Chapter 12[1]

Technology, Modernity and Development: Creating Social Capabilities in a POLIS[i]

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> He puts his engine [a watch] to our ears, which made an incessant noise like that of a water-mill; and we conjecture it is either some unknown animal, or the god that he worships; but we are more inclined to the latter opinion.
>
> Jonathan Swift, *Gulliver's Travels (1726)*

> We Westerners are absolutely different from others!_ - such is the moderns' victory cry, or protracted lament_. They do not claim merely that they differ from others as the Sioux differ from the Algonquines, or the Baoules from the Lapps, but that they differ radically, absolutely, to the extent that Westerners can be lined up on one side and all the cultures on the other, since the latter all have in common the fact that they are precisely cultures among others. In Westerners' eyes the West, and the west alone, is not a culture, not merely a culture.
>
> Bruno Latour, *We Have Never Been Modern (1993)*

1. Introduction

E. M. Forster, in his novel *Passage to India* observes that the "restfulness_ of an Indian gesture reveals a civilization which the West can disturb but will never acquire."[ii] In this brief passage

[1] Forthcoming, in Philip Brey, Andrew Feenberg and Tom Misa eds. Technology and Modernity: The Empirical Turn, The MIT Press, 2002

Foster sets up the dichotomies between East/West in terms that can reveal in their ambivalence a deconstructive gesture, perhaps unknown to its individual 'Western' author, that has the potential to interrogate the key terms of this essay. For technology, modernity, development - all three of these terms - are to be written under such a deconstructive gesture. The tension that is inherent whenever such theoretical terms are used with intended empirical correlates comes quickly to the fore under such writing *sous rature* which is also a way of putting these terms under question marks.

Such is the intention of this essay. Yet this venture is fraught with the perils of relativizing these terms, erasing their meaning and perhaps ultimately pointing to nihilism. How does one give the study of technology, modernity and development an 'empirical turn' under such circumstances? Reflection on this question soon leads to another. How does one offer a theory of technology, modernity and development so that correct empirical applications are indeed within reach? Therefore, the first task is to take seriously the tensions within the theoretical terms leading to a real threat of their dissolution (destruction - in Heidegger's terms). An analysis of these tensions and a way out of them will seem to be the minimum theoretical conditions for an empirical turn to be meaningful. Such an analysis also carries the potential for exposing the contradictions inherent in modernization theories and the conventional dichotomies encapsulated by the simple oppositional formula of an East-West dichotomy.

Accordingly, I will begin with some analysis of the theoretical connections among technology, modernity and development in a 'non-western' context. The discussion here is intended to suggest some methodological aspects of connecting theories of modernity with empirical approaches in the context of technology and development. Of particular significance are the modern/postmodern aspects of technological development in the newly industrialized economies (or NIEs). I will try to draw some lessons from my own studies of the Taiwanese innovation system. The argument presented here

will entail some suggestions for future directions of empirical investigations in other non-western societies and some warnings about possible pitfalls in this type of work. Throughout the essay the idea of technological systems as social, economic and political constructions that are historically path-dependent will play a crucial role.[iii]

2. Technology, (Post) Modernity and Development: The Western/Non-western Distinction

If the very nature of technology is put under scrutiny and thus problematized, we end up with what Hughes (1987) calls "messy, complex, problem-solving components._ Any such system gives rise to problems (reverse salients in Hughes' terminology) that require further negotiations. In Pinch and Bijker's (1987) study of the bicycle they underline the historicity and social construction of the very idea of the 'safety bicycle' in the 19th century during a protracted process of problem formulation, stabilization, and (social) closure. Thus, they point out:

> The invention of the safety bicycle was not an isolated event (1884), but a nineteen year process (1879-98). For example, at the beginning of this period the relevant groups did not see "
>
> the safety bicycle_ but a wide range of bi- and tricycles - and among these, a rather ugly crocodile-like bicycle with a relatively low front wheel and rear chain drive_. By the end of the period, the phrase safety bicycle denoted a low-wheeled bicycle with a rear chain drive, diamond frame, and air tires. As a result of the stabilization of the artifact after 1898, one did not need to specify these details: They were taken for granted as the essential ingredients_ of the safety bicycle.[iv]

