Part 1

THEORETICAL FOUNDATIONS OF INNOVATION SURVEYS

CHAPTER 1

The conceptual fluidity of national innovation systems: Implications for innovation measures

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The problem

A simple perusal of the list of references in the *Oslo Manual* (OECD 1992) provides an immediate indication of the genealogy of the methodology underlying surveys of innovation activities. Perhaps 1992 was too early to explicitly use the terminology that is now common among researchers of the economics of innovation. Subsequent publications of the Organisation for Economic Co-operation and Development (OECD) (such as OECD 1997) clearly identify the framework within which innovation would be measured and interpreted as the concept of 'national innovation systems'. This concept has thus been used, since the 1990s, as the framework for the construction of national innovation surveys. It has now become the largely unquestioned language of the analysis of innovation.

The formulation of the concept of a national innovation system (NIS) emerged from an evolutionary account of the economics of technological change that had arisen in opposition to the established neoclassical orthodoxy. The principal defining feature of the new paradigm was its emphasis on specificities as opposed to the universality assumed in the neoclassical account of technological change. Neoclassical theory treated technology exogenously as a universally applicable 'best practice', the accessibility of which was costless to all economic agents, irrespective of time or location. In contrast, studies that fell under the evolutionary rubric, while accepting some basic commonalities in the nature and manifestations of technological change, proposed contextual contingency as a crucial determinant of the paths of technological change. Thus the focus of the inquiry into innovation and technological change shifted towards specific characteristics, consequently reducing the capacity for generalisations, whether at the analytical or at the prescriptive level.

One of the fundamental divergences between the evolutionary and the neoclassical schools lies in their respective assumptions about the nature of the information on which economic agents base their resource allocation decisions. These assumptions are so distinct that it becomes impossible to place the associated postulated economic agents within the same category. Where the neoclassical paradigm assumes a fully specified information set (or one where possible future states are amenable to a probabilistic specification), evolutionary analysis sets agents within a context marked by areas of ignorance, which, moreover, grow as the planning and decision-making horizon moves away from present known states. The introduction of ignorance as an indelible property of the decision space opens the field of analysis to the corollary of tacit knowledge (in other words, knowledge and capabilities that cannot be codified, are not amenable to full specification, and hence are imperfectly transmittable).[1] From this corollary, there emerges the concept of core competencies that differ across, and hence differentiate, economic agents, whether these are individuals, firms

or nations. This forms the basis of the evolutionary school's analysis of comparative, and competitive, advantage.[2] The incorporation of tacit knowledge, technological capabilities and core competencies into the analysis of economic systems has therefore led to a growing appreciation that the idiosyncrasies of the diverse economic histories of nations have progressively precluded easy generalisations and hence generalised prescriptions.

As an analytical space, the idea of a national innovation system arose out of the proposition that technological capabilities are essentially native, in that the structures that generate them are specific to time and place, and therefore differ significantly across nations and through the histories of nations. The analysis of national innovation systems is thus an attempt to map out the web of complex institutional relationships that constitute and determine the context within which a nation's 'stock' of technological capabilities, and the consequent nodes of core competencies, are shaped.

As far as the current analysis of innovation is concerned, the original debate is over, and innovation surveys are firmly grounded in the framework of the NIS. So dead is the original debate, for all practical purposes, to researchers and policy-makers in the field, that there is a danger that the core contribution of the evolutionary account to the analysis of technological change may have become clouded, and that the manner in which the concept of the NIS has been adopted may itself be subject to the same critique posed by the original statement of the problem. The core of the evolutionary critique was not the concept itself (which in any case was a rather late arrival and a coalescence of the various strands of the approach) as much as the brunt of it. The core was rather a deconstructionist method, an archaeological excavation of the underlying layers of the then established orthodoxy. It was an attempt to disinter what was left unspecified in the elaboration of elegant neoclassical growth models. It is incumbent on theorists who work within an evolutionary framework to apply the critical analysis of their school to their own constructions. In this manner, there is a continuous check on a natural tendency to fix approaches, and in the process to cease to discover underlying assumptions.

While the shift away from the simplifying assumptions of the neoclassical account of technological change was an obvious quantum leap in the analytical prowess of the consequent innovation surveys, the abandonment of the assumption of universality came at a heavy price. With the incorporation of historical specificity into the core of the analysis of technological change, the problem of the choice of measures of innovation arose. In this case, there arises a tension between the need to specify a common process for the development of NISs and the consideration of the non-trivial idiosyncrasies of specific systems.

