CHAPTER 1

ALIGNMENT, MISALIGNMENT AND DYNAMIC NETWORK-BASED CAPABILITIES

NICK VON TUNZELMANN

1. Introduction — The Tasks Facing Network Alignment

'Network alignment' is a term that has been found useful in comparing the relative performance of development processes, particularly in the context of catching-up or transitional changes. It is intended to be a description of overarching links (or lack of them) in production/innovation/knowledge systems at varying levels of geographical units — especially the national, regional and local, though both wider applications (e.g. to the EU) or narrower (to the micro level) are equally feasible. Its comprehensive nature is both a strength in regard to its broad-ranging, umbrella-like properties and — to date — a limitation, in being unbounded and thus very difficult to specify in any precise way.

The latter issue contrasts with the major steps taken in recent years towards quantifying 'social network analysis' (SNA), which has developed powerful tools to measure such concepts as network centrality.[1] An important objective should be bringing such techniques within the ambit of network alignment. A stumbling block at present is that SNA tends to assume the existence already of a (single) network, usually with well-defined boundaries, and so the concepts like centrality are comparatively unambiguous. An individual unit is clearly located either near the centre of 'the' network, near its outer limits (periphery), or somewhere in between; the focus is on dyadic relationships.[2] Once the network alignment situation of multiple networks with fuzzy boundaries arises, the measurement becomes far less straightforward. Even so, the challenge ought to be taken up — but this task remains ahead.[3]

Much the same issue arises in connection with 'systems' and, more specifically, 'system integration'. Again, much of the recent literature is written as if the organisation in focus has one particular system to integrate, whereas in actuality it normally

[1] See for instance Carrington *et al.* (2005); Hanneman and Riddle (2005). Note, however, that 'centrality' has several meanings.

[2] For example, Kenny *et al.* (2006). The focus is usually on 'homophily', i.e. the pairing of similar partners, rather than, say, complementarity. More complex formats such as triads or groups are sometimes studied.

[3] Though see Perini (2009) for some initial steps towards reconciling SNA and network alignment.

finds itself spread across many 'systems' of different types, some more 'systemic' in the way they function than others. We will come back later to the differences between systems and networks, but in the meantime they can be regarded as analogous in these respects.

The ubiquity of network alignment is easy to illustrate from the level of an individual person. Many — indeed, probably most — readers of this book as academics will be engaged repeatedly (often several times a day) in differing networks. Some of these are discipline-based networks, of colleagues in the subjects in which we were trained or have later acquired. Another grouping of networks concerns the 'production' of research, teaching and administration, in functions that relate variously to our specific research units, membership of university/institute committees, sitting on national bodies like research council committees, and so forth. A third grouping relates to 'outputs', and these include teaching links with other universities globally, and research linkages that may be equally widespread. This somewhat stylised tripartite division into suppliers of inputs (like the scientific disciplines in which we were educated), producers and users of outputs is aimed at paralleling the experience of firms, and indeed all organisations. It brings out the multiplicity of the relevant networks at each level, though needing to go further into the bidirectional connections between the levels, e.g. through expecting to learn as much from 'users' as the knowledge supplied to them. All of this is to say nothing of social networks — of family, local associations, etc.

If such complexity applies at the comparatively insignificant individual level, how are we to see the totality? Unquestionably the notion of a single network is an immense abstraction, however amenable it may be to analytical tools and quantification (which we happen to support). The same goes *a fortiori* for a more complex organisation such as a firm, or even more complex organisations such as local or national governments.

The principal task confronting network alignment is thus to assess the consistency of this heterogeneity of networks in their ability to orient their effectiveness towards attaining certain goals for the relevant system. The organisations generally studied are at or towards the most complex end of what has just been cited (governments and the like). The systemic goals will be analysed somewhat further hereafter, but in the meantime we can take them to be development-oriented. The main point to be made here has rather to do with complexity — that far from there being any tendency towards a mega-consolidation of the multitude of networks, their numbers are probably expanding at a rapid pace, hence intensifying the need for 'alignment'. Can we find in our (ill-defined) patterns of individual networks an equivalent to Adam Smith's 'invisible hand' that he established for a system of individual agents?

Section 2 of this chapter outlines some of the forebears of the network alignment approach. Section 3 looks at 'systems', by way of a background to the issues raised by alignment: specifically at spatially oriented systems (typified by 'national systems of

innovation'), governance systems, and complex systems which incorporate both, together with other elements. Some of these (in particular the micro level of firms and the macro level of governments) are investigated in Section 4, cast in the more dynamic light of capabilities and learning. The tricky issue of how to measure network (mis)alignment is then taken up. Section 5 gives some brief conclusions.

2. Antecedents of Network Alignment

The network alignment approach thus tackles high-order complexity, in considering 'networks of networks', located in 'systems of systems'. The price paid for this generality is, as already implied, a blunter set of tools available for analytical purposes.

The origins of the network alignment perspective derive from at least three strands of the literatures that blossomed in the later 1980s and into the 1990s. The first of these is the 'systems of innovation' approach, resuscitated in the work of Freeman and especially in his study of Japan (1987). Freeman himself saw predecessors dating back at least as far as the political economist Friedrich List, publishing his agenda for the emerging nation state of Germany in 1844 (Germany was not actually united as a nation until 1871), though based on his observations in another young country, the USA, in the 1820s. Freeman's work was taken further in two major collected works of the early 1990s: Lundvall's book on national systems of innovation (NSIs) in 1992, which took what we shall later describe as a primarily functional approach to national systems, and that also on NSIs edited by Nelson in 1993, which took a more structural–organisational line. The focus here was primarily on spatially focused systems, most obviously national systems, though it was also soon applied to regional and local systems at one end, and what Freeman (2002) was to term continental systems — or even a global system — at the other end.

