



# Innovation Systems, Innovation Ecologies: Innovation Policy and The World of Restless Capitalism

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*Innovation Systems and Innovation Ecologies: Innovation  
Policy and Restless Capitalism*

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Innovation Systems and Innovation Ecologies: Innovation Policy and Restless Capitalism

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Innovation Systems, Innovation Ecologies: Innovation Policy and the World of Restless  
Capitalism

I Introduction

Our purpose in this paper is to provide a different perspective on the by now widely discussed idea of innovation systems, This perspective is designed to cohere with the problems faced by innovation policy makers as they seek to pursue the challenge of creating wealth from knowledge and to reflect the salient aspects of a modern capitalist economy. Virtually all economic commentators agree that the growth and application of human understanding to the solution of the problems associated with a scarcity of means relative to ends is the key to understanding the great increase in per capita income in the Western world since the 16<sup>th</sup> century. This incomparable growth of human understanding, in terms of the depth and breath of its application, is the clue to the importance of innovation in forcing the evolution of Western economic society. Schumpeter masterfully captured the crucial point about the growth of knowledge with his concept of creative destruction, the process of innovation driven competition that is the leitmotiv of capitalism. As a consequence, economic growth necessarily runs hand in hand with structural change and the progress and decay of birth and death of practices, of firms, industries and indeed ways of life. It is necessarily an uneven process, development in one sphere implies underdevelopment in another, it never can be a smooth process, the equiproportional steady state growth models so beloved by the macroeconomist simply miss the action, growth in one place requires decline in another at least relatively and often absolutely. Every economic historian knows this but sadly history rarely figures in the training of the modern economist (Mokyr 1989, Landes, 1998)

Yet we are faced immediately with a paradox. If innovation is, so to speak, built into the very core of the capitalist process, if it is the foundation of competition, why is there an innovation policy problem? Why is it considered necessary to enhance, or for that matter, retard the rate of innovation when the historical record is so compelling in relation to creative destruction? Why is any interference necessary at all? This is the question that has occupied governments at least since the early twentieth century, usually under the guise either of strategic fears about declining national competitiveness and overseas rivalry or a perceived need to develop certain sectors of the economy at a faster rate than would be naturally achieved by a free

enterprise system. To understand this paradox we need to explore two main themes, the nature of the connection between wealth and knowledge in capitalism and, secondly, the nature of innovation policy making. From this foundation we can then perceive more clearly the role of innovation systems in the policy process and the consequent foundations at national or regional level of the innovation ecologies from which innovation systems are emergent phenomena.

Such a discussion is certainly timely in the context of enduring European concerns about the links between public science and commercial innovation, the competitive threat from the USA and the emerging, large scale, low wage economies of India and China (Dosi et al, 2005). It has been rendered even more salient by the stagnation of European economies post 2008. It is also of vital importance in relation to the challenge of economic development more generally, and the related claim that innovation provides the only sustainable route to material prosperity for all economies and regions.

We shall set out our analysis in three main sections. We begin with a discussion of what might be meant by the idea of a knowledge economy, pointing to the fact that many of its properties arise because it is a distributed system of ignorance. Next we turn to the implications for innovation policy making by drawing a distinction between policies for market failure and policies for system development, a distinction which leads us to contrast the optimising policy maker from the evolutionary adaptive policy maker and leads to an important distinction between innovation ecologies and innovation systems. Finally, we turn to the policy problem of encouraging the formation of innovation systems

## II. Capitalism and the Ignorance Economy.

What is it that makes modern capitalism such an effective system for generating wealth from knowledge? Consider first some of its salient properties. First and foremost a modern capitalist economy is a highly ordered system of interconnected decision making processes based on an extended and continually changing division of labour within and between productive organisations. The division of labour is reflected in a great variety of specialised economic activities and forms of organisation which are rendered productive and viable by the largely self organising properties of the market process. Markets too are forms of organisation but, of course, they are quite different from the forms that we associate with firms or universities or legal systems. Any organisation operates by making linkages between its constituent parts so we

can state that the functioning of capitalism depends on its connectivity. Secondly, modern capitalist economy is an open system because the knowledge on which it is grounded constitutes an open system; both knowledge and the economy are self transforming as well as self organising and the principal means of self transformation are innovations and adaptation to the possibilities for change created by innovations. Capitalism is above all else a system for generating and adapting too emergent novelty. Thirdly, the system is a mixed system, neither a pure private market nor a pure public command structure but a combination of the two in ways that are important in relation to its long run dynamic behaviour. This is particularly so in relation to the modes of generating new knowledge through research and of disseminating knowledge through processes of education, which are primarily but not exclusively organised outside of the scope of the market system. The presentation of public and private action as antithetical is a sure way to misunderstand the capitalist dynamic.

Because of its open system properties, the system's dynamics cannot be understood solely in terms of average behaviours but rather in terms of the distributions of behaviour around those averages; economic history is written by the few though it is lived by the many. Such systems cannot be usefully described as existing in or tending towards a given equilibrium, they are restless systems always generating challenges to the *status quo*. Any novelty generating system is restless precisely because knowledge is restless, indeed we shall think of a modern capitalist economy as a system organised and instituted for the continuous creation of business experiments, very many of which come to nought but, in which, as in all evolutionary systems, a few outliers have quite disproportionate transformative effects. From this viewpoint innovations are the primary, variety generating events; they are instabilities from the point of the *status quo*, emergent novelties that invade the prevailing economic order. Emergent novelty is essential to development but it is also augmented by market processes through which these innovations displace already established activities. Consequently, a completely stable capitalism would be a stationary capitalism, a contradiction in terms as Marshall and Schumpeter knew very well. The corollary is that much that is tried fails, any experimental system proceeds by trial to discover error and so there is an inevitable waste of resources and evidence of inefficiency when we appraise with the benefit of hindsight<sup>1</sup>. It follows that innovation policy is ultimately concerned

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<sup>1</sup> Even Schumpeter expressed the view that "a majority of would be entrepreneurs never get their projects under sail and that, of those that do, nine out of ten fail to make a success of them" (1939, p.117)

with the generation of novelties, the “hopeful monsters” that may transform the world of production. These are the principal ideas that link the development of an economy as a whole to the development of its constituent components and they surely lead us directly to the idea of the knowledge economy.

At one level they do, modern capitalism is reflected in the use of many different kinds of knowledge, and the devotion of current resources to the generation of further knowledge. To think of capitalism in terms of the processes that generate new knowledge, of the multiple kinds of knowing, of the processes that produce and combine knowledge to ever expanding effects makes eminent good sense. But it also misses a crucial dimension of the problem, a dimension that leads us to suggest that capitalism is also an ignorance economy.