Surveys of any sort serve two distinct and separable functions. The first is to provide a performance monitoring and evaluation (PME) mechanism. PME essentially entails an evaluation of chosen indicators relative either to baseline or target values. It is quite conceivable that the PME indicator list could be altogether specific to the empirical case under consideration, bearing little or no correspondence to other empirical cases except for the PME method itself. The second function of surveys is to allow inter-system comparisons. This requires a common, or at least an essentially compatible, indicator list. Most surveys are designed to serve both functions, with a core indicator base that is common to all empirical applications, and lists of indicators that are specific to various settings. The problem then arises as to what should constitute the core. The basic assumption underlying the core questionnaire is that it reflects a structure that is common to all the empirical cases included in an inter-system survey.

In this case, the data that are captured by this survey are liable to two distinct interpretations. We assume a continuity and a linearity (in other words, a spectrum or a generic range), within which any national innovation system can be placed. Dosi (1991:354), however, cautions against an easy acceptance of linearity when he says that:

> ... evolutionary theories attempt to model economic systems rich in positive feedbacks [that is, self-reinforcing mechanisms such as dynamic increasing returns in innovation]. Relatedly, such systems tend to exhibit non-linear dynamics and multiple dynamic paths also *dependent on their history* [own emphasis]. On the other hand, we can allow that there are distinct breaks and divisions in the ordering and/or location of national innovation systems. That is, we allow for distinct range sets within a broader taxonomy of NISs [national innovation systems]. It is here that the problem of infinite regression arises as we discover ever-broader taxonomies within which specific taxonomies are set. We thus find ourselves eternally plagued by the problem of the specificity of the essentially arbitrary, or at best contingent, nature of any taxonomy.

It is therefore always advisable, perhaps crucial, to locate specific innovation surveys, or innovation survey models, according to a set of parameters or a reference frame. In the process, we will be able to identify the specific empirical reference of surveys. Given their underpinning of the concept of the NIS, it may be useful to examine survey format through an exploration of the fundamental components of the formulation of such systems. In the process, we may be able to identify what is assumed as given, and what is left unsaid, in the formulation and adoption of an innovation survey format. The three crucial components of the concept of the NIS are the proposal of the nation state as the space within which the analysis of innovation is contained, the institutional web that is assumed to be partially idiosyncratic to specific nation states, and the type of innovation capacity that is built up within a specific system.

The relevance of the nation state

The pinning of the innovation system concept to the nation state as the defining unit of containment is quite problematic. The critiques of this assumption come from two quarters. On the one hand, there are those who argue that the introduction of specificity requires that differences within the nation state can be significant enough to raise the possibility of distinct intra-statal systems of innovation. On the other hand, the phenomenon of rapidly accelerating globalisation seems to be reducing the economic sovereignty of individual nation states at such a rate that the notion itself will soon become obsolete. The obvious emerging containment space of innovation systems is the economic bloc. However, the histories of different nation states and the evolution of their economic sovereignty differ widely across the globe. In many parts of the world, the legitimacy of the nation state is still effectively contested. In cases where Gellner's (1983, 1996) prerequisite of the subsuming of ethnic and other allegiances has not been effectively fulfilled, the integrity of the nation state is tenuous and can only be maintained through the overt exercise of force. There are also numerous nation states whose economic sovereignty is substantially limited because of the burden of foreign debt and the restraining effects of structural adjustment programmes. Thus even if we consider economic blocs as the future focus of the analysis of systems, the progression towards the formation of this unit is extremely heterogeneous. In the case of successful blocs, the European Union (EU) is the foremost example; the emerging regional innovation system was built on the base of viable national systems. In the case of developing

economies, any regional system that is aimed at will have to be built on a much weaker base. Thus the nation state that is assumed in the construct of the NIS is far from being the same entity across settings. Successful innovation systems are built on the basis of nation states whose integrity is effectively undisputed. The absence of this prerequisite renders the development of a viable NIS unlikely.

