Centre on Regulation and Competition

WORKING PAPER SERIES

Paper No. 121

INNOVATION SYSTEMS AND THE COMPETITIVE PROCESS IN DEVELOPING ECONOMIES

Stan Metcalfe & Ronnie Ramlogan

ESRC Centre for Research on Innovation and Competition

ISBN: 978-1-905381-20-4

Further details: Centre Secretary
Published by: Centre on Regulation and Competition,
Institute for Development Policy and Management, University of Manchester,
Harold Hankins Building, Precinct Centre, Oxford Road, Manchester M13 9QH, UK
Tel: +44-161 275 2798 Fax: +44-161 275 0808
Email: crc@manchester.ac.uk Web: www.competition-regulation.org.uk

INNOVATION SYSTEMS AND THE COMPETITIVE PROCESS IN DEVELOPING ECONOMIES

Stan Metcalfe and Ronnie Ramlogan

INTRODUCTION

The problems of economic development and transformation, of closing the gaps between rich and poor countries appear, from the experience of the past half century, to be intractable. That is not to say the developing countries as a whole have not made some progress. Real per capita income growth in low and middle income countries averaged 2.3 percent annually between 1960 and 2000, a not inconsiderable achievement were it not for the fact that developed countries themselves averaged 2.7 per cent (Rodrik, 2004). True enough, developing countries are heterogeneous in nature and any aggregate picture hides the diversity of growth experiences both geographically and temporally. Some countries performed well, others poorly; some grew rapidly throughout (South East Asia), others experienced growth spurts for a decade or two (Latin America); some took off around 1980 (China, India) others (Latin America and Africa) went into reverse around 1980. It would be true to say, however, that the vast majority of developing countries were unable to sustain a rate of development sufficient enough to enable them to close the income gap with developed countries or to be able to overcome the ravages of poverty for substantial proportions of their populations. A considerable intellectual effort has been invested in trying to understand, from various perspectives, the lessons of these various experiences and to develop a broad understanding of the contours of successful strategies (Rodrik, 2004; Easterly, 2002; Fagerberg, 1994,). But as Rodrick articulates, igniting economic growth and sustaining it are two different enterprises. A narrow range of reforms not particularly taxing on the institutional capacity of the economy may be able to achieve the former. The latter however, is far more demanding as it requires a sound and evolving institutional foundation to create, to maintain and develop an adaptable economy resilient to shocks over the longer term. In this paper we argue that the instituted frames in relation to the growth and development of economic capability and its associated knowledge base are central to the development problem since the capture the fundamental point that economies only develop through their people becoming more knowledgeable. This frame allows us to develop a critical appraisal of the innovation systems literature in relation to the problem of development.

The experience of Latin America throws significant understanding on the knowledge development nexus and it is perhaps not an accident that Latin American scholars have made significant contributions to the innovations systems literature (Cimoli, 2000; Cassiolato and Lastres, 2003; Dutrenit and Dodgson, 2005). While there are great variations in the Latin American Experience, Dutrenit and Katz (2005) provide a valuable overview of recent developments. They point out that success at greater macro management in general and of inflation in particular has not necessarily lead to a transformation in productivity. With the liberalisation of trade, Latin American economies have been restructured to exploit resource based comparative advantages (pulp and paper, steel, soya), and or organised on a low skill, non engineering intensive *maquiladora* model controlled by foreign enterprises, often as elements in global supply chains with negligible local commitment to building innovation capacity[1]. This trade pattern works to reduce local innovation capacity and risks locking Latin America into increasingly unfavourable terms of trade and access to rapid growth markets based on the exploitation of different technological trajectories; a modern north/south echo of the Singer/Prebisch thesis. Wide recognition is also given in the literature to the need to manufacture new comparative advantages, no doubt taking the SE Asian experience to heart, and this will require an upgrading of technological capabilities and its translation into enhanced innovation. Arocena and Sutz (2003) express this point in terms of the need for approaching the question of innovation and development through a "southern framework of thought", that is to say one that emphasises core periphery relations with respect to the growth of knowledge and innovation. Among the characteristics of the Latin American situation they draw attention to low levels of enterprise R&D and negligible employment of QSEs in industry, and a University system that adopts the academic reward systems of the developed world with scant regard to local needs. The danger of a low (tech) road to development is manifest in this constellation of practices.

The key questions therefore are 'How can a transformation of innovation performance be achieved in a competitive international economy?', What are the appropriate policy instruments?, What role is there for universities?, and what stimuli can be given to entrepreneurial action? We explore these questions in terms of a critical evaluation of the idea of innovation systems and of the nature of innovation policy appropriate to innovation based development. To avoid misunderstanding we state at the outset our view that

[1] Lastres and Cassiolato, 2005 give the example of Fiat's operations in Brazil, where local engineering capabilities were run down by 75% after 2000, measured in terms of people employed in local R&D. See also Arocena and Sutz (2003) for a similar analysis.

innovation is a preeminent class of investment activity and that a macro policy that stabilises the general investment climate is a necessary condition for innovation led development. The problem is it is not sufficient.

We base our discussion on the claim that if development is a matter of self transformation arising from within an economy, then innovation must play a central role in the process and so to must the capacity for an economy to develop, integrate and adapt to novelty. This is at the core of the concept of self sustaining development and indeed why development is an emergent phenomenon. At root economic development is a process of a people becoming different in the sense of commanding greater knowledge of economic and business capability expressed in terms of marketing, of production engineering competence, of the organisation of supply chains, of production logistics etc. How the national capability fits into the global production and consumption context becomes crucial. It is not a matter of rewriting the principles of comparative advantage but of realizing that comparative advantages are constructed and reshaped by international innovative activities not naturally given or freely available. They must change as individuals, the activities they carry out must change and so too must the supporting institutional frameworks. It has long been a central theme in economic analysis to interpret market processes in terms of self organising metaphors but here we emphasise instead the self transforming character of knowledge based economies. The two ideas are closely related for the way the self organising process is instituted will shape what is possible and economically desirable in terms of self transformation. On this view, differential rates of development are a fundamental reflection of differential capacities at innovation.