If technology as a theoretical term and its empirical correlates are thus shown to be socially contested and constructed over significant time intervals(see also Schott's contribution

to this volume), the connection between technology and modernity are twice problematized. In the first place the ensemble of attitudes and institutions which are assumed to be coterminous with the idea of modernity are themselves in flux and need to be described as a system in motion. In the second place technology, as a crucial dynamic component of modernity is also destabilized and is itself destabilizing; it can find stabilization only through a set of historically contingent interplay of social forces. In this context, what the economic historians like Paul David (1985) or theorists such as Brian Arthur (1994) have called "path dependence" needs clear articulation and focus in the social construction of temporal sequences of technological systems and sub-systems. These sequences can now be seen as elements picked from a large set of intertemporally connected technologies. Indeed one can redefine the traditional choice set of microeconomic theory from one which deals only with an object of individual choice to the social choice of technology in historically conditioned and socially contingent circumstances. This redefinition of choice, as we shall see, can have rather profound theoretical and empirical consequences.

Recognition of the problem of path-dependence as a problem of sequencing (and sub-sequencing) of historically and socially contingent technological trajectories at once creates an opportunity and a seeming impasse. Grasping the contingency aspect gives a strong justification for specific, empirically grounded projects in technology studies. However, if contingency is all there is then there seems to be no way out of pure (Humean) empiricism. Avoiding such an empiricist (as opposed to merely empirical) turn requires an epistemological grounding beyond that of sense-data. But this is precisely where the dangers of a subjectivist neo-Kantianism or dogmatically objectivist realism become the greatest. This is also the point where debates on modernity/post modernity often lose their way into a nihilistic type of relativism.[v]

One way out of the impasse is to take the idea of freedom as a key feature of technology, modernity and development (Sen 1992; Khan 1998). As we shall see we are by no means free to characterize freedom any way we like. However, for the moment I want to take freedom as a primitive term and examine the claim that it is a key ingredient of all three of my principal terms in a provisional way. For this purpose, and for this purpose only, it is sufficient to think of freedom as an extension of the scope of action for the individual, society or nature.

Limiting ourselves thus to such a thought experiment with freedom we can think of technology as extending our scope of action over space and time. Such an extension is institutionalized in the history of development in the 'west' through a 'coherent' set of social, economic and political institutions and articulation of ideologies of modernity.The chapter on the contested rise of modernity in technology politics in this volume(by Johannes Schot) describes the complex forms such articulations and practices can take. Development, in this (western) sense, then, means the extension of similar types of technological progress embodied in similar types of institutions and expressed in similar ideational forms, for example, the modernization ideology.

The extensive debates on modernization, westernization and progress have put these ideas through much critical sifting. Very little that is intellectually coherent remains after the colonizing (sometimes racist), imperialist, and patronizing shibboleths are laid to rest. In fact, the very dichotomy East/West seems to be a peculiar 'western' hegemonic construction that remained uncontested only so long as the incoherence of modernity itself remained unrecognized.[vi] One way to read (sympathetically) the modern/postmodern debate and the Jihad/McWorld type of polarization (Barber 1995; Khan 1996, 1998) is to see in these a visceral response to modernity both in the "west_ and in the "east_.

Yet what is often lost in the intense heat of such debates is the intuition that the notions of technology, modernity and development all have to do with enhancing a complex sort of freedom. It is only through clarification of the meaning of freedom and its connection with the other terms that we can hope -if at all - to avoid the destructive (again in Heidegger's sense) implications of postmodern gesture. But to avoid the simplistic slogans of modernization/anti-modernization, westernization/nativism or development/non-development we must deconstruct in order to reconstruct the meaning of freedom. Again, the entire literature of postmodern and post-structuralist questioning is valuable precisely for this reason. But we need to find a way out of simple and misleading nihilism. We need to fight our way out of a complacent irony into the "real"[vii] world of uncertainty and confusion. I want to show that this movement in thought brings us face to face with technology as creativity. I also want to draw attention to the close links between technology as creative activity and human freedom as social capabilities (Sen 1992; Khan 1998; Levine 1997). Finally, I wish to explore the connections between this approach and reflexivity as a socially embedded relation. In the next section I proceed to discuss critically the relationship between technology, growth and development in the context of reflexive modernity and reflexive development.

