. 345–64) have outlined what they see as paradigmatic changes and structural adjustments of national systems of innovation since the late 1970s, this approach does not directly draw upon an evolutionary perspective, nor does it suggest what new transition stages will appear or when. The lack of any predictive element within systems of innovation thinking is a reflection of the fact that it represents a partial model rather than claiming to be a complete formal theory (Edquist, 1997, pp. 28–9). As yet, although the systems of innovation approach stresses historical processes, it has yielded few insights into the dynamics of the innovation process.

Systems as flows, links and networks

Although there is a general stress on ‘interaction’ and more specifically ‘interactive learning’ by Lundvall (1992a; see also Lundvall and Johnson, 1995) and on knowledge flows by, for example, David and Foray (1995; 1996) there are very few references to, let alone analysis of, the specific nature of these interactions in terms of flows and linkages connecting the actors in a network. This neglect of linkages and flows is strange, given that networks form one of the cornerstones in defining a system (Saviotti, 1997, pp. 193–5).

There are, of course, notable exceptions. An important analysis of the flows within and across systems of innovation is supplied by the literature on inter-industry technology flows (see Scherer, 1982; Pavitt, 1984; Archibugi, 1988; DeBresson ed., 1996). This literature has managed to map to what extent certain industries benefit from the innovations generated by ‘upstream’ suppliers which in turn has indicated the degree of sectoral integration amongst industries. This body of literature has also had the notable advantage of being able to quantitatively map these flows. However, this approach has so far not been specifically integrated into the framework of innovation systems.

As discussed above, the concept of innovation systems is much wider than inter-industry technology flows. Firstly, because it includes also flows which are not necessarily inter-sectoral, such as knowledge and information flows that occur within firms belonging to the same industry. Secondly, because it takes into account also the transfer of tacit and non-codified knowledge (Howells, 1996), which is not captured by the indicators that

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have so far been used to map inter-industry technology flows. Thirdly, because the innovation systems approach also considers flows which occur between different types of organisations and institutions, including firms, agencies and government establishments.

One attempt to take into account an extended framework is provided by Galli and Teubal (1997, pp. 347–8), who briefly mention linkages in their commentary on the main components of systems of innovation. Another is the analysis by Andersen (1992, 1996; Andersen and Lundvall, 1997) of innovation systems using firstly, ‘primitive graph techniques’ (see, for example, Andersen and Lundvall, 1997, p. 243, and for an earlier attempt, Santarelli, 1995) and, secondly, simulation modelling to describe vertical relationships in innovations, although as yet these techniques outlined by Andersen have not been empirically applied or tested (Andersen and Lundvall, 1997, p. 253).

This relative under analysis of linkages and flows within the systems of innovation literature represents an important barrier to the further conceptual development of the approach for three key reasons:

- 1 Firstly, the way that networks and, in turn, systems are usually defined is by the volume and characteristics of the linkages that bind them together. In short, systems are made up of the interactions between the actors or nodes in a system. Without any interaction between actors and nodes it is difficult to accept that a system exists.
- 2 Following on from this, flows and linkages in a system are also critical in defining an innovation system, and the way in which it functions and operates.
- 3 Lastly, a key element in gaining an adequate dynamic and evolutionary perspective on a system is by analysing the changing flow and linkage patterns between the actors and institutions that compose a system. Although the nature of the actors and institutions can change and forms an essential dynamic in itself, this change is also reflected and altered by the changing relationships between such actors and institutions.

Thus, growth in a system can be characterised in a number of different ways. In relation to an innovation system, growth could be confined within the individual elements or actors (the firms or other organisations), or it could result from increased flows between the elements of the system. Similarly, all the growth in a system could reside within the system if it was fully ‘closed’ but could flow out of it, to varying degrees, if it was an ‘open’ system. Even changing these two simple dimensions, in relation to growth and linkages within an innovation system, can alter its growth characteristics and dynamics radically. The fact that these aspects are as yet relatively under researched may reflect the ‘youthfulness’ of the systems of

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innovation research programme, and also the relative difficulty of trying to measure such innovation flows and linkages in a dynamic context. Nevertheless, a more detailed analysis of innovation flows and linkages is certainly required if an adequate model (or set of models) of innovation systems is to be provided.

Systems as innovation 'task environments' for firms

Another rich seam for future research within the systems of innovation literature is a bottom-up perspective of how national/sectoral systems of innovation may condition and influence the innovation decision making and behaviour of firms. The systems of innovation approach tends, by its very nature, to take a 'top-down' view of firms' innovative activity (see Howells, this volume). There is still much to be learned regarding how firms respond to, and interact with, the innovation system (national, sectoral or otherwise) at any point in time.