If the impetus here lay on political economy perspectives, the background of the second group of relevant authors came mostly from political science. These scholars shared for the most part a German or middle-European base (Marks *et al.*, 1996). They were concerned with 'multi-level systems of governance', such as those found in Germany with its reuniting nation, its federal system of comparatively powerful *Länder*, and its central role in the European Union. That is, they too were considering regional, national and supranational systems, but as overlapping (political) entities rather than as alternatives as in the NSI approach. The unifying element in this spatially heterogeneous context tended instead to be located in sectoral perspectives (Kim and von Tunzelmann, 1998), or what subsequently came to be known as 'sectoral systems of innovation' or SSIs (Malerba, 2004). Growth poles emerged around new technologies and sectors. It should be noted that, though SSIs were thought of as consolidating factors across the various spatial boundaries, there exists an alignment problem that lurks not far below their surface. Malerba, for instance, defines sectors as demarcated by groups of closely related products, much in line with

the conventional boundaries of 'industries', whereas the Swedish approach (Bergek *et al.*, 2008) sees technological systems as being defined by areas of technology. Neither are very purist about their (contrasting) definitions in reality — Malerba for example treats biotechnology as a 'sector' whereas it is evidently not a product area but a technology, and conversely the Swedish group admits product boundaries into its technological categories. We shall see later that this matters quite a lot.

A third source for network alignment, and in fact the closest to it in spirit, is based in France, and particularly around the CEPREMAP institute in Paris (Jessop, 2001). This can be called the 'social system of accumulation' school, though it is more popularly known as the '*régulation*' school. As one of its architects, Robert Boyer, has pointed out, '*régulation*' in the French sense does not mean 'regulation' in English, and he translates it as 'tuning'. It is, in fact, very close to what we mean by 'alignment'. For the most part, the French school has emphasised the role of aggregate wages, in a rather post-Keynesian sense, and in the context of national labour markets: in particular the potential for misalignment between production (keeping labour costs down) and consumption (keeping wage-based demand high). Our use of this approach focuses instead mostly on technology and knowledge, though this can also be said of some of their work.

3. Systemic Approaches

3.1. *National systems of innovation*

National systems of innovation (NSIs), like the others that we shall be assessing, can be approached either from a functional point of view or from an agent-based one. These positions are stylised so far as they relate to national technological systems in the panels of Fig. 1.1, the left-hand panel showing a simplified representation of the perspective of Freeman (1987) in his path-breaking study of Japan, the right-hand one that implied in many of the chapters of Nelson's collected national studies of 1993.

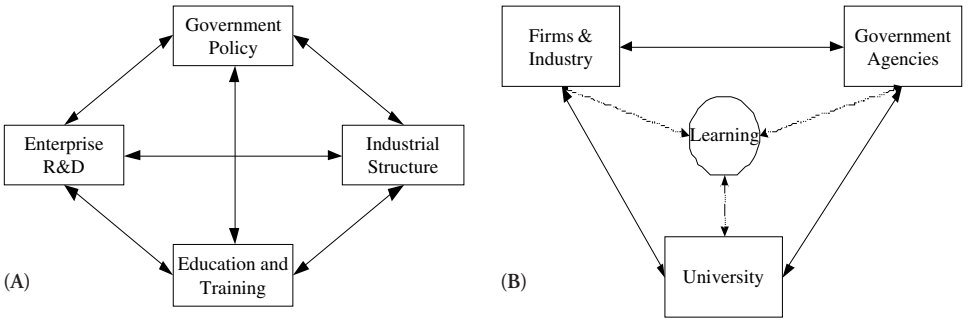


Fig. 1.1. (A) NIS structure of Freeman; (B) NIS structure of Nelson.

The diagrams exaggerate the differences of actual execution of the studies (for instance Freeman's strong emphasis on the former Japanese ministry MITI in his assessment of government policy), but serve to highlight one aspect of complexity — that there is a many-to-many relationship between the functions and the agents that provide them. Thus, for example, education and training in Fig. 1.1(A) is supplied by all three types of agents in Fig. 1.1(B), and so on. Clearly there will be issues of alignment that arise immediately, and do indeed emerge as a focal point in practice, of the intermingling of education and training provision from each source.

A very different approach emerges from the literature on industrial economics and strategic management, focusing, as in Porter's work (1990), on competitiveness as a national target. Figure 1.2 stylises the Porter 'diamond', with elaborations of the factors of 'chance' and 'government' that are concessions to reality in the model. Technology does not appear explicitly in this framework, though its influence is exerted mainly through 'factor conditions'.

A recent paper by Vanichseni (2000) aimed to bring the function-based technology perspective of Freeman *et al.* into alignment with the industrial economics viewpoint of Porter, as in Fig. 1.3. In this enlarged model, the technology component, if that is what it can be termed, appears as the left 'diamond', and the industry component as the right one. 'Firms and Industry Structure', as the common point of reference, takes on the critical role of a fulcrum between the two sub-systems. It is noteworthy that the system being discussed here is much broader than innovation, including production and even consumption (and reproduction), in line with the French school of *régulation*. The primary attention is implicitly directed at spatial proximity — generally the nation-state, though increasingly sub-national ('regional systems of innovation') and supra-national ('continental systems') as well.

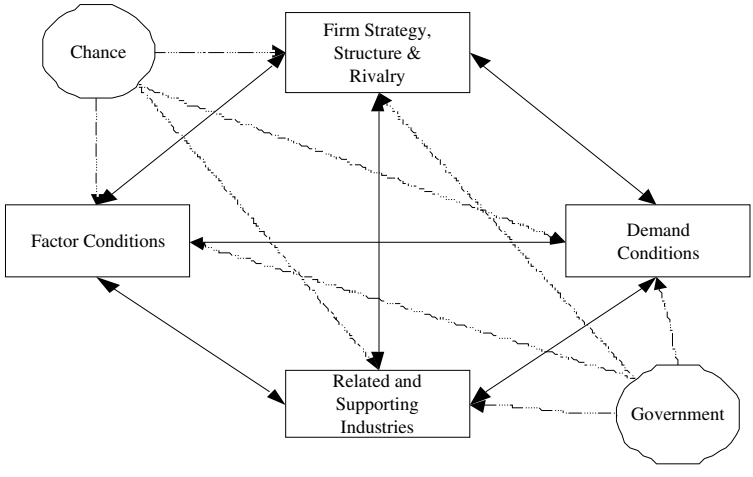


Fig. 1.2. Porter's industrial dynamics model.

