

Modes of Innovation and the Evolution of the South African National System of Innovation

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Abstract

This paper uses the concepts of means of innovation and modes of innovation to introduce an alternative approach to the understanding of the evolution of the South African system of innovation. Modes of innovation are defined in terms of ownership and control patterns of the means of innovation, as well as the role played by human capital. The relationship between ideology and modes of innovation is briefly examined. This paper lays the basis for an alternative approach to the analysis of the transition of South Africa's economic structure from apartheid to democracy and of the rifts and continuities in that transition.

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Introduction

The history of the political economy of South Africa is for the most part one of colonialism and the post-colonial system of apartheid. It is certainly a history that has disenfranchised the majority of the country's population for all but the last fifteen years. It is also a history whose peculiarities have formed the essential shape of the South African system of innovation. This is a shape that has not significantly changed since the end of apartheid, primarily because of the adoption of the neoliberal paradigm as the conceptual base for the first economic plan of the new democracy - the *Growth, Employment and Reconstruction* programme (GEAR).

Concurrent to the launch of GEAR, another plan, the 1996 *White Paper on Science and Technology*, introduced a systems of innovation approach to economic planning. Initially, this approach was severely curtailed by the overarching planning framework of GEAR but as disillusionment grew with overall economic performance, and in particular with the inability to effect the required structural transformation of the economy, a more strategic approach to economic planning has slowly emerged. However, even though there is now a widespread disillusionment with the neoliberal paradigm, both locally and globally, economic planning in South Africa is still caught up in a neoliberal language framework. Consequently, the various attempts to address the recognised shortfalls of GEAR have been fragmented and lacking in an alternative unifying informing conceptual framework.

Over the short period of time since 1996, the systems of innovation approach has certainly gained ascendancy within the sphere of science, technology and innovation (STI) planning in the sense that it has enlarged the sphere of STI planning to engage

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with other related areas of national policy. It has now laid the foundations for a more integrated approach to STI planning. There is however a scope to the systems of innovation approach which extends beyond STI planning and which can provide the conceptual foundation for an integrated planning framework to replace GEAR. The basis for this conceptual shift rests on a broad definition of innovation which essentially equates the national system of innovation to the economy. With the adoption of this approach we bring in the notion of specificity and the study of history as determining the specificity of systems to the fore of economic analysis.

In this paper I explore the concept of “modes of innovation” as the foundation for an evolutionary approach to economic historiography and to the understanding of national systems of innovation. In the sections which follow I first define the concept and its basis on a specific definition of innovation and on a particular definition of human capital. I then link the concept with national systems of innovation through a discussion of the role of ideology and the shifting meaning of sovereignty. Finally, I look at the evolution of the South African system of innovation from this approach.

Modes of innovation

There are a number of perspectives from which we may approach a definition of innovation broad enough to encompass all alterations in human activity which represent within specific contexts a, real or perceived, “better practice”. The Schumpeterian definition of innovation focusses on the firm’s strategy to alter its competitive advantage (Schumpeter, 1934). March and Simon (1993), and Williamson (1985) offer a behavioural and organisational explanation of the sources of innovation. This has been extended considerably by Lundvall’s (see Lundvall, 1996) substitution of the “learning” economy for the “knowledge” economy as a means to shift the study of systems of innovation firmly to the analysis of dynamic systems. Johnson (1988) and, obliquely, North (1990) bring in the broader institutional framework and institutional change as an integral element in the analysis of dynamic systems. From yet a different angle, Lancaster’s rearticulation of the orthodox neoclassical theory of consumption (Lancaster, 1966a, 1966b), as consisting of a multitude of, often apparently disparate, activities which serve complex combinations of consumer desire, opens up yet another perspective of the meaning and sources of innovation. The combination of these broad perspectives on the meaning of innovation can therefore expand the term to cover all changes within dynamic systems. We can go further than this, however, and propose that from the premise of this definition of innovation the value of all production and economic activity may be seen as the embodiment of past streams of innovation. This form the basis of what we may call an innovation theory of value. The source of innovation, mediated as it may be through institutions but also including institutional change, is closely linked to human capital from which all innovation ultimately derives and its counterpart would be a human capital theory of value. Again, there are numerous contentious definitions of this concept, and these will be further explored further on. Moreover, while human capital, in its various facets, is an input measure, innovation is a measure of the outcome of the deployment of human capital and other inputs within complex institutional frameworks.

