Revisiting some of the Theoretical and Policy Aspects of Innovation and Development

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1. Introduction to the Problematic

It is now well established in the literature that innovation constitutes a key process underpinning economic change within capitalism. This does not, however, imply that there is a single perspective that informs policy thinking about innovation. Over the preceding decades diverse interpretations have emerged resonating with the general idea that "...a national system of innovation can only be judged as healthy if the knowledge, technologies, products and processes produced by the national system of science, engineering and technology have been converted into increased wealth, by industry and business, and into an improved quality of life for all members of society" (DACST, 1996: 18). Whilst the South African reading of the literature has attempted to draw together commercial and social interpretations, both interpretations have generally derived 'innovation' narrowly from the science and technology (S&T) sector of the economy (Scerri, 2009 and Maharajh, 2011).

This interpretation typically represented S&T as the key element of 'the engine of growth' and thus, by proxy, the route to increased productivity, competitiveness and economic prosperity and consequently argued that an improved S&T sector would result from increased expenditure on research and development (R&D). Within mainstream economics and its attendant planning framework, the S&T sector is generally viewed as an important but essentially exogenous component of the general economy. This approach represents, in our view, a fundamentalist orthodoxy and remains largely embedded within the teaching of mainstream neo-classical economics. In effect, in mainstream economic thinking innovation is seen as an important exogenous determinant of the value added content of production which increases the competitiveness of firms and economies, leading to economic growth and therefore to an increase of overall societal welfare. This approach to the causal relationship between innovation and economic growth even if somewhat simplified here, represents the core of orthodox thinking on the economic role of innovation. As we will argue below, this questionable reasoning stems from the internal logic of mainstream economic theory.

[1] This paper has been developed through a novel 'crowd-sourcing' approach on the occasion of the tenth anniversary of the Institute of Economic Research on Innovation. The contributors to this paper are Erika Kraemer-Mbula, Rasigan Maharajh, Enver Motala, Lindile Ndabeni, Olusanya Osha and Mario Scerri.

The model for the perspective referred to above, of which we are critical, stems from research that focused predominantly on the 34 relatively more highly (some more than others) industrialised capitalist economies that now constitute the Organisation for Economic Co-operation and Development[2] (OECD). The unevenness of global development has resulted in policy-makers in less developed (including fast emerging and significant middle income) economies only rarely considering innovation as a legitimate area for economic analysis and planning. With the emergence of the concept of national systems of innovation (NSI), which was over time extended to the sub-national and supra-national systems, there emerged a shift towards a more integrated systemic approach to the understanding of the relationship between innovation, development and the dynamics of economic systems.

The development of NSI thinking, as will become increasingly apparent in this paper, is closely related to the emergence of the school of evolutionary economics. Researchers within this school have provided a valuable theoretical alternative to mainstream neoclassical economic theory which essentially treats technology as exogenously determined relative to the economic system, limiting neoclassical economic theory's ability to capture the dynamic elements of the relationship between technology, development and economic change. The concept of systems of innovation does not itself provide a clearly delineated and integrated body of theory. Rather it is an approach which is grounded in evolutionary (political) economy which recognizes heterodox approaches to theorization and the complex interplay between theory and policy. Approaches based on political economy recognize the interplay between economic systems and their ideological foundations, and this approach is largely absent from the discourse about systems of innovation. The concept of systems of innovation is however subject to a wide range of interpretations and this consequently raises difficult problems for its unambiguous translation into policy (an example of such problems in the case of post-apartheid South Africa is provided in the annex to this paper).

[2] Member states of the OECD with date of accession in brackets: Australia (1971); Austria (1961); Belgium (1961); Canada (1961); Chile (2010); Czech Republic (1995); Denmark (1961); Estonia (2010); Finland (1969); France (1961); Germany (1961); Greece (1961); Hungary (1996); Iceland (1961); Ireland (1961); Israel (2010); Italy (1962); Japan (1964); South Korea (1996); Luxembourg (1961); Mexico (1994); Netherlands (1961); New Zealand (1973); Norway (1961); Poland (1996); Portugal (1961); Slovakia (2000); Slovenia (2010); Spain (1961); Sweden (1961); Switzerland (1961); Turkey (1961); United Kingdom (1961); and the United States of America (1961).

This paper seeks to reflect on the variations that characterize the systems of innovation approach, classify them into broad categories, discuss their various attributes specifically in terms of their suitability in a development context, and examine their policy implications. Critical to this study will be an examination of the issue of causality in the relationship between innovation and economic and social development. We argue that the complex multi-directional chains of causality and co-evolution involved here are often poorly understood in regard to this issue. Applied as a theory of development, unidirectional causality is a deeply flawed premise which has compromised the design and effectiveness of innovation policy. It implies that the framework of planning that is still largely dominated, locally and globally, by orthodox economic theory grounded in a neoliberal/neoclassical paradigm has to be re-examined critically. The systems of innovation approach to planning on the other hand may, depending on its particular interpretation, be firmly located within the broader context of social and economic planning. The fundamental theoretical differences between these two schools of thought will be identified together with the contradictions in policy formulation resulting from the simultaneous adoption of the two paradigms for planning purposes.

This then is the problematic which is addressed in this paper. While innovation is now recognised as one of the main drivers of economic development, the theoretical foundation of this concept is still a highly contested terrain along manifold lines which in turn results in numerous crises in the process of policy formulation and implementation. The source of these crises can usually be traced to the failure to articulate and retain a specific approach to the understanding of the nature of innovation and its role in economic dynamics. This paper adopts a genealogical treatment of the evolution of this field, tracing its historical development and the main fissures which emerged in the body of theoretical literature. The following section looks at the main rift between mainstream economics, which is exemplified by the neoclassical/neoliberal hybrid, and the systems of innovation approach which stems from, and constitutes, a countervailing discourse. Section 3 looks at the rapid resurgence of this approach since the eighties. Section 4 then looks at the various lines along which the systems of innovation approach developed and the range of variations within this approach. This provides an understanding of the rifts and areas of contestation within this approach. The main issues which are dealt with in this section are the location of the system of innovation within the broader economy and the role of human capital/human capabilities in the evolution of the NSI. Section 5 builds on the discussion of the variations of the systems of innovation approach to look at the ensuing, and often contradictory, policy implications.

Finally, section 6 provides a brief summary of the main features of the systems of innovation approach.

2. Mainstream Economics and the Systems of Innovation approach

The origins of the concept of the NSI lie in the work of the evolutionary school of economics[3]. The growing dissatisfaction with the explanatory power of mainstream neoclassical analysis of the nature, sources and effects of economic change in the latter part of the twentieth century brought evolutionary economics back to the forefront of economic thinking (Hodgson, 2007) as part of the growing body of heterodox ideas about economics. Because of the continued dominance of the neoclassical paradigm in post-war economic theory, any other discourse which sought to locate itself within the discipline of economics necessarily had to be constituted as a counter-discourse rather than as an alternative to neoclassical economics. This is due to the claim of the neoclassical school to universality, the restrictiveness of its level of abstraction, and its positioning over the last fifty odd years as the defining authority over the discipline of economics (Scerri, 2008). Neoclassical theory does not, in general account for technological change, let alone innovation, except in a highly stylised manner (Reinganum 1989). Neoclassical theory includes the idea of technology and technological rationality treated as universally applicable and as equally available across time and space and which moreover, also required that the decision making environment is one of full and perfect information (the introduction of risk estimable statistically based on probability theory is an extension of certainty) which when combined with universal rationality enables unique solutions to be derived. A broader definition of innovation beyond technological change, and which includes a range of sources of change exposes the weak explanatory power of mainstream neoclassical economics which normally treats the institutional aspects of economic systems as exogenously determined in static and comparative static analysis.[4]

[3] The concept of a national system of production and innovation can be traced back to List (1841) as the basis of his counter argument to Adam Smith's position on free trade. In the late twentieth century its revival was first articulated specifically by Freeman (1987) and Lundvall (1992), but its antecedents are diffused across time and authors (see Maharajh, 2011 for further details). Nelson (1993) locates its origin in the contributions of a number of authors in Dosi et al. (1988).

[4] The New Institutional Economics School is the one area where the neoclassical paradigm seeks to endogenise institutional formation and development as an application of efficiency seeking behaviour. However, in its virtual elimination of history from the analysis of institutions and the placement of the rational benefit maximising agent at the analytical core, New Institutional Economics sought to supplant the approach formed

Neoclassical economics is essentially a static, and comparative static, analytical framework which, using an extremely high level of abstraction, aims at drawing out universal sets of normative guidelines for welfare maximisation. This school of thought is best exemplified in the general equilibrium model which, seeks to model an entire economic system and the interactions among its sub-sectors. It is a mathematically articulated model, formed of sets of simultaneous equations, which are deterministic, yielding unique solutions based on norms for the constrained maximisation of welfare in an economy. The claim to universality that this model makes is anchored in stringent *a priori* assumptions regarding the universality of the rational behaviour of human beings used to optimise their choices and decisions.

The foundations of the neoclassical school may be traced to Adam Smith (1799), David Ricardo (1817), John Stuart Mill (1848) and Jean-Baptiste Say (1880). These economists laid the foundation for the self regulating, full employment, free trade model which, with Leon Walras's (1874-1877) mathematical formulation of the general equilibrium framework and Alfred Marshall's (1890) mathematical rendition of constrained optimisation for partial equilibrium analysis, defined the essential parameters of neoclassical economics.

The most famous rebuttal to the neoclassical model of full employment equilibrium was that of John Maynard Keynes (1936) who, working within the general premises of the neoclassical model, showed how the macro-economy could settle at 'equilibrium' at less than full employment. His work, coming as it did during the Great Depression of the 1930s, invalidated the assumption of optimal markets and provided the policy framework for sustained state intervention which remained the norm in industrialised economies until the early eighties. A lesser known, and earlier critique of Smith and Ricardo (and by implication of Say, Walras and Marshall) was that of Friedrich List (1841) who argued that Smith's prescription of free trade could only be mutually beneficial to all trading countries if the economies of these countries were at a similar level of development and had similar production bases. Where unequal levels of development exist free trade would reinforce inequality and 'lock in' underdevelopment in weaker partners. The theoretical base of his argument constituted the earliest formulation of the NSI from an evolutionary perspective. His policy prescription was the 'infant industry' argument which advocated protectionism to

by Veblen (1898, 1899, and 1904), Commons (1924, 1934), among others. See Rutherford (2011) and Hodgson (2004) for historical reviews of institutional economics.

allow an appropriate learning period for local industries to mature before being exposed to global competition.