This is a particularly appropriate moment to confront the connection between innovation and economic development. There is a very real sense that in the aftermath of the limited success of the development paradigm (recipe) of the Washington consensus based on the pillars of liberalization, privatization and deregulation, new and challenging thinking and analysis can be brought to bear on the problems faced by developing countries. Sound macro policies and low inflation are undoubtedly important precursors to self sustainable growth but they are not in themselves sufficient. One might well agree that market prices 'ought to be right' but then what? Markets alone are part of the necessary link between innovation and development but they are not sufficient; other instituted activities, (education, research, public purchasing of technology) matter as the development of the SE Asian Tiger economies demonstrates. Getting the prices right does not guarantee innovation or transformation. It is in this context perhaps that we can best view the national

innovations systems literature as it attempts to confront issues of development (Johnson and Lundvall, 2003). Given the growing consensus about the centrality of scientific and technological advances in driving economic growth and progress, and that increasing national investment in innovation is essential to ensure a country's economic growth, the promotion of innovation in particular technological innovation has now begun to appear on the policy agendas of developing countries (Cimoli, 2000; Cassiolato et al, 2003; Lall, 2000; UNCTAD, 2005)

We organise the rest of our discussion as follows. Beginning with a brief outline of the national innovation systems concept and its application to developing economies we turn to some of its more obvious deficiencies and then explore four particular areas of weakness in the innovation systems literature, namely, the ambiguities in the treatment of information and knowledge, the market enterprise dimension of the innovation process, the distinction between innovation ecologies and innovation systems and, finally, innovation systems policy as the alternative to market failure based innovation policy.

NATIONAL INNOVATION SYSTEMS: APPLICATIONS OF THE FRAMEWORK TO DEVELOPING COUNTRIES

The National Innovation System (NIS) concept has been used as framework for a growing body of literature that addresses the process on innovation both at the national, regional and even sectoral level. Although there are often subtle differences in definition a good synthetic summary of the prevailing definitions is given by Niosi et al (1993):

> the system of interacting private and public firms (either large or small), universities and government agencies, aiming at the production of science and technology within national borders. Interaction among those units may be technical, commercial, legal, social and financial, in as much as the goal of the interaction is the development, protection, financing or regulation of new science and technology. (Niosi et al, 1993, pp. 212)

The concept emerged in the 1980s to explain the differences in innovative performances of industrialized countries (Nelson, 1993; Lundvall, 1992; Freeman, 1995). Proponents argued that differences in economic and technological performance across national states were due to the combinations of institutions involved – and their interactions – which determined the processes of accumulation of capital and technology. In other words, variation in national innovative performance depended on "institutional differences in the mode of importing,

improving, developing and diffusing new technologies, products and processes" (Freeman, 1995, pp.20). We shall see below that Niosi's definition equates too easily the idea of innovation systems with the production science and technological knowledge. The danger here lies in confusing invention systems with innovation systems and missing out the complementary economic processes required to turn invention into innovation. For the moment let this pass.

NIS has proven to be of considerable importance in terms of the extensive academic literatures that it has spawned and the fact that it has been discussed in policy frameworks supported by international institutions[2]. Successful economies it has been argued (CSPO, 2003) are characterized by a complex, integrated system for translating new knowledge and innovation into productive economic capacity. Successful economic development therefore is intimately linked to a country's capacity to acquire, absorb, disseminate, and apply modern technologies, a capacity embodied in its NIS. While the earlier literature focused mostly on the developed countries, recently there has been much interest in applying the NIS framework to developing countries. This growing body of the empirical literature has analysed the innovation experiences of those newly industrialising economies such as Korea, Taiwan and Singapore which have experienced more intensive technological learning and made some progress in closing the gap with developed countries (Kim and Nelson, 2000; Lee and von Tunzelmann, 2004); or contrasted the Asian and Latin American experiences, explicitly or implicitly (Viotte, 2001; Alcorta and Peres, 1998). Cimoli (2000), for example, has drawn together several empirical studies of the Mexican innovation system emphasizing the close connection they have with production systems and the interaction these have with separately organised separate science and technology systems whose (university) organisation is predominantly non commercial. The production and S&T systems overlap to a degree through industrial R&D and in exchanges of personnel. In Mexico, universities provide the principal concentration of scientific and technological talent but this very concentration it is suggested weakens the ability of industry to interact with the science and technology system by limiting its absorptive capacity (Casas, 2005; Casas et al, 2003).

An interesting case study of Embraer, the Brazilian aerospace company illustrates the many subtleties involved in applying innovation systems thinking to developing economies (Bernardes and de Oliveira, 2003). They paint a complicated picture of a company established for military purposes and developing a capability in the high engineering skills

[2] See for example 'OECD, 2002, 'Dynamising National Innovation System' OECD Publishing.

required for the design and production of regional passenger jets that made it a world leader. The story involves the growth of a regional cluster of supplying firms and technical institutes but with Embraer orchestrating the supply systems for components. It looks on the surface like a classic innovation system story. Yet it is not, for Embraer out-sources over 95% of the components from the international aerospace market and only relies on the local supply chain for essentially low tech components. Only 38% of turnover translates into local value added. Failures in the capabilities of the local aerospace research institute led in the late 1990s to the establishment of an engineering office in the USA to overcome skill shortages. The company was privatized in 1994 and subsequently major French aerospace companies took a 20% equity stake in Embraer in exchange for access to advanced technologies. It is a national company innovating in its own right but drawing extensively on an international production system and the *multiple* innovation systems that are embedded in it.

With increasing evidence in the literature that innovation processes are distributed across national boundaries an analytical focus on a national system seems something of a conundrum. The national perspective underlying NIS has been predominantly adopted on the basis that many institutions, culture, language, common norms, technology policy, and education influencing innovation have a national character (Lundvall, 1992). But, proponents of the approach admit that these systems are open and heterogeneous and that there can be other levels (local, sectoral) at which they can be analysed (Lundvall, 1992; Malerba, 2002). Freeman (1995) for example points to 'nether regions', or 'smaller sub-national regions' as opposed to upper regions – very large 'regional' trading blocs such as NAFTA, or the emerging East Asian 'region'. Nelson and Rosenberg (1993) further argue that the concept of 'national systems' may be too broad as the system of institutions supporting technical innovation in any particular field may have very little overlap with those institutions supporting innovations in another. These qualifications are matters of substance. The pursuit of fundamental knowledge has been an international activity from the very earliest days of science, the development of which seems least consonant with a national perspective. Science is a process of collaboration irrespective of political boundaries, moulded by its internationally instituted rules of conduct, particularly those in relation to priority, reproducibility and publication. The production of basic technological knowledge is very similar to pure science but with specific technology the focus is far more restricted, proprietary and national in its domain. Even so in some major technological

areas, for example, aerospace, medicine and electronics, the institutions may be transnational in character (Nelson and Rosenberg, 1993).