3. Technology, Modernity and Development: Refractive Reflexivities

Ulrich Beck's (1992) contrast of a 'simple modernity' with reflexive modernity has opened a wide area of reflection on matters central to the concern of this chapter. If advanced capitalist societies (presumably they are more developed) have entered a stage that Beck calls the "risk_ society, are the less advanced to be characterized as simple "scarcity_ societies with simple

modernity as the project of social, political and economic construction? Raising the question in this way allows one to reflect on the nature of the construction of a plurality of modernities. It may turn out that simple vs. reflexive modernity or simple vs. reflexive development are intellectual dichotomies that are too neat to sustain in the face of global complexities.

As Szerszynski et al. (1996: 6-7) point out:

> *Risk Society* itself had raised worries for many readers that Beck seemed to be offering a vision of a kind of hyper-Enlightenment where individuals and institutions were becoming increasingly able consciously to reflect on the premises of their own and others' commitments and knowledge claims.

However, in Beck et al. (1994) the possibility of an automatic and blind reflex is also acknowledged. For Beck risk societies are led by the riskiness of large-scale chemical, thermonuclear and other technologies to an abyss beyond calculability.

If reflexive modernity is limited in this way to a non-predictive society where any convergence to a semblance of a solution is contingent upon processes that are only partially visible and much less under anyone's control, then reflexive development can not be any more than only a partial attempt to manage the problems of development. Thus the whole idea of developing into modernity through technical progress is made opaque. This opacity is not natural, but rather political, social and cultural. In fact, it can be said to be an integral part of the modernist project. There is a large irony involved here -- the modernist project that emphasizes self-awareness and reflexivity is largely unaware of the limits of such reflection, and the continuous production of opacity in the social, political and the ideational realms. This is a tendency that is so pervasive that perhaps we need a name for it. Since one of the key aspects of the phenomenon I have in mind is an endemic distortion it may be appropriate to call this a "refractive_ reflexivity.

Under conditions of refractive reflexivity our partial knowledge and further reflections do not necessarily converge to a given, 'optimal' solution in the economist's sense. Rather, the institutional setting in which the discourse is carried out determines to a large extent the limits of our reflections. Wynne's example of the struggles between the sheep farmers in the north of England and the scientists from various agencies shows empirically how refractive reflexivity is indeed a question of power and not merely a debate on epistemological matters. Dependence on the power of experts leads to a 'constructed' insecurity and anxiety. Lack of democracy heightens such dependence.[viii] In his discussion of the contested construction of modernity in technology politics in this volume Schot mentions the strikes in Rotterdam docks in the earlier part of this century against grain elevators that were unforeseen by both the capitalists and the socialists--- each group under the thrall of modernist rationality in its own way.

To clarify further, conceptually refractive reflexivity can be seen at two distinct but related levels. First, at the level of the individual, it is the limitedness of rational calculation that appears to be primary. In this sense, refractive reflexivity points to the bounded nature of individual rationality.Miscalculation,limited computability, uncertainty and unintended cosequences are endemic. At best, reflexivity marks an incomplete rationality at the individual level.

The second, social aspect of reflexive rationality is perhaps even more important.Here, we have the social embeddedness of virtually all human institutions, including the 'reflexive' institutions of modernity.Take for example, the universities---perhaps reflexive institutions per exellence. Yet, in the history of the modern universities unforeseen developments arising from deeper social and economic forces have shaped the discourses and practices more than the conscious strategic plans that the administrators produce with such readiness and regularity.In the economic

sphere, the sharp debates on macroeconomic policies, technology and industrial policies, trade policies etc. result in partial advances at times; but the complex domain of socially embedded institutions make the economic policies less than optimal and subject to revisions that themselves are subject to revision without ever converging to an optimal trajectory even in a limiting sense.Political conflicts of the sort discussed by Schot and others in this volume are inevitably a part of this complex, non-convergent process.