Much of the discussion that does indirectly refer to firm-level action, *de facto* considers *individual* firms as simply reacting to changes that are occurring within the wider system – or within the more specific network or at the institutional level. There has been little discussion about firm behaviour and technology strategy in terms of their relationship with systems of innovation approaches, even though firms represent important actors within the innovation system. Exceptions include Carlsson and Stankiewicz (1995, pp. 25–6) who consider the issue of individual firm behaviour in their outline of a technology system.² Ehrnberg and Jacobsson (1997, pp. 320–6) also discuss firm-level strategy, although mainly within the context of a firm's response to technological discontinuities.

The key issue here is how much the presence (or indeed absence) of a national or sectoral system of innovation may affect the innovation behaviour, actions and outcomes of firms. Yet the systems of innovation research programme has, as yet, had little impact on the technology strategy and management literature. Certainly an empirical analysis of the innovative performance of firms in weak and strong national and/or sectoral systems of innovation might provide an interesting new avenue of research.

The empirical analysis of systems of innovation

Archibugi and Pianta (1992) and Patel and Pavitt (1994) set out a list of indicators that might be used to 'measure' a national system of innovation, and these have been taken up to varying degrees by a number of subsequent studies (see, for example, Gassler *et al.*, 1996). In this volume, a valuable set of empirically based studies, using aggregate data sets on a national and

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international basis, outline national patterns of innovative activity and performance (see the chapters by Guerrieri, and by Pavitt and Patel).

However, on a more micro, firm or organisational level, most acknowledge that there remains a gap between theoretical developments and empirical analysis (Saviotti, 1997) and researchers are still at the stage of discussing and defining which analytical tools and methods might most profitably be used in empirical studies to bridge this gap. The work by Andersen, noted above, using graph techniques and simulation modelling appears to be a promising avenue of empirical work along these lines (Andersen and Lundvall, 1997). However, more certainly needs to be done to review, systematise and apply existing empirical studies covering these issues to systems of innovation work.

Perhaps the biggest task that remains in the development of the systems of innovation approach remains in providing a better linkage between the more aggregate, macro level studies and the micro level analysis of firm relationships and behaviour. In terms of the conceptual framework of the approach it is at this 'meta' level where the role of institutions and wider organisational networks is crucial, and where further empirical work beckons.

What is globalisation?

It is certainly telling that the debate on national innovation systems has developed in an age when the forces of globalisation are transforming economic life. It seems that the pressures of globalisation have generated a new concern regarding the role played by nation-specific factors. The term 'globalisation', however, has been used and abused. The recent literature has used the concept in, at least, two different ways.³

The first is related to the mapping of global factors in economic and social life. Global factors have always influenced the performance of local and/or national communities, but the reason why we talk about globalisation in this age is based on the assumption (right or wrong) that the importance of world-wide relations has increased both quantitatively and qualitatively. To map the resulting global transformations requires the ability to identify the dynamic context which is leading, according to some authors, to a dramatic increase of cross-border flows of information, knowledge, commodities and capital.

The second meaning of globalisation is linked to policy analysis. For example, the term 'globalisation' is often used implicitly, if not explicitly, as equivalent to the term 'liberalisation'. This is however inappropriate since globalisation is mainly a descriptive concept while liberalisation has a prescriptive meaning. In a related context, the debate on globalisation has

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often collided with the assessment of the effectiveness of government policies (see Michie and Grieve Smith eds., 1995). It has been argued that globalisation is reducing the impact of certain policy instruments, for example interest rate changes, since all national public policies act under international constraints. Certainly, globalisation is putting new pressures on nation states which often lead to unwelcome outcomes. However, to influence these outcomes, a different mix of policies may be needed. While certain traditional macroeconomic policies, such as those based on exchange rates and interest rates, may have lost a significant part of their effectiveness, other kinds of policies, such as industrial policies, may be becoming increasingly important if governments are to pursue their own objectives.

Policies directed towards competence (such as those favouring training, education, the acquisition of managerial skills and encouraging technological change) become crucial instruments to allow national communities to face the processes of globalisation. Thus several of the subsequent chapters argue that policies aimed at the creation of technological competence are needed to strengthen national competitiveness and to preserve local well-being (see, for example, the chapters by Lundvall, by Pavitt and Patel, and Archibugi and Iammarino).

The boundaries of innovation systems in a global economy

Technological change provides a privileged viewpoint from which to understand the dynamics of globalisation. New technologies have always been international in scope; the transmission of knowledge has never respected states' borders. There is a complex interplay between technological change and globalisation. On the one hand, new technologies act as a powerful vehicle for the diffusion of information across distant communities. For example, it would be difficult to imagine the current globalisation of financial markets without the existence of the new information and communication technologies, since they have made it possible to obtain instant transactions across the world. On the other hand, the process of generating and diffusing new technologies has been moulded and strengthened by the flows of individuals, commodities and capital. This has created a circular process whereby technology has facilitated globalisation and vice versa.

The focus of several chapters in this book is on the following questions: (i) If the globalisation of technological innovation is occurring, will it lead to the eventual dissolution of national systems of innovation?⁴ (ii) Will national systems of innovation converge towards more similar structures