The origin of this perspective is naturally found in Adam Smith, it is the third and most powerful of his forms of the division of labour, the one that ultimately connects to increasing returns in the production of knowledge and the evolution of the economic system as a whole. Specialisation implies concentration of effort, a narrow focusing of learning activity and therefore gives rise to individuals who know a great deal about a very small part of the totality of human understanding. Of course the very operation of economic society means that there must be understandings in common, whether in relation to rules and laws regulating behaviour in society as a whole, or less broadly, in relation to the operational rules of particular organisations. But the vast body of productive knowledge, knowledge of the natural and human built worlds is not so held, each sub branch of understanding is known by only a few who are ignorant of the wider sphere<sup>2</sup>. How is it then that we are collectively rich when we are individually so ignorant? The answer to this too is found in Adam Smith, we benefit from the understanding of others because we are connected to them through different forms of organisation. Firms, hospitals, universities and schools are precisely such organisations for generating order from specialised knowledge but so are markets and it is through these different forms of organisation that we rely upon the knowings of others, very few of whom are we aware of, for our daily living. With the growth of knowledge as a whole comes an ever more refined division of understanding, raising the question of how the new knowings are to be connected within the existing body of understanding. For without connection and the necessary organising principles there is

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<sup>2</sup> How many of our readers know how to do one or more than one of the following “to milk a cow”, to design a printed circuit board”, “to navigate an ocean liner”, “to machine a piece of phosphor bronze”, “to insert an intraocular lens in a cataract patient”? Have we made our point?



fragmentation and lack of communication, a failure to benefit from the division of knowing. Thus the power of specialisation and the division of knowing to generate wealth from knowledge depends on the presence of complementary arrangements for communication and the integration of different kinds of knowledge. That is to say, it requires all levels of organisation to have the properties of a connected information system.

Here we need to say a little about the growth of knowledge in general since the relation between knowledge and belief is at the core of any model of economic action. Knowledge is necessarily a personal human attribute, only individuals can be said to know but what they know depends on accumulated sensory experience and thus on their interaction with the environment and fellow human beings. Thus the growth of human knowledge has always depended upon the connectedness of individuals, for it is connection (sensory experience) that makes possible the transmission of information and it is the transmission of information that challenges or reinforces existing beliefs. Of course it is not necessary to be connected to everybody that would make for impossible levels of complexity, rather are connections are limited but serve to indirectly connect the system as a whole. The development of institutional and organisational forms that permit information dissemination at multiple scales in multiple formats is precisely a central feature of modern capitalist economies. Science is a typical example of an information transmission and storage system but so is the market system, they are each instituted devices for the flow of and inheritance of information and thus the stimulation of understanding in common and disagreement in particular. Indeed, the nature of restless capitalism is that it depends on processes to establish the epistemic order required for organisation, the correlation of understanding, and on processes to destroy that order from within through the emergence of discordant beliefs about the economic world. This discordant role is played by the entrepreneur and to a substantial degree innovation policy can be understood as a concern to foster business experimentation through the promotion and support of enterprise<sup>3</sup>. Now, as Brian Loasby rightly insists, the growth of knowledge is neither rational nor random but resides in a middle ground of guided variation (Loasby, 2002). In part the underlying processes depend on calculation but in enterprise, as in science, calculation alone is not sufficient, both depend on the additional possibility of imagination and the presence of chreodic institutions which keep the system open to action based on divergent conjecture. Nowhere is this more transparent than in relation to

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<sup>3</sup>The nature of entrepreneurship is explored more fully in Metcalfe, 2004.

innovation and enterprise. If economic beliefs were ever to fall into uniformity or if they were randomly generated it would be the end of economic progress, hence the fundamental policy question becomes 'Is the system capable of generating and responding to new innovation conjectures to the appropriate degree?'

The systemic properties of an economy are thus brought into focus and with them a number of important corollaries in relation to innovation. The first of these is the need to continually break and remake connections and thus to change the prevailing pattern of organisation. Every innovation requires this to happen within firms and between firms and their customers and suppliers, for old connections to be abandoned and new ones forged as consumers and factors of production are switched to the new sources of production. Indeed the competitive process is in its essentials a dynamic for changing the pattern of interconnectivity in an economy. It is the possibility that allows us to speak of economies as open adaptive systems. Not only are they open to invasion by novelties, and innovations are novelties, but they are open to adaptation in response to novelties as the old methods, goods and services are displaced by their new challengers. There is a necessary fragility to an innovation-based economic system that places then between clouds and clocks, to use Poppers famous metaphor. They neither are fully deterministic, for if they were then innovation would not be possible, nor are they completely random, for then they could not display the coherence that is necessary to guide innovation. They necessarily lie between these extremes, displaying order but ever revising and renewing the prevailing order and every change of order implies a change of organisation.

A second corollary is that such systems develop in an evolutionary way, innovations create variation and the market process evaluates the competing varieties and induces their production at differential rates according to their profitability and merits in the eyes of consumers. Evolutionary development depends crucially on the exercise of economic imagination and on acts of enterprise. Entrepreneurial behaviour is crucial to the evolutionary dynamic and every entrepreneur conjectures that the prevailing order can be improved upon, that is why the characteristics of the prevailing order, prices and quantities of goods and factors, are so important to entrepreneurial calculation. The status quo always provides the information from which innovative conjectures can be formed, and every resulting innovation is tested by the prices that flow from the prevailing order, that is how the profitability of the new and the old are jointly determined.

As an aside, we might draw attention here to the remarkable similarities between the conduct of science and engineering and the conduct of the market economy, as creative, organised systems that lie between clouds and clocks. Both are open systems for generating and conserving knowledge by testing the validity of conjectures and differentially accepting the resultant information. Both are systems for creative destruction, even though the kinds of knowledge generated in the two cases is very different. In each sphere high rewards are given for successful original claims that pass the tests of acceptability though the tests are very different as are the rewards. It is in this respect that the instituted rules of science and the instituted rules of the economy share a remarkable property, they sustain durable patterns of behaviour while enticing and rewarding challenges to that durability. Little can occur without order and organisation but in each case development requires the transformation of order through the invasion of novelty and adaptation to the immanent possibilities that are so generated. In both cases, therefore, the challenging of order is an evolutionary process that adds new elements to the respective systems and alters the consequent patterns of connectivity.