The major influence on evolutionary economics is the work of Joseph Schumpeter. Schumpeter integrated sociological understanding to his explanation of economic development and growth. According to Esben Sloth Andersen, Schumpeter sought "to establish an economic science in the broad sense which covers economic history, statistics, economic theory, and economic sociology" (Anderson, 1993: 3). In a seminal contribution to the literature, The Theory of Economic Development (1912, revised in 1934), Schumpeter established that a circular flow of economic activity, excluding any innovations and innovative activities, leads to a stationary state which could be described as Walrasian equilibrium. In contrast, Schumpeter introduced his concept of the entrepreneur who as the maker of 'new combinations' would act as the driving force for the dynamic evolution of a capitalist economy[5].

The concept of 'creative destruction' is another major Schumpeterian contribution to the literature. Schumpeter defines this concept to denote a "process of industrial mutation that incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one" (Schumpeter, 1942: 81). Anderson argues that Schumpeter "upheld an opening toward a more comprehensive understanding of the evolutionary process by emphasising that his analysis did not only cover process innovation and product innovation but also organisational innovation, the opening up of new geographical regions and innovation with respect to economic inputs" (Andersen, 2010: 10). Schumpeter also helped define for subsequent scholars, the role of technological and organisational innovation in driving and shaping the growth trajectory of capitalist economies (Solow, 2007). Notwithstanding these advances, technology and technological change continued to be treated as exogenous to the neoclassical general equilibrium model and optimisation models in general. However, from the fifties onwards, the increased awareness of the role of technology in economic growth, led to attempts to endogenise technological change, especially in the analysis of firm behaviour within neoclassical theory.

[5] The five new combinations described by Schumpeter were: 1) production of new types of goods, or change of properties of the existing goods; 2) introduction of the new method of production, that may be based on the new scientific discovery; 3) opening of a new market; 4) use of the new sources of raw materials and intermediate goods; 5) new organisation of production.

Within the neoclassical framework, the factors of production which underlie the economic system are land, labour and capital. Technology is basically seen as a given exogenous element which determines the optimal allocations of these three factors. The earliest attempts to account for technology in neoclassical economics can perhaps be traced to Solow's (1956) estimation of the total factor productivity of the USA economy which identified a substantial portion of productivity growth that could not be explained by the conventional inputs of capital and labour. Solow attributed this unexplained contribution to output growth to technology. This seemingly allowed neoclassical theorists to regard technological change as endogenous, following his approach.[6] Since the seventies, attempts at explaining these 'other' contributions to growth boiled down to 'shaving the residual', i.e. trimming down the large contribution to economic growth which could not be explained as attributable to conventional factors of production. This approach was fuelled by the accelerating productivity and competitiveness of the Japanese economy at the time. 'Shaving the residual' essentially amounted to finding plausible determinants of output, other than the conventional inputs, quantifying them, and introducing them as explanatory variables in the specification of extended national production functions. In this exercise the main sets of variables which were considered were education and technology. However, two related fundamental theoretical impediments remained for neoclassical theory's attempt to incorporate technology in its modelling of the economy.

In the first place there was the requirement to translate theoretical economic relationships into stochastic specifications for the purpose of econometric estimation. In the case of technology it is particularly difficult to capture quantitatively this highly heterogeneous 'product' in a uniform manner across economies. Patent data, was used as a measure of technology, pioneered by Schmookler (1966) and applied by Scherer (1984), among others, who used the distribution of patents across patent categories to determine the "technological position" of firms in the construction of an inter-industry technology flow matrix for the purpose of

[6] The two areas of neoclassical economics where these efforts were most pronounced were the analysis of the firm's decision making (constrained optimisation) mechanism and the refinement of total factor productivity analysis through the extension of the production function to include technology as an input. In both cases there are serious theoretical and logical shortcomings. In the first place the full and perfect information requirement of constrained optimisation models strips the proposed analysis of technological change from its crucial characteristic, i.e. that it concerns the less than fully known or predictable. Moreover, the introduction of a variable representing technology as an input on the right hand side of the production function equation violates the logical basis of the neoclassical production function itself since technology is the fabric that defines and determines production relations and cannot therefore be included as a variable. Within the neoclassical formulation, technological change requires a re-specification of the production function, a redrawing of the isoquant map, and cannot therefore itself constitute a part of the function or the map.

estimating the impact of R&D on productivity. This usage of patent data was eventually largely abandoned as unsuitable as a macro measure of technology.[7] Subsequently input data, such as R&D expenditure statistics, were used as a proxy for technological change. The attraction of this measure was that it appeared to offer comparable data across countries and sectors over time. The problems of using R&D statistics for modelling the role of technology in the economy were also acknowledged by neoclassical theorists. These included under-reporting and the inability to capture innovative activity outside formal R&D laboratories which factors tend to skew the representation of innovative activity across sectors and countries. A more problematic assumption implicit in the use of R&D data, as a proxy measure for technological change is that the 'productivity' of R&D is taken as given and essentially unchanging. This relegates the analysis of innovative activity to a 'black box' (see Rosenberg, 1982), a shortcoming that has been recognised by a number of mainstream economists (see Griliches, 1979, 1980a, 1980b and Griliches and Lichtenberg, 1984) who argued that the accumulated stock of knowledge is a major determining variable in the firm's decision on R&D expenditure which itself is liable to depreciation over time.

In effect attempts at accounting for the contribution of technology to economic growth have been severely constrained by the assumption of uniformity which extends to institutions and institutional networks across contexts in neoclassical analysis. Without this assumption, the predictive and prescriptive prowess stemming from the internal logic of the neoclassical approach would be severely compromised. However, this assumption severely limits its explanatory power with respect to the analysis of economic dynamics in general and of innovation in particular. In her comprehensive survey of game-theoretic models relating to the timing of research activity, the licensing of innovations and their adoption and diffusion, Jennifer Reinganum (1989), herself a pioneer of game-theoretic modelling of innovation, concludes that such models are highly stylised and counter factual[8].

A further critical issue dogging neoclassical attempts to explain the role of technology and its determinants was the assumption of full and perfect information, an inescapable premise of this school. This premise flies in the face of innovation in general and R&D programmes in

[7] See Scherer (2005) for extensive discussions on the limitations of patent data in measuring technological change in industry.

[8] Reinganum (1989: 905) states categorically that the game-theoretic model has

> "...not had a significant impact on the applied literature in industrial organisation; its usefulness for policy purposes should also be considered limited. For these purposes, one needs a predictive model which encompasses the full range of firm, industry and innovation characteristics."

particular which are only partially amenable to an actuarial estimation of probable outcomes where uncertainty is an important (non-trivial) element of the decision making process. The binding and restrictive effect of this premise based on the twin pillars of an ostensibly fully known decision making process and the premise of universal rationality is also evident in its analysis of institutions and institutional change. Orthodox economic theory has looked at institutions, their formation and their change in terms of their transactions-cost reducing function.[9] From this perspective, institutions come into being when their cost reducing benefits outweigh the costs of their establishment and operation. Changes in these parameters could however alter the nature and evolutionary paths of institutions. Consequently a highly reductionist account of institutional change is particularly damaging to the analysis of innovation extended beyond technology and technological change.

The emergence of a systems approach to the study of innovation brought in a much richer, albeit a less elegant, account of the evolution of networks of institutions. It allowed for specificities to emerge within a less than certain and predictable world, thus opening up the systematic study of differences, as well as the commonalities among different economies. This approach also allows for a richer analysis of multi-directional causality with, for example, the institutional web viewed as simultaneously determining and determined by the production of knowledge.[10] The direction of causality, relative to development and finally social upliftment, also becomes less determinate and certain once the extreme reductionism of orthodox economics is abandoned.

Evolutionary accounts of innovation focus on contextual contingencies as a core determinant of innovation and thus provide the basic foundation of the concept of national systems of innovation. The adoption of the NSI approach brings in the specificities of individual systems to the study of the nature and effects of innovation, thus significantly reducing the

[9] See Coase (1937) and North (1981). Johnson (1988) defines institutions terms as those "sets of routines, rules, norms and laws, which by reducing the amount of information necessary for individual and collective action make society, and the reproduction of society, possible" (Johnson, 1988: 280). It is interesting to note the shift in North's approach from his early formulation of institutions as efficiency maximising mechanisms when he states that "a dynamic theory of institutional change limited to the strictly neoclassical constraint of individualistic, rational purposive activity would never allow us to explain most secular change" (North, 1981: 58).

[10] Simpson (1995) explains this dichotomy in terms of the tension between the autonomy of technology in its internal logic which renders it potentially formative of human needs and technology as instrumental, i.e. as subservient to needs. In the latter aspect needs, which are mediated through social institutions, act as constraints on technological development paths, but needs are themselves affected by changing technological opportunities.

capacity for generalisations, be it at the analytical or the prescriptive level. Dosi (1991: 354) captures this succinctly when he says that

> "...evolutionary theories attempt to model economic systems rich in positive feedbacks (that is, self-reinforcing mechanisms such as dynamic increasing returns in innovation). Relatedly, such systems tend to exhibit non-linear dynamics and multiple dynamic paths, *also dependent on their history*." (emphasis added)

The evolutionary base of the NSI approach is quite central to its departure from mainstream economics. However, care must be taken not to equate the metaphoric use of evolution developed by evolutionary economics with a vulgar neo-Darwinian 'survival of the fittest' version which has been adopted, at least implicitly, by neoliberal economists. Evolution, as it is used in NSI analysis is a systems development analysis with the acceptance of incomplete knowledge, contingency, partial success, dead ends and calamities as inescapable properties of the search for development paths.[11] Evolutionary economics, unlike neoclassical theory, recognizes the tension between the focus on specific cases of national development and the imperative to identify some underlying common principles governing the mutation of various innovation systems over time. The search for commonalities is required especially for prescriptive purposes, but is prejudiced by the fundamental assumption of contingency which renders cross-national comparisons particularly problematic.