Given this vast diversity in the organisation of the basic political and economic context within which innovation occurs, it is crucial that innovation surveys somehow reflect the nature of the fundamental setting within which the activities that are measured occur. The tensions between the various systems as they affect a specific case – the local and the regional, the local and the global, and the regional and the global – differ widely, depending on the relative wholeness of the components of the meshed systems sets. The same measure can mean radically different things and have significantly different implications for policy in different contexts, as has just been outlined.

Systems of innovation

The crucial element of the concept of the NIS hinges on the definition of the term 'system'. As defined by Nelson (1993:4–5), an innovation system is:

> ... a set of institutions whose interactions determine the innovative performance... a set of institutional aspects that, together, plays the major role in influencing innovative performance.

Nelson accepts that the broadness of the definition of innovative activity renders the constraints on the types of institutions that should be included rather hazy, especially considering the wide range of activities that are covered by the term 'innovative performance'. The consequence is that, given the intricacy of the concept and its multidimensional nature, a multiplicity of systems of innovation is possible, and context specificity is inevitable. Neale (1987) points out that the plethora of definitions of institutions is a serious source of obfuscation in economic theory and proposes that confusion at the definitional level arises because insufficient attention has been paid to the distinction between orthodox economics and institutional economics. Where the former is defined by the tenets of constrained optimisation, the latter focuses on the context-specific norms and 'sign-posts' that govern the ways in which members of a society proceed to muster resources to achieve ends. The result is that in the case of institutional economics, unlike that of neoclassical theory,

> ...[n]o universal aim, no universal method or logic is assumed. Rather, what people want to achieve and how they go about it – the institutions that govern provisioning – become the subjects of study. (Neale 1987:1180)

Following the lines established by Coase (1937) and extended by North (1981), Johnson (1988:280) defines institutions in broad terms as the:

> ...sets of routines, rules, norms and laws, which by reducing the amount of information necessary for individual and collective action make society, and the reproduction of society, possible.

In this tradition, the instrumental *raison d'être* of institutions lies in the economising of transactions costs. The term 'system' requires us to go beyond this definition, however. An institutional web simultaneously is determined by, and determines, the knowledge system that binds a specific society, culture or age. Simpson (1995) defines this dichotomy in

terms of the tension between the autonomy of technology in terms of its internal logic, which renders it potentially formative of human needs, and technology as instrumental (in other words, as subservient to needs). In the latter aspect, it is needs, mediated through social institutions, that act as constraints on technological development paths, but needs are themselves affected by changing technological opportunities. Marglin (1990) isolates four parameters that identify a specific knowledge system – its epistemology, its modes of transmission and inter-temporal self-perpetuation, its modes of innovation, which determine its adaptability and dynamism over time, and the expression of power, both within the system, in terms of power concentrations and relations among its constituents, and with respect to other knowledge systems. Thus a knowledge system needs to be identified in terms of its constituting principles and its ability to survive and evolve, which can be charted through an examination of its internal power relations, and of its location within a power grid relative to other existent, or potential, knowledge systems.

One of the main commonalities in the analysis of various national systems is the nature of the relationship between state and market. On the one hand, NISs can be, to different degrees, the product of conscious, goal-driven policy initiatives at the macro level. On the other hand, they are determined by the reactions to, and the results of, such policies. The results of these policies are therefore, at least partially, driven by limited micro, or sectoral, imperatives. This relationship stamps the unique 'character' of a particular system while at the same time rendering studies amenable to comparative analysis both across systems and over time. Varying as it does from the one extreme of a *laissez faire* context to the other marked by a national coordination of all technology initiatives within a national development plan, it is crucial in determining the setting within which all the measures that are used to identify a system fall. The appraisal of NISs can be based on an understanding of four broad constituent categories. These cover an understanding of who the innovators are, of the power relations within the system of innovations, of overt science and technology policy and, finally, of other policies that affect the context within which innovative activity occurs.

Johnson (1988) focuses on the trade-off between stability and flexibility, which is inherent in all institutional systems, as the crucial factor that determines the survival of systems in a context of rapid technological change. Stability may, through a detailed formal specification of all the aspects of human interaction, result in a rigid system that is vulnerable to change and can only survive by resisting change. Flexibility and the ability to internalise change can only be purchased by relinquishing some of the behaviour-specification prerogatives of institutions and the consequent enlargement of spaces of possible non-prescribed behaviour. Technology is, as Neale (1987) argues, intertwined with institutions, and technological change consequently poses both one of the main stimuli to institutional change and one of the main potential threats to the stability of institutions. The strength and nature of the stimulus, of course, depends on the type of technological change. Unless institutions are rigid to the point of fossilisation, they should have the ability to incorporate some degree of change, and their degree of flexibility can therefore be assessed in terms of the limits of the radicality of technological change to which they can adapt without running the danger of collapse. Johnson identifies two main causal relationships between institutional and technological change, each of which has different implications for the ability of institutional frameworks to adapt to, and provide a stimulus for, technological change.