The knowledge economy and the ignorance economy are two sides of the same coin, the one entails the other and we gain a far deeper understanding of the dynamics of capitalism by recognising the two dimensions of the problem. Thus our next corollary, the knowledge/ignorance economy is an open system that is ordered but out of equilibrium. As Schumpeter well knew the challenges to the status quo arise from within, they are a reflection of and a response to the present constellation of activities, which is why there is an inevitable historical dependency to the development of an economy. Open human systems are necessarily restless, there is no end to their possible transformation but, of course, we cannot predict with any exactitude how they will evolve in the future. Moreover, a world in which many specialised individuals know many different things is a world in which innovation conjectures are likely to arise in many different contexts. While we can be entirely confident that innovations will occur somewhere in the economic system, the matter of who innovates, where they innovate, how they innovate and the consequences that follow are deeply unpredictable and this is simply a fact of economic life.

There is a third, deeper underlying reason for the restless nature of capitalist economic systems, the simple economic idea of scarcity. For scarcity of means in relation to ends is not only a contributing principle to economic organisation it is a problem that invites the search for

solutions. Scarcity is the incentive to challenge the *status quo*, but as is the case, the solution of one problem serves to identify yet further problems (conjectures and refutations in unending sequence as Popper emphasised) within the system so that each innovation by changing the distribution of knowledge changes the terms on which future innovations occur. Far from being a static idea that invites us to think in equilibrium terms, scarcity is a dynamic principle that invites us to think in terms of internally induced challenges to the *status quo*. Capitalist economic systems are self ordering and self transforming and the manner of the transforming is a direct consequence of the manner of the ordering. It is a remarkable feature of the capitalist rules of the game that the instituted frameworks which encourage the formation of economic order are the very same rules that induce the subversion of order. Indeed all innovations rest on a sufficiently strong belief that the economic world can be ordered in a different, more profitable way. Thus innovations are premised on differences in belief and that some of these beliefs must turn out to be false precisely engenders further revision of beliefs over time as does the fact that some of these conjectures successfully invade the established order. The system is rendered restless by virtue of its epistemic foundations.

This is a description of an entrepreneurial, experimental process and it is a process that is ineluctably evolutionary in nature. It is also a process in which the profit mechanism is vital and in which profits are the rents to superior business ability, they are as Schumpeter expressed it 'the child and victim of development' (1911, p.154). Abnormal returns are not to be harvested by acting on the same, rational beliefs that others hold, profits are the result of disagreement over the best economic or business 'model' for specific circumstances. Thus innovative variation is the chief route to superior profitability in knowledge based capitalism and markets are the context in which selection takes place to continually redefine the pattern of economic order via processes of differential growth, exit and entry. In short, progress cannot be grounded in consensus. Innovation occurs in public enterprise too, where markets are replaced by bureaucracy or quasi markets, such as in many health care systems and there different constraints and incentives operate. Here we can see why central planning is orthogonal to the market process; it is not just a centralized version of perfect competition as the planning versus market debates of 1930s had it. Markets lead to a market process and the process is not only about the allocation of resources but the discovery of new allocations, new means and new ends (Hayek, 1948, Nelson, 1981). To summarise what is significant about the capitalist market order is its

transience, a temporal dimension that reflects open ended self transformation emerging out of economic order. It is on this particular knowledge dynamic that modern capitalism depends and so too does the impact of innovation policy.

A fourth fundamental consequence of this view is that the evolution of the market order must be uncertain in the Keynes (1921)/Knight (1921)/Shackle (1972) sense of the lack of basis for probability calculation. The open unpredictability of the system beyond immediate horizons generates many of the features of its ordering institutions. That one does not know what others know or believe is simply a fact of existence, a fact which explains the surprise with which innovations are often received by the incumbents they challenge. This knowledge is only revealed in the course of the market process and only if agents experiment (Loasby, 2000, 2002). This is precisely the reason why we need markets to provide a basis for ongoing adaptation to the opportunities created by innovations. In a stationary economic world, markets are redundant once the initial pattern of resources has been determined, for the corresponding pattern of activities will by definition repeat itself indefinitely. To put it more strongly, we have the market institutions we have because they have co evolved to adapt to a system based on the internal growth of knowledge and innovation.

Finally, we cannot let slip by the darker side of the restless theme, the very uneven distribution of gains and losses that follow from innovation-led economic transformation. Specialisation renders individuals vulnerable to innovations in other parts of the system. It renders them liable to the destruction of their human capital, precisely because of the specialised nature of their understandings and associated productive capabilities, and here lies the source of many of the welfare destroying dimensions of economic change. Although innovations generate gains to economic welfare on average, we should not fall into the trap of thinking that all innovations are welfare enhancing, should not hide the fact that the gainers do not normally compensate the losers. To impose such a requirement would be to radically alter the terms of the competitive process so instead we fall back on the idea of the welfare state and progressive taxation as ways of limiting the adverse consequences that are felt by some.

We have proposed that capitalism is an innovation driven, open system, marked by a very uneven distribution of knowledge cum ignorance, that the division of labour is a division of knowing. It is a system of distributed ignorance that is always adding and losing components and changing the patterns of their interconnection in unpredictable ways. Indeed for the modern

system of capitalism to progress at all, the orders it generates must be fundamentally unstable in the sense that the current constellation of activities can be invaded by new alternatives. If this were not possible, if the orders were stable in the evolutionary sense, then enterprise, innovation and the diffusion of innovation would have no place in economic history and development. Certainly since Schumpeter published The Theory of Economic Development (1912), economists should have known the essential veracity of this view and the corollary that economic development cannot be squeezed out of an equilibrium framework. Yet change depends on order, and the key point is that the prevailing constellation of prices, quantities and activities in a market economy generate the opportunities, the incentives and tests that must be passed for innovations to invade and transform the system from within. It turns out that self organisation and self transformation are the two sides of the same market process. How might this perspective influence our understanding of innovation policy?

### III. Theories of Innovation Policy Making: Market Failure and System Development

It will be as well to begin by stating some of the main attributes of the innovation process, as it is found in Western capitalist economies, albeit recognising that there are important variations across different national domains (Whitley, 2009). We list them in no particular order of importance as follows.