The means of innovation include human capital, machines, tools, plant and equipment, and infrastructure which are combined in production and economic activity and reflect current and past streams of innovation. If we use Marxist terminology, as we should, given that the conceptual basis for this paper is essentially Marxist, we can use the term “forces of innovation” as an alternative. This would however imply a significant departure from the analogy with “forces of

production” since it would include both human and non-human means of innovation, whereas Marxist analysis distinguishes quite clearly between labour and the material means of production. As a stock and a flow concept, the means of innovation capture both the innovation embodied in economic activity and the streams of innovation which are at the heart of dynamic systems. The distinction between the human and the non-human means of innovation is crucial because it directly affects the patterns of the ownership of and the control over the means of innovation. It also allows for the analysis of the generation of a surplus over and above the returns to the human means of innovation. The patterns of control over the means of innovation normally derive from three sources. These are control over one’s own human capital, control of the non-human means of innovation and control of the coordinating mechanisms and institutions that determine the “innovation production function”. In none of these cases does control necessarily equate to ownership. The possible combinations of the means of innovation and the ownership and control structures which bring them together define the modes of innovation. This concept can be used to classify shifts in the evolution and the “development stages” of systems of innovation.

Within the context of the national system of innovation, the different modes of innovation are defined by the combination of two core characteristics. These are the patterns of ownership and control of the means of innovation, and the rates, spread and types of human capital investment that are required to reproduce the specific mode. The combination of these two categories of parameters determines the power configuration of different modes of innovation. The evolutionary forces inherent in dynamic systems would be the source of the shift from one mode of innovation to another, but different modes of innovation can exist within the same system of innovation and the relationship between them would provide another defining feature of the national system of innovation. Modes of innovation are fundamentally dynamic and can be further defined by the institutional tension between innovation and conservation. Systems are thus in a perpetual state of flux and apparently static systems are those where the forces for innovation and conservation are temporarily balanced, giving the appearance of stability.

Within this approach, the concept of an innovation theory of value proposes that the value of output is defined by the streams of innovation that have gone into its production and into all inputs that are used in production. This concept differs from that of a labour theory of value in that it shifts the notion of value away from the general category of labour to that of human capital and the innovative capacity of labour. The second distinction is the shift of emphasis away from production to knowledge. Moreover, the object of the analysis of control and ownership also shifts from tangibles to knowledge. Once knowledge and innovation become immanent across the economy, it no longer makes sense to talk of the “knowledge economy” as representing a special case in the history of the evolution of economic systems. Once an innovation theory of value is adopted an economy is necessarily a knowledge economy and the rupture represented by the current common use of the terms would rather be captured by shifts affecting the speed and paths of innovation, the altered demands on the generation of human capital and altered patterns of the control and ownership of the means of innovation. The means of innovation are closely related to technological capabilities, defined as the ability to absorb, adapt and create innovation but they also include the determinants of technological capabilities, those institutional factors that promote, shape and deploy technological capabilities.

In terms of classification, the post-Enlightenment period can be divided into three stages which are associated with different predominant modes of innovation. However, although these stages are presented as chronological, any of the

associated modes can and often do exist concurrently within most systems. The first stage is the early industrial period characterised by the owner/manager “captain of industry”. This period, spanning from the beginning of the industrial revolution to the last part of the 19th century, was marked by radical innovations and techno-economic paradigm shifts which altered the foundations of the economy but which were still widely separated over time. Freeman and Perez (1988) show how different techno-economic paradigm shifts within this long period were linked to technological revolutions in core materials and transport. This period also marked the introduction of standardised production, division of labour and economies of large scale production. This was also the stage which, in a historically unprecedented manner, was marked by a heavy dependence on natural resources. The initial voyages of conquest and the start of the age of western imperial power combined with the nascence of the industrial revolution were driven by the need to control the supply of natural resources across the globe. The proletarianisation of labour did require an investment in skills but the demand for broad based skills levels was generally low and static. Human capital formation and reproduction mostly occurred via non-formal institutions such as apprenticeships. In this stage the predominant means of innovation at any point were largely non-human and successive technological breakthroughs did not normally require an accompanying quantum leap in the skills base of the labour force or much of an increase in the rate of investment in human capital. Consequently, during this stage the combination of a high degree of lumpiness of capital and technology and relatively low requirements of broad based skills resulted in a high level of concentration of both the ownership and the control of the means of innovation.

The second mode of innovation is that of mature industrialisation which reached its epitome after the Second World War. Its main distinguishing feature was the progressive separation between the ownership and the control of the means of innovation. With the diffusion of equity, control shifts to the new technocracy and the principal-agent problem with the possibility of divergent objectives arises. To a large extent this was caused by the increasing capital requirements of new technologies within a context of a growing frequency of radical innovations and techno-economic paradigm shifts. The demand for broad based technological capabilities and the necessary higher rates of human capital investment also increased. Within this mode, the process of human capital formation and reproduction was increasingly formalised through schooling systems encompassing primary and secondary schools, technical colleges and higher education institutions. Simultaneously, with the separation of management from ownership, a new managerial class was developed and scientific management was introduced with Taylorism and Fordism in the early part of the twentieth century. This was the age of ever larger production runs in a global economy whose core feature was an apparently inexhaustible supply of cheap energy. This exerted an upward push on wages marked by a progressive shift in the global division of labour with heavy natural resource/low skills based industry moving out to the global periphery. The power of capital within this mode was tempered by organised labour and by heavily regulated political economies within a Keynesian macroeconomic policy framework. At the same time the war had ushered in big science with the initial public investments in R&D leading to a wide range of commercial applications and this heralded the emergence of the third stage.