The premise that knowledge is partly tacit and context specific, and hence imperfectly transmittable and adaptable, gives rise to the notion of appropriate technology, and by extension to that of appropriate institutions. This concept was initially introduced in the context of international technology transfers, with which it is still associated in most of

the pertinent literature. It is based on the premise that no technology exists *in vacuo*, on its own merits. An innovation is developed and validated within a context and will often incur transfer costs when applied in a different setting. While some of these costs can be approximated by the costs of adapting the innovation to a different environment, there is a wide range of transfer costs that are not immediately evident and for which no market adjustment is possible. This is due to contextual complexities that can only be imperfectly defined and assessed by a range of parameters, which can vary widely. Physical characteristics are the more obvious ones. Standard economic factors, such as differing factor price ratios, can also be easily incorporated in the calculation of transfer costs, as can differences in the physical infrastructures between the country of origin of an innovation and the recipient country. Less easy to calculate are parameters that originate in cultural and institutional differences, which orthodox economic theory excludes from consideration.

There is still another level at which the issue of appropriate technology can be considered. Unless we assume a homogeneity across agents within national borders, there is no reason why the appropriateness of technology should not be considered within the intra-national as well as the inter-national context. A specific technology may reinforce the power base of a specific part of the body politic to the detriment of others. It can render certain skills obsolete, while increasing the market value and power of others. It reinforces and raises the social value of certain goals to the detriment of others – the environmental debate is an example of this type of conflict. A change in the power base of any society, whether through democratic elections or a revolution, will often result in a re-ordering of priorities, and hence a reclassification of alternative technologies as more or less appropriate. Technology thus becomes inextricably linked to power and hence to conflict. Given the danger implicit in explorations that can potentially threaten the fabric of the body politic, the issue of control arises. Control mechanisms of various types therefore become essential to limit the potentially dangerous consequences of explorations whose outcomes are not perfectly predictable.

While the application of the concepts of cumulativeness, path dependency and irreversibility was initially limited to technological change, they have been extended to the analysis of the evolution of institutions (North 1981; North & Wallis 1994) and to the relationship between technological and institutional change. In this sense, the costs of altering development paths are linked to institutional inertia, which, in turn, is an essential symptom of the stability that institutions require to fulfil their function. This extension alters fundamentally the constitution of switching costs, through the introduction of the accumulation of power by agents associated with specific paths and their ability to resist path switching. Thus the assessment of costs now becomes partially mediated through the conflicting renditions of the stakeholders in the prevailing path choice, on the one hand, and the outsiders who have been excluded from its benefits, or whose power base within the political economic web has been diminished because of it, on the other. Consequently, the evaluation process is itself a political one, contingent on the relative power of the contesting claimants, and a result of it.

The fundamental reason why a specific technology and its related institutional base may become inappropriate is thus the impossibility of fully specifying, *a priori*, the outcome and effects arising from it. Often the divergence between expectations and outcome is so wide as to render models based on expectations utterly meaningless. This divergence is most pronounced in the case of those innovations that Freeman & Perez (1988) label as the cause of techno-economic paradigm shifts. A new technology may thus, because of unpredicted effects, be deemed inappropriate *a posteriori* by its own initial promoters, as well as by sections of society whose power has been eroded by the change.