- Innovation is not to be equated with invention alone. Invention is the stage of generating a working prototype, while innovation is the stage of applying that concept to the economic process. As Schumpeter expressed it innovation is a new productive combination that involves using existing resources in hitherto untried ways. It often turns out that what are proclaimed to be innovation policies are in fact policies to stimulate invention.
- Innovation in modern conditions involves the combination of many different kinds of knowledge not only the kinds of knowledge that we equate with science and technology. Knowledge of how to organise new combinations, knowledge of what consumer's value and knowledge of how markets are instituted are just as important for the innovator. Hence the knowledge that must be accumulated in support of innovation cannot be reduced to that which flows from research and development processes alone, knowledge of how to combine different kinds of knowledge is thus of paramount importance. There

is much more to innovation than R&D, important though the latter is. Not least we must include the investments necessary to create the capacity to exploit the innovation and the investments necessary to build the market.

- Although firms are the primary units of innovation activity they rarely have the resources at their disposal to command all the elements of knowing that are required for innovation. Consequently their internal efforts to learn and generate understanding have to be augmented by efforts to draw upon the testimony of others. Because ignorance is distributed, the innovation process is distributed and firms need an external organisation (as Marshall put it) of connections in order to gain access to what other specialists know (Von Hippel, 1988, Coombs et al 2002, Chesborough 2003).
- The consequence is that multiple organisations are contributors to the innovation process. As well as for profit firms we have universities, hospitals and other public and private research establishments that are loci of specialised knowledge and problem solving capabilities.
- Innovation is a form of future oriented investment activity with highly uncertain prospective outcomes attached to it (Carter and Williams 1958). All innovations are necessarily conjectures the acuity of which is only expressed ex post. Consequently, Keynesian animal spirits must loom large in the innovation process and, while rational methods of innovation appraisal are not to be discounted, they are there to serve as decision heuristics not as definitive predictors of outcomes. There is little point in pretending that innovations fall within the calculus of probability. They are singletons and every innovation changes the terms on which the success of future innovations is determined. An obvious consequence of this ineluctable uncertainty is that many innovations can fail and that the success of some innovations turns out to depend on factors quite unforeseen by their proponents.

Drawing these elements together, we can suggest that the process of innovation is influenced by four distinct elements: the availability of resources to invest in innovation; the incentives to invest in innovation; awareness of the opportunities to innovate including access to the knowledge and knowledge acquisition skills required to innovate; and, access to the capabilities needed to manage the internal and external processes that preoccupy any innovating

organisation. These four elements provide a natural frame with which to analyse the problems of innovation policy (Metcalfe 1996)

All innovation policy is premised on a judgment that the innovation process can be improved upon but the nature of the assumed deficiencies varies widely and here there are two broad schools of thought, one based on the ideas of welfare economics, the other on the ideas of systems complexity. The first is from the world of equilibrium thought, the other from the world of out of equilibrium thinking. (Allen 2001, Lane and Tierna 2010)

### *Market Failure*

From welfare economics we have the idea that equilibrium market signals may give distorted information to prospective innovators and that these market failures can be corrected by the policy maker through the use of taxes, subsidies and other incentive schemes. The purpose of innovation policy is to restore an economic optimum so this naturally gives rise to the parallel concept of the optimising policy maker whose task is to correct market distortions in an efficient manner. Some of the more important distortions arise from monopolistic and monopsonistic pricing elements in an economy, others from externalities that are not priced properly, and yet a third stream arises from the conduct of public goods activities. The environmental effects of pollution or the need to publicly fund defense expenditures are familiar sources of such “failures”.

It is often claimed that knowledge also has the properties of a public good, in this case in relation to the fact that it is only used and never consumed. But insufficient attention has been paid to the distinction between personal knowledge and public understanding. That knowledge is indefinitely extensible that it may be used to produce any quantity of a good (the increasing returns aspect) or may be absorbed by indefinitely many minds (the correlation of understanding aspect) is of course correct. More telling is the point that the same knowledge may be used an indefinite number of times for the production of further knowledge (increasing returns in the production of knowledge), the fact essential for the combinatorial cumulativeness of knowledge production. However, this extended replicability property does not lead to the idea that all knowledge is accessible in the public domain without cost. Information, the representations of knowledge accessible to the senses, is what is distributed publicly but without absorptive capacity and channels of communication no link with a recipient’s knowledge can be made. In



fact the generation of absorptive capacity may require, and typically does require major investments in education, training and prior R&D to acquire a capacity to understand and locate the information flow. Access costs are not to be equated with transmission costs and this is the potential flaw in treating knowledge along with information as inseparable public goods. Of course, secrecy is the extreme aspect of this point, the knowledge that is deliberately hidden from the public domain, often for good commercial reason.

Yet another fundamental source of deficiency arises from the radical uncertainty which is a corollary of the innovation process and radical uncertainty about the future necessarily means that market connectivity is incomplete. It is not surprising to note that a system marked by ineluctable business uncertainty fails to develop markets for future activities, There is no basis for writing futures contracts and identifying prices in relation to events that are yet to be imagined, so the markets for unknowable future events cannot be organised and this incompleteness means that the market information to guide investments in innovation is also incomplete. How exactly can a contract be written today for the supply of an unknown commodity produced by an unknown method and delivered to an unknown customer at an indeterminate date in the future? These characteristics of the ignorance economy are scarcely to be described as ‘failures’ whenever they arise out of the very phenomena that make a market process possible, those phenomena are innovation and the growth of knowledge.

Now the consequence of missing prices or distorted prices is that the private costs and benefits of economic action need not correspond to the associated social costs and benefits, so there is scope for the optimising policy maker to correct the price signals and induce private individuals to behave in a “socially correct” way. Judicious use of taxes and subsidies to the innovation process are the natural instruments to modify the market incentive mechanism. This is familiar territory, the rationale for policy intervention is to correct for the market failures and replace the market optimum by the socially efficient optimum. But just how is the policy maker to know what others do not know? Clearly this places great demands on the capabilities of a policy maker, because distortions are specific not general and every policy intervention should be crafted in an ideal world to reflect its particular context.(Nelson, 1993; Edquist *et al*, 1997; Malerba, 2004).

It is perhaps no further surprise to claim here that the fundamental case for public policy in respect of coordinating the innovation process arises precisely because restless capitalism

itself is the chief cause of the absence of future markets<sup>4</sup>. To eliminate the uncertainties that flow from innovation it would be necessary to eliminate innovation. Thus it is perfectly rational for private firms not to invest in fundamental general knowledge that is “far from market application” if they consider the scope for exploitation too slender; and the general knowledge of science and technology is typically of this kind. If there is a failure it is in thinking that markets can deal efficiently with every kind of human activity independently of the breadth and nature of the consequences. That government provides the bulk of the funding for fundamental work in science, technology and medicine in modern capitalism is perfectly understandable in terms of the provision of ‘general’ goods and services that generate widely distributed and uncertain benefits and costs. It is equally understandable that some private firms do invest heavily in basic scientific and technological knowledge to build absorptive capacity when it is deemed profitable to do so (Rosenberg, 1990; Cohen and Levinthal, 1989).