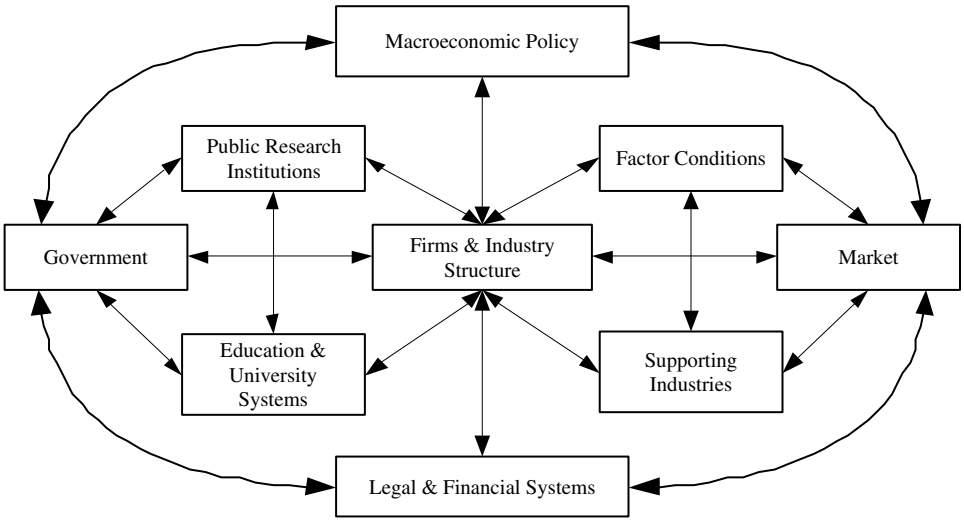


Fig. 1.3. Vanichseni's industrial innovation system.

In this version of the model, 'Macroeconomic Policy' and 'Legal and Financial Systems' are taken as broader contexts, though they too could be endogenised in an even more complex structure. The notion of firms and industries as a fulcrum will be returned to below, after we first develop the key concepts relating to network governance.

3.2. *Governance systems*

We take as a short-hand definition of 'governance' that by Prakash and Hart (1999): governance is 'organising collective action'. Here those agents undertaking such organising actions are the key actors in national and regional (etc.) systems of innovation. The concept of governance embraces: (i) structure, (ii) control and (iii) processes. The modes of governance surveyed here, as is conventional, are: (i) markets, (ii) hierarchies (both corporate and political) and (iii) networks. For our purposes, and in contrast to a lot of more precise terminology in sociology, 'networks' are defined residually, as all forms of collective action that do not primarily involve either financial exchange (markets) or the exercise of power (hierarchies). To exclude the kinds of social networks referred to earlier, such as those based on kinship (though of course some of these may lie underneath our chief focus), we will confine our attention here to collective action that involves collaboration in the development of knowledge, and in large part to those concerned with knowledge associated with production and technology. In practice, many such knowledge exchanges in the real world will at the same time involve elements of market exchange or power imbalance. However, we will suppose that in the networks that concern us these supplementary

modes of governance are secondary to the main desire to interact through knowledge formation, and usually *ex post*. Thus the transactions of goods and services that come about, say, through markets, in our instances come about *after* the partners have agreed on the nature of those products, e.g. between a component supplier and an automobile manufacturer.

Each mode of governance is associated with a particular type of 'failure': market failure, corporate failure, government failure and 'network failure'. Around each of these, except the last, a substantial literature has accumulated, which we will not try to summarise beyond listing the quaint terminology of 'hands' that has developed alongside the modes of governance and their respective sources of failure. Some of these are listed in Table 1.1.

Network failures relevant to knowledge flows at the system level include the following situations (von Tunzelmann, 2004):

1. The network required to permit the interflow of knowledge does not exist;
2. The network required does exist, but is anti-developmental (e.g. based on a *nomenklatura* system);
3. The networks do exist and are pro-developmental, but function in ways that make them incompatible with achieving the development goals.

Social network analysis is mostly concerned with the first of these, particularly through Burt's notion of 'structural holes' (Burt, 1992), e.g. in 'clusters'. It is clear from an abundance of empirical evidence, including that on the CEE countries noted below, that network (mis)alignment in reality involves the consideration of targets as well as instruments. The most interesting case of the three is probably the third, and is in fact the one on which much of the study of network alignment to date has focused.

Networks and their failures should be distinguished in principle from the more widely studied areas of 'systemic failure', even though both concepts are relevant to our area of investigation. System failures are regarded as those that arise not in individual instances (here labelled 'intrinsic') — specific to the individual market, corporation, etc. — but across the systems in question (Larsen and von Tunzelmann, 2006). Table 1.2 gives some randomly chosen examples by way of illustration.

Table 1.1. Modes of governance and their failures.

Mode of governance		Mode of failure	
Markets	Invisible hand	Market failure	Trembling hand
Hierarchies (corporate)	Visible hand	Corporate failure	
Hierarchies (political)		Government failure	Grabbing hand
Networks	Greeting hand	Network failure	

Table 1.2. Examples of intrinsic (particular) as opposed to systemic failures of governance modes.

Governance mode	Examples of intrinsic failure	Examples of systemic failure
Markets	Under/over-supply of good	Shortage economy
Corporate hierarchy	Bankruptcy of firm	Antiquated organisational systems across a nation
Political hierarchy	Corrupt ministers	Central planning problems
Networks	Too few/many members	Network misalignment

Networks and their failures constitute a row of the matrix whereas system failures constitute a column, cutting across all modes of governance failures. A parallel could perhaps be drawn with the concepts of partial disequilibrium and general disequilibrium in economics.

3.3. *Complex systems*

A major reason accounting for both the growing importance of networks and for their failures, both intrinsic and (especially) systemic, in modern times is the growth of 'complexity'. As we have charted elsewhere, the sources of this rising complexity can be traced both in breadth ('relational complexity') and depth ('cognitive complexity') (Wang and von Tunzelmann, 2000). The former concerns the range of constituents involved and the latter the degree of difficulty associated with the constituents, i.e. sophistication. Many of the problems confronting the agents in national and other systems of innovation in recent decades have been a compound of complexity in breadth and complexity in depth, because of the need to integrate newer elements into the wider system.