It is curious that the works of Karl Marx have not in general entered the literature on innovation systems except obliquely through the school of *régulation* theory (Aglietta, 1976, Boyer, 1988 and Boyer and Saillard, 1995). The general failure to develop a strong countervailing Marxian variation on the systems of innovation approach can perhaps best be understood through the genealogy of the 20th century development of the approach to innovation. This genealogy may be partially attributed to the overwhelming importance of Schumpeter, rather than List, as the origin of modern thinking on systems of innovation and

[11] Dosi clearly specifies that the manner in which the biological metaphor of evolution is applied to innovation theory:

> "... (the) economic and social environment affects technological development in two ways, first selecting the 'direction of mutation' (i.e. selecting the technological paradigm) and then selecting among mutations, in a more Darwinian manner (i.e. the *ex post* selection among 'Schumpeterian' trials and errors)." (Dosi, 1982: 156)
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> "... 'evolutionary' does not imply a notion of necessary gradualism: it is also consistent with abrupt changes, instabilities, revolutions (even in biology, evolutionary theories allow for discontinuities). Moreover, an 'evolutionary' theory should not be merely equated to simple Darwinian metaphors on selection tournaments based on near-tautological criteria of differential fitness. ... in the social domain, evolution is certainly quite Lamarkian, involving both learning and selection." (Dosi, 1991: 354)

the now general assumption that the requirements of reproducing capitalism now shape and influence the direction of human development. As Paul Sweezy observed in his editor's introduction to Schumpeter's *Imperialism and Social Classes*, the creation of a broad Schumpeterian system was comparable in its scope to Marxian social science, though not to the corpus of Marxist ideas as a whole. According to Sweezy, Schumpeter sought throughout his work to provide what he might have called a 'reasoned history' [*histoire raisonnée*] of capitalist development (Sweezy 1957: xii) especially in his *Capitalism, Socialism, Democracy* which was comparable to Marx's economic approach. In a review of Schumpeter's Business Cycles (1939), in *The Nation* (February 3, 1940) Sweezy wrote that: "Better than any economist since Marx, Professor Schumpeter has succeeded in viewing capitalism as essentially a transitory historical epoch with its own ethos and its own laws of development." The essence of Sweezy's debate with Schumpeter, which had to do with the role of innovation in stimulating profits and accumulation, was about whether innovation was premised on the role of the entrepreneur, as Schumpeter argued, or was subordinate to the accumulation process, as Sweezy insisted.

A critical reading of the literature would suggest a more specific and directed attempt at studying the effects of technical change. These attempts were largely undertaken in the aftermath of the Second World War. As noted by Sidney Winter, "R&D had become quite a hot topic in applied economics after the mid-1950s" (Winter 2005:2). A formidable institution in the initially inconspicuous form of the Research and Development Project (Project RAND[12]) of the United States Air force would attract analysts who would later occupy prominent places in the evolution of the research concerned with endogenous growth theories. Whilst most of the allied forces involved in the War had begun to nationalise components of their military industrial complexes, the United States of America opted rather to contract out its scientific research development to the private sector. The USA worked on the assumption that this would create new weapons at a faster pace and more competitively, free of the public sector procurement obligations and the personnel restrictions of the United States Department of Defence.

[12] "Project RAND is a continuing program of scientific study and research on the broad subject of air warfare with the object of recommending to the Air Force preferred methods, techniques and instrumentalities for this purpose." *Charter*: 1st March 1946.

A major social science innovation emanating from the RAND Corporation was Rational Choice Theory. It set out a model explaining all human behaviour based on self-interest. According to Ben Martin, "Nelson was part of a group of prominent economists then working at the RAND Corporation on the economics of R&D and technical change, headed by Burton Klein and included Armen Alchian, Kenneth Arrow, William Meckling, Merton Peck and (from 1959) Sidney Winter. However, much of their work took the form of classified RAND reports rather than being published in journals, and none of this work from the 1950s seems to have been cited highly until Nelson's article on the economics of basic research was published in 1959 (Martin 2008: x)

It can be argued that the exclusion of the Marxian perspective in the study of innovation is particularly problematic in the systems of innovation approach which also places the study of history at its core. According to Immanuel Wallenstein (2010), the underlying objective of capitalism is the endless accumulation of capital, wherever and however this accumulation may be achieved. Since such accumulation requires the appropriation of surplus value, it precipitates class struggle. The first phase of global capitalism has its origins in the industrial revolution which saw dramatic changes in the manufacture of goods from about the middle of the 18th century in Europe concentrated largely in England and Western Europe. This period of industrial capitalism is sometimes caricatured as a period of liberal (laissez-faire) competition. The establishment of the capitalist mode of production proceeded on the basis of the separation of people from property and the consequent destruction of land-based livelihoods.[13]

The ensuing relations of production between owners of capital and those with only their labour to sell matured over a long period until the end of the 19th century. According to Marx (1867), the capitalist mode of production was essentially the process of commodity production whose sole purpose was the accumulation of surplus value which was necessary for the continued reproduction of capitalism.

[13] A stark example of this process is provided by the 1913 Land Act in South Africa which played a critical role in securing labour resources needed for the gold and diamond mines as well as the White-owned commercial agriculture. In order to accomplish this objective, it was necessary to disrupt people's land-based livelihoods. By denying rural people access to natural resources, they could no longer sustain themselves thus forcing them into a growing pool of labour in order to survive. Again, when the mining operations demanded large numbers of harvested trees for shoring materials, more land in rural Natal was earmarked for gum tree plantations. Consequently, people were removed to make way for gum tree plantations. This situation further disrupted and destroyed forms of land-based livelihoods in rural Natal (Ndabeni, 2013).

David Harvey (1982) recognised that in the circuit of capital described above, the suppliers of the means of production and labour would also be the potential consumers of the commodities of capitalist production. As a closed system, the same firm would need to generate the additional value required for production even while it would only be realised in the future. This required the establishment of a credit system and the creation of 'fictitious capital.' The latter category represented money brought into circulation as capital without having any material basis in real commodities or in actual productive activity. This was the base on which the banking system expanded and eventually came to occupy such a significant role in contemporary society.

Following the development of capitalism throughout the 19th Century, scholars such as Hilferding (1910) described the transformation of competitive and pluralistic liberal capitalism into a monopolistic 'finance capital.' The unification of industrial, mercantile, and banking interests defused the earlier liberal capitalist demand for the reduction of the economic role of a mercantilist state. Finance capital in particular sought a centralized and privilege-dispensing state. According to Hilferding, this changed the demands of capital and of the bourgeoisie from its initial constitutional demands and affected all citizens alike. Now they sought, under the direction of a strengthening finance sector, state intervention on behalf of the wealth-owning classes: capitalists, rather than the nobility of the feudal and earlier modes of production.

This phase of the capitalist mode of production has variously been identified as a period of monopoly capitalism and in Lenin's (1916) writing imperialism has been proposed as the highest stage of capitalism. This stage took root early in the 20th Century and extended well into the early 1970s and its expansion is a long-run phenomenon which nevertheless remained crisis prone and violent. The basic thrust of this stage of capitalist development was the expansion of capitalist relations of production across the globe. Accompanying this phenomenon in the 'short century' have been the integration of banks and manufacturing industries, the export of capital, the exacerbation of inter-imperialist conflict, a reduced life cycle for fixed capital, accelerated technological innovation, the permanent military economy, the growth of multinational corporations, and the expansion of credit with the resultant international indebtedness between countries evincing different levels of development.

It is possible to discern a third phase in global capitalism that develops in response to the global crises of the early 1970s. This phase accelerated the expansion of capitalism through an even more intense financialisation, the integration of international markets and globalisation. In this period the success of national liberation struggles in the former colonies led simultaneously to their reinsertion into the global circuit of capital, trade and inevitably debt, on terms essentially dictated to by finance capital. These were followed by the imposition on former colonies of the structural adjustment programmes which have held much in common with the market fundamentalist doctrines of Milton Friedman (1962) and which have held sway over the more advanced and mature capitalist economies.

3. The resurgence of the Systems of Innovation approach

The origin of the recent upsurge in the countervailing discourse on the economic role of innovation may be traced to Nelson and Winter's (1982) seminal text which provided an eloquent critique of the limitations of economic orthodoxy from within the internal logic of the neoclassical paradigm. This was the re-introduction of evolutionary economics close to the centre of the practice of the discipline which opened the way to a body of literature that brought the NSI concept to the fore not only in academia but also into the lexicon of policy makers globally (Maharajh, 2011). Dosi et al (1988) presented a volume of work which brought together an array of writers fleshing out the multifaceted approach that would constitute a strong heterodox contender to the mainstream account of economic dynamics. Lundvall (1992) and Nelson (1993) produced writings specifically on the NSI concept. Lundvall was especially important in the introduction of the concept of the 'learning' economy in preference to the commonly used 'knowledge' economy.

Martin recognises Nelson and Winter's book as the "most highly cited single publication in the Science Policy and Innovation Studies field by some margin" (Martin 2008: 23). "This book outlines their focus on understanding the role of knowledge in the economy. Their work begins with a critical note regarding the neoclassical tradition in economics which they argue had deviated from the classical concern with appreciating patterns of long-run economic change. They proposed that the neoclassical interest in providing "a satisfactory mathematical statement of a static theory" (1982: 195) seemed easier than the much more intensive and

difficult task of exploring more dynamic perspectives which were not predicated upon a general equilibrium.

Metcalfe also recognises that evolutionary economics represents "a change in perspective for the equilibrium viewpoint" (1997: 271). For him the key problematic encapsulated in the work of Nelson and Winter is that of economic development, within which innovation acts as spur to growth.

The location of the firm at the centre of industrial dynamics has precedence in the literature. David Teece highlights the incredible contribution made by Nelson and Winter to our understanding of how, through routines and learning, organisational processes underpin the abilities of firms to innovate and grow (1998: xx-xxi). Edith Penrose (1959) developed a resource-based perspective which would be suggestive of later work concerning dynamic capabilities. For Nelson and Winter, the work of Penrose "provided the elements of an analysis linking firm growth, structure, and the nature of the management function" (1982: 36).

Nelson and Winter's theory of evolutionary economic change rests on three basic conceptual devices (Nelson and Winter, 1982: 400-401). These are "organisational routine", "search" and the "selection environment". The first conceptual device sets the context of established routines and practices which define an organisation. They define an organisational routine as the ways of doing things that are organisationally framed combined with the "ways of determining what to do" (ibid). They stress the non-static nature of their deployment of the concept in contrast to the more orthodox terminology of "capabilities" and "choices". They also advantage the reality over the normative and state that "The class of things a firm is actually doing or has recently done deserves a very different conceptual status than a hypothetical set of abstract possibilities that an external observer might conceive to be available to that firm" (ibid).

