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Reinventing Knowledge Systems: With an Application to Recent Systemic Changes in East and South Asia

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ABSTRACT *The paper is built around a critique of the recent book by McNeely and Wolverton, entitled Reinventing Knowledge. The paper first contests the concepts of 'knowledge' and 'institutions', before arguing that the 'systems' within which knowledge is embedded are in reality growing more and more complex. The huge scale and scope of the present-day Internet in our view invalidate their rather one-dimensional view of knowledge accumulation and their downplayed interpretation of the impact of the Internet. Our historical studies indicate that the Internet 'revolution' lies at the core of the 'Third Industrial Revolution' the advanced industrial nations are currently experiencing, which seems likely to transform the worlds that such nations are facing, not just in certain technologies or products, but in broader domains of the organization of production and innovation, their management and governance. The final section of the paper assesses the recent 'growth dynamics' in Eastern and Southern Asia and finds mostly confirmation of the points already made, in societies that eagerly await them.*

Keywords: knowledge; innovation; systems; institutions; history; Internet

1. Introduction

The work of Ian McNeely and Lisa Wolverton (2008) entitled *Reinventing Knowledge*[1] provides a compelling yet controversial picture of the evolution of institutions dedicated to the storage and production of 'knowledge', from the library at Alexandria in ancient times to the laboratory of the last two centuries or so. On the way to producing their synoptic view of institutions for containing knowledge, McNeely and Wolverton offer various asides that have courted publicity and notoriety in about equal measure; an example of some importance being their downplaying of the role of the Internet, as being simply the latest stage of the most recent phase of the 'laboratory' as the institution associated with knowledge (creation) in the modern world.

There are several potential lines of weakness in the McNeely–Wolverton argument, some of which we will explore at length in this paper, others of which we

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shall no more than note before passing on to the next. One of the latter is the question of a relationship to 'stage theories' of societal development. Typically stage theories have two main analytical requirements: first that they provide enough information to identify which stage any given society is in at any point in time; second, they ought to give some reason why a particular stage should come to an end at a particular time, and what carries the system logically on to the next stage. By these outwardly reasonable standards there is probably no historian or other academic alive or dead who has ever produced an adequate stage theory. McNeely and Wolverton's approach involves some overlaps of time periods etc.—a concession to reality but not very helpful in analytical ways. The logic of the succession is also far from transparent, perhaps involving some kind of modernization view, but if so rather muted. My approach set out later in this paper equally involves stages-like thinking, which exposes it to similar criticisms, but it does not aim at making any great theoretical contribution.

There are three particular areas to explore at somewhat greater length. The first concerns the nature of 'knowledge', and in what respects the implicit definition of McNeely and Wolverton differs from standard treatments of the subject. The second relates to the nature of the 'institutions' that they cover in the course of their exegesis, and especially their role as causes or effects of changes in knowledge accumulation methods. And the third takes up on the second point, but explores its scale and scope dimensions—thus bringing us into the realm of knowledge 'systems' and some of the heartland topics of recent times in the arena of 'innovation studies'.

These topics will be summarized in the three sub-sections of Section 2 of this paper. Section 3 will expand on the present author's work on the various 'industrial revolutions' (or otherwise 'long waves') in the history of the last quarter-millennium. Section 4 will come up to date and assess recent developments in Eastern and Southern Asia in an incomplete attempt to meet the allocated task of 'what lies beyond'. Section 5 briefly concludes the study.

2. Knowledge, Institutions and Systems

2.1. Knowledge

Several on-line critics of the book by McNeely and Wolverton have pointed out that, while it is accepted that 'knowledge' is hard to define, it does seem negligent not to have any effective definition in a monograph devoted to the history of whatever knowledge might actually be. Many of us are probably thankful that, for most purposes in our lives, it is enough to have no more than a very tacit, informal understanding of what knowledge consists of, but that raises big problems for a book with the scope of *Reinventing Knowledge*. In presenting the history as a succession of 'reinventions', the story lacks conviction unless some substance were to be given to the content, for instance of what was under attack and from what quarter.

In rather 'Whiggish' fashion, the patterning of content, or the ontological aspect of the knowledge base, is assumed to have developed as it did, purely exogenously. Parallels could be drawn with T.S. Kuhn's notion of a scientific paradigm,[2] but as just intimated, the Kuhnian approach seems considerably more subtle and better able to cope with conditions of complexity (see below).