However, science and technology systems are only part of the innovation system nexus and here Ernst (2000) argues that a focus on the national is particularly relevant for developing strong innovation systems that provide a foundation for sustained economic growth particularly in an era of intense global competitive pressures. Moreover, given that interactive learning may be best facilitated by co-location, the argument within NIS is that national linkages are more likely to be effective that international ones is persuasive, particularly for developing economies. However, this begs the question as developing countries are in general characterised by narrow and incomplete domestic linkages, a dualistic industry structure and underdeveloped knowledge bases. Developing countries simply may not have a broad base of local knowledge on which local firms can draw. With limited opportunities to develop indigenous innovation systems, there is little recourse in the short term to relying on foreign technology and knowledge. The question is whether this engagement with foreign sources of innovation can spark indigenous learning and capability formation[3].

Continuing this theme, Mytelka and Oyeyinka (2003) point to a number of systemic barriers to innovation systems development in developing countries that provide a rationale for interventions to build competences and promote greater systemic cohesion. Firstly there may be r*igidities at the institutional or organisational level* that resist change in the face of new conditions and challenges. The pure scientific model of Africa's higher education system for instance, a legacy of nineteenth century colonialism, is seemingly unable to adapt or be adapted to serve the region's present development objectives (see also Oyelaran-Oyeyinka and Barclay, 2004). Secondly, existing knowledge networks may be underutilised with links between critical actors sparse or inappropriate for various reasons. In some cases knowledge "producing" institutions including universities and R&D laboratories are centralised and remain unknown to producers who are not co-located. Thirdly, organisational performance may be path dependent, with the accumulation of inefficiencies arising from membership of an obsolete self-reinforcing network. Inertia and resistance to change result from poor judgement, the excessive hold of tradition, lack of vision and fear of the unknown. Fourthly, the organisational ineffectiveness referred to

[3] The recent Chinese experience is significant here with over 57% of its exports coming from foreign enterprises and 37% of these exports classed as high tech. Yet the impact in transforming indigenous technical capabilities appears minimal. See also Lall and Weiss (2005) on the China Latin America trade relations and the implication for Latin America.

above manifests itself as system inefficiency. The outcome of poor linkages between research and training institutes and the productive sector is poor co-ordination between knowledge and economic production. This is reflected in imbalances in the demand and supply for skills both in terms of quantity and quality throughout the economy. Even when there is a consensus that new organisations and institutional structures are required, or that poorly performing structures should be reformed, the institutions for policy-making lack competencies to exercise the necessary coordination functions. In the absence of strong market coordination this leads to a situation in developing countries in which policy coordination is largely politically driven. Finally, systemic weaknesses that characterise innovation systems in developing countries are partly related to fundamental weaknesses of political-policy institutions and processes. Such inadequacies manifest themselves as lack of knowledge about how the system functions; poor enforcement of contractual laws and inadequate intellectual property laws may stifle innovation and technological learning.

Especially pertinent to the discussion of developing countries is the definition given to innovation. Much of this literature argues Mytelka (2000) continues to associate innovation with activity taking place at technological frontiers (invention) hence the importance attached to the science and technology and to research and development at the national and international levels. Some national policies pay little, if any, attention to the importance of imitative innovation or those based on the transfer and mastery of product, process or organisational technologies developed elsewhere. Equating innovation narrowly with invention is less useful, possibly damaging, for policy in developing countries than a broader concept that perceives innovation, as a learning process in which firms master and implement the design, production and marketing of good and services that are new to them, although not necessarily so for their competitors – domestic or foreign. This latter concept of the innovation process, embracing continuous improvement in product design and quality, changes in organisation and management routines, creativity in marketing and modifications to production process is of the first importance to firms in the developing world (Mytelka, 2000).

A further feature of developing countries is the mode and degree to which they are integrated in a world innovation system. Under the NIS approach the firm is perceived as the learning organisation embedded within a broader institutional framework that is national in scope and could therefore be leveraged towards innovation by policy interventions. The phenomenon of globalisation however leaves national governments with fewer degrees of freedom. The production systems of many developing countries have been becoming part

of an internationalised production system managed and coordinated at the global level by transnational corporations. This is complemented at the international level by growing pressures being exerted on them to be incorporated into a 'level playing field' (WTO, TRIPS, TRIM's) of the factors shaping innovation. These are geared to eliminating national idiosyncrasies and in the process create a more uniform, trans-nationalised innovation environment. Clearly globalisation is a powerful force that inevitably shapes and constrains the parameters within which national actors make innovation decisions, this does not mean, however, that degrees of freedom have disappeared altogether; indeed, the new rules of the game appear to consist in knowing how to identify and take advantage of them.

KNOWLEDGE, INFORMATION AND INNOVATION SYSTEMS

We begin our appraisal of innovation systems with a paradox. If scientific and technological information is ever readily available, as talk of knowledge based societies increasingly claims, why does any country experience a difficulty at innovating? Why are not all countries and the firms within them nestling together on the global best practice knowledge frontier?

To begin with, all societies are knowledge based, indeed the very notion of society means they could not be otherwise, so the more careful way of addressing the paradox is to enquire into the kinds of knowledge based society that we observe and here there is great variation. The distinction between information and knowledge is crucial at this point. Our position on this is foundationalist: only people can know and only activity in individual brains can lead to a change in knowledge. In this sense knowledge is always hidden it is always private and discussion of its tacit or codified nature is simply misplaced. However for knowledge to lead to social and economic action it must to a considerable degree be shared across individuals; there must be understanding in common so that the same questions or instructions elicit sufficiently similar responses for co operation to take place whether in the production system or more generally. The correlation of what is known across different minds is thus the key problem in addressing the nature of knowledge based society. If knowledge is always private, 'How is this problem of correlation to be addressed?' We do so by distinguishing private knowledge from its public representation, through the category of knowledge representations, principally verbal, or visual. Information on this view is the codified representation of knowledge that is accessible through the senses. In many case the knowledge and its representation are synonymous so that to talk of knowledge

simpliciter is not unwise but in many other cases they are not and these are the cases that matter for the progress of knowledge and more radical types of innovation.

Communication in all its forms is the means to correlating knowledge and the major step made in these terms is not the emergence of language but the development of technologies for storing and transmitting information so making it possible to communicate in anonymous fashion either with the present or the future. Beginning with the printed book in 1453 and culminating for the present in the internet an entire trajectory of technical advance has separated communication processes from face to face contact and set the frame for a vastly greater combinatorial growth of impersonal knowledge. This trajectory is one in which the application of non human energy to the activity is the dominant factor, mirroring the same trends in the processes of physical production and transport. Processes of correlation depend on more than language and communication technology they also require a substrate of connecting principles in individual minds and this is where notions of education and culture become important as devices to correlate private knowing into common understanding.