The third mode of innovation is that of the post-industrial knowledge economy whose defining feature was the microelectronics revolution. This is characterised by the shift of the economy away from manufacturing to services and from long batch production to shorter lines with ICT enabled design pervading most manufactured product lines. The frequency of radical innovations and techno-economic paradigm shifts is historically unprecedented with the consequent rapidly changing

requirements of new sets of technological capabilities. There is the dawn of new techno-economic paradigms with biotechnology and nanotechnology indicating coming structural shifts in production and cost structures and the emergence of new economies of scale and scope. The global division of labour is further differentiated with economies being distinguished by the predominance of specific modes of innovation. This mode of innovation is also associated with globalisation and the integration of global markets in a manner dictated by the neoliberal/neoclassical ideal. However, globalisation is not a necessary condition for this mode to emerge.

The new human capital requirement of the post-industrial mode of innovation represents a radical shift from the relatively linear progression in the earlier two modes. This mode sees the disappearance of lifetime jobs or even careers, professions and trade. It requires an ongoing personal investment in own human capital, an ever expanding learning capacity and multi-skilling, translated as the requirement to shift skills bases rapidly in response to the ever accelerating rate of change, be it technological or institutional. There is also a shift in the onus of human capital investment away from the state to the individual as university subsidies are reduced in favour of student loans and with industry increasingly demanding "job ready" graduates.

The implications for the ownership and control patterns of the means of innovation are complex. On the one hand, there is a quantum leap in own investment in human capital by individuals combined with a proliferation of economic sectors where the lumpiness of other means of innovation has been dramatically reduced. On the other hand, the global integration of markets has led to a high degree of concentration of employers engaging with globally competing "knowledge workers". Thus, while the individual ownership of the means of innovation has increased substantially there is a countervailing increase in the monopsonistic power of international capitalism. This complexity is compounded by the fact that the ownership of the non-human means of production at any point in time is widely dispersed among a vast pool of anonymous shareholders, which also includes all knowledge workers. The control of the non-human means of innovation is now totally divorced from ownership and lies with the new technocratic class. Globalisation and the emergence of neoliberalism due to the economic crises of the 1970s have also shifted the balance of power between capital and labour. As regulation, and the enforcement of regulation, withered away and capital became internationally fluid and able to source cheap labour from across the globe, the power of nation-based organised labour has been significantly eroded.

National systems of innovation can therefore be classified by identifying the dominant mode of innovation and by assessing the degree of convergence of modes of innovation within the system. The combination of these two factors determines the evolutionary path of national systems of innovation. A system of innovation is defined as a network of institutions (formal and informal) within which innovation occurs. It may also be seen as a configuration of modes of innovation with complex sets of institutional relationships within and between the various modes present in a specified system. Systems can therefore range from a uniformity of modes, with an overarching mode of innovation, to a diversity of modes, with various modes coexisting within the same system. The nature of that coexistence, the nature of the linkages among different modes of innovation within the same national system of innovation, provides a scope for the reinterpretation of various concerns of underdevelopment. Such concerns would include phenomena such as dual and enclave economies, the rural-urban divides, and the possibility of a strong system of science and technology existing within an underdeveloped national system of innovation.

In the process of the classification of national systems of innovation on the basis of modes of innovation, two interrelated questions arise which directly address the political economy foundations of the national system of innovation. The first issue is the relationship between ideology and specific modes of innovation. The second is the relationship between the national system of science and technology and the national system of innovation. Before we get into that, however, we need to examine further the pivotal role played by human capital in the shift from one mode of innovation to another. Skills and the more generalised, and possibly ephemeral, concept of human capital are the ultimate source of innovation and, more than other factors, determine the enabling factor and at the same time the major constraint in the transition from one mode of innovation to another. It is therefore opportune to look a bit more closely at the nature and determinants of human capital.