A bigger point but one that relates to a similar context is the emphasis on formal learning procedures and thus formal knowledge accumulation. Outside of anything as radical as 'reinvention', the downplaying of the role of the Internet in the final chapter of the book comes about partly because of the rather single-minded focus throughout on formal knowledge creation processes. It is at this juncture that McNeely and Wolverton paradoxically emphasize that knowledge is much more than information—this however is an argument (which in isolation I fully accept) that in their case cuts both ways. The authors reject the Internet as a latest 'key institution', on the grounds of its continuing to use the same techniques as a laboratory, though surely the scale of production and the extent of extra-organizational impact are of a totally different order of magnitude (see below). Moreover to exclude the Internet as a new phase in knowledge development on the grounds that it has not learnt enough self-censorship seems a somewhat bizarre point to make—not least because it involves an implicit definition of 'true knowledge' that the book cannot offer to supply.

According to the language used in the work of Lundvall and various colleagues,[3] the McNeely–Wolverton analyses are drawn almost exclusively and entirely from the 'STI' (Science, Technology, Innovation) model, identified with formal search procedures[4] rather than the more fluid and flexible 'DUI' forms of learning (by Doing, Using and Interacting)—identified with learning in production or consumption as compared with learning from supplying. The links between each of these are not well developed in the literature with which we are familiar, but there is enough to go on to be assured that much is being missed in overlooking these aspects (their existence and neglect is accepted by McNeely, though the implicit losses involved are not).

2.2. Institutions

A number of the reviews of the book by McNeely and Wolverton have made the point that the nature of the guiding institutions in each of the six eras that it covers varies considerably. Four of the six are set up as organizations, and can be identified in governance terms as 'hierarchies' even though they diverge from North's definition of institutions as 'rules of the game', etc.[5] A fifth era (chronologically the fourth) is the 'Republic of Letters', essentially a closed network structure; while the next one, 'the Disciplines', would seem out on a limb as a cross-cutting ontology rather than an institution proper. Most controversially, their identification of the source of modern knowledge with the 'laboratory' suggests to them that there is nothing especially new about the Internet. I have previously used the same image of the laboratory in my own writings, and in that sense find criticism awkward; but there are issues of external as well as internal alignment that need to be resolved.

The main obstacles to an institution-centered approach to knowledge accumulation over the very long term would seem to be: (i) whether such a focus can achieve a level of explanation that is adequate enough in either logical or empirical terms; (ii) if so, the fact of having to choose at all between alternative selections of 'institutions'; and (iii) questions of alternating causality and explanations of the 'which came first?' type.

These issues raise matters of both scale and scope in relation to the production and consumption of knowledge. It is surely no accident that the modern era—alone—is being spoken of as the 'knowledge society' or 'knowledge-based economy'. Such phrasing could perhaps be a little optimistic, in heralding a false dawn, or conversely—and what McNeely would presumably claim—unduly pessimistic, in the sense of overlooking the knowledge bases inherent in past activities. Far from rejecting the latter view, I would fully endorse the point being made; however at the same time some further observation is required, namely that the composition of the 'box of tricks' which is represented by the make-up of the learning (i.e. knowledge accumulating) processes is deflecting in the direction of more structured and formalized knowledge *spread across wide portions of the community* in an advanced industrial economy of the present day. As Mowery and Sampat recently pointed out,[6] just 20 or so years ago, surveys of innovation in industries could be—and for the most part typically were—written with little or no reference to inputs from university research; now that could not be the case in any treatment trying to aim at being at least remotely comprehensive. Although such concepts as the 'Triple Helix' or the 'entrepreneurial university' may have been (knowingly?) oversold, they do contain elements of validity. Even so, there can in my view be little doubt that the main contribution of universities even in the most advanced industrial nations remains still indirect, via their supply of well-taught graduates to industry and government,[7] in which unfamiliar (to them) environments they can use the expertise they have acquired through 'learning to learn' to solve the kinds of puzzles that crop up so frequently in the firms.

Issues of 'scale' raise questions about size in relation to performance, with the latter defined in terms of output (e.g. combining two plants engaged in producing the same type of product will produce more output than the two did when operating separately) or—as the dual to this outcome under competitive conditions—of cost (the two combined plants will be able to produce the same level of output more cheaply). These can operate at any level, from an individual machine up to global levels of the whole world's machinery, so long as we are still considering the same product and process. They can potentially be found in any of the firm's productive functions—in technology (R&D), in the organization of production (production processes), in marketing (products), and in financial and other administrative systems at firm (or other) level.[8] While these are crucial for a macro-level understanding of the expansion of China and India (see Section 4 below), it is the dynamic scale opportunities opened up by modern ICTs that truly capture their key advantages—their geographical ubiquity (thus leading to the associated 'death of distance'),[9] their growing sectoral ubiquity ['chips with everything' and their General Purpose Technology (GPT) nature], their 'store and forward' nature (permitting the transformation of many services such as listening to a concert into a time-unconstrained activity, and above all the immense speed-up they offer in every application, driven by the heuristic of miniaturization. The opportunities for economies of scope, defined similarly except that we are here talking about enhanced output or reduced costs on combining different products (or processes etc.), may yet turn out to be even greater, inasmuch as there is more ground to be made up from the legacy of the past and its inefficiencies.