It follows immediately that knowledge is not automatically 'in the ether' that its public nature is disputed, and that only the information content of the knowledge representations is potentially public. These distinctions are important in the following terms. First they indicate that states of knowledge are states distributed across individual minds. When we speak of the state of knowledge its distributed nature becomes and its degree of correlation varies widely: some knowledge must be known in common by all members of the society, other knowledge is known only to much smaller groups according to the dictates of the division of labour. To speak of a stock of knowledge, a single number, in this context is clearly misconceived there is no obvious unit by which such an aggregate could be constructed (Metcalfe 2001; Steedman 2003).

Secondly, even though only individuals can know the manner in which knowledge is acquired depends greatly on social processes of interaction and communication and thus on organisation. The consequence is that the development of knowledge, and thereby innovation, depends on these same social processes. What any individual comes to know depends crucially on experience and thus on the activities that are engaged in and on who else participates in these activities. What individuals choose or are directed to think about, who they interact with and to what purpose is essential to the growth of knowledge, so that the development of individual knowledge is not only cumulative it is history dependent.

Thus the peculiar characteristics of knowledge, that its state is distributed across individual minds but its changes are determined by social processes. "Know who" has always been important but modern information technology has opened up many new opportunities to connect and interact impersonally and personally. However, the implication that it is the convergence of understanding and the corresponding correlation processes alone that matter should be resisted. Order is essential for economic activity and this depends on understanding in common but of itself order does not generate development. The growth of knowledge is intensive as well as extensive and individual disagreement matters very greatly in this regard. Individuals may receive the same stream of information but they do not necessarily translate this into equivalent knowing, and indeed if they did the further growth of knowledge would cease. The progress of science makes this abundantly clear: scientists in a field agree about many thing but the significant breakthroughs reflect disagreement, often profound disagreement on the status of what can be reliably known. As we shall see below enterprise has many of the same characteristics. This discussion points to three layers of problem, the coding of knowledge into information for transmission, the mode of transmission, and the subsequent decoding of information to add to knowledge. What matters for the growth of knowledge is the possibility of copying error and interpretive error, on personal differences in view despite sharing the same information flux, and ultimately on the notion of individuality.

In modern society these problems are made more complex by the reliance on an extended division of knowledge labour. Some things have to be understood in common but for many other activities the knowing is limited to a small domain of individuals, and as Adam Smith pointed out this intellectual division of labour contributes greatly to the growth of knowledge: for to conceive of the division of labour is also to conceive of the notion of increasing returns in the production of new knowledge. The same ideas can be used indefinitely in the production of further knowledge limited only by their potential obsolescence. This is the most powerful of all the potential kinds of increasing return, because it is based on combinatorial possibilities of combination, vastly more significant than the corresponding idea of economic increasing returns in the application of knowledge in production that Arrow and others rightly drew attention to.

That knowledge is a distributed concept in relation to its state and its development, and that it is premised on a division of labour maps directly onto the idea of innovation systems. Innovation systems are reflections of the limits on individual knowing that require firms, for example, to look beyond their boundaries for the necessary understanding. They are

reflections of the need to communicate, that communication cannot always be impersonal, and that it requires commitments to collaborate in the trade of understanding. Innovation systems reflect more fundamentally the limitations of the idea that knowledge is a public good in the economist's sense. Non rivalry of use is not in question but non excludability is. Knowledge can be kept private and that which is placed in the public domain is not automatically accessible. Whether we claim that individuals need the prior capacity to absorb information before it can add to their knowledge, or claim that there are real costs of receiving and interpreting information (Cohen and Levinthal 1984; Rosenberg, 1990) does not matter. The point is clear. Information does not necessarily equate with knowledge and the activities that define innovation systems are a reflection of this fundamental point: knowledge is definitely not 'in the ether' to be breathed in at will. Expressed in these terms the paradox with which we began is not a paradox at all. Uneven development is a natural consequence of differential knowledge and of very different instituted ways that societies correlate existing knowledge and promote the growth of knowledge.

MARKETS, ENTERPRISE AND INNOVATION

The great strength of the innovation systems approach is to highlight the role of non market institutions and processes in fostering innovation but this strength risks turning to weakness when it is forgotten that market processes and innovation systems are mutually embedded. We cannot have the one without the other and this warns us that innovation systems are not to be equated with invention systems and that enterprise has become the forgotten element in the innovation systems story – a most non Schumpeterian stance. Innovation systems like markets are instituted arrangements to govern different kinds of human exchange and neither can be assumed to exist naturally or without the expenditure of effort. This is particularly so for the problems of developing economies where the question might be posed in terms of 'Where do innovation systems come from?' and 'What might policy do to promote their formation?' We will later establish a central principle that we suggest guides innovation system formation but first we must say more on the complementary roles of markets and enterprise in the innovation process.

One of the central claims in Schumpeter's *Theory of Economic Development* is that invention is not to be confused with innovation, that the later is an economic act and indeed that innovation may depend not on new technology but on new perceptions of market opportunity. There is a danger that this insight is lost if we slip into equating innovation systems with science and technology systems or with activities carrying out R&D. They are

part of the picture but not the active part. Every innovation depends on an act of enterprise, on an entrepreneurial judgement that the economic world can be organised differently, on a reading of the market data which suggests to the alert mind that through using invention, whether technical or organisational, a new activity can displace an existing constellation of activities. Just as with the successful scientist the successful entrepreneur has formed a different view of the world and possesses the leadership and strength of opinion to carry the vision to fruition. As Schumpeter pointed out the consequence is that the innovation process is highly uncertain and it threatens established positions and encourages those positions to resist the innovation process. Johnson and Lundvall (2003) have rightly drawn attention to this power aspect of innovation but the consequence is that innovation generates political as well as economic responses. Those who lose by innovation are not typically compensated by those who displace them and their only resort is to use politics or other means to protect their position. Thus a fundamental innovation systems question is the degree of openness of the current economic structure to innovative challenges. If politics and economic power combine to suppress enterprise then little can be expected of innovative experimentation.

The strong claim that is made for the market economy is that, properly instituted, it is open to and creates incentives for innovative challenges to established positions. It is the openness to resource reallocation that is the key to the success of market economies not their efficiency in allocating given resources to given ends. Thus the system is competitive not to the degree that it meets the canons of Pareto optimality but to the degree that it generates innovation and the reallocations of resources that follow. This is the key held by enterprise and the entrepreneur and we may note that neither can exist in equilibrium[4]. If the innovation development link has any force at all it is to be found in non equilibrium terms and the idea that markets are devices to facilitate economic order they are not devices to establish economic equilibrium for systems in equilibrium do not develop.