The factors underlying this rising level of complexity include the following.

1. The spread of 'knowledge-intensive' production. This has led to an increase in complexity in depth through the inherent cognitive and practical difficulties that particularly characterise high-tech production and technology, e.g. in microprocessors, but also complexity in breadth through the rise (for instance) of what has been termed 'Mode 2' knowledge production (Gibbons *et al.*, 1994), involving a more diverse range of actors in knowledge production and a more extended degree of interaction among these more populous actors. The latter has affected all industries and many services, not just the high-tech ones (as emphasised in the EU's PILOT programme, *cf.* Hirsch-Kreinsen and Jacobson, 2008).
2. At the upstream end, so far as producer firms are concerned, technologies are accumulated over time, and are for the most part cumulative. The advent of a new technological paradigm rarely causes the old one to disappear, instead adding to the complexity of multiple interactions of association between old and

new technologies. To the extent that there is competition among them, we increasingly face a situation of 'hyperchoice' of a variety of ways of effecting similar — though often not identical — results.

3. At the other end, the products produced from these technologies face intensifying market pressures of competition, increasingly from global sources, even in many services. There are pressures for the *rapid* development of new products, especially those with advanced technological features, as product lifecycles allegedly shorten (von Tunzelmann and Acha, 2005). This reacts on the pressure to bring on new technologies more rapidly, notwithstanding their increasingly complex nature, as evident in, say, the somewhat disappointing progress of 'red' biotechnology (Hopkins *et al.*, 2007).
4. ICT networks have developed to try to cope with the associated problems of coordination arising from more complex delivery in shorter periods of time; however, these have raised coordination problems of their own at a variety of managerial levels.

To turn from the functions to the agents, we can see firms, at the fulcrum of the NSIs as in Fig. 1.3, themselves becoming more complex organisations over the longer term: first, in moving from production in one region to production in several regions or countries (multinational organisations), second in shifting from producing a single product to producing a range of products (multi-product organisations), and third in developing a range of core technologies that they utilise rather than a single core technology (multi-technology organisations). Multi-technology companies (Granstrand *et al.*, 1997) emerge from the growing relational complexity of modern technological systems. Firms 'know more than they make' (Brusoni *et al.*, 2001), partly for negative reasons of being unable to align the competencies that they possess, but also for more positive reasons of 'dynamic capabilities' to be expanded on below — in effect providing for a future of still greater complexity. Even in a number of industries dominated by SMEs the multi-technology context now prevails, e.g. in 'rapid prototyping' (Hwang, 2006). It goes almost without saying that this growing complexity increases the problems of integrating these dispersed technological competencies, and they are exacerbated by the pressures of time.

4. Capabilities and Learning

4.1. *Sources of learning*

An issue of growing importance has been that of whether the multiple technologies can be internally developed or instead externally acquired. Until the advent of the modern era of new technological development in ICTs, biotechnology and the rest — the so-called Third Industrial Revolution — the standard practice had been for large

corporations to develop all their key technologies in-house. The rise of complexity in technologies, in products and geographically, tipped the balance towards external acquisition. On the external side this increased the complexity of inter-organisational linkages, through widening networks for technology among the diversifying types of agents already touched upon (universities, public R&D labs, hospitals, etc.). On the internal side it placed new burdens on assimilation, through enhancement of 'absorptive capacity' (Cohen and Levinthal, 1990), which could turn competencies into 'capabilities'.[4] Downstream as well as upstream firms developed 'system integration' capabilities, but in the context of the 'systems of systems' that we have previously adumbrated, the way each firm envisaged its system was likely to differ from the way its partners saw things.

In this complex structure, there is no *a priori* guarantee that the way in which the capabilities of one type of actor (say producers) evolve will go in the same direction as those of another type of actor (say, consumers). This is because (i) asymmetries of information may take them in different directions; (ii) even if asymmetries of information do not exist, *asymmetries of knowledge* may prevent them from even going in the same direction. Thus interaction among types of agents may be necessary: (i) *ex ante*, through knowledge exchanges; (ii) *ex post*, through market exchanges. It may be noted that a common pattern in such interactions as they evolve through time is to begin with a knowledge exchange (e.g. between component supplier and manufacturer), and to follow that up once component specifications are agreed with a set of market purchases/sales, thus as already noted adding market governance to knowledge network governance. Since different actors (e.g. different firms) have differing capabilities for interaction, we can therefore talk about differences in 'interactive capabilities'.

Note especially that all agents in systems variously act as producers, consumers and suppliers, but to different units of analysis. Thus, to revert to the view of the individual given in the Introduction to this chapter, university appointees 'produce' lectures and papers, in so doing 'consuming' IT equipment as well as basic necessities — not to mention the previous academic studies that we cite — and in the course of so doing, aim to 'supply' students, colleagues and perhaps policy-makers with the fruits of our knowledge. The same goes for all agents. 'Agents' are thus the individuals or organisations involved; 'actors' reflect their position in terms of how their activities are being envisaged.

[4] 'Competencies' and 'capabilities' are often used more or less interchangeably, but here we differentiate them. Put most simply, the former represent enhancements to productive resources of a particular organisation that are developed outside the organisation and then 'hired in' or otherwise acquired by that organisation. Thus a semiconductor company may hire graduates in solid-state physics on grounds of the potential they offer to improve output, technology, etc. in relation to its products. The actual enhancements are carried out in the universities from which those graduates originated. The firm would of course hope to convert the potential into actual improvements, in which case the competencies convert into the firm's own capabilities (von Tunzelmann and Wang, 2007).

The context of 'dynamic competition' (in the sense of Schumpeter) means the environment (landscape) may be constantly changing — there is a need for innovation in technologies, products, organisations, finance, etc. This entails interaction occurring in 'real time'. The extent to which the capabilities of producer firms are 'dynamic' is therefore dependent on the degree to which the resources and/or products are novel but also appropriate to the changing environments in which they are positioned (vis-à-vis their consumers and suppliers). Formally, the dynamic interactive capabilities of firms represent the extent to which the changes in their capabilities influence or are influenced by the changes in the capabilities of consumers and/or suppliers, all in real time.