There are therefore a number of interlinked parties, and hence potential situations of conflict, in the development of the institutional base for innovations. The relation between state and market has already been mentioned. This relationship can take numerous forms, as can the nature of its participants. The focus of most innovation studies is the firm, since in most economies, the bulk of innovative activity is carried out by firms, and firms are the main users of new technology. Firms do not, however, constitute a homogeneous category. They can be fully private sector owned, directly state owned or parastatal. Moreover, different contexts generate crucially different corporation cultures. It is difficult to place within the same category the lifetime employment Japanese firm, the 'hire and fire' American corporation and the South Korean *chaebol*. The environment within which specific industrial cultures grow can best be understood through an examination of the interaction of extra-market institutions with firms. Within the context of science and technology, these other institutions usually lie within the public and the tertiary education sectors. Firms are generally assumed to be motivated by some notion of 'profit-maximisation', and innovation, once it is brought in as a strategy variable, is assumed to be determined by this objective. The concept of 'profit-maximisation' is, however, operationally meaningless in the strategies of real corporations. In a context of limited knowledge and bounded rationality, the objectives that guide firms' strategies are those that pertain to security, expansion and competitive advantage.

Given the premise that the discourse on technological change is intertwined with that on power, we can approach an appraisal of the shapes and contours of specific systems through an analysis of the relative strengths and effectiveness of the various power bases and the permutations of the resulting negotiated positions. The snapshot assessment of the power base underlying an innovation system can proceed through an analysis of the concentrations of ownership and control throughout the economy. The main internal agent groups that are relevant are the business sector, government, organised labour and consumer bodies. NISs are, as already discussed, becoming increasingly integrated within a global framework and, especially in the case of small developing economies, agents from outside a country's national borders play a significant role in shaping the country's innovation system. This last category comprises transnational corporations, international aid and finance institutions, and other governments.

The potential for conflict is endemic in any process that entails changes in structures underlying the relations of production, and technological change has, since Marx, been assigned a central role in the often-contentious relationship between capital and labour. The articulation of this basic conflict has obviously become more complex and less starkly polarised, given the fundamental manner in which technology, on a number of fronts, has mutated into configurations arising from unforeseen paradigm shifts, which could not have been conceived of by classical economists. The diverse requirements for skilled labour inputs by different technologies directly affects the bargaining power and policy of organised labour. The particular bias of a NIS, towards greater or lesser dependency on broad-based human capital, is therefore instrumental in positioning labour within the national power grid, but this bias itself is partially a result of the pre-existing factor of market power relations.

The relationship between state, capital and labour can take numerous forms. Some are significantly more conducive to the emergence and development of viable innovation systems than others. In fact, the viability of systems is often associated with an accord, whatever form it may take, among the main stakeholder categories. Unless the countries

being surveyed have roughly similar inter-sectoral power relations, the capacity to interpret innovation indicators for analytical and policy purposes would be severely restricted.

Measuring innovation

Within the evolutionary approach, the concept of 'innovation' is localised to specific agents and contexts. The introduction of a new product or process is thus termed innovative, regardless of its origin, as long as it represents a practice that was hitherto unknown or unutilised within the specific context under consideration. As used here, therefore, the term 'innovation' includes the ability to adopt (and adapt) existing knowledge to one's requirements as well as the generation of new technologies or techniques. As applied to technical advances, this usage is broader than that adopted by Schumpeter (1954), who considered only the agent who generates the invention as an innovator. Here the emphasis is shifted to include the user(s) of an innovation. In its focus on technical innovations, however, it is a narrower concept than that of Schumpeter, who also included in the category of innovations any alteration by an economic agent to the context within which it operates.[3]

The term innovation covers a vast set of changes, ranging from the trivial to those that alter the very foundations of economic, social and political organisation. Freeman & Perez (1988) offer a taxonomy wherein innovations are classified into four categories, namely: (1) incremental innovations that tend to occur continuously, often outside the ambit of formal research and experimental development (R&D) structures, resulting in an improvement in productivity; (2) radical innovations that are discrete breakthroughs resulting from a planned, goal-oriented programme of R&D; (3) changes in the prevalent 'technology system' that affect several related sectors and involve a coordination among various firms across sectors – these have been compared to Schumpeter's 'constellation' of innovations and can also be compared to systems development as discussed in Nelson (1993); and (4) 'techno-economic paradigm' shifts,[4] which are the result of a change in technology that is so fundamental that the whole economy is affected.

There is, however, a case to be made for the extension of the definition of innovation to any alteration in production relations that affects what is produced and how its is produced. This would then include institutional change. Again, the setting makes a considerable difference to the relevance of alternative measures of innovation. In the case of viable and flourishing innovation systems, the institutional underpinning is usually assumed to be appropriate for growth and development. In such cases, as in the case of Eurostat's third Community Innovation Survey (CIS-3), organisational change is not counted as innovation unless directly related to technical innovations. In the case of developing economies, however, structural transformation is a crucial and critical component of development. In such cases, broader institutional change has to be included in the measures of innovation.