Postulating refractive reflexivity as a dominant condition of modernity and development can help us grasp why such fear and anxiety are part and parcel of these constructs. It can also help us understand why 'scientific' surveys of risk can exacerbate this anxiety. Unlike Latour (1993) who claims that 'we have never been modern' I observe that the refractive nature of our reflexivity shows that modernity can never escape its own complexities and contradictions. There is no epistemic safehouse of alterity to be found in a pre-modern or undeveloped state of affairs.[ix] Technological development is also a refractive development. It enhances as much as it distorts our freedom to become fully human as the next section shows.[x]

Like Beck, then, I accept that "the critical issue is that industrial society sees itself as risk society and how it criticises and reforms itself_ (Beck 1996: 34). But the refractive operations of the social body and the unevenness of the distribution of power are precisely at stake here. What is implicated through the globalization of the risk society even when scarcity persists both as an ideological construct and a real redistributive issue could be described as the limits of a (fractured) global society's capacity for self-correction. Under a fractured globalization (Kumssa and Khan 1999) there is both globalization and regionalization of risk. Through the export of risk to the South through relocation of dangerous industries, poor countries

may become an ecological waste dump for the wealthy "risk_ societies. There may also be some import of risk in the form of communicable and infectious diseases from the south to the north.

All these interactions between risk societies and the rest of the world under the program of a new liberal international economic order also create risk awareness and conflicts among different groups. Hence the transnationalization of a critique of science, technology and corporate policies is countered by partial co-optation and intensification of efforts to offer technocratic solutions. Even NGOs are not immune from this counter-counter movement on the part of the modernizing forces.

Thus we have to confront a situation in the field of development that can not be simply characterized as a modernization/economic growth perspective to be opposed by a social transformation/multi-dimensional perspective. The problem is deeper than the simple dichotomies (economic/non-economic, one/many, or modernization/alternative development). Beck's insight that "the critique itself must be democratised and _ a critical theory of society will need to be replaced by a theory of societal self-critique_ applies here exactly. In the never-ending process of questioning one's proneness to refraction, conscious reflection clearly plays a key role. But so do qualities such as empathy, compassion, and more than mere intellectually consistent regard for others by self-regarding individuals.

If the argument with regards to refractive reflection and the need for bringing both our intellectual and emotional resources to our collective rescue is correct, then freedom for the individual and for society involves a new recognition of necessity. A necessity for self-critical and other regarding reflection as well as the limits of such instrumentally rational reflection becomes apparent. In contrast to the classical meaning of the phrase, *freedom is the recognition of necessity*, necessity here points to the need for going beyond instrumental reason to call upon

the totality of our humanness and creative power so that new institutions of solidarity and freedom can be built globally. Only from such a perspective of freedom can we assess empirically the nature of technological systems and their development in 'non-western' parts of the world.

4. Freedom as Social Capability and Development as Freedom

Amartya Sen, the recent Nobel laureate in economics, has done much to broaden and deepen the discussion of freedom in development economics. Sen's initial project was to offer a critique of utilitarianism and social choice theories based on utilitarian approaches. Eventually the critique led to a complete rejection of utilitarianism in favor of a framework of positive freedom called capabilities. Aristotelian philosophers such as Martha Nussbaum have pointed out the ambivalence in Sen's initial formulation of capabilities approach. In Nussbaum's view, an Aristotelian approach based on a concrete concept of a good life_ is a better foundation for the capabilities approach than the classical liberal view of individual goods being determined by individuals' subjective preferences. Khan (1998) attempts to establish a dialectical relationship between the individual and the (ethical) community and thus bring out the fully social nature of capabilities. While the determination of capabilities can be social, their concrete manifestation is only possible through individuals. Individuals are the bearers of capabilities. Calling capabilities social merely draws attention to the fact that freedom of individuals to lead a certain life is always already constructed and constrained by their social context.

At this point, a partial list of the most important capabilities may make matters concrete for the reader. In table 1 (compiled by David Crocker 1995), 'N' and 'S' refer to Nussbaum and Sen.