The role of markets as innovation system components brings to the fore the idea that knowledge of market opportunity is crucial to innovation, that much innovation relevant knowledge is generated by experience and awareness of the market process and that innovation depends just as much on the willingness of consumers to change their behaviour as it does on producers. This is obvious in the case of product innovation but it applies just as much to process innovation and consumer response to the lower prices that the

[4] See Metcalfe and Ramlogan (2005) on the competition-development link and Metcalfe (2004) on the relation between enterprise and economic theory.

innovating firm can offer consumers. Consequently a supply oriented theory of innovation systems misses half the story. Openness to new ideas matters on both sides of the market process. In relation to innovation markets play several roles. First they generate the price and quantity information without which effective innovative conjectures cannot be formed. This is why the 'right prices' matter as guides to enterprise to change the allocation of resources in productivity enhancing ways. If the prices are wrong the potential entrepreneur is doubly blind, neither price conjectures nor quantity conjectures are a true reflection of innovative potential and enterprise is correspondingly distorted. Markets also provide low cost access to customers and inputs and the ability to use economic incentives to compete for resources. This matters for markets in skills and it matters especially in relation to capital markets and the way they are instituted. Reflect on the role of venture capital for start up companies on the role of equity markets and the initial public offerings of shares in a recently founded company, and on the role of the market for corporate control on the ability to trade bundles of capabilities embodied in particular business units. All are crucial to innovation and match Schumpeter's insistence on the role of the banking mechanism in the innovation process. Innovation scholars have perhaps forgotten this point of late and it indicates that financial markets are integral elements in effective innovation systems. If the financial sector is poorly developed and instituted then entrepreneurs are forced to seek funding from social networks or rely on retained profits to fund investments in innovation, or rely on the state to take on the role of innovation development bank. From whatever angle one approaches the problem innovation systems and financial systems are inevitably interwoven (Cassiolato et al, 2003). On this point we should also remember the scope for the state as purchaser of innovative goods and the considerable purchasing power it could command for this purpose.

It follows that the general rules of the market process in a society will greatly influence the likelihood of innovation based business experimentation. The rules in relation to the formation of new businesses and the rules which determine the conditions under which a business fails and the sequelia of failure are central to innovation systems since they shape business entry and exit in its most fundamental forms. Similarly the rules that constrain investment in plant and equipment in its specific locations will influence deeply the ability of a firm to capitalize on its innovative advantages. Similarly rules and regulations in relation to product quality as in the pharmaceutical and medical devices case shape the profitability of innovation. Markets have always been instituted processes and it is this which makes it so amenable to seeing them as components of innovation systems that are also necessarily

instituted. Innovation systems are distinctly not alternatives to the market process for innovation is a market process.

These issues come to a head in relation to markets for information and their relation to the innovation systems approach. There is a well established tradition in economic theory that markets for information will fail but this is not at all transparent. Markets in skilled labour are clearly ways through which firms gain access to the particular knowledge embodied in an individual just as markets in books and publications of a specialist nature are ways of accessing the information they contain. It is not at all obvious why or how these markets fail and if they do why a change in the rules of the game cannot remedy the matter. Similarly trade in business units serves the same purpose of providing access to knowledge in organised teams as noted above and plays an important role in innovation.

However, not all information is codified and made available as a representation of someone's knowledge. Secrecy is always a strategic choice and so the deeper market question is that of the conditions when it is economic to reveal knowledge bilaterally and even more to turn it into codified information for multilateral distribution. Since there are increasing returns to codification it follows that the extent of the market for the particular information is the determining factor[5]. Codification of information is in this respect an economic decision which in the presence of limited market opportunities is likely to be inhibited.

Having emphasised the role of markets in innovation systems we should not forget the role of firms; firms do what markets cannot do, take decisions about what is produced and how, and they are naturally key elements in any innovation system. Much innovation arises within existing firms and enterprise and is not to be equated solely with the new technology start up company. Two dimensions of this are relevant to are discussion. Since only individuals know, the competence of a firm depends on how it organises the interaction between its individual members, organisation is an operator for turning sets of individual knowing into a collective competence. The same individuals placed in different organisational structures will constitute very different competences. Secondly, it is only the firm, of all the organisations within an innovation system, which has the unique responsibility to combine together the multiple kinds of knowledge required for innovation including knowledge of markets and organisation. Many organisations, universities, research

[5] Libraries can be interpreted as devices to capture increasing returns and reduce the costs of information search. The advent of the internet and the great decline in the costs of codification and transmission of coded information

consultancies, individual inventors, may contribute necessary information flows to a firm but only the firm can combine those different flows into effective innovation. This is perhaps why Alfred Marshall gave such prominence to the external organisation of the firm in relation to the competitive advantages it may enjoy

Yet the ability to draw on external information flows cannot be taken for granted. It requires a facility to seek out the information, a facility to combine it with internal knowledge (overcoming well documented NIH tendencies) and this requires it to have internally the necessary absorptive capacity as noted above. Rosenberg (1990), for one has pointed out that a significant proportion of R&D is motivated by the need to create a capacity within a firm to interact with academic science. If this capacity is low then the firm is unlikely to understand the significance of much of the scientific and technical information it may receive. It is clearly a problem for small firms to fund the accumulation of absorptive capacity and it cannot, in the nature of the problem, be offset by co-operative research arrangements.

To summarise, innovation systems are embedded in market processes, processes that determine the payoffs to innovation, that generate the resources for innovation (including customers willing to pay) and that determine how experimental, in a business conjecture sense a firm, an industry or economy is. Thus innovation systems are not to be equated solely with Science and Technology systems, essentially in Universities, but are to be found at the intersection of these S&T systems with market processes. This market emphasis in no sense denies a role for the state in innovation processes or the idea of an innovation tariff behind which competencies are built but it does suggest that the state works with the instituted grain of the market process as appears to have been the case in South Korea (Amsden, 1989; Chang, 2002). We return to the question of trade and industrial policy below but for the moment this insight takes us to a new set of problems in relation to the formation of innovation systems.

INNOVATION ECOLOGIES AND INNOVATION SYSTEMS

The thread of the argument so far is that states of knowledge have the properties of distributed systems based on an extended division of knowing. Relatively little of our knowledge is correlated in a widespread fashion with other individuals, most is specific to a very narrow range of activities. These aspects also shape the growth of knowledge which necessarily reflects the division of labour and specialisation and the evolution of knowledge.

The way this division of labour is organised is central to the innovation systems perspective. Innovation systems organisation is not a natural given but is to be constructed and deconstructed as circumstances dictate and this leads us to the two remaining themes of the paper. First we distinguish the ecology of individuals and organisations from the innovation systems into which they can be assembled and, secondly, we explore the dynamics of innovation system formation in terms of the dynamics of problem sequences.