These issues will be considered in the context of my line of research in Section 3 below. First, let us expand on the issues of levels and of scope by looking at the kinds of systems that have been proposed for production and especially for 'innovation'.

2.3. Systems

The fields of 'innovation studies' and 'science and technology policy studies' which I have been working in for the last quarter of a century, since my arrival in SPRU in 1984, were shaken up by a comparatively slight volume produced by SPRU's first

Director, Chris Freeman, in 1987, in which he quite gently pointed out that the system of innovation that had emerged and developed after the Second World War in Japan was *qualitatively* different from the equivalent national systems in countries of Western Europe or North America.[10] This was something that my more experienced colleagues had long known about, yet it took someone of Freeman's intellectual stature to point it out, and for it to become an axis for a new way of thinking about national differences in the context of globalization. With his usual modesty, Freeman himself claimed to be predominantly drawing on classical works and especially those of Friedrich List[11] for his framework and motivation.

List and later Freeman were talking about 'national' systems of production, for reasons of catching-up in technology (especially). But systems thinking can be applied—usually with success, though sometimes only with a crash in the metaphorical gearbox—at all levels from the individual human body up to the global level, and that is just to take on the full range of spatial levels. For example, there has been a rush of recent attention at the so-called 'regional' level in regard to 'regional systems of innovation',[12] with the region here being defined as subnational (albeit not necessarily a respecter of national boundaries).

Geography however is just one way of thinking about systems. Almost as popular in recent years has been the work of Malerba and various Italian colleagues on 'sectoral systems of innovation',[13] based on the notion that different product fields as represented by (say) NACE codes for sectors have innovation structures and patterns that are internally consistent and crossing national boundaries in this respect, while being at the same time quite different in their structures etc. from any other sector or product field—compare innovation behavior in pharmaceuticals with laptop computers with the cement industry, for instance. The problems with this approach include the fact that NACE data (or any other data format) are in reality not purely organized on a product basis—instead their structure is always a pragmatic hybrid, between some sectoral boundaries that do reflect product differences, whilst others compromise by also taking into account technology differences, organizational differences, or other factors. Nor is the logic of a products dimension, which ought to place market demands on at least an equal footing with technology supply, much explored.

Roughly converse arguments apply in the case of 'technological systems', strongly pursued by a Swedish school of advocates.[14] Here it is the 'technology', such as biotechnology or information technology, which is driving the rest of the system concerned. In general, these various approaches can be brought together in an 'Archibugi box', a multi-dimensioned lattice originally proposed and used by the eponymous researcher in his doctoral thesis to classify patent systems.[15] Archibugi was pointing out that each patent could be classified not just by its technology (where it comes from), or in his terminology the patent 'subject', but also by the intended area of application (e.g. product or sector), or the patent 'object'. Given the rise of complex technological systems, in which some key 'breakthrough' technologies like ICTs could serve many markets or products, while conversely key products like automobiles were becoming 'multi-technology', e.g. with the rise of electronic control systems in the vehicles, the subject-to-object relationship was becoming, after sub-aggregation, an increasingly dense matrix.[16] This in turn implied that any attempt to convert an array of patents into a schema of (say) NACE sectors through a concordance would face growing difficulties from ignoring the 'subject' side, and hence become an increasing anachronism. Take, for instance, the example just given of car-based electronic systems—if these patents are ascribed to the auto industry rather than to the suppliers in the electronics industry, it could provide a misleading picture of innovativeness in the former (overstated) and the latter (understated). A more extreme example is that of so-called 'green biotechnology', i.e. genetic modification etc. of plants and so on: again placing all of this in the agricultural sector as the 'object' may be gross flattery of its innovation efforts, or indeed a gross indictment of them if the agricultural sector would prefer to do without GM crops.

These examples imply that the user–producer relationship between the relevant agents must be taken into account in any attempt to understand the sources of innovation, and this is where the third dimension of the Archibugi box comes into play. This dimension indeed represents the agents involved—the 'who patents?' issue. The results are often non-obvious, e.g. in cases of serendipity in patenting behavior. Unless the agents are subscripted by region, this schema does not lend itself easily to graphical forms when geography is added as a fourth dimension, not to speak of 'time' as yet another dimension (i.e. year in which the patent was filed, or granted). There is also a serious empirical problem attached to formalizing this approach, which is that most countries (Canada is the only known exception) do not publish data on the 'objects' side.

Leaving that point aside, we can find a substantial body of literature on the need for 'interactive learning', spearheaded by Lundvall's emphasis on this point in his book of 1992 on national systems of innovation.[17] Such interactivity can be vertical (up and down the various supply chains that feed into the resources and functions of micro-level units such as firms, as well as the macro level of nations), or horizontal, involving competitors or collaborators. A host of other types of agents may be involved in such interactions: clients, customers, intermediaries, banks, universities, governments, and so forth.