The second device, termed "search", looks at those activities, themselves largely set as routines but with a stochastic component, which assess the need to modify or replace established ways of doing things. Search describes "all those organisational activities which are associated with the evaluation of current routines and which may lead to their modification, to more drastic change, or to their replacement" (ibid). They propose that we

recognise "search"-related activities as patterns. As patterns have a distribution characterised by random probability; the "searches" of firms offer scope for statistical analysis (ibid). They further suggest that just as understanding genetics allows scientists to appreciate mutations; applying similar tools to the organisation of the search mechanism within firms generates a possibility to predict outputs and outcomes.

The third part of their theoretical foundation is the "selection environment" which sets the "ecology" within which an organisation operates, which sets limitations to its actions and which determines the survival and welfare of sets of routines and organisational forms. This refers to "the ensemble of considerations which affects its well-being and hence the extent to which it [the firm] expands or contracts" (1982: 401). In its deployment, the selection environment internalises perceptions from outside the firm and transforms the externality into a concrete internal reality. Included in this knowledge internalisation are product demand and factor supply conditions combined with information regarding the "characteristics and behaviour of the other firms in the sector" (ibid). They also use scale differences between genotypes and individual organisms to introduce "differential growth" as another defining feature of evolutionary economics. Nelson and Winter thereby and through their major conceptual devices refine our understanding of the firm away from the convention of organisational form or structure into a much more elaborate co-ordinator of "routines".

In summary, Nelson and Winter (1982) proposed a model for understanding evolutionary economic change with the following eight key characteristics:

- Technology is an endogenous result of production
- Information is imperfect and asymmetrical
- Dynamic modelling reveals complexity and chaos
- Changes in organisational routines form the base of innovation
- Searching for new, better, more efficient routines is critical
- Selection environment determines the pace and scope of finding new routines
- Resultant innovation is the source of cost, quality and scarcity advantages
- Learning aggregates from the firm to industry and sector levels, but without linearity.

Nelson and Winter's evolutionary perspective provided analysts with the means through which the dynamics of economic growth could be understood without simply assuming the profit maximisation function premised by static equilibrium models. "Diversity and

pluralism" replace the rhetoric of "social optimums" or the "hidden hand" (1982: 402), and encouraged economic analysis to be practiced in a practical and non-dogmatic spirit (ibid: 404). By focusing on the unit of the firm, we can appreciate the complexity and unevenness which lies at the core of the capitalist system. At the level of aggregation to an industry, sector or country, the multiple and complex characteristics of firms and their differentiated rates of change provide us with the defining features of an evolving system (Metcalfe 2001: 18).

Three other notable names in the history of the development of analytical foundations of systems of innovation are Christopher Freeman, Bengt-Åke Lundvall and Francois Chesnais. While tracing the origin of ideas is always difficult, one of the relevant questions relating to this issue is whether the concept of systems of innovation was introduced to policy circles or in academia. Using a social constructivist approach and armed with masses of interview data from the leading intellectuals of the field, Sharif provides the definitive answer to the effect that the "concept arose simultaneously in academia and policymaking (with regards to the latter, specifically in the OECD) at around the same time" (Sharif 2006:750).

Bengt-Åke Lundvall expanded the definitional parameters of the NSI and encouraged the appreciation of aspects of learning within the economy (1992, amongst others). Lundvall was for many years involved in the OECD and has variously contributed to global, regional, national and Nordic policy work on the topic. Francois Chesnais, who is also closely associated with the OECD, advanced the literature on this issue significantly and helped steer the Technology/ Economy Programme (OECD: 1992). Chesnais recognised that "the social circumstances surrounding each new long cycle of technological and economic development differ from the preceding cycle" (Cited in Freeman 1982: 9). He would later broaden this argument to suggest that beyond changing contexts, "it is high time to develop a full critique of liberalisation, deregulation, and "globalisation" on numerous theoretical grounds" (2003:1).

4. Differing Interpretations of NSI

From its conception, as early as in List's writing in the first half of the nineteenth century to its revival in the eighties, the NSI concept has been prone to a wide range of interpretations. As a concept derived within the political economy school it cannot be a delineated

deterministic 'model' of the economy, especially because of its abandonment of high levels of abstraction in its analysis of systems and its focus on the specific circumstances of individual cases. Its incorporation of historical conjuncture as path-dependent development moulds the nature of specific NSIs and leads the systems of innovation approach away from the neatness and ostensible clarity of neoclassical economics. As already pointed out, an assumed homogeneity and an ignorance of variations in the approach can be misleading in policy formulation. There have been numerous definitions of the NSI and the following are notable amongst these

> " ..the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies." (Freeman, 1987)
>
> " .. the elements and relationships which interact in the production, diffusion and use of new, economically useful, knowledge ... and are either located within or rooted inside the borders of a nation state." (Lundvall, 1992)
>
> "... a set of institutions whose interactions determine the innovative performance ... of national firms." (Nelson, 1993)
>
> " .. the national institutions, their incentive structures and their competencies, that determine the rate and direction of technological learning (or the volume and composition of change generating activities) in a country." (Patel and Pavitt, 1994)
>
> ".. that set of distinct institutions which jointly and individually contribute to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artefacts which define new technologies." (Metcalfe, 1995b)

At the basic level, all of these definitions focus on institutions and inter-institutional relations as providing the fabric of the NSI within which innovation happens. The two main sources of variation in the interpretation of the NSI concept are (a) the type of activity and output which is seen as innovative, and (b) the nature of the institutions which are considered relevant to the NSI. Therefore the determinant factors in the different versions of the NSI are its basic constituents – innovation and institutions. The different definitions of these two categories, in various combinations, yield a wide spectrum in the definitions of the NSI.

The common usage of the term 'innovation' tends to equate it with technology and technological change, as in the definitions of Freeman, Patel and Pavitt, and Metcalfe above.

The restriction of the term to technology excludes the analysis of all other forms of change which are therefore, at least implicitly, seen as contextual 'enablers' for innovation.[14] An alternative approach is to consider innovation as all novel forms of organising economic activity which, within a specific context, are seen as preferable to existing forms. Lundvall expands the notion of innovation to 'economically useful knowledge', while Nelson talks broadly of 'innovative performance'. In an earlier work Nelson (1991) had made a strong case for the expansion of the concept of innovation to include organisational and institutional change when he proposed that

> "... devising and learning to use effectively a significantly new organizational form involves much the same kind of uncertainty, experimental groping, and learning by making mistakes and correcting them, that marks technological innovation and invention. New modes of organisation are not simply 'chosen' when circumstances make them appropriate as neoclassical economists are wont to argue. They, like technologies, evolve in a manner that is foreseen only dimly" (Nelson, 1991: 351).

At the formal level of organisations, the choice of institutions which should be considered as part of the NSI depends on the definition of innovation which is adopted and its perceived integration with the economy. At the most restrictive level, the relevant institutions would be firms (with R&D laboratories), higher education institutions, independent research laboratories, and government agencies of science and technology. A wider range of institutions which are considered relevant would normally include government agencies in charge of industrial and trade policy, as well as firms without formal R&D laboratories.

The other set of institutions which form part of the NSI are informal institutions which can be generally defined as established, but not codified, routines and practices which are accepted as a fundamental part of the governance of inter-personal relationships in society. While formal institutions with explicit statutes and goal sets are often structurally identical across NSIs, the specific nature of individual NSIs is historically determined and formed by their informal institutional contexts. It is this context which mediates the formal institutional structure and shapes its implicit form. Informal institutions are a product of history, and unlike laws and regulations, are not codified and hence difficult to locate. The main function of informal institutions is the conservation of social structures although these too have

[14] Note for instance the original Sussex Manifesto (Singer et al., 1970)

(varying) degrees of adaptability in order to enable a successful evolution within a changing global environment. Johnson (1988) points to the ever present tension between the drive to conserve and that to adapt within any institution, formal and informal. A high degree of conservatism, while protecting entrenched values and norms, also renders institutions inflexible and vulnerable in a rapidly mutating global environment. At the same time too high a degree of adaptability could lead to a dissolution of the existent social fabric and generate an erosion of values and norms. Informal institutions can, and often are, inimical to overall societal welfare and serve to entrench privilege. Structural inequality often co-evolves with innovation[15] while corruption in its various context specific manifestations is often an integral part of national and global[16] economies. This brief discussion, of the various interpretations of innovation and of the institutional network within which innovation emerges, should provide some idea of its many interpretations.

Whilst Schumpeter had provided a solid theoretical background linking innovation activities to the progress of countries, regions and firms (Schumpeter, 1934), issues related to transnational investments in STI and the development of poorer countries had received less attention. Gerschenkron (1962) laid the foundations of the literature on the so-called "technology gap" pioneering the idea that technology gaps between technology frontier economies and laggards provide the latter with great opportunities to acquire technology through the assimilation of existing technologies. The technology gap literature, was revisited in the 1970s and 1980s by scholars such as Gomulka (1971), Cornwall (1977), Maddison (1979), Abramovitz (1979) and Fagerberg (1988), who explored the processes of "catching-up" by lagging countries. Their main hypotheses are that: technology growth rates have a positive impact on economic growth rates; lagging economies may exploit the backlog of existing knowledge through a catching-up process that allows them to approach the technology frontier; their absorptive capacity determines a lagging country's ability to embark on a successful catching-up process; this ability depends largely on direct government intervention, particularly by steering resources to the most technologically progressive sectors of the economy (Kraemer-Mbula and Wamae, 2010). The technology gap literature, therefore, stressed the role of investments in science and technology (S&T), highlighting the role of government in determining the speed and orientation of technological

[15] See Cozzens and Kaplinsky (2009) and Soares et al (2013) for literature on the co-evolution of innovation and inequality.

[16] The global financial crisis can be traced to a global financial markets and regulatory framework which have become institutionally entrenched and remain so in spite of their core role in the crisis.

change, leading to a stream of policy recommendations directed at promoting scientific and technological outputs – scientific research and development (R&D), technical manpower, patents and scientific publications (Tassey, 1997; Patel, 1995; Furman et al., 2002).

Interpretations of the 'technology gap', thus, varied amongst scholars; and in fact, some considered underdevelopment a potential advantage giving developing countries the chance to distil valuable lessons from the experiences of industrialised nations and "leapfrog" to more efficient developmental stages. However, as Perez and Soete (1988, p. 476) remarked, this view of catching-up was a "matter of relative speed in a race along a fixed track, and technology was understood as a cumulative unidirectional process". A critical response called for a more context-specific understanding of innovation suiting the changing reality of both the global and developing-country dynamics.