The current guidelines for innovation surveys

The task of locating an innovation survey can be undertaken through an examination of its emphases, its inclusions and its omissions. A number of features of the *Oslo Manual* can be noted with reference to the arguments presented in this paper. In general, we can see that hardly any of the fundamental components of the concept of the NIS are reflected in the survey guidelines. This may be the result of an attempt to make surveys generally applicable to a number of settings, but this may be a self-defeating quest. The limited focus of the *Oslo Manual* guidelines actually renders consequent innovation surveys highly specific, especially

when it comes to inter-system analysis. Thus, for example, the results of the Eurostat survey can be used for meaningful analysis of innovation only if we assume a rather rigid set of commonalities among respondent countries.

The core CIS-3 questionnaire follows the *Oslo Manual* closely,[5] and one major characteristic is worth noting. The targeted respondents of CIS-3 are business enterprises. This is based on the standard assumption that firms are the main source of innovation and that the role of the state is to act as a facilitator of market functioning in this particular area. However, as already argued, the validity of this assumption is strongly contingent on the economic context. In a first world, industrialised economy, one can safely accept that the assumption of a reasonably efficient market for innovation holds. The problems generated by periodic productivity slowdowns, the effects of globalisation on intra-first world location of innovation activities and the movements of research personnel can to a large extent be addressed as specific adjustments to a developed NIS. The role of the state in industrialising economies is quite different. The less industrialised the economy, the weightier the responsibility of the state to set up appropriate structures for developing a NIS that is suitable for a modern economy.[6]

Moreover, a number of the questions listed in the survey address the perceptions of the business community about a range of factors, including bottlenecks such as those relating to skills and to the role of the state. In an industrialised setting, the perceptions of firms with a long history of innovation and well-established core capabilities can indeed be used as a strong approximation of the actual functioning, deficiencies and requirements of the specific NIS in which they are located. In the absence of such histories, the perceptions of firms that have been established within the context of poorly developed and distorted NISs are rarely reliable indicators of the requirements for the development of the system. As it stands, existing survey methodology rests on patchy theoretical foundations. In its practical exclusion of agents other than business enterprises from its consideration of the determinants and characteristics of innovation capacity, it can also be interpreted as being strongly ideology laden. To belabour the point, the implicit assumption of linearity in the adoption of a standardised innovation survey simply cannot be maintained when we strive for general coverage, and the *Oslo Manual* allows little leeway for the consideration of ruptures and breaks in the range of innovation systems that can be surveyed.

The inclusion of factors that have been identified in this chapter as forming the core structure of innovation systems would, of course, be difficult, and the specification of a survey format to accommodate them would be a long and arduous process. However, the benefits for policy-informing analysis would be substantial. Surveys that covered structural elements would enable taxonomic approaches to the analysis of NISs that could provide invaluable guidelines for the location of specific systems. On the basis of such surveys, analysts could derive the ordering criteria of member countries' NISs within extended OECD surveys. The process of determining these criteria could significantly enrich debates in this field. Moreover, alternative taxonomic parameters that identify threshold levels could be identified in order to enable the drafting of those crucial policy imperatives that are required to shift countries into more feasible development paths.

Concluding remarks

The *Oslo Manual* provided a major breakthrough in the measurement and analysis of innovation activities. Surveys based on its guidelines can be profitably used for intra-system monitoring and evaluation purposes as long as the restricted space that they refer

to is recognised and acknowledged. In this sense, they would provide an understanding of the provenance, type and intra-industry characteristics of innovation activity undertaken by business enterprises. They would also provide a monitor of business perceptions of the environment in which they conduct such activities. Such surveys are not, however, suitable for inter-system analysis unless strong structural commonalities are assumed. Where this assumption does not hold, their use for this purpose can at best be a theoretically empty exercise, and at worst a dangerous guide to policy.