The dynamic capabilities approach acts as a bridge between competing theories of innovation management: (i) the resource-based view (RBV) of non-imitable capacities, primarily for firms; and (ii) the strategic management view (e.g. Porter's 'diamond'), primarily for industries. The former looks mostly backwards, at the massing of competencies and (static) capabilities accumulated over past time ('resources'), while the latter looks mostly forwards, to the prospects for future development ('strategic'). Neither is complete in our context without the other — the RBV needs capacity for change in a context of Schumpeterian competition, while at the same time strategic management needs to be anchored in the existing strengths of an organisation.

Capabilities change as circumstances change — and to the extent that this is represented by changing regulation, standards, etc., it can fall to the role of other actors in the system as briefly indicated below — but especially as abilities change, which is mostly the consequence of 'learning'. Table 1.3 sets out a structure for sources of learning, adapted from the work of Malerba (1992), though a little differently arranged, and distinguishing in the columns as between internal sources of learning and external sources. The rows are arranged according to our threefold classification of actors as producers, consumers and suppliers. In the last-named, we adapt Malerba's specification of 'formal search' to include learning in human capital form as well as in technologies (R&D and S&T — Science & Technology).

The table strongly implies the need to blend together the internal and external sources of learning associated with each actor, and this relates again to the issue of 'absorptive capacity'. Implicitly the learning can arise not just in technologies, but in

Table 1.3. Channels of learning (after Malerba, 1992).

Sources as actors	Internal	External
Producers	Learning by doing	Learning from (horizontal) spillovers
Consumers	Learning by using	Learning from (vertical) interacting
Suppliers (formal search)	Learning from R&D and training	Learning from S&T and education

all the functions of the firm or other type of organisation, an issue to which we turn next.

4.2. *The functions of the firm*

In this section, we take the firm to be the relevant agent in the system, in view of the fulcrum role highlighted in Fig. 1.3 above. Other agents can be examined in similar ways, but the task of so doing is left mainly to future research, aside from the role of governments to be assessed in the sub-section to follow.

From the discussion immediately above, one can in the first place envisage the firm from the viewpoint of the various functions that it carries out. Figure 1.4 shows the layout of the functions of the firm in its core. The role of the producing firm is seen as one of transforming technologies into products (von Tunzelmann, 1995), involving the functions of techniques and marketing. To do this it can call on the functions of production processes and administration (financial and legal operations, etc.). These four functions are coordinated internally by management in terms of trying to optimise within given external constraints, and by entrepreneurship in dynamic contexts of bringing about changes in those constraints (Lazonick, 1991).

The functions of the firm at micro level each relate to functions of the national system of production and innovation at macro level. These go beyond the S&T system at national level to embrace national (or for that matter regional) systems of

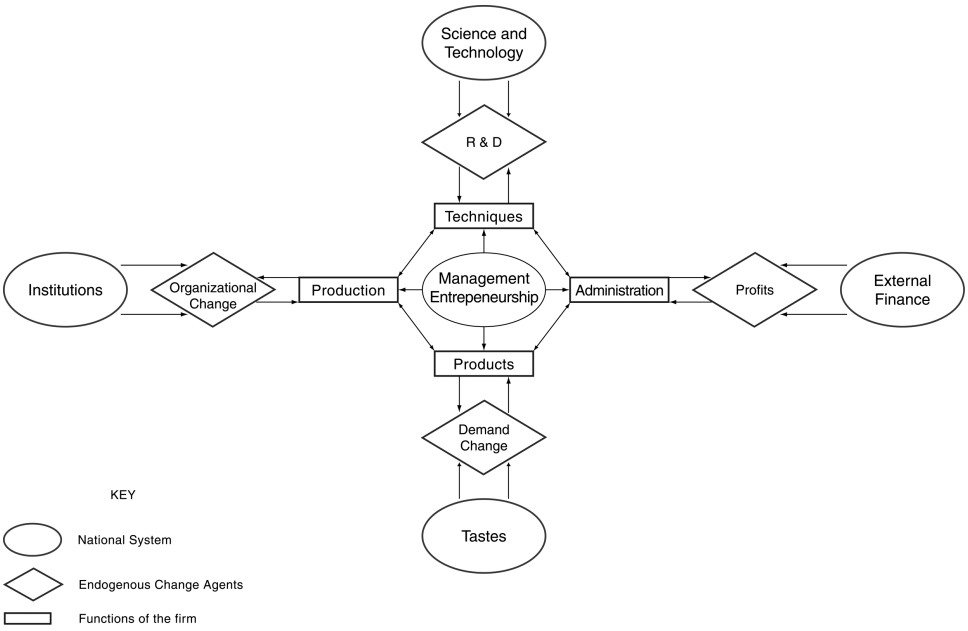


Fig. 1.4. The functions of the firm in a national system setting.

finance, consumption/taste patterns and 'institutions', with the latter here referring to the norms and rules of the game as they pertain to the organisation of production, broadly interpreted (*cf.* North, 1990).