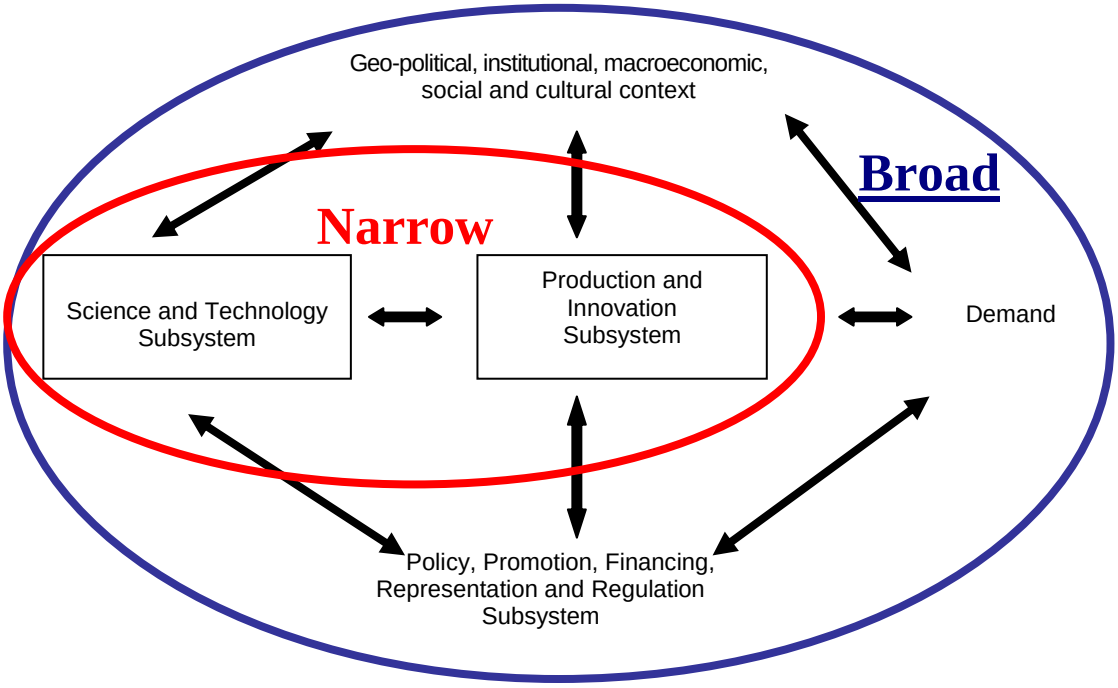
The advent of the systems of innovation approach in understanding economic dynamics provided a badly needed theoretical alternative to the static mainstream body of economic theory. It has enabled a deeper and more comprehensive analysis of the role of innovation in the development of national economies. The variety of its interpretations is due to the theoretical richness of this approach which is possibly also the major weakness of this approach at both the analytical and the prescriptive levels. The numerous versions of the NSI approach can range from a narrow system of science and technology conceptualisation at one extreme, to the NSI as an alternative account of the political economy of a country, at the other. Figure 1 provides a depiction of the interrelatedness of the various interpretations of these approaches.

The space contained by the smaller oval in Figure 1 depicts the narrow version of the NSI with the main interaction between the S&T subsystem, including all sources of S&T and its promotion mechanisms, and the production and innovation subsystem, which covers the output sector of the economy, and its specific sub-sectors. The link between the two is based on diffusion pathways. All R&D surveys and most innovation surveys implicitly take this version of the NSI as their framework of analysis.[17] This may be called the National System of Science and Technology (NSST). The opening up to the broader perspective of NSI allows the consideration of the relationship between the two sub systems within the NSST

[17] See Blankley et al (2006) for a critique of the OECD Innovation Survey methodology.

and the policy environment within the broader political economy which directly and indirectly affects innovative activity. It also brings in the role of demand in the overall nature and evolution of the NSI. A breakdown of the demand for innovations in the public sector, household consumption, the production sector, and export markets would provide an important indicator of the base of the specific NSI. The two oval demarcations in Figure 1 should not of course be taken as two distinct ways of viewing the NSI. They are rather two poles of a range of perspectives on the NSI. Thus, as one moves out of the narrow perspective, the NSI concept becomes progressively inclusive. When the limits of the broad version, circumscribed by the broader oval demarcation, are reached then the NSI becomes indistinguishable from the national political economy.

Figure 1- The Narrow and the Broad Perspectives on NSI



Source: adapted from Cassiolato & Lastres 2008

We can therefore see a progression in the placement of the NSI within the national political economy as we move from the narrow to the broader perspective. From the narrow perspective the NSI is normally conceived of as a sub-sector of the economy, which may or may not exist or be integrated with the overall economy. As we move towards the broader interpretation of the NSI, a move towards an integration of the NSI with the national political

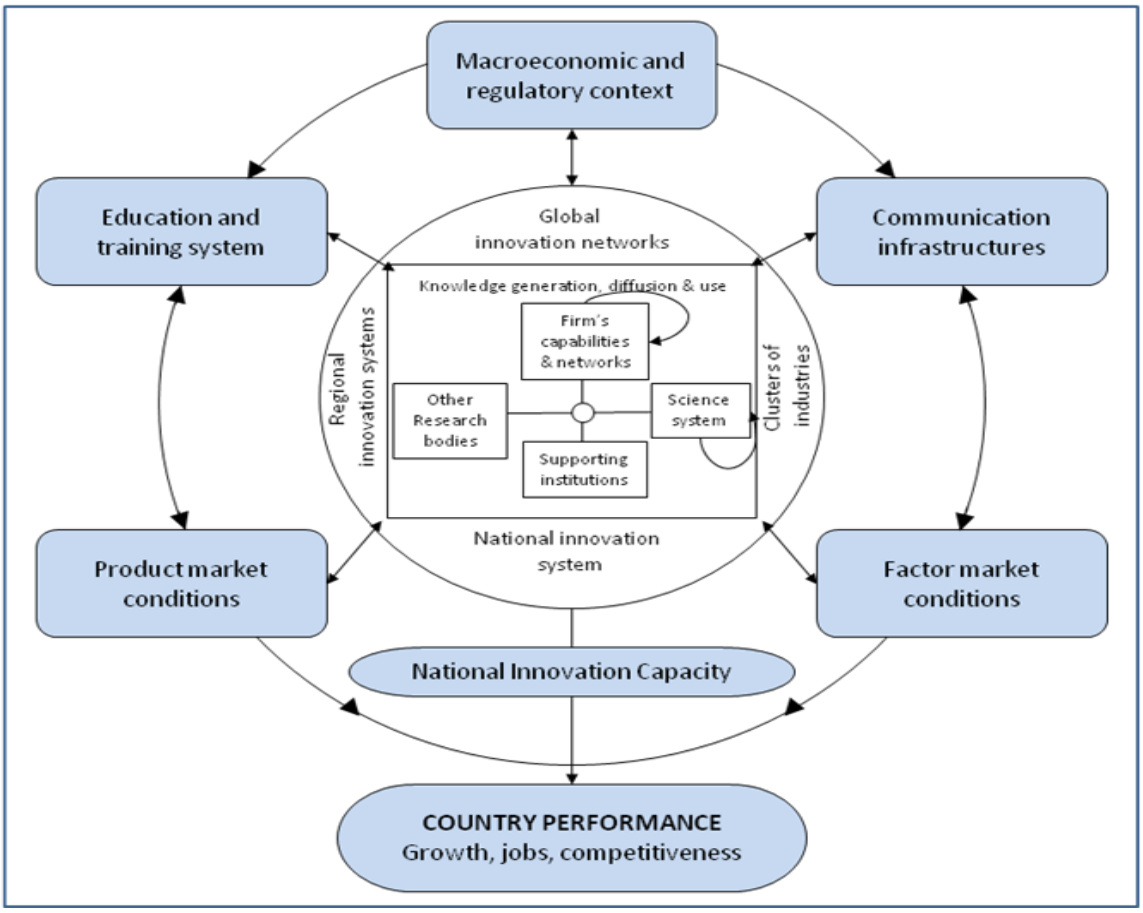
economy as an organic entity integral to it can be contemplated. In this latter sense NSI can be interpreted as an alternative general theory of the political economy.[18]

In effect, broadening the definition of the NSI integrates other elements of it, including institutional, social and cultural elements, as determinants of the shape and evolution of the NSI. This approach goes beyond focussing on the science and technology sector alone and incorporates institutions other than those directly related to science and technology. It focuses on the institutional formations which serve to translate innovation into sustainable economic growth and development. As the idea of the system of innovation broadens, so does the definition of innovation and consequently that of technological capabilities to reflect the capabilities of the general population. As we move from an economic to a political economy approach of systems of innovation we increasingly locate economic factors in a political, cultural, geographical, and historical context. In the process the definition of institutions is also expanded to include informal institutions in the form of established routines and practices which implicitly take account of established values and norms and interpersonal relationships within the society. In this way the analysis of the nature and evolution of national systems of innovation becomes increasingly context specific.

We can contrast this depiction of the versions of the NSI to the OECD representation of the broader NSI concept. Figure 2 taken from the OECD (1992) confirms the location of the micro dynamics of the innovation process within a broader political economy. Unfortunately, its narrowly circumscribed appellation of a "market economy" tends to allocate equivalence to different components such as the education and training system, communication infrastructures, market conditions and the macroeconomic and regulatory context. This conflation is problematic because it assumes a non-hierarchal representation. Most evidence of the silo-nature of policy formulation and practice tends to suggest that this proposition is counter-factual.

[18] For an elaboration of this argument, see Scerri (2012b).

Figure 2: Location of the micro dynamics of the innovation process



Source: OECD (1992)

The one core factor which is identified by the NSI approach as crucial to the evolution of the NSI is human capabilities. However, the definition of relevant capabilities differs substantially among the different versions of the NSI approach. In the narrow perspective of the NSI, analysts think of the determining human factor in terms of scientists, engineers and technologists. As the perspective of the NSI broadens, however, increasing importance is

placed on technological capabilities, defined as the ability of the labour force (as constituting the national skills base) to generate, absorb, deploy and adapt innovations. Conventionally the human factor in the NSI is interpreted as human capital, usually measured in terms of education indicators.