Market failure really is a distorting mirror in which to reflect the case for innovation policy. Its foundations in the idea of perfect competition imply perfect knowledge, quite contrary to the working of an innovation based economy in which knowledge is necessarily imperfect. Innovation is not only a source of monopolistic elements it is the reason why the future is indistinctly perceived. We simply do not know what the price and quantity system will hold in store a year, a decade, a century hence. The alleged market failures are in fact the *sine qua non* of a market process. This is the Faustian bargain that capitalism has, as it were, written with human understanding. As we know more we push back the boundaries of scarcity but at the price of not knowing the future contours of the economic system. Innovation is an inseparable part of the complex dynamics of capitalism; it is the major source of business uncertainty and the basis of the open ended unpredictable evolution of the system. Moreover, the market failure doctrine deals at best with the matter of incentives and resources to innovate and leaves untouched the more fundamental dimensions in relation to the identification of opportunities to innovate and the capabilities to manage the innovation process. It is here that an evolutionary perspective comes into play<sup>5</sup>.

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<sup>4</sup> Discussion with Cristiano Antonelli on this point is gratefully acknowledged. See Antonelli 2005 for further elaboration

<sup>5</sup> This applies to the vast innovation policy literature as well, which we treat in a most cursory fashion. A fuller introduction is in Metcalfe (2003). See Branscomb and Keller (1998) and Malerba (2004) for much valuable material on the innovation process in the USA and Europe respectively.

## *Systems Development*

Let us turn to an alternative perspective, the one that leads to the idea of innovation systems as the framework for policy action. The foundations here are in the variation cum selection tradition of evolutionary thought and the parallel linkages to the idea of a self transforming economic system that is ordered but never in equilibrium. The foundations of an evolutionary rationale stand in sharp contrast to the traditional ‘market failure’ and optimizing policy maker perspectives. From an evolutionary viewpoint, markets are instituted devices ‘designed’ to promote and adapt to the unpredictable growth of knowledge and its application through innovation and the self transformation of economic arrangements. Here lies a further dimension of innovation policy, the importance of maintaining open experimental conditions. This is one reason why competition policy and a proper concern with open markets are so important to innovation policy. It is not about keeping markets close to a perfectly competitive state so that resources are optimally allocated but in keeping them open to invasion and the consequences, including the exit of marginal enterprises that follow from innovation-led competition. All of these elements point to the futility of pretending that capitalism is a system that establishes and maintains market equilibrium. Quite the opposite, its central dynamic is that it induces self transformation out of the self organising market order.

A helpful starting point is Richard Nelson’s view that market and non market arrangements and processes are complementary elements in the innovative division of labour and that each sphere consists of an array of vastly different organisational forms and instituted rules that preclude any simple idea that markets or governments can fail (Nelson, 2002). Markets may be too extensive or too restrictive, and the same for any non- market alternatives, it is all a matter of the relative advantages of broad organisational form and thus where the boundaries should be drawn. In this context, we shall argue that the innovation systems concept is the natural frame in which to design adaptive policy initiatives but that these initiatives are necessarily general and facilitating in the sense of generating instituted ‘spaces’ for otherwise unspecified individual actions. Innovation policy should not be, indeed cannot reasonably be, about individual innovations<sup>6</sup>.

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<sup>6</sup> This does not rule out initiatives in relation to particular broad areas of innovation, biotechnology or aerospace for example, in which the innovations to appear are necessarily unknown, although the strategist or policy maker may wish to assume away the unanticipated consequences of action. It is important to remember that relative certainty about the lines of technical development does not necessarily map into relative certainty about the lines of market

Innovation policy of all policy arenas needs to build from these fundamental facts and the highly ordered but non equilibrium nature of the economic process. From this follows a fundamental perspective on adaptive policy making, that policy must evolve too and that policy frameworks must accept uncertainty and permit processes of variation and selection to work on policy ideas. The adaptive policy maker is necessarily a learning policy maker for whom an innovation systems perspective provides the appropriate rationale for an evolving innovation policy

If policy is intended to alter the operation of an economic system it is clear that an appropriate policy must rest on an accurate understanding of the system it seeks to influence<sup>7</sup>. The policy maker needs to comprehend the institutions that promote business experimentation and their connection to experimentation in terms of science and technology. Two aspects of these processes need to be distinguished. The first resides in the fact that substantial resources are devoted to the production of knowledge and dissemination of information in public research and education systems, and to some this is a defining characteristic of a modern knowledge based economy. This activity is “offline” in the sense that it is not directly connected to the solution of specific business problems and this makes it a powerful source of radical variation in the economy. The second is that the market process is also a knowledge generating process producing much of the practical knowledge that is essential to effective innovation. This is so not only in relation to the market incentives to invest in formal or informal R&D and the gathering of market intelligence but more fundamentally in relation to the day to day conduct of business and trade. This is the practical knowledge of time and place that Hayek drew attention to, the knowledge that is neither embodied in the scientific paper nor resonates in the lecture theatre.

Here it is useful to turn to Michael Gibbons and colleagues (1994), who make a distinction between two systemic modes of knowledge formation, modes that are complements not substitutes. In mode I, the traditional discipline oriented and organised research process in

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development. Christensen, (2002) is a recent example of a long tradition in the management strategy literature that makes the point.

<sup>7</sup>Ulrich Witt (2003) has drawn attention to three approaches to evolutionary policy analysis in terms of what is done by policy makers in practice, what could be done in particular circumstances, and, what should be done to achieve particular policy objectives. Our concern is with the last of these, the broad grounds under which innovation policy is justified, ‘What is it that policy is meant to achieve from an evolutionary perspective?’