Our systems perspective allows a distinction to be made between 'innovation ecologies', the sets of individuals, usually working within organisations, who are the repositories and generators of existing and new knowledge, and the 'system making' connections between the components that ensure the flow of information whether in general or directed at a specific purpose. Included in this ecology are those organisations that store and retrieve information as well as those that manage the general flow of information in multiple formats but the principal actors are usually for-profit firms, universities and other public and private specialist research organisations. They exhibit collectively a division of labour that is characteristic of the production of knowledge and this is reflected, for example, within and between the academic specialisms in universities and public and private research activities that are major components in any modern knowledge ecology. Ecologies are typically national in scope, with sub national degrees of variation, which reflect rules of law and language, business practice and the social and political regulation of business (Carlsson, 1997; Carlsson et al, 2002; Cooke et al, 2002).

However, and quite crucially, any innovation ecology is the basis for a system but it is not a system of itself until subsets of the actors are connected with the intention of promoting innovation. Furthermore, the purpose of the connections is to combine multiple sources of knowledge and innovative capability through the flow of information. Thus barriers to information flow, barriers to converting information flow into knowledge, lack of appropriate sources of the requisite information all fit under the umbrella of connecting ecologies into systems (Casas, 2005).

While the presence of national innovation ecologies is not in doubt, it is not at all obvious that there are unified national innovation systems in the sense usually meant and explored above. Depending upon the problems in hand there will be multiple innovation systems supported by the relevant ecology, reflecting the problem sequences in hand, the location of the actors at the leading edges of technological advance, particular links with the science base, and the specific uses towards which the intended innovations are directed. Moreover,

it follows naturally that the connections and actors can, and increasingly do, spread across national boundaries. It is common place to find firms collaborating with overseas suppliers or customers, to find them drawing on the skills of foreign universities or even setting up R&D facilities in overseas markets to promote innovation. Gibbons and colleagues (1994) have drawn attention to the emerging characteristics of knowledge production, a view, which, fits exactly with the view that innovation requires many kinds of knowledge for its successful prosecution. What they term "mode-2" knowledge is produced in the context of application, seeks solutions to problems on a transdisciplinary basis, is tested by its workability not its truthfulness and involves a multiplicity of organizational actors, locations and skills. Together this entails a distributed system for innovation with no one to one correspondence with traditional national or sector boundaries.

This leads to our second theme the principles on which innovation systems are constructed. Since systems require connections as well as components, it is the formation of the connections, which is the necessary step in the creation of any innovation system. Innovation systems do not occur naturally, they self organize to bring together new knowledge and the resources to exploit that knowledge, and the template they self-organize around is, we suggest, the problem sequence that defines the innovation opportunity. Hence, innovation systems are emergent phenomena, created for a purpose, they will change in content and pattern of connection as the problem sequence evolves, and they are constructed at a micro scale. Within these networks, firms, the unique organizations that combine the multiple kinds of knowledge to innovative effect, play the key role in the self-organization process. Science and technology systems, networks and communities of practice, are necessary parts of the innovation networks but they are not sufficient.

The logic of this view is that innovation systems are constructed to solve 'local' innovation problems (Antonelli, 2001, 2005) and that they are constructed around the market problems that shape innovation not only the problems that shape the growth of science and technology. Moreover, since the solution of one problem typically leads to different and new problems we would expect that as the problems evolve so the actors in the system and their pattern of interconnection must also evolve and that while ecologies are more permanent the systems are transient. Once a particular problem sequence is solved the associated system can be dissolved. Thus there is a close connection between the notion of trajectories of technological solutions within a particular technological paradigm, the evolving problem sequence, and this dynamic notion of an innovation system (Dosi, 1982). Innovation systems will be a normal part of restless capitalism; they are a reflection of the

multiple ways in which innovation processes can be instituted and organized and these processes are simultaneously embedded in a matrix of market and non market relationships. The dynamism of an economy thus depends on the adaptability with which innovation systems are created, grow stabilise and change as problem sequences evolve.

INNOVATION POLICY AND THE ROLE OF THE STATE

Finally, some brief remarks on the related policy issues. The list is alarmingly long but discussion of innovation policy is facilitated by our distinction between ecologies and systems. Consider the ecologies side of the problem for here the central policy problem may be expressed as follows: it is to ensure that there is a rich, national knowledge ecology on which innovation processes can draw and that means the presence of knowledgeable minds and appropriate organisational and institutional structures in which they can pursue the growth of knowledge and contribute to innovation. In practical terms this suggests a layer of policy themes that we may list as follows. First, general policies in relation to the education system and public research and development, primarily to provide the supply of trained minds whose imagination will be crucial to the experimental process and the growth of knowledge. These individuals are the basic building blocs of the innovation ecology and they require an appropriate supply of appropriately resourced research organisations in which to work. The range of disciplinary skills available and their closeness to the world best practice frontier will also determine the absorptive capacity to adapt to knowledge generated within foreign ecologies; for science and technology are global systems and the formation of innovation systems will increasingly reflect a search for the best partners wherever they are located (Harvey and McMeekin, 2004). More specifically, government can take the lead in supporting particular areas of new generic research, to give firms and other actors the confidence that local capabilities will be available to contribute to innovation problem solving (Antonelli, 2005). Thus governments frequently create new elements of the innovation ecology, for example, establishing capabilities in new areas of science and technology or new research organisations focused on a particular broad area of exploitation where it is necessary to combine together multiple disciplines to facilitate problem solving (Kaiser and Prange, 2004).

The second dimension of innovation policy concerns the creation and oversight of a set of rules of the game that openly facilitate the formation and co-ordination of innovation systems to solve particular innovation problems, in respect of which the State has no particular detailed knowledge. Here we have policies not aimed at the ecology *per se* but at

making and destroying the patterns of connection between different components of that ecology. These are bridging policies that do not take for granted a free flow of information but rather recognise the costs of forming network relationships. Of course innovation related connections come in many forms including markets for technology licenses or for routine testing, informal exchanges of information in professional networks, collaborative partnerships to develop particular projects, and deeper alliances for collaborative programmes to develop platform technologies. Each mode of connecting facilitates information flow but with different costs and benefits distributed across the system members. The process of connecting the relevant ecology raises new dimensions of innovation policy. For example, the mobility of knowledgeable minds, nationally and internationally, is surely one of the most effective contributors to the making of connections in innovation systems. Indeed, historically, if not presently, the mobility of skilled individuals has been a principal form of international technology transfer and innovation diffusion. In distributed innovation processes network formation is crucial and, as Nelson (2004) reminds us, it is vitally important to keep the ecology open to the possibility of connection. It is not possible to predict which exact combinations of knowledge and individuals will solve a particular innovation problem, no one can know this in advance, the solution is emergent and emergence is a problem in unfathomable complexity. We need only remind ourselves at this point of Schumpeter's insistence that innovation is a break with tradition. Universities as well as firms have to be receptive to collaboration in the innovation process and the barriers to collaboration need to be minimised.