Human capital

Unlike skills, the precise definition of human capital is difficult since it tends to go to the essence of the human condition. More than problem solving abilities which are shared by a number of other creatures, especially primates, it refers to the ability to formulate problems, to invent new questions and in the process to alter the human condition. Narrowly, it can be defined as knowledge, both tacit and codified, that is embedded in human beings and the ability to apply that knowledge to the production of goods and services. Tacit knowledge, the foundation of the propensity for learning, is developed primarily through specific cultural practices of problem solving and formulation. Its development is complex and long-term and it is specifically this aspect of human capital development that makes it such a costly long-term investment process. It is costly because it requires a large diversity of inputs whose supply must be guaranteed and secure over time. It is also a fragile process since human capital deteriorates unless there is continuous investment and it can disintegrate when the institutional underpinning of tacit knowledge is severely damaged, as is the case in times of political upheaval and war.

The usage of the concept of human capital within the context of systems of innovation requires that the term be explicitly defined. Within this analytical framework the definition of human capital is far removed from the neoclassical full information optimising model of human behaviour. This rightly draws a Marxist critique on a number of levels, especially in its commodification of labour, its exclusion of social formation and power, and its inference that in “competitive” markets labour is paid the equivalent of its marginal revenue product.¹ From the perspective of innovation theory, human capital is assumed to be a less than perfectly known composite datum, including social capital, which is relatively open to a multitude of determinants. Human capital formation is similarly a process which is not subject to full specification. It is a social process which also serves to reinforce existing power relations through socialisation and the internalisation of norms and values. It is a complex process, both overt as in the explicit skills transmission of education and covert as is the case with the more subtle forms of socialisation, which has to be contextualised in space and time in order to allow an understanding of its specificities. The introduction of this concept also allows for an engagement with the heterogeneity of labour and the different abilities of the different fractions of wage earners to reduce the surplus value of their work that would have been appropriated by capital.

¹ See Bowles and Gintis (1975) for an extensive coverage of the Marxist critique of neoclassical human capital theory.

From a system of innovation perspective, human capital is possibly the foremost public good whose provision determines the evolutionary path of national systems of innovation. It essentially a public good in that its returns cannot be appropriated entirely by any single individual, who owns it, buys it or rents it. It is subject to large potential externalities, where only a small portion of its returns can be captured by the individual and that portion is far outweighed by the returns to the economy as a whole. However, human capital formation without the corresponding institutional setting is not necessarily conducive to public welfare. The articulation between the human capital formation process and the skills requirements of the economy is essential to avoid the brain and skills drain from developing to industrialised economies that is endemic in a number of countries.² Secondly, without the appropriate employment conditions, human capital may translate into antisocial activity in the form of organised crime and widespread corruption. Finally, if human capital formation falls below specific thresholds it will be impossible to reproduce its base, let alone develop it. The returns on human capital will then tend to be mainly private with little or no spillovers to the economy at large.

Human capital is a complex phenomenon. Its formation is the resultant of a convergence of various elements which include education, health, secure basic needs provision and a secure base of social capital. If we stray momentarily into neoclassical language we could say that human capital formation is a production process with several inputs that can be combined in different ways to produce a complex output. From within this language we can say that the marginal productivity, or the effectiveness, of any single input is highly dependent on the other inputs. Thus, for example, the effectiveness of public spending on education, its marginal productivity, is positively and strongly correlated with the availability of the other inputs.

Human capital development is the result of a long term investment process requiring a stable guaranteed environment. The extent of the outlay on this long term investment, combined with its high externalities content requires state intervention on a wide front which covers much more than education. The long-term nature of this investment requires a set of stability conditions that would guarantee long term planning horizons. While the specifics of the location of human capital formation is often contingent on cultural, political and economic factors, it is generally the family unit, however that is defined, which is the main formative context for human capital. The stability conditions of the average family would therefore have to be guaranteed and protected from the vagaries of economic fluctuations in order to protect the source of this, the most important economic resource. From this perspective a welfare system that guarantees adequate housing, health care, food and education should be seen not only a right of the country's citizens but also as a basic requirement for the country's development.

If we analyse human capital formation from a reductionist economic viewpoint, we may say that this public good is one whose production has been privatised in its location within the family unit. The focus then shifts to the degree of privatisation. In most countries the rights of parents over the rearing of children are severely circumscribed. Laws against child labour, mandatory education laws and laws against the sexual abuse of children are all limitations on the power of parents over children and these institutions determine the context within which the family performs its role as the producer of human capital. Furthermore, we can propose, again using the production analogy, that the less the fiscal support of the state, the more costly it is for the family to perform this function and hence the less likely it is to perform it. An "absent state" in this area will result in human capital formation becoming more of a private good, belonging to the privileged few since human capital formation is too

² South Africa has been experiencing a steady net skills drain since 1994 (Kraak, 2004).

costly a process for all but the wealthiest families to bear and certainly much too costly, given the externalities, to be provided by the private sector. The responsibility for a country's human capital formation thus lies fundamentally with the state.