Table 1: Social Capabilities

1. Capabilities in Relation to Mortality 1.1. N and S: “Being able to live to the end of a complete human life, so far as is possible” 1.2. N: “Being able to be courageous” 2. Bodily Capabilities 2.1. N and S: “Being able to have good health” 2.2. N and S: “Being able to be adequately nourished” 2.3. N and S: “Being able to have adequate shelter” 2.4. N: “Being able to have opportunities for sexual satisfaction” 2.5. N and S: “Being able to move about from place to place” 3. Pleasure 3.1. N and S: “Being able to avoid unnecessary and non-useful pain and to have pleasurable experiences 4. Cognitive Virtues 4.1. N: “Being able to use the five senses” 4.2. N: “Being able to imagine” 4.3. N: “Being able to think and reason” 4.4. N and S: “Being ‘acceptably well-informed’ 5. Affiliation I (Compassion) 5.1. N: “Being able to have attachments to things and persons outside ourselves” 5.2. N: “Being able to love, grieve, to feel longing and gratitude” 6. Virtue of Practical Reason (Agency) 6.1. N: “Being able to form a conception of the good” S: “Capability to choose”: “ability to form goals, commitments, values” 6.2. N and S: “Being able to engage in critical reflection about the planning of one’s own life”	7. Affiliation II: “Being able to live for and to others, to recognize and show concern for other human beings, to engage in various forms of familial and social interaction” 7.1.1. N: Being capable of friendship S: Being able to visit and entertain friend 7.1.2. S: Being able to participate in the community 7.1.3. N: Being able to participate politically and being capable of justice 8. Ecological Virtue 8.1. N: “Being able to live with concern for and in relation to animals, plants and the world of nature” 9. Leisure 9.1. N: “Being able to laugh, to play, to enjoy recreational activities” 10. Separateness 10.1. N: “Being able to live one’s own life and nobody else’s” 10.2. N: “Being able to live in one’s very own surroundings and context” 11. Self - respect 11.1. S: “Capability to have self - respect” 11.2. S: “Capability of appearing in public without shame” 12. Human Flourishing 12.1. N: “Capability to live a rich and fully human life, up to the limit permitted by natural possibilities” 12.2. S: “Ability to achieve valuable functionings”

Both Sen and Nussbaum agree that these capabilities are distinct and of central importance. One cannot easily trade off one dimension of capability against another. At most, one can do so in a very limited way. They cannot be reduced to a common measure such as utility.

As Crocker points out 'capability ethic' has implications for freedom, rights, and justice going far beyond simple distribution-of-income considerations. If one accepts the capability approach as a serious foundation for human development (see Sen 1992, Khan 1995) then it follows that going beyond distributive justice is necessary for a complete evaluation of the impact of economic policies.

The social capability approach outlined above emphasizes the positive freedom to choose a good life. Given the limitations of space, it is impossible to elaborate on all the aspects of both well-being and agency freedoms that such a concept of development must encompass. I will briefly touch upon the area most relevant to the theme of this chapter: the freedom of difference and diversity in developing societies attempting to 'modernize'.

The postmodern turn has correctly focused our attention on these two aspects of our planetary civilization in the age of high technology -- especially transportation, information, and communication technologies. The goal of modernization theories in the past was to emphasize a certain kind of uniformity that might obtain with economic growth and technical progress: free markets, formal democracy, high technology, westernization and related values. The recent revival of these ideas in the international organizations and in western academia has less to do with their intellectual merits than with the collapse of any coherent alternative vision of development. The relativism (and in extreme cases nihilism) fostered by the postmodern turn has not prevented - and cannot prevent - this narrow 'modernism' from being the only game in town.