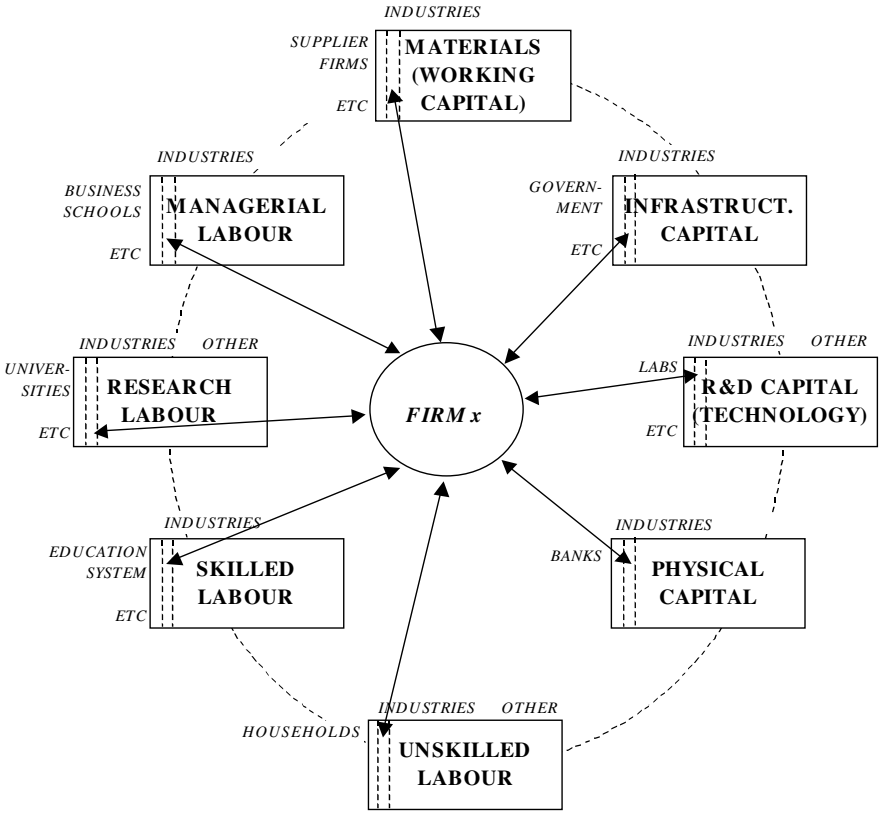
The alignment of these national levels of functions is, of course, the central issue of the topic at large, executed through the various modes of governance outlined previously. The diagram, however, emphasises the interplay between macro and micro levels, conducted through the changes taking place at the various interfaces — in R&D as an interface for technology, and so on. The relationships between R&D and national S&T run in both directions, downward from the national level and upward from the firm level, as do those between the firm's techniques and its R&D. The same goes for the other functions. Again, issues of absorptive capacity in all functions remain paramount. Clearly the diagram is a simplification, in that the links between the macro and micro level are once again many-to-many rather than one-to-one, but the nature of the relationships to be observed is evident enough.

To bring these micro and macro levels of production and innovation into effect, interflows of resources are required. These operate at all levels, but will be illustrated in Fig. 1.5 from the situation of a particular firm, *x*, located in a particular industry, *i*.

Firm *x* appears as the nucleus of a hub-type network of supply chains, with each rectangle indicating a different type of input being supplied. The firm is taken to be in industry *i* located as a particular column in the meso-level input-output table. The table is shown in the same format for each type of input. The pattern shown focuses on inflows of labour and capital of various types, while the actual pattern for a firm should also include inflows of land and mineral resources, here excluded only to reduce the complexity of the figure. The primary source of each type of input is shown to differ: banks for physical capital, laboratories for R&D capital (technology), and so on. Once more, the pattern in reality is more complex, e.g. with governments supplying some external finance, technology, skilled labour, etc., to firms as well as infrastructural capital. The arrows as before run in both directions, inward from the supply side and outward from the demand side. The meso-level becomes highly complex when the range of firms and industries in the national/regional system is taken into account.

Finally we can show the spatial level of interactions, as set out in Fig. 1.6. This diagram makes use of the governance modes previously described to articulate the various geographical levels, though of course it can be done in other ways.

The political hierarchies are displayed at the top, here supranational (e.g. EU) and national governments, though regional and other levels could equally be shown. Markets and corporate hierarchies (firms) are shown at the bottom. In between are the various spatial levels of networks — here global, national and local networks, pictured as ovals. The two-headed arrows again simplify the multiplicity of real-world interactions. The networks are shown as partly (though only partly) overlapping.



Notes: Each rectangle (box) represents an Input-Output relationship for the source specified.
Input agents (suppliers) are listed down the vertical axis of each box.
Directions of Output (demands) are listed across the boxes (same in each case).
The Industry relevant to Firm x is shown as the dotted column.

Fig. 1.5. Resource networks, from the viewpoint of the firm.

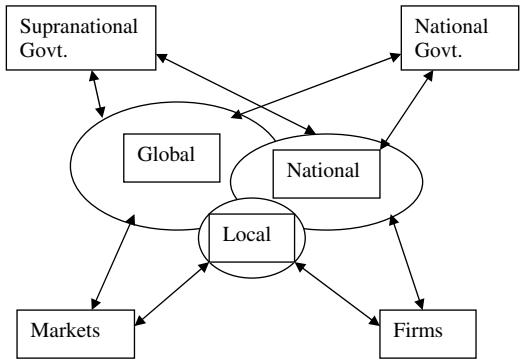


Fig. 1.6. Spatial interactions, viewed as modes of governance.

Once more, this spatial level of interaction in Fig. 1.6 intersects in many-to-many fashion with the functional networks of Fig. 1.4 and the resource networks of Fig. 1.5. Thus production in firm *x* is the simultaneous outcome of its functional structure (techniques etc.) and corresponding external relationships, its resource structure and corresponding external relationships (land, labour and capital), and the spatial structure of governance modes that it fits into (global, national and local). Naturally, any of these ties may be weak or strong depending on individual circumstances.

4.3. *The capabilities of government*

As compared with alignment at firm or individual organisation level, alignments at the meso level of industries and the macro level of countries are likely to be much more diffuse. Work on alignment at industry level is at an early stage of development, arising partly out of the recent work on sectoral systems of innovation (SSIs), though with antecedents in regional networks (e.g. for the 'Third Italy'). To the latter can be added work on industry associations and modes of governance (e.g. Cooke and Morgan, 1998), and the more analytical studies in the context of political scientists' approaches to governance as already mentioned.

Here we focus on the macro level, and particularly the role of governments in helping to bring about — or obstruct — the management and coordination of national systems ('social systems of accumulation'). Central to any success in this role are the needs for due alignment of governments within their social systems and for learning behaviour through all the internal and external channels of Table 1.3 — in this instance, 'policy learning'.

Some of the key requisites of adequate alignment on the part of governments include:

1. the need to operate through demand as well as supply factors, including (macro-) economic policy;
2. the need to enhance interactivity in space, e.g. through clusters;
3. the need to promote interactivity in 'real time', for global competition, e.g. building clusters into dynamically effective 'regional systems of innovation';
4. the need to align objectives of all types of agents, in both public and private spheres (if knowledge is substitutive, 'crowding out' can arise between public and private actions, if knowledge is complementary there should be 'crowding in');
5. the need to inculcate policy capabilities to make connections, through 'policy learning' (both internal and external).