The ideological implications of modes of innovation

The relationship between the ideological base of any specific political economy and the dominant mode of innovation in that economy is to a large extent dependent on the diffusion patterns of the ownership and control of the means of innovation. These, as I have argued are closely and causally linked to the mode of innovation. Another factor that enters into the relationship between ideology and the mode of innovation is the relationship between systems of innovation and systems of science and technology. There is a body of theory and empirical research that indicates a positive relationship between democracy and technological innovation (see Coccia, 2008). However, a historical analysis of the South African system of innovation indicates that a non-democratic and overtly racist political economy may actually have promoted the development of a sophisticated system of science and technology while at the same time seriously compromising the evolution of the national system of innovation. This apparent contradiction is the problematic that may be addressed by a "modes of innovation" approach, specifically if we consider the concurrent existence of different modes of innovation within the same national system of innovation.

In the case of the diffusion of ownership the post industrial mode of innovation with its heavy knowledge and learning requirements would be best served by a political economic base that is democratic, both legally and economically. The distinction between the two types of democracy is important since each can exist without the other. Constitutional democracies can, and frequently are, marked by high levels of inequalities in income, wealth and life opportunities. In such cases the ownership of the means of innovation is highly concentrated and path dependency can prove a major impediment to the transition from one system of innovation to another. On the other hand, some political economies which are constitutional one-party states can often exhibit a greater levelling of the access of individuals to the individual ownership of the means of production and the appropriation of the returns on such ownership.

The early industrialisation mode, with its relatively low broad based skills requirements, is often comfortably served by a political economy whose ideological base is, at least from an economic perspective, non-democratic. The shift to the late industrialisation mode puts a greater pressure for at least an economically democratic political economy to emerge, since the increased requirement for a broad skills base implies a higher degree of the diffusion of the ownership of the means of production. This in turn implies a higher degree of equality in income, wealth and life chances.

The other relationship that has a bearing on the ideological base is the relationship between the system of science and technology and that of innovation. While the broad definition of innovation conceptually requires the necessity of the existence of systems of innovation, there is no such necessity for the existence of systems of science and technology. While systems of innovation exist, those of science and technology have to be created. It is therefore possible to think of the possibility of stable and healthy systems of innovation that have a poorly developed system of science and technology. The main requirement for this combination is the spread of the ownership of the means of innovation that is associated with a high degree of economic equality. The opposite is also true. One can have a strong system of

science and technology within a poorly developed system of innovation with low evolutionary prospects. This is often the case in the case of predatory states where the oppressed form the majority of the population and which therefore have high concentrations of ownership and control of the means of innovation. In this case the historical context is also significant since the global acceptance or rejection of such regimes depends on the time and determines to some extent the national investment in science and technology.

The relationship between modes of innovation and ideologies is mediated through a discourse on power. This discourse is shaped by two main characteristics. The first is a two-way direction of causality between knowledge and power. Knowledge endows its owner or controller with power but power also determines the direction of emerging knowledge. Herein lies the imperative for institutions to reproduce, grow and perpetuate themselves. Secondly, *à la* Marx and ironically Schumpeter, the innovation process is essentially dialectical in that every knowledge system and system of innovation with the associated political economy contains within itself the inherent contradictions which lead to the possibility of its eventual destruction. The main concern with the post-apartheid system of innovation is whether or not it constitutes a rupture with the pre-democratic system. That system, built as it was over forty odd years of progressively isolated siege economy not only gave rise to a sophisticated and idiosyncratic system of science and technology but also deeply entrenched an early industrial mode of innovation as the predominant one. The late industrial mode of innovation only started emerging towards the second half of the apartheid era but is still placed within a context of low levels of human capital and high degrees of inequality. The proof of rupture can therefore only be found in evidence of a shift in the dominant mode of innovation.

The question of sovereignty

Up to this point, this discussion on modes of innovation and their relationship with the national system of innovation has proceeded under the implicit assumption of autarky. If we bring in the relationship of the national system of innovation to the global economy, a further dimension, another level of complexity, is added to the analysis of national systems of innovation. Globalisation has certainly affected the integrity of national systems of innovation, in the sense that it has rendered the national delimiters of such systems hazy and has significantly reduced the ability of nation states to shape the evolution of their systems of innovation. However, not all national systems are equally placed within the topography of what we may call the globalised system of innovation. In this respect it is history that determines this placing, this degree of economic sovereignty that defines the degree of the self determination of national systems of innovation and their power placing relative to other national systems.