Notes

1. Marglin (1990) calls this type of knowledge 'technic' (derived from *techne*). He contrasts this with his definition of 'epistemic' knowledge (that is, theoretical, fully codified knowledge). Freeman (1991:502–503) stresses the importance of tacit knowledge in the process of technological acquisition: 'It is now very generally recognised that in the technology accumulation process within firms and other organisations, tacit knowledge is often more important than codified formal specifications, blue-prints, etc.'
2. See Nelson's (1991) discussion of tacit knowledge as the explanation for variability among firms within the same market.
3. The fundamental impulse that sets and keeps the capitalist engine in motion comes from the new consumer goods, the new methods of production or transportation, the new markets, the new forms of industrial organisation that capitalist enterprise creates (Schumpeter 1954:83).
4. Freeman & Perez (1988) substitute the term 'techno-economic paradigm' for Dosi's 'technological paradigm', which owes its origin to Kuhn's (1970) formulation, to shift the emphasis away from the purely scientific realm to a consideration of those technological paradigms whose effects extend throughout the economy. Perez (1988:86) defines a techno-economic paradigm as 'an interrelated system based on a set of shared principles' which forms the 'common sense' of engineers, managers and investors... a[n] ideal model for best productive and most profitable practice.'
5. CIS-3 covers the following broad areas: basic information on the firm, labour skills, information on type, sources and effects of innovations, the funding of innovation, the strategic objectives of innovation, cooperation in innovation, sources of information, perceived bottlenecks to innovation, information on innovations that have been generated, patenting activity, expenditure on innovations, organisational changes related to innovation programmes, and state support.
6. A report (Ogbu, Oyeyinka & Mlawa 1995) quoted in by the International Development Research Centre (IDRC 1999:16) study identifies a 'need for the state to display a more interventionist role in the underdeveloped countries than in the industrialised ones. Implicitly what is being argued for is a set of national systems of innovation with the state actively laying down the regulatory, physical, human and social infrastructure.'

References

Coase, R.H. 1937. The nature of the firm, *Economica*, 4:386–405.

Dosi, G. 1991. Perspectives on evolutionary theory, *Science and Public Policy*, 18:353–361.

Freeman, C. 1991. Networks of innovators: synthesis of research issues, *Research Policy*, 20:499–514.

Freeman, C. & Perez, C. 1988. Structural crises of adjustment, business cycles and investment behaviour, In Dosi, G., Freeman, C., Nelson, R., Silverberg, G. & Soete, L. (eds), *Technological Change and Economic Theory*. London: Pinter.

Gellner, E. 1983. *Nations and Nationalism*. UK: Basil Blackwell.

Gellner, E. 1996. *Conditions of Liberty: Civil Society and its Rivals*. UK: Penguin Books.

IDRC. 1999. *Framework for Regional Cooperation in Science and Technology*. Cape Town: Edunet Consulting.

Johnson, B. 1988. An institutional approach to the small country problem, In Freeman, C. & Lundvall, B-Å. (eds), *Small Countries Facing the Technological Revolution*. London: Pinter.

Kuhn, T.S. 1970. *The Structure of Scientific Revolutions.* Chicago: University of Chicago Press.

Marglin, S.A. 1990. Losing touch: The cultural conditions of worker accommodation and resistance, In Marglin, F.A. & Marglin, S.A. (eds), *Dominating Knowledge: Development, Culture and Resistance*. Oxford: Clarendon Press.

Neale, W.C. 1987. Institutions, *Journal of Economic Issues*, 21:1177–1206.

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

North, D.C. 1981. *Structure and Change in Economic History*. New York: W.W. Norton.

North, D.C. & Wallis, J.J. 1994. Integrating institutional change and technical change in economic history: A transaction cost approach, *Journal of Institutional and Theoretical Economics*, 150/4:609–624.

OECD (Organisation for Economic Cooperation and Development). 1992. *Oslo Manual: OECD Proposed Guidelines for Collecting and Interpreting Technological Innovation Data*. Paris: OECD.

OECD. 1997. *National Innovation Systems*. Paris: OECD.

Ogbu, O.M., Oyeyinka, B.O. & Mlawa, H.M. 1995. *Technology Policy on Africa*. Ottawa: IDRC.

Perez, C. 1988. New technologies and development, In Freeman, C. & Lundvall, B-Å. (eds), *Small Countries Facing the Technological Revolution*. London: Pinter.

Schumpeter, J.A. 1954. *Capitalism, Socialism and Democracy*. London: George Allen & Unwin.

Simpson, L.C. 1995. *Technology, Time and the Conversations of Modernity*. USA: Routledge.