However, because the component actors work in different organisations on different primary tasks, it is not difficult to see that their respective absorptive capacities will not be the same and that the costs of the effective correlation of knowledge may be considerable. There is a coordination problem and there has to be a set of incentives that leads the individuals and organisations concerned to reveal and trade information or to collaborate in knowledge production. The differences in communication cultures between firms and universities are well known and the incentives to further or restrict the correlation of knowledge differ greatly across public and private organisations. The distribution of absorptive capacity and the costs and benefits of different modes of collaboration also shape the formation of the relevant innovation systems. Here the State emerges as the keeper of the potential for the formation of innovation systems, its role should be to set in place the conditions for innovation systems to emerge and evolve.

What kind of general policy instruments facilitate innovation system building?' The policy instruments may be, for example, to facilitate collaborative research, to incubate University ideas, to use public procurement to build networks or to stimulate the formation of clusters but in each case the point is to create connections that will not otherwise arise spontaneously[6]. Their principal purpose is to create opportunities and enhance innovative capabilities by stimulating innovation system formation (Metcalfe 1995, 2004; Smits and Kuhlmann, 2004). However, there is no general basis for predicting which innovation systems will form or who the actors will be, and this implies an obvious corollary, that the connection between instruments and their effects will be 'loose' with many unanticipated outcomes. Innovation systems are complex systems in which the growth of knowledge changes the actors involved so that learning effects continually shift the relation between policy cause and innovative effect (Ockrutch, 2003). Thus the evolutionary policy maker is not an optimizing supplement to the market, correcting for imperfect price signals in such a way as to guide private agents to a better innovation mix. Rather the role is an adaptive one; the effective policy maker is as boundedly rational as the agents that are the policy target. This perspective may be contrasted with the traditional view of innovation subsidies or R&D incentives that took innovation possibilities and capabilities as given and thus encountered the constraint of diminishing returns to R&D effort. The system perspective seeks to overcome diminishing returns by enhancing the innovation possibilities and capabilities and take advantage of and coordinate better the division of labour in the innovation process.

The distinction we have made between national innovation ecologies and spatially unconstrained innovation systems carries an implication as yet unexplored. It is that when innovation systems transcend national boundaries they are naturally influenced by the policy jurisdictions of multiple states. The possibility arises at least in principle for policy conflict to arise and inhibit innovation system formation. Put more sharply it may result in competition between nation states to have key elements of innovation systems within their national ecologies. The problem of innovation policy coordination, as for example within a European innovation space, as well as more widely is worthy of much closer investigation.

[6] See the detailed discussion in EC (2003) of European approaches to innovation systems policy. DTI (2003) covers related ground for the UK. The recently announced Framework 7 proposals (April 2005) put considerable stress on the systemic dimensions of innovation policy through technology platforms, and joint technology initiatives.

It should now be clear that innovation policy directed in a narrow sense at innovation systems formation must be complemented by the wider range of policies that influence the innovation ecology and the propensity to make connections. Education policy and the supply of skills and the mobility of labour are important framing conditions and so is tax policy in relation to business experimentation, and so also is public procurement policy. Most important of all perhaps is a competition policy that fosters an enterprise driven competitive process, keeps the market order open to entrants and recognises that abnormal returns are more likely the result of transient innovative superiority rather than the exploitation of static market power. Indeed the relation is symmetric in that the best form of competition policy will be an effective innovation policy that maintains economic evolution.

However, the ability to develop local innovation competences presumes that sufficient firms already have the capabilities to compete in international markets or at least hold their own against domestic multinationals. At this point the Washington consensus is potentially in conflict with the innovation systems approach. For the implications of open markets is not limited to their static resource allocation effects but additionally lead to particular dynamic outcomes namely that firms and industries which get ahead in competitive terms are more likely to be able to innovate and stay ahead. The ability to manufacture a competitive advantage and to reflect this in a comparative trade advantage requires sustained investment and this is less likely to occur the further behind world practice a particular firm lies. The case for infant innovation protection is as valid as ever here, given the imperfections of capital markets and the real issues relate to the choice of tariffs or subsidies to promote domestic competence formation. Thus innovation policy does not stand alone but only as a integrated package of industrial and trade policies that not only result in new local capabilities but make it possible to exploit these capabilities in an internationally competitive fashion. In short policies for creative destruction must stray beyond a narrow concern with innovation systems.

BIBLIOGRAPHY

Alcorta, L. & Peres, W. (1998) Innovation Systems and Technological Specialisation in the Latin America and the Caribbean, *Research Policy,* Vol. 26, No. 7-8, pp. 857-881.

Amsden, A. (1989) *Asia's Next Giant: South Korea and Late Industrialisation*, Oxford University Press.

Antonelli, C. (2001) *The Microeconomics of Technological Systems*, Oxford University Press.

Antonelli, C. (2005) The Governance of Localized Knowledge, *mimeo*, Laboratorio di Economia dell'Innovazione, University of Turin.

Arocena, R. & Sutz, J. (2003) Knowledge, Learning and Innovation: Systems and Policies in the North and South, in Cassiolato, J.E., Lastres, H.M.M. & Maciel, M.L., *Systems of Innovation and Development*, Cheltenham, Edward Elgar.

Bernardes, R. & de Oliveira, L.G. (2003) Building up Complex Productive Systems in Developing Countries: the Embraer Experience, in Cassiolato, J.E., Lastres, H.M.M. & Maciel, M.L. (2002), *Systems of Innovation and Development*, Cheltenham, Edward Elgar.

Carlsson, B. (ed.) (1997) *Technological Systems and Industrial Dynamics*, Kluwer, Dordrecht.

Casas, R., de Gortari, R. & Luna, M. (2000) University, Knowledge Production and Collaborative Patterns with Industry, in Cimoli, M. (ed.), *Developing Innovation Systems: Mexico in a Global Context*, London, Continuum.

Casas, R. (2005) Exchange and Knowledge Flows between Large Firms and Research Institutions, *Innovation: Management, Policy, Practice*, Vol. 7, pp. 188-199.

Cassiolato, J.E., Lastres, H.M.M. & Maciel, M.L. (2003) *Systems of Innovation and Development*, Cheltenham, Edward Elgar.

Chang, H-J. (2002) *Kicking away the Ladder*, London, Anthem Press.

Cimoli, M., (ed) (2002) *Developing Innovation Systems: Mexico in a Global Context*, London, Continuum.