We may trace this history in the transition from the age of imperialism, through the post-colonial period, to what, following Hardt and Negri (2000), we may call the age of Empire that was ushered in with globalisation. In terms of economic power, most modern economies may be classified as formerly colonisers or colonised. From the perspective of systems of innovation we may see the transition from the colonial to the post colonial period as one which saw the legal perimeters of the former colonial powers shrinking and the emergence of new, legally defined, national systems of innovation. The post-colonial period also saw the enduring links, both economic and cultural, of the newly decolonised national systems of innovation to the former coloniser. The various policy prescriptions adopted by the former colonies determined to a large extent the degree to which the sovereignty of the new national

systems of innovation was established and the placing of specific national systems within the new globalised era. The shift into Empire, tied as it was with globalisation, the post-industrial mode of innovation and the apparent corporate denationalisation, brought about a reconfiguration of the concentrations of economic power and new loci of economic sovereignty. Those formerly colonised economies which eventually became the success stories of post-war development saw a progressive increase in the sovereignty of their national systems of innovation from the shift to independence to their emergence into the list of global corporate power in the age of Empire. The clearest example of this class is provided by most of the Asian Tigers, with the relatively recent emergence of India as a global economic power. Others, notably in Latin America, have, since the nineties, achieved an increasing degree of self-determination over the evolution of their systems of innovation. Sub-Saharan Africa, in general, shows little signs of economic sovereignty.

The case of South Africa is an exception in two distinct ways. The first, which is commonly observed, is the fact that, in terms of the sophistication of its physical and institutional infrastructure, it is the only modern economy within the region with a well developed physical and institutional infrastructure. In this sense it is the source of a strong asymmetry in the configuration of economic power in the region and is simultaneously the main source of intra-African foreign direct investment and destination of substantial flows of human capital from the rest of the continent.

The second distinct feature of the evolution of the South African system of innovation is the path of its various transitions. The formation of the Union of South Africa in 1910 saw the start of a transition into the post-colonial stage that saw political power and sovereignty shifting to an indigenous white (Afrikaner) minority. The odd feature of this phase was that the large majority of the population was excluded from a democratic participation in the new political economy under an overtly racist political regime. Otherwise the South African system of innovation retained strong economic links with the former colonial power. The contradictions of this situation gave rise to its labelling as “colonialism of a special type” or “internal colonialism” to try to capture the coexistence of an indigenous advanced capitalist economy with the legislated disenfranchisement of the indigenous majority of the population.³ The inter-war period saw the rapid industrialisation of the South African economy catalysed by state intervention on a number of fronts. The establishment of apartheid in 1948 and the exclusion of South Africa from the Commonwealth in 1961 ushered in a period of an increasing political and economic isolation of the South African national system of innovation. This period saw a progressive diffusion of the economic links with the formal colonial power and at the same time laid the foundations for a rapid development of the South African system of science and technology with the rapid emergence of the military-industrial-complex. Concurrently, however, the implementation of apartheid legislation, especially those parts which affected the various aspects of broad based human capital development, progressively impoverished the South African system of innovation, especially in relation to the systems of innovation emerging in the post colonial world.

The official end of apartheid marked by the 1994 elections brought in an urgent need to transform the national system of innovation. The failure to do so was partly responsible for the flight of most of the foremost corporations out of a country which had suddenly become a legitimate part of globalized capital. This was a perverse result of democracy. Corporate power had evolved within the specific conditions of the South African political economy since 1910 and had transmuted into a non-ethnically defined white owned capital base during apartheid. Towards the last decade of apartheid the increasing isolation of the South African economy generated an incremental cost to South African corporations. Moreover, the deteriorating

³ See Wolpe (1988: 61-63) for a discussion of this concept.

human capital base severely constrained the economy's transition to the post-industrial mode of innovation. The end of apartheid suddenly made South African corporate power globally legitimate and mobile and this enabled the exodus of corporations towards economic centres. Thus, again perversely, we have seen a degradation of the South African system of innovation back to a post-colonial stage with the core of corporate planning, decision making and R&D activity taking place in the "North" and lower value-adding operations located within South Africa.

The South African case

At the turn of the (20th) century the South African system of innovation was dominated by the early industrial mode. The economy was mostly based on mining and ancillary industries, and agriculture. The skilled labour requirements of the economy were those that were associated with mining and mostly quite specific to mining technology. Moreover, the ownership of most of the mining houses was British and foreign. The country's first Science and Technology plan was part of the initiative that was running through the British Empire, driven by the crisis created by the First World War.⁴

The first concerted drive for industrialisation in the manufacturing sector came in the inter-war period and interestingly enough the foremost large scale initiative, in the steel industry was driven by a state established enterprise. The case made for this intervention was explicitly that of market failure (Scerri, 2009: Ch. 3). The state also set up an extensive rail transport network which added a further stimulus to the expansion of the manufacturing sector. One of the consequences of this drive was the increasingly diversified skills requirements, especially in engineering and tool making, away from those which were specific to mining. The Second World War provided a further massive stimulus to the expansion of the South African manufacturing sector. Until this period the political economy of South Africa was not markedly different from that of other, settler colonial economies within the Empire. It was overtly racist with ownership, employment and residential rights defined by race but this was the common feature of the colonies, even if the Union of South Africa with an Afrikaner dominated government had its specific characteristics. Within this context South Africa's system of innovation was evolving in line with the rest of the Empire.