The origin of the prevailing commonly accepted definition of human capital lies in neoclassical economics which (see Schultz, 1971 and Becker, 1993) proposes that skills and knowledge embedded in human beings may be viewed as capital, in a manner equivalent to other forms of capital. From this perspective human capital can be analysed in terms of investment flows, costs, depreciation rates, and the returns on investment relative to it. While its theoretical basis lies in neoclassical theory, the concept of human capital has been co-opted by neoliberal economics, posing theoretical and normative problems. The general equilibrium framework of neoclassical economics is a fully determined system which depends critically on the premise of fully specified objective and constraint functions in order to derive unique welfare maximisation solutions. As we have said previously, its fundamental underlying assumption is that of full information as facilitative of the possibilities for the optimisation of the decisions of economic agents (called consumers, producers, etc.). This, as we have argued, is a highly abstracted conceptualization that is far removed from reality.

Machlup (1967) warned against confusing the consumer or the firm in neoclassical theory with the reality of life. He was quite clear that these constructs were designed to trace changes in one market, based on simplified assumptions and their translation into generalized models. In this way a body of assumptions driven by positivist approaches to economics and its normative implications are built on the assumptions that inform nonexistent and hypothetical situations. This is the inherent contradiction of a theoretical framework whose ostensible elegance and clarity of exposition render it a formidable pedagogic aid to neoclassical economics (see Scerri, 2008) despite its poor empirical analytical value. The transition from the liberal economics of Adam Smith to modern neoliberal economics associated with neoclassical theory constitutes the theoretical fallacy that Machlup warned about. The fact that neoclassical theory has no place for competitive behaviour (see Stigler, 1957 and McNulty, 1968) has been ignored in the bestowing on neoliberal economics the mantle of scientific validity based on a mathematical exposition of the general equilibrium model.

As we have argued, the neoclassical formulation of human capital theory rests moreover on a model of full information based decision making guided by a specific, highly restrictive, definition of rationality. The high level of abstraction which is fundamental to its approach enables it to claim a universality of application which is independent of time and place. Yet, as soon as the fundamental assumptions of a specific, asocial and universal rationality, based on full information, are relaxed, the parameters of neoclassical economics become untenable, and invalidate the conflation of neoliberal economics with the neoclassical analytical framework as it has evolved since the late seventies to buttress the translation of a *laisssez faire* ideology into policy. Schumpeter, and even Hayek and von Mises had little regard for the analytical limitations of the general equilibrium model, yet Becker derived his free market prescriptions from the constrained optimisation and marginal cost-benefit models of neoclassical economics.[19]

As applied by Becker (1993), human capital theory was co-opted to eliminate labour as a meaningful economic category imputing to it no more than another form of capital. As Becker (1993: 16) argued

> ...if capital exploits labour, does human capital exploit labour too – in other words, do some workers exploit other workers? ...are skilled workers and unskilled workers pitted against each other in the alleged class conflict between labour and capital?

Becker uses the human capital concept to dismiss the validity of a Marxian theory of exploitation premised on the idea that only owners of capital can exploit labour. For him, since some workers are also owners of human capital we are able to conclude that those workers who are skilled exploit those who are not. In fact this argument is illogical and absurd since if all workers are assumed to own human capital to varying degrees, then, to the extent that that they are the owners of some amount of human capital, they exploit themselves.

[19] Chang (2001: 11) argues that "(n)eoliberalism emerged out of an 'unholy alliance' between neoclassical economics, which provided most of the analytical tools, and what may be called the Austrian-Libertarian tradition, which provided the underlying political and moral philosophy [Footnote in text: 'I say an .unholy alliance., because the gap between these two intellectual traditions is not a minor one, as those who are familiar with, for example, Hayek's scathing criticism of neoclassical economics would know (e.g., see essays in Hayek, 1949)]

An alternative approach to the analysis of the human factor in economic systems may be found in the concept of technological capabilities which is at the core of the systems of innovation approach. As we have argued, in the narrow version of the NSI the focus is on the relation between the science and technology (S&T) subsystem and the institutional mechanisms which translate the S&T output into commercially viable innovations. In this approach the human capabilities required for the functioning of the NSI are scientists, engineers and technologists within formal R&D institutions, mostly embedded within the production sector, and the managerial capabilities to translate innovations into production. This in itself requires certain levels of human capabilities in the shop-floor work force for its success.

Technological capabilities are in reality a manifestation of human capability in economies and systems of innovation. This capability may be rendered in a restrictive and reductionist sense as the set of skills in a country's population. The introduction of the notion of human capital in economic dynamics introduces considerations of time, investment, returns on investment and depreciation. Much of the theoretical development of the concept of human capital in neoclassical economics has focused on the relationship between education and human capital development. Education and training as key to human capital formation are treated as a standard constrained optimisation exercise for the family unit and the individual agent, while allowing for externalities and public goods. While Becker (1993: Ch 2) considered factors other than education, such as health, social values and the non-monetary returns related to quality of life, as determinants of human capital formation, his approach remained bound within a broad marginal cost-benefit analysis framework.

Several scholars on innovation have contributed to the literature on technological capabilities and its underlying learning processes. Fransman and King (1984), Lall (1992), Bell and Pavitt (1993, 1995), Kim (1997) and Figueiredo (2003)[20], identified taxonomies of technological capabilities suggesting the different stages and sequences in which firms acquire, accumulate and use knowledge. These capabilities are intrinsically linked to firms as the basic unit of analysis, occasionally differentiating between the various levels of employees within the firm (e.g. manager and various types of skilled and unskilled workers). Amartya Sen (1999) advanced the concept of human capabilities as a more general set within

[20] For an extensive review of this literature see Kraemer-Mbula (2009) – unpublished PhD thesis.

which the neoclassical version of human capital. He does not however enter into the essentially ideological basis of the neoclassical/Marxian contestation about human capital.

Bowles and Gintis (1975) acknowledge that human capital theory had enriched neoclassical analysis by bringing in social institutions as important determinants of the supply of labour accounting for the differentiation of forms of labour. Their critique of the neoclassical human capital theory rests on its view of the implicit and explicit equivalence between human and other more conventional types of capital. For them this alleged equivalence excluded questions about power and class formation from economic analysis. In this way labour has been commodified as a tradable commodity along with other inputs into a production process thus removing it from its social, political and historical context.

Conversely, placing human capabilities at the core of a broadly defined national system of innovation requires that we adopt a version of the concept which anchors the formation of human capabilities as a process within specific social formations. Specifying this would provide a wider analytical framework, extending the idea of human capabilities socially. In this way certain categories of skills and competencies could be codified for their use across contexts. The engineering competencies to build bridges are of this type, as is the technique required for arc welding. These are competencies ranging from the higher levels of SET to basic skills which are transferable in situations less dependent on context. However there are other sets of capabilities, related to broader problem formulation and resolution which are formed in particular social contexts, and are largely tacit and 'sticky'. These capabilities are conceptualized and learnt within a framework for the formation of more explicit codified competencies usually through formal education.

The formation of implicit tacit capabilities which are value and ideology laden takes place in largely informal processes tied into various forms of socialisation and internalisation inevitably related to power/knowledge configurations and class and other differentiating structures in society. As Bowles and Gintis (1975:77) have argued, human capacities formation serves to reinforce established social and political power

> (t)he allocation of workers ... and the definition of 'productive' worker attributes simply cannot be derived, as the human capital theorists would have it, from a market-mediated matching of

technically defined skills with technically defined production requirements. Issues of power, and ultimately of class, enter on a rather fundamental level.

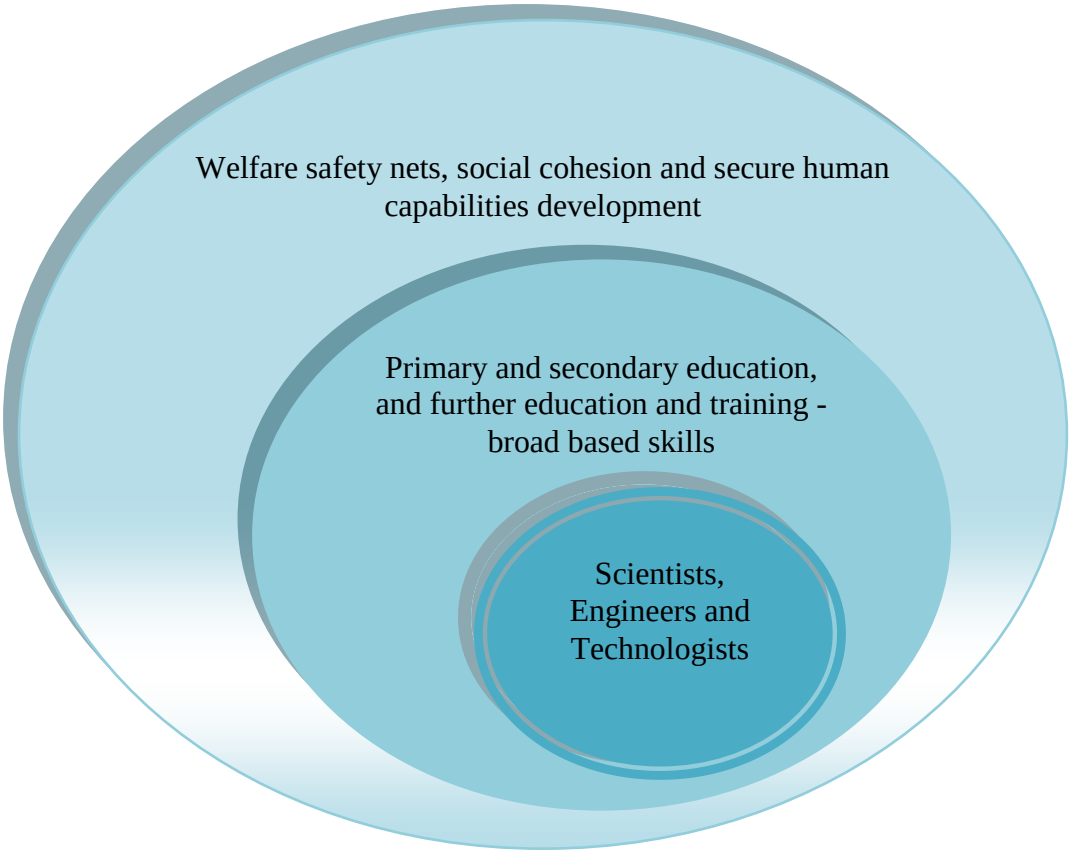
The supply of human capital, through education, is similarly grounded in the prevalent structures of capitalism specific to a particular political economy. Marxian analysis rejects the individual, or household, rational constrained optimisation choice model of the supply of human capital. Bowles and Gintis (1975: 78) dismiss individual choice as a case of 'misplaced emphasis' (see Scerri, 2008) largely irrelevant as an explanation when set against other more weighty explanations of the formation of human capabilities. Bowles and Gintis also caution against the assumption inherent in neoclassical human capital theory that skills and competencies are homogeneous. Not only *what* is taught but *how* it is taught vary according to class, race, ethnicity and gender. An understanding of the relations of power configured along these lines is important to explain the path dependence of systems and bring to the fore the role of an extra market agent, such as the state, both as a reinforcing factor and on occasion as, a possible disruptive force in the established relations of power.