Cohen, W. & Levinthal. D. (1989) Innovation and Learning: The Two Faces of R&D, *Economic Journal*, Vol. 99, pp. 569-596.

Cooke, P., Boekholt, P. & Todtling, F. (2000) *The Governance of Innovation in Europe: Regional Perspectives on Global Competitiveness*, Cheltenham, Edward Elgar.

CSPO (Consortium for Science Policy and Outcomes), (2003) *Knowledge Flows and Knowledge Collectives: Understanding the Role of Science and technology Policies in Development*, Vol. 1, available at http://cspo.org/products/reports/index.html

Dosi, G. (1982) Technological Paradigms and Technological Trajectories - A Suggested Interpretation of the Determinants and Deviations of Technological Change, *Research Policy*, Vol. 11, pp 147-162.

Dutrenit, G. & Katz, J. (2005) Innovation, Growth and Development in Latin America: Stylised Facts and a Policy Agenda, *Innovation: Management, Policy, Practice*, Vol. 7, pp. 105-130.

Easterly, W. (2002) *The Elusive Quest for Growth*, MIT Press, Cambridge

Ernst, D. (2000) Global Production Networks and the Changing Geography of Innovation Systems: Implications for Developing Countries, *East-West Center Working Papers Economic Series*, No. 9.

Fagerberg, J. (1994) Technology and International Differences in Growth Rates, *Journal of Economic Literature*, Vol. 32, No. 3, pp. 1147-1175.

Freeman, C. (1995) The National System of Innovation in Historical Perspective, *Cambridge Journal of Economics*, Vol. 19, No. 1, pp. 5-24.

Gibbons, M., Limoges, C., Nowotny, H, Schwartzman, S., Scott, P. & Trow, M. (1994) *The New Production of Knowledge*, Sage, London.

Harvey, M. & McMeekin, A. (2004) Public-Private Collaborations and the Race to Sequence *Agrobacterium tumefaciens*, *Nature Biotechnology*, Vol. 22, No. 7, pp. 807-810.

Johnson, B. & Lundvall, B.A. (2003) Promoting Innovation Systems as a Response to the Globalised Learning Economy, in Cassiolato, J.E., Lastres, H.M.M. & Maciel, M.L. (2002) *Systems of Innovation and Development*, Cheltenham, Edward Elgar.

Kaiser, R. & Prange, H. (2004) The Reconfiguration of National Innovation Systems - The Example of German Biotechnology, *Research Policy*, Vol. 33, pp. 395-408.

Kim, L. & Nelson, R.R. (2000) *Technology, Learning and Innovation: Experiences of Newly Industrializing Economies*, Cambridge University Press, Cambridge Mass.

Lall, S. (2000) The Technological Structure and Performance of Developing Country Manufactured Exports, 1985-1998, *Queen Elizabeth House Working Paper Series*, No. 44, University of Oxford.

Lall, S. & Weiss, J (with assistance from Oikawa, H) (2005) China's Competitive Threat to Latin America: An Analysis for 1990-2002, *Queen Elizabeth House Working Paper Series*, No. 120, University of Oxford

Lastres, H.M.M. & Cassiolato, J.E. (2005) Innovation Systems and Local Production Arrangements: New Strategies to Promote the Generation, Acquisition and Diffusion of Knowledge, *Innovation: Management, Policy, Practice*, Vol. 7, pp. 172-187.

Lee, T. & Von Tunzelmann, N. (2004) A Dynamic Analytic Approach to National Innovation Systems: The IC Industry in Taiwan, *Research Policy*, Vol. 34, No. 4, pp. 425-440.

Lundvall, B. (1992) *National Systems of Innovation*, Pinter, London.

Malerba, F. (2002) Sectoral Systems of Innovation and Production, *Research Policy*, Vol. 31 No. 2, pp. 247-267.

Metcalfe, J.S (1995) The Economic Foundations of Technology Policy, in Stoneman, P. (ed.), *Handbook of the Economics of Innovation and Technological Change*, Oxford, Oxford University Press.

Metcalfe, J.S. (2004) The Entrepreneur and the Style of Modern Economics, *Journal of Evolutionary Economics*, Vol. 14, pp. 157-176.

Metcalfe, J.S. & Ramlogan, R. (2005) Competition and the Regulation of Economic Development, *Quarterly Review of Economics and Finance*, Vol. 45 (2/3), pp. 215-235.

Mytelka, L. (2000) Local Systems of Innovation in a Globalized World Economy, *Industry and Innovation*, Vol. 7, No. 1, pp. 15-32.

Mytelka, L. & Oyelaran-Oyeyinka, B. (2003) Competence Building and Policy Impact Through the Innovation Review Process: A Commentary, paper presented to the *IDRC-UNESCO Joint Workshop on Future Directions for National Review of Science, Technology and Innovation in Developing Countries*, UNESCO, Paris, 23-24, April.

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

Nelson, R.R. (2004) The Market Economy and the Scientific Commons, *Research Policy*, Vol. 33, pp. 455-471.

Nelson, R.R. & Rosenberg, N. (1993) Technical Innovation and National Systems, in R.R. Nelson (ed.), *National Innovation Systems: A Comparative Analysis*, Oxford University Press, New York/Oxford), pp. 1-21.

Niosi, J., Saviotti, P., Bellon, B. & M. Crow (1993) National Systems of Innovation: In Search of a Workable Concept, *Technology in Society,* Vol. 15, No. 2, pp. 207-227.

Ockruch, S. (2003) Knowledge and Economic Policy: A Plea for Political Experimentalism, in Pelikan, P. & Wegner, G., *The Evolutionary Analysis of Economic Policy*, Cheltenham, Edward Elgar.

Oyelaran-Oyeyinka, B & Barclay, L. (2004) Human Capital and Innovation Systems of Innovation in African Development, *African Development Review*, Vol. 16, No. 1, pp. 115-138.

Rodrik, D. (2004) Growth Strategies, sourced at http://ksghome.harvard.edu/~drodrik/papers.html.

Rosenberg, N. (1990) Why Firms Do Basic Research (With Their Own Money)?, *Research Policy*, Vol. 19, pp. 165-174.

Schumpeter, J. (1934) *The Theory of Economic Development*, Oxford University Press.

Smits, R. & Kuhlmann, K. (2004) The Rise of Systemic Instruments in Innovation Policy, *International Journal of Foresight and Innovation Policy*, Vol. 1 (1/2), pp. 4-32.

Steedman, I.,

Viotte, E. (2002) National Learning Systems: A New Approach on Technological Change in the Late Industrializing Economies and Evidence from the Cases of Brazil and South Korea, *Technological Forecasting and Social Change*, Vol. 69, No. 7, pp. 653-680.