When we revert to the McNeely–Wolverton book, we find more micro-level rather than macro-level 'systems' under discussion—the library at Alexandria rather than a 'library system' proper, and so on. To be sure, the 'Republic of Letters' was a network, but for long quite a tiny one. In terms of the Archibugi box, 'the disciplines' are clearly 'subjects' rather than 'agents', as has already been intimated. But what is really missing from their story is much notion of interactivity. This is what distinguishes the bulk of modern universities from universities up to the Second World War, and maybe later with a few heroic exceptions. To be sure, there is still considerable antipathy in many universities from significant numbers, especially from non-science disciplines, to making them more commercially oriented.[18] However in most universities I know enough of to be able to question them on such things, I have detected some recovery of confidence in recent times.

3. Constructing and Deconstructing Innovation Systems in History

The solution presented here (as well as in some earlier work) is an updated economic historian's view of industrial history as evolving through a sequence of 'industrial revolutions'. According to my rough chronology these emerged at intervals that occurred almost exactly a century apart, following a surprisingly similar path in each of the three 'industrial revolutions' to date. This contrasts with a long-wave interpretation of the pathways to fix the most commonly recurring problems facing these economies; an account which rests on the emergence of 'techno-economic paradigms' (TEPs) at intervals originally decided by Kondratiev and Schumpeter of 50±10 years.[19] Thus Freeman and Louçã[20] present a thought-out

Table 1. Long-wave interpretation of TEPs since industrialization

Technical and organizational innovations	Dates	Key inputs	Managerial and organizational changes	'Carrier' industries
Water-powered mechanization of industry	1780s–1848	Iron, raw cotton, coal	Factories, entrepreneurs, partnerships	Cotton spinning, iron products, bleach
Steam-powered mechanization of industry and transport	1848–1895	Iron, coal	Joint-stock companies, subcontracting	Railways, machine tools, alkalis
Electrification of industry, transport and the home	1895–1940	Steel, copper, alloys	Professional management, Taylorism, giant firms	Electrical equipment, heavy engineering, heavy chemicals
Motorization of transport, civil economy and war	1941–??	Oil, gas, synthetics	Mass production, Fordism, hierarchies	Automobiles, aircraft, refineries
Computerization of entire economy	??–??	Integrated circuits	Networks	Computers, telecoms, biotechnology

Source: Freeman and Louçã (2001, p. 141), simplified by present author.

schema that takes the story from the First Industrial Revolution in Britain in the late eighteenth century to the present day, in the course of which it logs up some five long waves built around each successive TEP in turn: water-powered, steam-powered, electrification, 'motorization' and lastly computerization (see Table 1).

In Table 1, the 'techno' side of the TEPs (techno-economic paradigms) is given by the first and third columns, while the 'economic' side emerges from columns 4 (organizational aspects) and 5 (markets). In column 1 it will be observed that in all periods except the final one, the technological paradigm chosen has to do with power and energy forms. With the passage of a few more years we are now a little more ready to fill in the blank dates at the foot of column 2—the missing date from the end of the motorization wave and the start of the general computerization wave could be put anywhere between 1989 and 1991, with a slight preference for the middle year of 1990 (ending of the Cold War with reunification of Germany; development of HTTP, HTML etc. as the major steps by Berners-Lee *et al.* at CERN, etc.). The final column gives some indication of the potential scope for market opportunities associated with each technology. Column 4 will be linked to its rival format in Table 2 for a multitasking set of managerial and government responses.

Table 2 therefore adds my interpretation of the historians' tradition of 'industrial revolutions', indicating another way of considering the long-run experience. The table in fact updates and extends my earlier work on the subject,[21] with some changes of heart in the final column.

The first and most obvious contrast with the long-wave view in Table 1 is the fewer number of 'waves', plus the equally obvious point that there are chronological gaps between these waves. The industrial revolutions portrayed in Table 2 are periodic events—the consequences of 'punctuated equilibria'[22] or of 'fast history'.[23] The intervals between can be thought of as periods of 'exploitation' of the main technological consequences of the 'exploration' phases set out in this table, to use the language of James March.[24] Such 'exploitation' can involve the