Forging the links required for this demanding set of needs is in part an orthodox matter of targets and instruments — having common targets and sharp enough sets

of instruments. The conventional requirement is for there to be as many instruments as targets, though it has long been known that this is not strictly the case. The tendency in the 1980s to 'roll back the frontiers of the state' left many governments with too few instruments and ones that were too blunt to cope (von Tunzelmann, 2009). In the modern era, national and supranational governments have to respond to the additional burdens imposed by the 'globalising learning economy' (Lundvall and Borrás, 1997), where the market sector is particularly unlikely to provide adequate resources and capabilities for proper alignment.

As complexity grows in depth as well as breadth, new pressures are thus placed on governments to sustain development processes. In this, they tend to be limited by the insufficient 'capabilities' of the state/authority to link its policy-making to client needs. As emerges from the list of requisites above, governments need to exert dynamic capabilities of their own, by keeping abreast or ahead of the game, but nowadays in a networked society potentially able to call on a wide range of talent and expertise rather than a hierarchically structured one.

4.4. *Gauging network alignment*

The problem of trying to measure the extent of network alignment — and hence trying to gauge how much misalignment is tolerable — begins at the beginning, with attempting to measure such notoriously elusive concepts as 'knowledge' and 'innovation'. The limitations of widely practised measures of the knowledge base and its diversity are well known — much can be said against each of the 'usual suspects', such as patents, R&D, skill levels or innovation surveys. The problems do not need to be laboured at this point. Nor is it a question of averaging out, since it is precisely the specificity of each measure that is likely to be valuable here. An immense amount of damage has already been done to the whole field of innovation studies by such elementary confusions as (crudely) measuring technologies from products, and so on. For example, the EU's Community Innovation Surveys have for a number of years been carried out in the absence of much semblance of a clear definition of what 'innovation' is, leading to often absurd results.

Without effective measures of these very basic concepts, it becomes difficult to assess in quantitative terms the goals or targets of a network structure. Yet network alignment must be about achieving common goals across a network or across networks of networks, without innate contradictions between the methods adopted in trying to attain them (the 'instruments'). We can, however, proceed to attempt to assess the targets of individual organisations in the network structure. Specifically we might wish to select the following list of targets for key agents:

1. for firms: one branch of literature, coming from international business studies, sees the goals of firms in diversification as market-seeking, cost-seeking or

knowledge-seeking, while that in strategic management has a somewhat different but reconcilable list of such goals;
2. for universities: widely observed targets tend to embrace research, teaching and revenues;
3. for governments: competing models in political science seeking to classify governmental behaviour list the regulatory, developmental and distributive states as viable choices.

The heterogeneity of these goals is highly suggestive of typical network alignment problems — how can this variety of aims and objectives be harnessed to the good of any visible purpose? This brings us back to the analogy with the invisible hand theorem in a network economy context, as mentioned at the start. In fact the 'developmental' goal was assumed for a national system of innovation (NSI) in our discussion of network failures; but this may have been simplistic or at least premature. To the extent it remains valid, one would need to see university–industry links as pro-developmental (contradicting the presuppositions of attempted measurement such as the UK's Research Assessment Exercise), and likewise for business–government links.

In trying to reap these rewards, agents are constrained by their capabilities, as explained above. Those that especially concern us here are the networking capabilities, i.e. the need for effective and efficient interaction between and among organisations. The diagrams presented in Figs. 1.4 to 1.6 suggested multiple agents interacting in both functional and resources respects in differing spatial contexts. These interactions give clues as to the economies of scale and scope ('synergies' in depth and breadth) present at system or network level, though again these are hard to quantify unless we are able to measure the knowledge itself, or (even less likely) how one piece of knowledge is ontologically related to another piece to achieve the synergies. In this context the contrast that Mokyr (2002) has drawn, to explain the historical evolution of NSIs, between learning focused on what and why (epistemic) as against how (technical, applications), could prove to be a very valuable insight.

The static scale and scope economies in any case probably pale alongside the potentials for dynamic scale and scope economies. These latter typically take the form of real-time economies in the short and medium term ('time-saving technical change') and increasing returns from learning in the medium-to-longer term. And this brings us back to assessing dynamic capabilities as real-time, learning-oriented expressions of the drivers of effective interactivity in conditions of 'dynamic competition'.

5. Conclusions and Implications

Establishing that a particular system of networks is or is not aligned is relatively straightforward, at least conceptually, in that it relates to the notions of various kinds of network failure previously listed. What is much harder to assess is the *extent* of

network (mis)alignment. It seems obvious that the more restricted the goals or targets of a particular set of networks, and the smaller the number of relevant agents involved, the more likely it is that the structure will be fairly well aligned, *ceteris paribus*. But what degrees of misalignment are tolerable, and how can the amount of diversity needed in any system to maintain momentum be allowed for? In the CEE countries particularly, where at the time of writing newly emerging market-based mechanisms are being put under pressure by new waves of global market-based disruption, it would seem vital to know.

It is apparent from our currently limited information on this issue that no optimal solution is ever likely to be found, at least in the kind of real-time context that is relevant to practical situations confronting policy-makers at the macro level or strategic decision-takers at the micro level. Countries regarded as highly successful in recent times, e.g. China or South Korea, would seem to feature among those with quite extensive degrees of duplication in administrative circles, despite their periodic attempts to rein in the more excessive cases of overlap. Network misalignment would appear to be endemic in complex many-to-many environments. So does it matter?

The answer in our view is that, while the body politic — like the human body — can learn to adjust around the edges of minor setbacks, major weaknesses can be quite damaging. Localised and piecemeal improvements may end in an outcome that is far from acceptable, much less optimal. The East Asian governments alluded to above share with their nations some 'vision' of where they are heading, and this yields an outcome in terms of dynamic capabilities that may not be perfect but at least seems satisfactory. It is less clear that the countries described in the remaining chapters of this book do share such visions as to where they are going.