University departments looms large, physics, chemistry and engineering are its exemplars. In these disciplines, clear methods exist for the verification of novel knowledge claims and the driving forces in the evolution of knowledge are the problem sequences that are cumulative and internal to the discipline. Broadly speaking, disciplines develop through their own internal logic and the respective practitioners are usually keenly aware of the boundaries which determine the limits to the content of that discipline and the rights to professional recognition within it. The productivity of this mode of organisation in terms of the growth of fundamental knowledge in science and engineering has been quite remarkable, a fact that scholars began to point to with increasing awe in the 1960s (De Solla Price 1963). If mode I is characteristic of the specialised academic discipline, with mode II knowledge we are far closer to the form that is characteristic of innovation problem solving. Its process of production is characterised by four features: the synthesis of ideas from different disciplines; the overwhelming importance of the context of application in shaping the process of collaboration in knowledge production; the great diversity of the organisations (including firms) that contribute to solving problems in this mode; and, the greater role of criteria external to science in determining the incentives to and assessment of the resulting outputs. It is the combinatorial and distributed aspects of mode II knowledge generation that command our attention, that its problem sequences are not discipline based but follow the logic of commercial innovation entwined with emerging technical possibilities. For our purposes these two modes coexist and are complementary, a point that is particularly important in terms of current concerns about the role of universities in the innovation process and it is hardly surprising that this issue should lie at the core of much contemporary thinking on the respective roles of universities and firms in the wealth creation process. Placed within the conduct of business, mode II production requires the combination of information flowing from within and without the market process and it is inevitably the case that new information will challenge some prior beliefs as to what defines an innovative opportunity. This is why a market order is never in equilibrium, except in the sense of the transitory consistency of plans and actions, but is rather an evolving sequence of out of equilibrium orders in which every ordered state conveys new information to stimulate the creation of new knowledge and beliefs. As it were, the very process of creating economic order establishes the reasons for transforming that order.

Much has been written in recent times on the concept of innovation systems but it is also noteworthy that Alfred Marshall in his *Industry and Trade* (1919) sketched the main features of what we would now call an innovation system by distinguishing different kinds of research organisation, universities, technology intensive firms and private consultancies and other knowledge intensive intermediary service providers, each type full filling a different role in an economy's knowledge ecology.<sup>8</sup> As with any division of labour, the functioning of the resulting system depends on how the specialized components are interconnected, in this case not by arms-length anonymous market transactions but by personal scientific contacts and common reference to published bodies of highly codified information. Thus, Marshall explains, the technical research laboratory of an industry benefits from keeping in touch with the chief scientific laboratories, and "the later may gain much and lose nothing" by keeping in touch with the industries whose methods may be improved by the fruits of fundamental research. Marshall's thoroughly modern account of the innovation processes therefore is one in which advances in knowledge are made by different actors, having differentiated capabilities and specialisations, working in different kinds of organisation with different motives and distinctive methods. However, it works to the degree that the component elements interact and connect. What Marshall does not tell us is how this diversity of objectives and modes of functioning, funding and organisation, may encourage or inhibit the coordination process, the problem that so concerns policy makers world wide

One obvious coordination process that motivates the connections and relations within an innovation system is the flow of information between the specialised actors. If the transfer of knowledge from universities to business could be fully and efficiently achieved through placing knowledge in the public domain there would be little need to consider the matter further. Because university researchers have strong incentives to publish their findings, such information would be readily accessible to firms; the managers of commercial innovation projects need only "read the relevant literature and connect". Publications are indeed an important source of innovation related ideas but the issues are far more subtle. Not all of the knowledge possessed by scientists is placed in the public domain, and the unexpressed (tacit) components of

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<sup>8</sup> Today we would include in the latter category the metrology laboratories and public or quasi-public "standards institutes" charged with setting and disseminating physical and technical standards, and checking compliance of products with specifications mandated by government regulations. On the general classification and role of innovation intermediaries see Howells (2006)

knowledge often matter critically in translating a generic scientific discovery or technological result into a specific, commercially viable application. Fundamental knowledge is too abstract in many cases to map easily onto practical problems in firms, and a translational or developmental gap usually needs to be bridged, a gap between proof of concept (invention) and commercial realisation (innovation). Here there is a matter of some substance. Only those who have made the requisite investments in their own understanding of the relevant fields can expect to translate new information into new personal knowledge. The implication is clear, firms need to invest in absorptive capacity if they are to pose the relevant questions and recognize the relevant answers, and this absorptive capacity is largely based on the employment of qualified scientists and technologists, certainly in R&D activities but also in more operational positions within the organisation (Carter and Williams, 1957, Cohen and Levinthal 1997). A firm must invest in the absorptive capacity to know what questions to ask, and who to address them too, and how to interpret the answers in the resolution of its innovation problems.<sup>9</sup> Not all companies grasp the point, or have the resources to make the necessary investments nor should we expect them to.<sup>10</sup>

Survey evidence adds strong support to the self organisation theme. Alan Hughes and his colleagues in Cambridge have shown that universities contribute to innovation performance in many subtle ways (Cosh, Hughes and Lester 2006; Hughes 2007; Cosh and Hughes 2008):. Most obviously they do so through the supply of the trained minds of graduate employees, through research contracts, through the sale of licenses, and through consultancy arrangements; and, least obviously but very importantly, by being a public space for the organisation of conferences, for the conduct of professional scientific networks, and for a plethora of other routes to social interaction including periods of secondment between academy and industry. When ranking the relative importance of different kinds of connection in the innovation process, they find that it is

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<sup>9</sup>Rosenberg, (1990) is one classic reference in a large literature on absorptive capacity. A recent review by Agrawal (2001) is a useful starting point for the interested reader. See also Perkmann and Walsh (2007)

<sup>10</sup>Abreu *et al* (2008) provide many examples of different modes of connectivity in the UK system ranging from joint research laboratories set up by a company and different university partners (the Rolls Royce model and the BP institute model), to general co operative framework agreements between a firm and a university department (Waitrose and Lancaster University), and to firms providing projects to serve as the basis for a Phd (Electronic Arts and UCL). That there is so much diversity in the modes of interaction is exactly what one would expect of a complex adaptive process, in which novel modes of interaction are proposed and tested continually. Many fail, one might imagine, but others become part of a transforming spontaneous order. D'Este and Patel (2007) provide detailed evidence on the different modes of interaction and the factors influencing the propensity of research grant holders to engage with business firms in the UK. Link, *et al* (2007), provide evidence for US universities on the propensity to engage in informal collaboration. Further examples of the wide range of connection modes may be found in Kitson *,et al* (2009)

informal contacts, recruitment of students, publications and conferences that contributed most to innovative efforts, while licensing, research projects in universities and consultancies are numerically far less important in contributing to the innovative efforts of firms. Exclusive and non exclusive licensing were the least significant of the contributing interactions (Cosh, Hughes and Lester 2006, Howells, *et al*, 2012).