Table 2. Industrial revolution interpretation of TEPs since industrialization

		First Industrial Revolution	**Second Industrial Revolution**	**Third Industrial Revolution**
Approx. dates		1760–1815	1870–1914	1973–
Head location		Britain	USA, Germany	E & S Asia
Technological paradigms	Manufacturing	Machinery	Chemicals	ICTs, biotech
	Energy	Water, steam	Electricity, oil	Renewable, nuclear
	Materials	Iron	Steel, plastics	Nanomaterials
Automation of		Transformation	Transfer	Control
Process type		Labour	Capital	Information
Market size		National	International	Global
Size of firm		Small	Large	Mixed
Scope of firm		Specialization	Internal integration	External integration
Production scale		Local	Multiregional	Multinational
Organization		Entrepreneurial	Multidivisional	Networked
Industry structure		Competitive	Oligopolistic	Mixed
Type of capitalism		Proprietorial	Managerial	Collaborative
Mode of governance		Markets	Hierarchies	Networks

fusion between the manufacturing, energy and/or materials technologies listed in the table, or the widening of the range of applications sectors (the 'carrier industries' of Table 1) in the GPT sense. Thus the gap between 1815 and 1870 is marked by first the massification of steam power in the textile manufacturing industries, and later by the application of steam to transportation via the coming of the railway system. Similarly the gap between 1914 and 1973 is characterized by the fusion of electricals and chemicals in fields of electro-chemicals, by the adoption of oil in the automotive industry, and by the extension of electrical technologies into electronics from the early years of the twentieth century, paving the way for the next revolutionary period after about 1973. It hardly needs stating that the dates are conventional, and the choices of illustrative material both in the table and in this discussion highly incomplete.

It needs underlining, however, that as between the periods of technological exploration and technological exploitation, the two sides of the techno-economic paradigm get out of kilter. The periods denominated in the table may be those with high rates of emergence of new technologies, but they tend to be also periods of slow economic growth at the macro level.[25] There are various possible explanations for this so-called 'productivity paradox' (so named in the wake of Robert Solow's quip from the late 1980s: 'You can see the computer age everywhere but in the productivity statistics'). The first and most obvious explanation for the lag in productivity growth comes down again to questions of scale—their diffusion simply has not proceeded far or fast enough to make any perceptible positive dent in the macro-level numbers. This factor naturally can account for much of the noticeable shortfall in the growth of output or productivity compared with initial high expectations, but as an explanation, this rather begs the question of why diffusion rates for such evidently superior items were not much greater, even though they seemed high enough by past standards. To answer this formally would take us into complexities of intertemporal elasticities of supply and demand—places not desirable to visit in this critiquing paper. Essentially, on the supply side the costs of product and process development long remained high and in certain respects actually continued to rise in unit terms, for example as design complexity increased so did the associated real unit costs.[26] Production costs however began to fall after a time, when capacity had risen to capture some economies of scale. On the demand side, it took until the mid-1990s, when the user-friendly Web, high-speed search engines, laptop download capacity, cheap mobile phones etc., had not just appeared but had major price advantages over competitor forms of data transmission and generation, for the computer-based network systems to 'fly'.

This seeming misalignment between the technological and the economic sides of the TEP—which if our argument is correct is rather a situation of alignment occurring only after the occurrence of very 'long and variable lags'—helps account for the poor results that many scholars have obtained in econometric and other exercises on productivity or competitiveness indicators. To claim that the results come out weakly is not to prove that the relationships do not exist. It is possible that McNeely and Wolverton have been seduced by such apparent inconsistencies into arguing for the comparative unimportance of the Internet, whereas my argument above would draw precisely the opposite conclusion.

The other lines in Table 2 have for the most part been considered before, and I do not propose to repeat myself. The main additions to my earlier works as previously cited above are more on scale and scope effects, and more on the demand or market sides. The row entitled 'market size' compares the international markets of the Second Industrial Revolution period after 1870 with global markets from 1973—the difference is reflected in the quite orthodox model of trade and exchange in the former years with primary resources being exported from the colonial empires (both formal and informal, and including ex-colonies such as the USA) in exchange for their imports of consumer manufactures and capital goods from the industrial countries of Europe, and the much more interwoven structures of trade in recent times, counting thus as a more truly globalized level of interchange.

The remaining rows, though not given explicit attention here, do show how much the production and innovation systems have changed in each century's pattern of transition. It is not just a matter of some new technological knowledge coming on-stream, because to accommodate this involves for a start a broader set of matches between the supply factors directly associated with the new knowledge and the demand side to adjust to—and perhaps further promote—these supply-side shifts, through changes in both market quantities (scale) and qualities (scope). Assisting in these new sets of matchings, and probably critical for them, are radical changes in processes (Table 2), in organization and management (Tables 1 and 2) and in modes of governance (Table 2). The chicken-and-egg question of the order in which they arise, which I have tried before to solve by using concepts such as 'coevolution',[27] must await more detailed examination in future research.

One final change in Table 2 as compared with its predecessors does however merit further attention here, and that is the issue of 'head location' for the core of the new activity. In my first attempt to devise such a table about a dozen years ago,[28] I broke a self-imposed rule of not having the same entry in two cells of the same row. Specifically I put the USA alongside East Asia as the likely 'winners' in the Third Industrial Revolution, as well as being found to have already been a winner in the second period. At that time few were thinking about the potential of the 'sleeping giants' of China and India, and particularly about how quickly they would awaken. In the table as now revised I have instead inserted 'East and South Asia' as the head locations, although the USA might still outperform the others in non-ICT fields such as biotechnology or parts of nanotechnology.