However, the end of the war and the onset of apartheid shunted the evolution of the South African system of innovation on to a different path right at the dawn of the post colonial era. The two immediate concerns of the apartheid regime were the interpenetration, and hence the homogenisation, of Afrikaner and English capital and the institutionalisation of a unique type of racial capitalism. The simple fact that the disenfranchised made up the majority of the population froze the South African system of innovation into a particular mix of an early industrial mode of innovation alongside an emerging late industrialisation mode. This mix became entrenched, cumulative and path dependent to the extent that it formed the basis for the late post-apartheid presidential description of the South African economy fifty years later as the mix of two distinct and separate nations – the "first and the second economies". It was also a system that lacked the basic prerequisite for the transition from a late industrial to the post industrial mode of innovation.

At the same time the increasing international isolation and the anti-apartheid movement promoted the emergence of a siege economy and the rapid growth of the

⁴ This was the only national S&T plan ever drafted in South Africa before the 1996 White Paper on Science and Technology. The plan and the agencies that it established were abandoned shortly after the First World War (see Scerri, 2009: Ch 3).

military-industry-complex. This development was typically highly conducive to the development of the country's system of science and technology. The establishment of the Council for Scientific and Industrial Research (CSIR) in the mid-forties laid the basis for the institutional base for this system. Perceived military dictates pushed scientific and technological breakthroughs on a number of fronts, including synthetic fuels, nuclear and missile technology, electronics and guidance systems, and materials technologies. This development was against the backdrop of an unskilled and deskilled labour force and generally poor supplies of human capital. It was stamped by a structural and endemic inequality in income, wealth and life chances, a structure which was cumulative and path dependent and determined the fundamental nature of the national system of innovation inherited by the post-apartheid political economy. This particular evolution path of the South African system of innovation was in contrast to a global environment where the transition to the knowledge (and learning) economy was fundamentally predicated on the plentiful availability of highly skilled, and multi-skilled, labour which is in a perpetual learning and adaptive mode, ready to respond to the shifting demands of a rapidly accelerating technology environment.

The South African system of innovation had been built on the basis of an institutionalised (formal under apartheid and informal thereafter) exploitation and subjugation of the vast majority of the population. Through numerous pieces of legislation on education⁵ it had deprived the labour force of most its ability to invest in its own human capital. This was the effect of numerous pieces of legislation which affected education, job access, and rights of residence. Not only were the direct determinants of education affected, but the integrity and the support for the family unit as the incubator of human capital were also seriously compromised. The ownership and control patterns of the means of innovation within the South African system of innovation were to be identified with the early industrial mode of innovation and the dominant industrial structure in the South African economy until the end of apartheid was still firmly set within this mode.

Wolpe (1980, 1989) argued that the group areas act which moved a substantial portion of the black⁶ population to townships, homelands and *bantustans*⁷ effectively shifted the responsibility of the reproduction of labour power, or, in terms of this paper, human capital away from the private sector and the state to the family unit. The fundamental structure of apartheid could not allow for the upward mobility of the black population and this entrenched the consequent dominant early industrial mode of innovation. The human capital reproduction system which was an integral part of apartheid was also fundamental to the reproduction of this mode. The ensuing preponderance of the non-human means of innovation within the national system of innovation also resulted in high concentrations of the ownership and control patterns of the means of innovation within the system.

⁵ *Amendments to the Bantu Education Act* in 1954, 1956, 1959 and 1961; the *Coloured Peoples Act* of 1963; the *Indians' Education Act* of 1965; *Extension of University Education Act* of 1959

⁶ The term "black" is here used in the political and not the biological sense to represent all population groups disenfranchised by apartheid.

⁷ Four "independent" *bantustans* were created along ethnic lines. These were Transkei (Xhosa), declared independent on the 26th October 1976, Bophuthatswana (Tswana), declared independent on the 6th December 1977, Venda (Venda), declared independent on the 13th September 1979, and Ciskei (also Xhosa), declared independent on the 4th December 1981. The other six homelands - Gazankulu (Tsonga [Shangaan]), KaNgwane (Swazi), KwaNdebele (Ndebele), KwaZulu (Zulu), Lebowa (Northern Sotho or Pedi) and QwaQwa (Southern Sotho) - were assigned partial administrative autonomy. The several townships were created to house a permanent black labour force as "foreigners" within a "white" South Africa.