Thus, Marshall was pointing to two important facts about this sophisticated and uneven division of labour. First, that few firms can manage to innovate entirely through their own internal efforts, and secondly, that access to external knowledge requires that the firm develop an external organisation to complement its internal arrangements. Here there is a considerable shift of focus away from problems of incentives to innovate and the resources devoted to innovation, the traditional basis for R&D policy subsidies, towards questions of the perception of innovation opportunities and the capacity to manage the innovation process.

This is the frame work within which an adaptive innovation policy maker necessarily operates, he has to be as entrepreneurial as the business decision makers that he seeks to influence. He has to begin by recognising the multiple kinds of knowledge that need to be combined in the innovation process and that these forms of knowing are distributed across multiple actors from many specialisms operating within diverse kinds of organisation.. Consequently, the generation and diffusion of new knowledge is a system problem in which different actors need to be connected to solve particular problems (Edquist, 1997; Smith 1997). This is the point that leads immediately to innovation systems and their development. The component actors, ultimately specialised, knowing individuals, are connected through instituted arrangements that permit the flow of information and facilitate the growth of knowledge necessary for innovation. Such a system may fail to operate in the desired way because knowledgeable actors are missing, because connections are absent or because system boundaries are drawn in the wrong place. Thus the policy problem is one of system construction and co-ordination. Attention to these issues provides the primary rationale for innovation systems policy<sup>11</sup>.

### *Innovation Systems and Innovation Ecologies*

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<sup>11</sup> See Woolthuis *et al* (2004), Smith (1999), and Smits and Kulhmann (2004) for more detailed elaboration.



A systems perspective allows a distinction to be made between ‘innovation ecologies’ on which much of our discussion now depends. The latter is coterminous with the set of individuals usually working within organisations who are the repositories and generators of 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 the primary organisations such as universities and firms that generate and store knowledge as well as those intermediary organisations that serve as brokers between the primary agencies (Howells 2009, Metcalfe 2010). They exhibit collectively a division of labour that is characteristic of the production of knowledge but they do not off themselves constitute an innovation system. Ecologies are typically national in scope, and a great deal of attention has been devoted to this dimension, with attention drawn to those variations which reflect rules of law and language, business practice and the social and political regulation of business (Nelson, 1993, Carlsson, 1997; Carlsson *et al*, 2002; Cooke *et al*, 2002).

Innovation systems are parts of the ecology that are connected and focused upon the solution of particular innovation problems. They are constructed for this purpose and depend upon various mechanisms to ensure the necessary connectivity and flows of information between the constituent members. The logic of this view is that innovation systems are constructed to solve ‘local’ innovation problems (Antonelli, 2001, 2005, Metcalfe et al 2006) and that they are constructed around the problems that shape innovation not only the problems that shape the growth of science and technology. In this process firms play a key integrating and connecting role, for it is firms that are the principal innovators in a modern economy. 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 more transient. Thus there is a close connection between the notion of trajectories of technological solutions within a particular technological paradigm, the evolving problem sequence, and the dynamic notion of an evolving 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.

Hence, we would argue that, while there are national and regional innovation ecologies, it is not at all obvious that there are national and regional innovation systems in the sense usually meant. 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 the 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. One need hardly add that collaboration on an international scale has for long been a characteristic of university based research. The same logic applies at regional level too, there are well defined innovation ecologies but this does not mean that the relevant innovation systems are circumscribed by the ecology of the region.

#### IV Policy for the Development of Innovation Systems

What are the ensuing policy issues? Many of them flow directly from the concept of the ignorance economy, and the facts of detailed specialisation in human understanding and the corollaries outlined above. It simply cannot be taken for granted that the relevant information to innovate is ideally distributed and several consequences follow from this elementary fact. The first is rather obvious but little discussed, it is that one cannot expect policy makers to be any better informed than the community of innovators that they seek to influence. They too are bounded by their ignorance and so an ever present requirement is for policy makers to develop their own capabilities and to bolster this with the advisory systems that connect them to the worlds of business and the university. What policy makers do have is the power to influence patterns of connectivity but they can only do this to positive effect if they too are well informed about emerging developments with respect to invention and innovation. The point to grasp is that operational innovation systems are not naturally given, they have to be constructed and there are limits to their self organisation. Because the component actors work in different organisations on different primary tasks, it is not difficult to see that their respective absorptive

capacities will differ and that the costs of the discovery of an effective combination of already existing knowledge may be considerable. There is a coordination problem of a non market kind. 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 are the principal influences on the formation of the relevant innovation systems. Here the authorities, whether national or regional emerge as the keepers of the potential for the formation of innovation systems, their role should be to set in place the conditions for innovation systems to emerge and evolve. In turn this requirement can be subdivided into two principal responsibilities: the one is to ensure that there is a rich knowledge ecology on which innovation processes can draw and the other is to establish and oversee a set of rules of the game that openly facilitate the formation and co-ordination of innovation systems, That is to say their task is to promote connectivity to facilitate the self organisation of the interactions to solve particular innovation problems. The birth, growth and decline of innovation systems is their natural sphere of influence.

In relation to the richness of the innovation ecology a familiar set of questions come to the fore. Does a nation support appropriate kinds of scientific and technological research and the associated scientists and engineers? Is the disciplinary balance of funding right? How easy is it for new disciplines and combinations of disciplines to emerge? Do research groups exist that are at the forefront of international research? As Polanyi (1962) emphasised, these are not matters of central planning but of the organisation of distributed decision making processes that draw on the expertise of the appropriately knowledgeable communities. Nor are these matters that can be fruitfully thought of in terms of optimal resource allocation but rather in terms of adaptation to emergent opportunities. While government may rightly set the overall volume of resources devoted to public knowledge acquisition, it also has a responsibility to ensure that the processes of allocation to scientific research programmes and projects are open to the emergent possibilities inherent to the growth of knowledge. In part this is achieved by the scientific community itself and its role within the framework of scientific advice for budget allocation, the Polanyi principle, but it is also achieved by ensuring that the allocation procedures engage with the business community, and there is a very clear reason for this that we alluded to in our comment above on Mode I and mode II knowledge. The organisation of science and technology

is predominantly discipline-based but the problems of innovation are typically multidisciplinary, their solution is in the nature of a connected research programme not an isolated research project. A discipline focus is likely, therefore, to miss important knowledge synergies and complementarities and to put barriers in the way of emerging areas of scientific advance. A wise policy will ensure that the pattern of advice is plural in nature, that it is designed to keep the system open to new combinatorial possibilities. This is not a question of choosing between fundamental or applied research, as is often claimed, but rather it is a question of filling Pasteur's quadrant with fundamental research on the natural and the human built worlds which engages with innovation problems, and which in turn becomes the stimulus to the development of further bridging research (Stokes, 1997)

In practical terms this suggests a layer of policy themes. First, general policies in relation to the education system and public research and development expenditure, 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 their absorptive capacity to adapt to knowledge generated within foreign ecologies; for science and technology are global systems and the formation of innovation systems will reflect a search for the best partners wherever they are located (Harvey and McMeekin, 2004, 2007). 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 Faraday Partnerships and the Technology Strategy Board in the UK come to mind as do the Fraunhofer and Max Plank Institutes in Germany, and the Manufacturing Extension Partnerships and The Advanced Technology Programmes in the USA (Mina and Hughes2012, Branscomb and Keller, 1998).