4. New Techno-economic Systems in East and South Asia

The main aim of this section is seeking to understand the nature of 'new' forms of growth dynamics in the countries of Eastern and Southern Asia, in the context of the 'global knowledge-based economy'. It is taken from the introduction to a forthcoming book[29] that sets out to examine the interaction among these multiple strands of new developments in a selected subset of Asian countries or regions, namely China, South Korea, Taiwan, Singapore and India, and covers the period from the 'Asian crisis' of 1997/8 until the onset of the global financial crisis in 2007/8 (which these countries seem to be weathering much better than Western industrial nations). What the book is finding that is 'new' about recent Asian growth dynamics includes the following five strands: the contextual base, the technological base, the geographical base, the political economy base and the policy base.

4.1. Contextual Base: The 'Global Knowledge-based Economy'

The concept of the 'global knowledge-based economy' is far from new, but envisaging recent Asian developments in this context does shine new light on the subject. Previous views have focused on the electronics industry and its conditions of production, in which these Asian countries appear to demonstrate relentless superiority. However within those countries there is emerging a shift of emphasis from electronics to ICTs and their use, and from production to 'knowledge'. Wong[30] has urged the need to draw distinctions between:

(a) the *ICT production* sector that creates, makes and distributes ICT appliances and equipment;
(b) the *information content* production sector that creates, makes and distributes information contents and services;
(c) the *ICT network infrastructure* providing for connectivity; and
(d) the *informatization* component, where ICT goods and infrastructures are utilized to access and consume information contents.

These distinctions are central to understanding a 'new international division of labor' in Eastern and Southern Asia that is arising partly in the form of and partly in response to the dramatic rise of China and India. This re-division of labor implies a global basis of interactions around knowledge and learning, in terms of: (i) technological and market convergence; and (ii) external as well as internal dynamics.

4.2. Technology Base: The Convergences of Technologies and Markets

Again, the subject of technological 'convergence' has been around for several decades, but the emphasis in analytical assessments that lie beyond crude marketing 'hype' is on the likely *pervasiveness* of technological change, as expressed for instance in: (i) long wave views, that argue for a shift from an early narrow sectoral focus on production to a long-term spread of use; and (ii) the 'e-paradigm' ('e' here being meant in the ICT sense) as in countless e-services as well as products (e-business, e-commerce, e-government, etc.).

This shift implies a new emphasis that is less on narrow convergence of technologies (e.g. between computer and telecommunication technologies) and more on a broader convergence between the (converging) technologies and their markets. This in turn implies a refocus from supply (technology) to demand (applications), which carries very broad implications, such as: (i) a new level of complexity of interactions, where these are becoming of the many-to-many kind, as the number of sectors affected diversifies rapidly; (ii) a spread of use from the 'high-tech' product arena to remaining sectors of advanced industrial economies, i.e. to the great majority of output and employment; and (iii) a spread of input sources, including those for 'technology' but also for the market-based areas of knowledge, as part of the new demands on 'dynamic capabilities'.

The global sourcing of 'technology' in this broad sense brings into play global knowledge bases including a role for other regions—and thus spatial complexity alongside technological complexity.

4.3. Geographical Base: The Rise of China and India

The increasing heterogeneity of technologies has opened up many new niches for smaller countries, yet the effects of scale and market power seem to be evident in the overshadowing impact of the rise of two new superpowers in the ICT arena—the formerly quiescent nations of China (on the hardware side) and India (on the software side). Their strengths lie in large-scale adoption of labor-intensive but time-saving activities.

To some extent, though not yet fully evident, the rise of China, especially, may denote a decline of Japan as compared with its old position in the Triad. Some loss of Japan's old 'locomotive' role in the wider region seems evident. The extent to which this may be compensated by migration 'upstream' into high value-added activities, including technology development, remains to be seen, but is of substantial interest to other countries that may be envisaging a similar future for themselves.

In other respects Japan appears to be 'joining' the new regional pattern through offshoring etc., rather than trying to 'beat' it. The other countries that are of concern here are being compelled to refocus in the light of the rise of China in particular, and this appears common to many of the countries and regions examined here. The choices they face include low-wage competition with China/India, or developing new market niches, or informatization strategies (i.e. shifting from producing to using ICTs). Each has advantages and disadvantages that are of general interest, since other countries are likely to be caught up in similar choices in times ahead. For the Asian countries, any change may be problematic because of path dependencies in the electronics/ICT field.