References

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

Brusoni, S., Prencipe, A. and Pavitt, K. (2001). 'Knowledge specialization, organizational coupling, and the boundaries of the firm: Why do firms know more than they make?', *Administrative Science Quarterly* 46: 597–621.

Burt, R.S. (1992). *Structural Holes: The Social Structure of Competition*, Cambridge, MA, Harvard University Press.

Carrington, P.J., Scott, J. and Wasserman, S. (eds.) (2005). *Models and Methods in Social Network Analysis*, Cambridge, Cambridge University Press.

Cohen, W.M. and Levinthal, D.A. (1990). 'Absorptive capacity: A new perspective on learning and innovation', *Administrative Science Quarterly* 35: 128–152.

Cooke, P. and Morgan, K. (1998). *The Associational Economy: Firms, Regions and Innovation*, Oxford, Oxford University Press.

Freeman, C. (1987). *Technology Policy and Economic Performance: Lessons from Japan*, London, Pinter.

Freeman, C. (2002). 'Continental, national and sub-national innovation systems: Complementarity and economic growth', *Research Policy* 31: 191–211.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P. and Trow, M. (1994). *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies*, London, Sage Publications.

Granstrand, Ö., Patel, P. and Pavitt, K. (1997). 'Multi-technology companies: Why they have "distributed" rather than "distinctive" core competence', *California Management Review* 39: 8–25.

Hanneman, R.A. and Riddle, M. (2005). *Introduction to Social Network Methods*. Riverside, CA, University of California, http://www.faculty.ucr.edu/~hanneman/nettext/.

Hirsch-Kreinsen, H. and Jacobson, D. (eds.) (2008). *Innovation in Low-Tech Firms and Industries*, Cheltenham, Edward Elgar.

Hopkins, M.M., Martin, P.A., Nightingale, P., Kraft, A. and Mahdi, S. (2007). 'The myth of the biotech revolution: An assessment of technological, clinical and organisational change', *Research Policy* 36: 566–589.

Hwang, J.-T. (2006). *The Role of Small Innovative Firms in Multi-Technology Innovation: The Case of Rapid Prototyping Industry*, DPhil Thesis, SPRU, University of Sussex.

Jessop, B. (ed.) (2001). *Regulation Theory and the Crisis of Capitalism*, Cheltenham, Edward Elgar.

Kenny, D.A., Kashy, D.A. and Cook, W.L. (2006). *Dyadic Data Analysis*, New York, Guilford Press.

Kim, S.-R. and von Tunzelmann, N. (1998). *Aligning Internal and External Networks: Taiwan's Specialization in IT*, SEWPS (SPRU Electronics Working Paper Series), No. 17, University of Sussex.

Larsen, M.T. and von Tunzelmann, N. (2006). 'Non-market failure: The role of public science in the development of generic technology', Aalborg, DRUID Summer Conference Paper.

Lazonick, W. (1991). *Business Organization and the Myth of the Market Economy*, Cambridge, Cambridge University Press.

Lee, T.-L. and von Tunzelmann, N. (2005). 'A dynamic analytic approach to National Innovation Systems: the IC industry in Taiwan', *Research Policy* 34: 425–440.

List, F. (1844). *The National System of Political Economy* (transl. S.S. Lloyd), London, Longmans, Green & Co. (1904).

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

Lundvall, B.-Å. and Borrás, S. (1997). *The Globalising Learning Economy, Implications for Innovation Policy*, DG Science, Research and Development, Brussels, European Commission.

Malerba, F. (1992). 'Learning by firms and incremental technical change', *Economic Journal* 102: 845–859.

Malerba, F. (ed.) (2004). *Sectoral Systems of Innovation: Concepts, Issues and Analyses of Six Major Sectors in Europe*, Cambridge, Cambridge University Press.

Marks, G., Scharpf, F.W., Schmitter, P.C. and Streeck, W. (eds.) (1996). *Governance in the European Union*, London, Sage Publications.

Mokyr, J. (2002). *The Gifts of Athena: Historical Origins of the Knowledge Economy*, Princeton, Princeton University Press.

Nelson, R.R. (ed.) (1993). *National Innovation Systems: A Comparative Analysis*, New York, Oxford University Press.

North, D.C. (1990). *Institutions, Institutional Change and Economic Performance*, Cambridge, Cambridge University Press.

Perini, F. (2009). *Organising Innovation between Multinational Companies and Innovation Systems*, DPhil thesis, SPRU, University of Sussex.

Porter, M.E. (1990). *The Competitive Advantage of Nations*, New York, Free Press.

Prakash, A. and Hart, J.A. (eds.) (1999). *Globalization and Governance*, London and New York, Routledge.

Sen, A.K. (1985). *Commodities and Capabilities*, Amsterdam, North-Holland.

Vanichseni, S. (2000). 'National systems of industrial technology development', in Arnold, E. *et al.* (eds.), *Enhancing Policy and Institutional Support for Industrial Technology Development in Thailand*, Brighton, Technopolis.

von Tunzelmann, G.N. (1995). *Technology and Industrial Progress: The Foundations of Economic Growth*, Aldershot, Edward Elgar.

von Tunzelmann, N. (2004). 'Network alignment in the catching-up economies of Europe', in F. McGowan, S. Radosevic and N. von Tunzelmann (eds.), *The Emerging Industrial Structure of the Wider Europe*, London, Routledge, pp. 23–37.

von Tunzelmann, N. (2009). 'Technology and technology policy in the post-war UK: "market failure" or "network failure"?', Revue d'Economie Industrielle*, forthcoming.*

von Tunzelmann, N. and Acha, V. (2005). 'Innovation in "low-tech" industries', in Fagerberg, J., Mowery, D. and Nelson, R. (eds.), *The Oxford Handbook of Innovation*, Oxford, Oxford University Press, pp. 407–432.

von Tunzelmann, N. and Wang, Q. (2007). 'Capabilities and production theory', *Structural Change & Economic Dynamics* 18: 192–211.

Wang, Q. and von Tunzelmann, N. (2000). 'Complexity and the functions of the firm: Breadth and depth', *Research Policy* 29: 805–818.

Welle, K. (2009). 'Monitoring access to rural water supply in Ethiopia', DPhil research outline, SPRU, University of Sussex.