The creation of a rich science and technology base is only one half of the necessary ecology for the primary responsibility for identifying opportunities to innovate, as distinct from opportunities to invent lies with commercial firms. They are the focal points in any innovation process and if they are to draw on the science base they must have the appropriate human capital capabilities to connect. Hence a second strand of an innovation systems policy is to further the absorptive capacities of private firms through the employment of qualified scientists and engineers and the conduct of R&D and thus facilitate communication with the public knowledge base as well as with other firms whether suppliers or customers wherever they are located. It is apparent that a principal reason why university based investments in knowledge may fail to stimulate innovation in the broad is a lack of the requisite knowledge absorbing capacity in the relevant firms (HM Treasury, 2003).

Thirdly, and quite differently, we have policies not aimed at the ecology but at making and destroying the patterns of connection between different actors in the innovation process and thus explicitly at the formation of localised innovation systems. These are bridging policies that do not take for granted a free flow of information but rather that recognise the barriers to and costs of forming network relationships. Of course connections that transmit information 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 the innovation process. For example, because the connected elements of the ecology form the external capital of the firm or other innovating unit these may be internalized through the market for corporate control, indeed the ability to acquire and dispose of established bundles of business capability is one of the most important aspects of any innovation system. Similarly, mobility of knowledgeable minds is surely one of the most effective contributors to the making of connections in innovation systems, which is perhaps an unexpected take on the significance of flexible labour markets. Indeed, historically, if not presently, the mobility of skilled individuals has been a principal form of international technology transfer and innovation diffusion.

This is not to downplay barriers to connection and system emergence or the formulation of policies that reduce the costs of connection. The natural desire for commercial confidentiality

in a firm does not fit easily with the rules of open science in the university system, indeed some authors have expressed deep concerns that too close a degree of interaction between universities and firms can undermine the nature of academic research and subvert the public commons character of university research (Nelson, 2004). On the other hand, conflicts of a public vs. private nature can be shaped and accommodated to by the emergence of new instituted rules of the game, as Harvey and McMeekin (2007) demonstrate for the new biosciences. On the university side, the organisational context in which their faculty work, and the structure of the institutionalized incentives and constraints are crucial to their connectivity with other agents and the productivity of their activities<sup>12</sup>, and act as powerful shapers of their propensity to interact across the research system in general and with business firms in particular. Nor should the opportunity costs of business-university engagement be forgotten, time is always a scarce resource. There is no single best way to improve on connectivity and a wise policy will set general rules and foster many experiments exploring the merits of different approaches. In respect of any spontaneous order good policies are emergent and the outcome of variation cum selection processes. More fundamentally, they develop social technologies that reflect a shift in the balance of innovation policy away from allocating resources to R&D towards enhancing awareness of the opportunities for innovation and improving the management of the external innovative organisation of firms.

Fourthly, because innovation systems are more than invention systems, particular attention has to be paid to the integration of potential users into the innovation process. It is already well established that firms identify their customers and suppliers as key providers of information in relation to innovation, a natural consequence of innovation systems being embedded in the self organisation of market relationships. Public purchasing programmes and the identification of lead users are important ways in which the demand side of innovation systems can be influenced by public policy (Edler and Georghiou, 2007 )

It should now be apparent that a wide range of complementary policies provide a basis for promoting the formation of innovation systems. They include policy instruments 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

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<sup>12</sup> Foray, (2004). Link, *et al* (2007)

will not otherwise arise spontaneously<sup>13</sup>. Their principal purpose is to create opportunities and enhance innovative capabilities by stimulating innovation system formation (Metcalf 1995, 2003; 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, Metcalfe *et al* 2005, Mina *et al* 2008). The very point of being between clouds and clocks is neither to say that innovation policy is impossible nor to say that it is mechanically predictable in its effects. This is why 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. This is not at all to argue that there is no place for innovation subsidies, whether tax based or direct. The very penumbra of uncertainty in the innovation process means that innovation risks cannot be insured away in the market so that private firms will not invest in otherwise potentially profitable innovation projects. As we stressed above, this is not a market failure but rather the reality of restless capitalism and the ignorance economy and so public partnerships of various kinds become vehicles to accommodate to the uncertainties. Nor is this a matter of picking winners. As Alan Hughes (2011) has argued it is more a case of placing bets on different possibilities and setting the conditions for innovations to successfully emerge through public private interaction.

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

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<sup>13</sup> See the detailed discussion in EC (2003) of European approaches to innovation systems policy. DTI (2003) covers related ground for the UK. Recent Framework proposals put considerable stress on the systemic dimensions of innovation policy through technology platforms, and joint technology initiatives.

skills and the mobility of labour are important framing conditions and so is tax policy in relation to business experimentation. Most important among these is a competition policy that fosters the 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.

## V. Conclusion

The general thrust of this paper has been to propose that an innovation systems policy is the proper domain of attempts to enhance the rate of innovation. We have argued in terms of a double policy domain, on the one hand, concerned with the availability of the components of innovation systems and, on the other hand, with the potential for their self assembly into localized innovation systems that are focused on emerging problem sequences. The broad rationale is system development rather than the traditional market failure arguments. For the latter derive from an equilibrium theory of competitive resource allocation whereas the appropriate framework is one of a competitive process that is ordered but never in equilibrium. Indeed the purpose of innovation policy is to reinforce the natural tendency for any capitalist economy to be “out of equilibrium”. The evolutionary economic approach to innovative competition, embedded in co evolving instituted frames of market and non-market arrangements provides the necessary understanding that innovation policy makers require to deal with restless capitalism and the ignorance economy.



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