4.4. Political Economy Base: Collaboration with Competition

Linking together the changes in context, technology and geography as described above are changes in 'political economy', in which collaboration coexists with competition, contrary to theoretical perspectives and to many expectations. Despite this, such coexistence is not necessarily new, since Germany for instance developed along with 'collaborative capitalism' for many decades,[31] yet this was long seen as a deficiency in such countries, whereas enlarged networking is more often nowadays seen as the secret of success. The reasons for this change of view need not be elaborated here, but developments within the Eastern and Southern Asian region do provide some new twists to this tale. The offshoring or outsourcing of components, assembly and services, together with the rise of new integrative roles for Asian multinational companies (including those from countries other than Japan), are acting as key drivers of this new organizational structure.

In the realm of technology more narrowly, while much remains to be done to bring about the 'convergence' between technologies and markets, what is new is a *vision* of the 'knowledge-based society', going under the neologism of 'informatization' across the Asian countries. This vision represents a shared take-up across all interested parties. We describe this as the E–M–U paradigm, adopting the terminology of successive government policy programs. It goes beyond the e-paradigm (of electronics) into the m-paradigm based on complete 'mobility', and ultimately to the u-paradigm of 'ubiquity', according to which 'anyone, anytime, anywhere' will be digitally connected, with full security. It involves extensive cross-sectoral and cross-functional R&D. In its intended realization, old distinctions between high-tech and low-tech sectors, and between manufacturing and service production, will be eroded. It involves moving on from ICT production (hardware) to the production of information content, infrastructure and 'informatization'.

These developments within the Eastern–Southern Asian region have their match in developments in the global economy in similar directions, even if at a less accelerated pace, like global offshoring, including that of technology and design, and new roles for global MNCs. China, India, etc. are fostering centers of excellence both within the country and abroad that appear to buttress their strengths in production, and betoken yet more dramatic shifts in the international division of labor. Other polities may need to readjust radically to these developments.

4.5. Policy Base: Mobilizing and Energizing the Knowledge

The particular policy mixes adopted by governments within and without the region have to be envisaged in these settings, in order to promote growth and cohesion. The main drivers are increasing complexity (in technologies and markets, etc.) and increasing globalization (via collaboration plus competition). Interactions within government are required to prepare 'joined-up policy' to meet these complex demands—what might be called an 'internal alignment' of the policy mix. In practice we observe chaotic mixes of policies and policy-makers, not least in countries such as China and South Korea that are heading many of these new developments, alongside repeated attempts to improve policy structures and policy learning therefrom.

'External alignment' of the policy mix involves new kinds of interactions between states and markets—and here we make the point that it is indeed becoming an issue of 'states *and* markets' rather than 'states *versus* markets'. This goes beyond the notion of 'governing the market' adduced by Wade for Taiwan,[32] to a bi-directional interdependence. It involves institutions and IPRs in the process of market-making but also market-tolerating. The arenas for potential conflict are many (e.g. top-down vs. bottom-up decision-making), and the resolutions merit close attention.

5. Conclusions

Clearly our analysis is quite different from that of McNeely and Wolverton as regards their most controversial finding, that the Internet is no more than another stage along the path towards confirming the 'laboratory' as the key institution for developing knowledge in the modern era. Such a view, in our opinion, masks huge differences of scale and scope between the laboratory and the incipient global knowledge-based society even if one can readily concede that we collectively are still some way short of achieving this latter vision.

In Section 2 of the paper, we assessed the McNeely approach in relation to three perceived analytical shortcomings, namely their treatments of knowledge itself, of institutions and of systems (of production and innovation particularly). In Section 3 we charted our own considerably more complex 'system' and how empirically it has evolved over a period in which those authors would regard it as doing little more than 'treading water'. In Section 4 we provided a richer story, admittedly highly condensed, of how the East and South Asian countries are now evolving, and what their own visions for ICTs consist of. At the same time, I would personally like to add my appreciation to them for provoking some rethinking on my part, to say nothing of the much wider public that their work has reached.