The systems of innovation account of the political economy, with its emphasis on knowledge and learning as critical to all economic activity, brings in the human factor as a core element of the NSI. The availability of indigenous skills, the ability to generate them and absorb them, is often one of the main challenges faced by developing economies. Yet as we have argued the provision of appropriate capabilities is not simply a function of education, even less that of tertiary education as is often the case in the analyses of NSIs and their innovation potential. The supply and impact of scientists, engineers and technologists within the NSI is strongly dependent on the strength of the primary and secondary education sector for two reasons. In the first place this sector provides the potential cohort of participants in the post school education sector having a direct impact on its size and quality. Secondly, the absorption of innovation at the level of production depends on a broad based technological capability in the labour force. In the absence of this, the impact of higher end capabilities on the evolution of the NSI would be severely constrained.

In addition the provision of broad based human capabilities is not simply a function of education. Education itself is rooted in a specific historically determined social and economic context and its effectiveness in skilling a population is strongly contingent on the nature of this context. Conceiving a human capabilities pipeline whose outlet is the provision

of highly skilled citizens, is not possible without reference to historical context and the social and material conditions of life in which the citizenry is formed from childhood, in families and as the general populace. The secure provision of basic needs (nutrition, energy, water, health, shelter and safety), pre-school education facilities, as well as a stable societal context could ensure an effective and assured lifelong learning process which is at the heart of human capabilities formation. All of these are affected by the evolving social relations of power in any society.

Figure 3: The layers of human capabilities provision



The relationships implied in this approach to human capability formation may be visualised as layers in a topographical map, as depicted in Figure 3, rather than the linear progression implied by the 'pipeline' analogy although even this representation does not quite capture the complexities of social relations and the forms of power extant in any society. Here the provision of high end capabilities is premised on a sound pre-tertiary education, not only in terms of the supply chain but also in providing the base of technological capabilities for the

system wide absorption of innovation. Without this base, not only will the supply of higher end capabilities be limited but their absorption will also be compromised because of the constraints on economic production imposed by the low availability of technological capabilities. Furthermore these two layers are placed on a wide base of complex societal relationships which may be regarded as versions of the social contract where, explicit and implicit sets of agreements and guarantees exist to enhance the possibilities for secure livelihoods engendered by components of civil society, the state, labour federations and the private sector. This is the base that can secure the long term national investment in human capabilities development. A failure at this would compromise the entire supply chain of capabilities in the NSI.

Once this approach to human capabilities formation is adopted, the direction of causality from innovation to economic development to social upliftment is understood more fundamentally. From the perspective of mainstream economics the elements which enter into the human capabilities formation are essentially about a set of minimum goals such as those espoused in the Millennium Development Goals. These goals moreover, are seen as the outcome of economic growth and development which may to some extent be attributed to innovation. A broader perspective of the NSI necessitates more than these goals as necessary to the growth and long term development of the political economy.

5. Policy Implications

The multiplicity of interpretations of the NSI concept yields a wider range of possible policy scenarios, specifically in terms of what should be included and excluded as legitimate areas of innovation policy. Again, the discussion on innovation policy will have to be set against the context of economic orthodoxy which sees the NSI as a subsector of the general economy and consequently regards innovation policy as a relatively minor part of the macroeconomic policy framework. It can be argued (see Scerri, 2006) that this approach may be suitable for industrialised economies where the institutional framework for innovation can be assumed to be in place and reasonably efficient. But even in the case of industrialised economies there is an increasing emphasis on the broader approach to innovation policy, ranging considerably beyond conventional science, technology and innovation (STI) policy, as may be seen from the taxonomy of innovation policy proposed by the OECD (2005) and presented here as Table 1.

The first row in this taxonomy of innovation policies stems from the narrow interpretation of the NSI and represents the standard elements of STI policies which address the both the S&T and the production and innovation subsystems depicted in Figure 1. The second row in Table 1 extends innovation policies somewhat into the broader perspective on the NSI giving consideration to innovation in areas other than the directly productive sectors, which affect social welfare and areas with a high public good content.

Table 1: A taxonomy of innovation policy

Goals	Sectoral Innovation Policy	Multi-sectoral Innovation Policy
Innovation policy, i.e. aimed primarily at innovating industries and economic growth	Innovation policy in a limited sense (basically technology and industrial policies	Integrated STI policies
Innovation policy in a wider sense, i.e. aimed at economic growth and quality of life	Innovation policies in other sectoral domains, e.g. innovation policies innovation policies in health, innovation policies in the environment	Horizontal/comprehensive/integrated or coherent/systematic innovation policies

Source: OECD (2005: 22)

In the case of developing economies the requirement for a broader perspective of the NSI for innovation policy is significantly stronger. Development planning is, at least implicitly, premised on the understanding that current institutional structures are ill suited to the development needs of the country and that radical process of structural transformation are often required. In this case the narrower conceptualisation of the NSI becomes dangerously misleading, resulting in policy fragmentation. It is therefore important to map out the policy implications of the different versions of the NSI concept, covering issues of policy integration and the ambit of innovation policy. From this exercise we can derive some conclusions about the relationship between innovation policy and development planning.

The two main areas which we examine are the policy implications of the general systems of innovation approach compared to those of mainstream economic theory, and the policy implications of the contending versions of the NSI approach, specifically in a the context of developing economies. As already indicated the range of elements of the development policy environment that are adopted as relevant to the NSI is wide and depends on the choice of a specific definition of the NSI. This is why clarity about it is critical to policy design premised on the interests of various, and often competing, stakeholders including the state. A lack of clarity about what version of the NSI is used can result in the breakdown of communication among stakeholders who may use the NSI without agreeing on its conceptualization.

A narrower definition avoids a substantive orientation to NSI. State policy in this case would be to decide on the minimum critical conditions required for the NSI to come into existence, to create such conditions, and to ensure that this sub-sector of the overall economy is sufficiently linked into the economic system so as to act as a catalyst for economic growth and development. In the broader definition, the NSI is seen as substantive either as planned or unplanned and, as long as the state remains strong. Thus, except in extreme cases such as civil war or foreign invasion, even those countries which have no public R&D expenditure, STI planning agencies, or even private sector R&D activity, would still be seen as having an NSI.[21]

From the perspective of an NSI as an alternative account of the national political economy, the role of the state becomes that of the shaper and the architect of the system in which its evolution is aligned to the structural transformation and development requirements of the national political economy.[22]

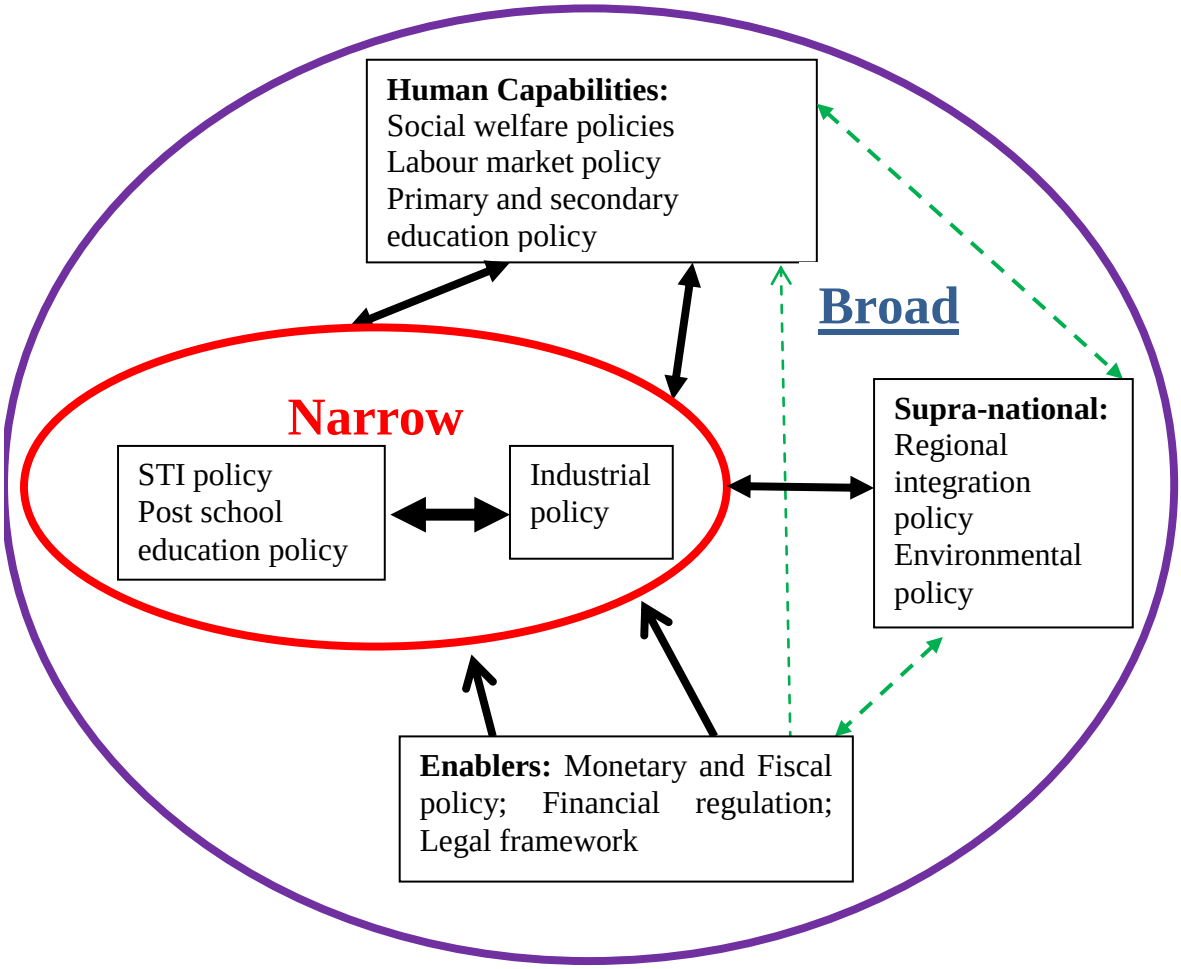
Figure 4 depicts the different policy spheres aligned to different perspectives of the NSI and possible relations among them. From the narrow perspective of the NSI the typically relevant policy areas are those which are directly STI policy, normally allocated to ministries and departments of science and technology, as well as trade and industry, and higher education

[21] The case is quite different in the case of sub-national systems of innovation, such as provincial or municipal systems whose legal definition is usually not tied to sovereignty. In the case of these entities, the conditions for the existence of a system of innovation, other than the legal definition, would have to be specified.