The post apartheid system of innovation was determined, virtually at its inception by the neoliberal *Growth, Employment and Redistribution* (GEAR) economic plan that was put into legislation in 1996. This plan, drafted at the zenith of the global acceptance and advocacy of neoliberalism as the only viable model of economic coordination, was premised on the assumption that the growth of the private sector would, through the “trickle down” effect, benefit the whole economy and address the inequalities entrenched by apartheid. Its critics maintained that the withdrawal of the state from the option of strategic intervention meant that there would be a structural continuity with the apartheid economy.⁸ In fact, the old structure would be reinforced since its legitimacy would be established with the end of apartheid. Thirteen years after the plan was put into effect, there is no doubt that not only did the plan not deliver on its promised growth rates but that it dismally failed to address the employment and redistribution parts of its promise. In terms of the language used in this paper the plan failed to alter the dominant mode of innovation in South Africa. Indeed it could not do so, almost by definition.

The failure of post-apartheid economic planning to create a definitive break in the evolution of the national system of innovation was threefold. The first, which was a direct consequence of the informing economic paradigm, was the drive to the liberalisation of markets and the abjuration of strategic intervention. It is difficult to see how this could have altered the inherited economic structure since it is rarely the business of business to alter the overall economic structure within which it operates. It is rather the function of the state to alter structure and to change the rules of the game within which private enterprises operate. The inter-sectoral relations inherited from apartheid, based as they were on the assumption of a generally low skills base and relatively cheap capital could not possibly be changed without an informed programme of strategic intervention designed to alter inter-sectoral price ratios. The one systemic effect of the liberalisation programme was the impact of trade liberalisation which proceeded at a rate that was even faster than that required by the WTO.⁹

The second case of failure was in those areas of state intervention that were aimed at directly altering the inequities of apartheid. Within the context of GEAR, state intervention was to be neutral and restricted to the provision of basic needs, such as housing, water, energy, health and education to households, which would raise the human capital base of the economy but which, because of its high externalities content, would not be provided by the private sector. However, there is an acknowledgement that the state has largely failed to execute this mandate both in terms of the actual levels of provision of basic needs and because of the countervailing impact of the liberalisation of markets such as transport and staple food. This liberalisation has seen the costs of the privately owned transport sector and the cost of staple food items rocketing and in effect imposing a regressive form of effective tax on the poor.

The third failure was in the redress of the disastrous spatial economics of apartheid. The redrawing of the provincial map of South Africa after apartheid should have aimed at creating sound local systems of innovations which, while different

⁸ See Adelzadeh (1996) for an orthodox economic critique of GEAR.

⁹ Lall (1993) argued that the tariff system under apartheid was perverted in that it protected mature industries with limited potential for technological advance while exposing emerging industries with a high technology potential to international competition. From this perspective, trade liberalisation would have removed the distortion effects of tariffs. However, the rapid removal of protection for labour intensive low skilled industries such as textiles and clothing caused the collapse of specific sectors and an increase in unemployment. Of course the more appropriate policy would have been to re-draw the tariff regime on the basis of some version of the “infant industry” argument.

because of different nodes of core competencies a competitive advantage would have laid a sound basis for a convergence within the national system of innovation. Instead the effect of history distorted the new economic geography to the extent that dramatic differences in the performance of the various provinces have led to a self-perpetuating and self-reinforcing path of divergence (see Scerri, 2008).

South Africa may now well be at the threshold of a possible break in the evolution of its system of innovation. This is due to a combination of three factors. The first is the long simmering and widening acceptance of the failure of the GEAR programme to achieve its stated goals. This forms the first basis of a policy equivalent of a Kuhnian paradigm shift. The second is the recent reconfiguration of the ruling party with organised labour and the South African Communist Party in the ascendance. The third is the global disillusionment with neoliberal economics which has spread dramatically with the onset of the global financial crisis. These are the preconditions for a definitive rupture in the evolution of the South African system of innovation. What is now needed for its coming into being is the introduction of an alternative planning coordination paradigm.

Conclusion

This paper hopefully provides an initial articulation of a novel approach to the understanding of systems of innovation, an approach which subscribes to a broadly Marxist analysis. If it is theoretically coherent, it will still have to be assessed on the basis of its empirical usefulness, i.e. it will still need to demonstrate a novel explanatory capability, apart from the internal logic of its argument. This is the subject of future work. The brief application of this approach to the South African case is similarly preliminary and cursory; again this is a subject that deserves a much more thorough treatment, both in the interest of doing justice to it and to assess the explanatory power of the approach.

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