Notes and References

1. Ian F. McNeely with Lisa Wolverton, *Reinventing Knowledge: From Alexandria to the Internet*, W.W. Norton, New York, 2008. All further references to these authors will be based on this work.
2. As argued in Thomas S. Kuhn, *The Structure of Scientific Revolutions*, 2nd revised edition, University of Chicago Press, Chicago, IL, 1972.
3. For example, Morten Berg Jensen, Bjorn Johnson, Edward Lorenz and Bengt-Ake Lundvall, 'Forms of knowledge and modes of innovation', *Research Policy*, 36, 5, 2007, pp. 680–93.
4. See especially, Franco Malerba, 'Learning and incremental technical change', *Economic Journal*, 102, 1992, pp. 845–59.
5. Douglass C. North, *Institutions, Institutional Change and Economic Performance*, Cambridge University Press, Cambridge, 1990.
6. David C. Mowery and Bhaven N. Sampat, 'Universities in national innovation systems', in Jan Fagerberg, David Mowery and Richard Nelson (eds), *The Oxford Handbook of Innovation*, Oxford University Press, Oxford, 2005, ch. 8.
7. As summarized in the paper by Ammon J. Salter and Ben R. Martin, 'The economic benefits of publicly funded basic research: a critical review', *Research Policy*, 30, 3, 2001, pp. 509–24.
8. Sigbert J. Prais, *The Evolution of Giant Firms in Britain: A Study of the Growth of Concentration in Manufacturing Industry in Britain 1909–70*, Cambridge University Press/NIESR, Cambridge, 1976.
9. Frances A. Cairncross, *The Death of Distance: How the Communications Revolution is Changing Our Lives*, revised edition, Harvard Business School Press, Cambridge, MA, 2001.
10. Christopher Freeman, *Technology, Policy, and Economic Performance: Lessons from Japan*, Pinter, London, 1987.
11. Friedrich List, *The National System of Political Economy*, 1841, translated by Sampson S. Lloyd M.P., 1885 edition; cf. Christopher Freeman, 'The national system of innovation in historical perspective', *Cambridge Journal of Economics*, 19, 1995, pp. 5–24.
12. Summarized in Bjørn Asheim and Meric Gertler, 'The geography of innovation', in Fagerberg *et al.*, *op. cit.*, ch. 11.
13. Summarized in Franco Malerba, 'Sectoral systems: how and why innovation differs across sectors', in Fagerberg *et al.*, *op. cit.*, ch. 14.
14. See for example Anna Bergek, Staffan Jacobsson, Bo Carlsson, Sven Lindmark and Annika Rickne, 'Analyzing the functional dynamics of technological innovation systems: a scheme of analysis', *Research Policy*, 37, 3, 2008, pp. 407–29.
15. Daniele Archibugi, D.Phil. thesis, SPRU, University of Sussex, 1989.
16. G. Nicholas von Tunzelmann, *Technology and Industrial Progress: The Foundations of Economic Growth*, Edward Elgar, Aldershot, 1995.

17. Bengt-Åke Lundvall (ed.), *National Innovation Systems: Towards a Theory of Innovation and Interactive Learning*, Pinter, London, 1992.
18. Arianna Martinelli, Martin Meyer and Nick von Tunzelmann, 'Becoming an entrepreneurial university?: a case study of knowledge exchange relationships and faculty attitudes in a medium-sized, research-oriented university', *Journal of Technology Transfer*, 33, 2008, pp. 259–83.
19. Nikolai D. Kondratiev, *The Major Economic Cycles*, Moscow, 1925, translated in 1984; Nikolai D. Kondratiev, 'The long waves in economic life', *Review of Economic Statistics*, 17, 6, 1935, pp. 105–15; Joseph A. Schumpeter, *Business Cycles: A Theoretical, Historical, and Statistical Analysis of the Capitalist Process*, McGraw-Hill, New York, 1939.
20. Chris Freeman and Francisco Louçã, *As Time Goes By: From the Industrial Revolutions to the Information Revolution*, Oxford University Press, Oxford, 2001.
21. For example, Nick von Tunzelmann, 'Innovation and industrialization: a long-term comparison', *Technological Forecasting and Social Change*, 56, 1997, pp. 1–23; and Nick von Tunzelmann, 'Historical coevolution of governance and technology in the industrial revolutions', *Structural Change and Economic Dynamics*, 14, 2003, pp. 365–84.
22. Joel Mokyr, *The Lever of Riches: Technological Creativity and Economic Progress*, Oxford University Press, Oxford, 1992.
23. Burton H. Klein, *Dynamic Economics*, Harvard University Press, Cambridge, MA, 1977.
24. James G. March, 'Exploration and exploitation in organizational learning', *Organization Science*, 2, 1, 1991, pp. 71–87.
25. Nick von Tunzelmann, 'Technology generation, technology use and economic growth', *European Review of Economic History*, 4, 2000, pp. 121–46.
26. *Ibid.*
27. von Tunzelmann, 2003, *op.cit.*
28. von Tunzelmann, 1997, *op.cit.*
29. Nick von Tunzelmann, Marc Bogdanowicz and Annaflavia Bianchi (eds), *The New Dynamics of Growth and Change in Asia*, World Scientific Publishing, Singapore, forthcoming 2010.
30. Poh-Kam Wong, 'The challenge of ICT cluster development in Singapore', in *Growing Industrial Clusters in Asia*, IBRD/World Bank, 2008, pp. 91–146.
31. Alfred D. Chandler Jr, *Scale and Scope: The Dynamics of Industrial Capitalism*, Belknap Press, Cambridge, MA, 1990.
32. Robert Wade, *Governing the Market: Economic Theory and the Role of Government in East Asian Industrialization*, Princeton University Press, Princeton, NJ, 1990 (revised edition, 2003).