[22] See Scerri and Lastres (2013) for a discussion of the various perspectives of the role of the state in the evolution of the NSI.

policy. In this approach industrial policy in general should work closely with STI and higher education policy to ensure the absorption and deployment both of innovation and of higher end human capital which is seen as the prime generator of innovation. In the case of STI related policies, in this depiction of the narrow definition of the NSI, the state can enact policy in a number of ways. It can itself be a performer of R&D activity, directly or through parastatal enterprises. It can address bottlenecks in basic research, usually through subsidising university research. The state can act as the facilitator of R&D partnerships between the private sector and universities. Tax and other incentives are also normally used to promote R&D activity and the supply of university graduates.

Figure 4: Policy spheres relative to the Narrow and Broad Perspectives of the NSI



In the broader definition of the NSI the policy areas which become relevant as innovation policy include those which address what is normally labelled as 'social development', pre-university education and labour market conditions. These policy areas would both feed into,

and be affected by policies which are drawn from the range of policies associated with the narrow perspective on the NSI. The same relationship exists with respect to policy areas which govern relationships with the global economy. The more important policy areas in this case are those relevant to economic integration, as well as environmental policy which is now an important issue in global regulation.

Still broader policies based on the broadest possible definition of the NSI are the standard macroeconomic policy tools, financial regulation and the country's legal framework. This set of policy areas could best be seen as enabling policies *vis-à-vis* the narrowly defined NSI policy area. This is an inversion of the orthodox thinking where STI policy is normally seen as being a subsector within the overall macroeconomic policy. With the adoption of the broad version of the NSI, macroeconomic policy is now seen as the regulator of short term economic fluctuations within an upward trend premised on effective innovation policy. Policies aimed at the regulation of the financial regime and about the national legal framework also act as enabling policies. In the case of this set of policies their relationship to the space of narrowly defined NSI policy areas is unidirectional. These policies affect but are not affected by the traditional STI policy environment.

Similarly, the relationship between enabling policies and those for 'human capabilities' development is unidirectional, with policies on social welfare, pre-university education and labour markets affected by but not affecting these 'enabling' policy areas. On the other hand, the relationship between the latter (enabling) policy areas and 'supra-national' policy is multidirectional. Policies on the macroeconomic, financial and the legal fronts have an impact on other policy areas but are also are affected by policies on regional integration and the environment. Finally, the relationship between the 'human capabilities' policies and 'supra-national' policy is multidirectional, reflecting the increasingly globalised nature of the NSI.

The debates on what constitutes the appropriate type and level of state involvement in the economy has ranged between positions that adopt an extreme *laissez faire* position and support for the command economies that existed until late into the twentieth century. These two extreme positions have largely disappeared, both because of the collapse of the USSR in the late eighties and more recently because of the global financial crisis of 2008 and beyond. The neoliberal argument around the minimal state is based on the assumption of efficient

markets as the optimal allocator of resources although only the most extreme of neoliberal economists would argue for no intervention at all today. They would not, for instance, go as far as to exclude a legal system which guarantees property rights and individual safety and security. Those economists labelled by Lall (1994) as 'moderate neoliberals' see the role of the state as correcting for market failures, mainly in the presence of externalities and in regard to public goods; in general these economists would argue for a 'neutral' intervention which generally leaves inter-sectoral price ratios untouched. Some STI policies recognize that, even within neoclassical economics, inevitably high externalities exist. These tend to arise from a combination of intra and inter-industry spillover effects and the difficulties in the private appropriation of returns on R&D expenditure. Here a case can be made for state intervention, through incentives, subsidies, partnerships in the performance of basic research, etc, to correct for what would otherwise be an under- spending on R&D.

The role of state intervention is based on scepticism about the claims made by neoclassical/neoliberal economists for market efficiency. This scepticism is strongest when it comes to the context of developing economies where current economic structures and the functioning of markets are regarded as inadequate for, or even inimical to, the goal of a self-sustained development and growth trajectory.[23] One of the earliest rationales for strategic intervention was proposed by List (2005), the pioneer of the NSI concept. List's infant industry argument suggested that free trade in the case of trading partners at different levels of economic development would lead to a widening of the development gap. He consequently advocated protectionism as a means to ensure that infant industries in underdeveloped economies had sufficient time to go through a learning period within the context of the home market in order to meet the rigours of global competition.

The debate above has been re-visited at numerous times since the nineteenth century and recurred most famously about the early 1990s when the Japanese government challenged the World Bank's account of the success of the Asian Tigers as the epitome of successful neoliberal market friendly policies (Wade, 1996). The Japanese government argued that its post war success, and that of the other South East Asian Tigers was the result of a strongly strategic interventionist policy which was, moreover, quite specific to each of the Tigers

[23] One common manifestation of this approach in a development context is the policy of 'picking winners' on the basis of scenario building. This exercise is based on the assumption that current market structures would not by themselves result in an industry mix which is best suited for the development needs of the economy.

(Lall, 1994). There is now an increasing recognition, buttressed by the relative success of stories such as the Asian Tigers and more recently of the Brazil, Russia, India, China and South Africa (BRICS) group of emerging economies, that the dichotomy between the state and the market is unhelpful. The role of the state, as the enforcer of the 'rules of the game' of the political economy, as a partner in production and innovation, as a sole provider in specific areas of production and innovation, and as a major component of the demand sector, especially for innovation intensive products and services, is inextricably intertwined with the business sector, organised labour and civil society. The form which these sets of relationships take is specific to individual NSIs.

A political economy perspective of the NSI offers a novel approach to 'social upliftment' policies. If these policies are now seen to be addressing the human capabilities requirements of the NSI then the separation between the social and the economic in political economy becomes untenable. Instruments of 'social upliftment' become the instruments for long term economic development and in the process the standard neoliberal prescription of economic growth being the antecedent of 'social upliftment' is rendered invalid and detrimental to development.

6. Conclusions

In conclusion, a few salient features of the review undertaken in the previous sections are summarized as follows:

The wide range of perspectives of the NSI is a source of confusion in debates on innovation policy which can be particularly damaging for sound policy formulation and implementation. It is therefore important that innovation policy forums should be explicit about their specific formulation of the NSI concept, with all its defining delimiters, adopted as the basis for policy formulation.

The narrow perspective on the NSI exhibits a strong correspondence with orthodox neoclassical economic thinking on the role of innovation in the general economy. This is especially the case if the perspective is restricted to the science and technology subsystem depicted in Figure 1. Policy implications for the narrow perspective on the NSI effectively limit innovation policy to the solution of 'market failures'.

The broader perspective on the NSI provides a more appropriate understanding of the role of technology in the process of structural transformation. This approach to the NSI interprets innovation as extending far beyond technological change to include institutional and organisational change and questions about social relations. In the process it allows for feedback and learning mechanisms which extend across the national political economy.[24]

The adoption of the broader perspective allows for the consideration of multidirectional causalities among innovation, economic development and social upliftment. This opens up the discourse on innovation policy to also considering social welfare as a core area of innovation policy.

[24] See Smits, Kuhlmann and Shapira (2010: Introduction) for an elaboration of the 'Innovation Policy Dance' model of interactions and feedback relationships among the various innovation partners in the NSI.

Annex: STI planning in South Africa

The example of post-apartheid South Africa provides a good example of problems of definition and interpretation of the NSI concept. South Africa was one of the first countries to adopt explicitly the NSI concept in its formulation of the White Paper on Science and Technology in 1996 (Scerri, 2009, 2013; Maharajh, 2011). However the 2012 report of the Ministerial Review Committee on the NSI concluded that:

> "the country's efforts as a whole are insufficiently supporting a transition from strong reliance on a resource- and commodity-based economy to one that is characterised by value-adding and knowledge- intensive activities. This has implications for government's priorities in relation to employment creation and poverty alleviation" (DST, 2012: 11-12).

To a large extent the failure in the design and implementation of an innovation policy framework which was appropriate for the achievement of the country's development goals can be attributed to a lack of clarity and consistent understanding of the specific approach to the NSI concept which should inform policy. The first recommendation in the Review Report proposed the establishment of a National Council on Research and Innovation (NCRI) as a supra-ministerial planning authority for the NSI. This might have represented a crucial step in moving away from a narrow to a broader vision of the NSI recognizing the need for an overarching planning process which placed innovation policy closer to the centre of macroeconomic planning. Regrettably, the body of subsequent recommendations in the Ministerial Review tended to circumscribe the scope of innovation policy for the NCRI favouring a narrower definition of the national system of innovation (NSI).The burden of its recommendations, apart from those pertaining to public sector agency reforms, addressed the stimulation of business sector R&D and post-school education to which all eight recommendations (recommendations 14-22) relevant to human capabilities formation refer. . In regard to social innovation its only recommendation (recommendation 13) was vague and largely limited to an approach dealing with poverty alleviation This approach fails to recognize the importance of social innovation as a core instrument of innovation policy, rather than simply as an 'objective' of it.

Furthermore the starting position of the Ministerial Review document is an acceptance of the OECD (2007) review of the performance of the South African NSI. While the critical findings of the OECD report are valid, its conceptual base is tied to the narrow definition of

the NSI as a sub-sector of the economy. In addressing the failures of the NSI as identified in the OECD report, the Ministerial Review seems to have locked itself into a narrow version of the NSI with damagingly limiting implications for the future elaboration of a more progressive and inclusive innovation policy.

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