In contrast, the emphasis on freedom in a socially determinate way that follows from the capability approach is indeed a viable alternative to an intellectually discredited and narrow form of modernism. By celebrating differences of race, gender, and ethnicity, and emphasizing the underlying unity of our need to develop the above-mentioned functionings, the capability approach can offer a clear-sighted alternative to both an absolutist modernism and an indiscriminately relativist postmodernism. Fostering technology systems congruent with these goals would seem to be especially relevant for such an approach to development. A critical look at technology systems in the newly industrialized economies such as South Korea and Taiwan can help ground the discussion in concrete, theory-based empirical research. Before such an examination can be carried out, however, we need to address an important puzzle regarding the capabilities approach as an appropriate evaluative framework.

5. A Non-essentialist View of Capabilities: A Network Approach to Technology and Capabilities

The foregoing account of development as the process of human flourishing through the positive freedom of capabilities can help to overcome the nihilism of the postmodern turn. However, doesn't it carry some danger - even with the qualifier 'social' tacked before capabilities - of an essentialist bias? The question is a serious one because, as Feenberg (1999) reminds us an essentialist view of technology interprets a historically specific phenomenon in terms of a transhistorical conceptual construction."[xi] If this is true of technology, it can apply in a similar way to a historically formulated view of capabilities as well.

Therefore, it is important to add that capabilities are fully social only when they can be viewed in concrete, historical context. Viewed in this manner, they appear not as some unchanging human nature or need, but as an evolving, socially mediated sense-making activity of what human needs really are in the context of the actual evolution of human societies and artifacts.

The last word in the last paragraph -- artifacts -- is not accidental. Humans make artifacts and are in turn transformed by them. This is not technological determinism. Rather, to put it in Latour's terms, there is a need to go beyond purification -- the forcible separation of nature and society -- and acknowledge the hybridity that modernity produces. The complex production of hybridity is both an integral part of modernity and a problem that it generates. Going beyond this into a "parliament of things_ acknowledges the network of quasi-objects that exist as the very condition of our own existence and discourse.

Thus, taking the capabilities perspective beyond a 'humanist' interpretation will involve integrating a non-essentialist, network approach to technology with a view of humans as one significant form of life among others. At the same time, the human social and political activities - interpreted historically and in a field of social networks and forces - must be given their appropriate recognition. Without such recognition the very meaning of the lived world of humans and technology is in danger of serious distortion. In his critique of Heidegger's 'seen-from-above' view of modern technology Feenberg expresses this point quite forcefully:

> From the standpoint of the ordinary human being - and even system managers and philosophers are ordinary human beings in their spare time - networks are lived worlds in which humans and things participate through disclosive practices.[xii] This lifeworld of technology is the *place of meaning* in modern societies. Our fate is worked out here as surely as on Heidegger's forest paths. (Feenberg 1999: 197) [Italics mine]

If technologies and human beings are thus formative of the same network, space is opened from below for a genuine critique of technology, modernity and development. I would argue that this is in fact where the empirical turn beyond the East/West dichotomy should really take us. In the next section I offer a critical empirically-based view of the National Innovation Systems (NIS) in developing countries. Arguably, what the developing countries need - to anticipate a little - are not systems of innovation from above in order to catch up with the 'West' but rather the creation of a Latourian parliament of things. But, first, it is necessary to clarify the relationship between technology and democratic freedom in the context of development.

When the process of development is characterized as the creation of social capabilities, the issue of positive freedom comes to the foreground. Political freedom, that is, the freedom of citizenship, is inextricably connected with any reasonable list of positive freedoms. In order for citizenship to be meaningful citizens must be able to participate fully and democratically in the affairs of society and the state. I have used the term 'deep democracy' to underline the necessary capabilities – economic, social and cultural – that must exist for citizenship to make any sense at all.[xiii] In a similar way Feenberg (1999) stresses the importance of agency .

In this context, claims Feenberg, the fundamental problem of democracy today is quite simply the survival of agency in the increasingly technocratic universe._

> The design of technical institutions disqualifies modern men and women for meaningful political participation. The division of labor becomes the model for the division of society into rulers and ruled. As in the factory or hospital or school, urban centers, media, even unions are reconstructed around the paradigm of technical administration. Expertise legitimates power in society at large, and 'citizenship' consists in the recognition of its claims and conscientious performance in mindless subordinate roles. (Feenberg 1999: 101)

Feenberg analyzes this translation of the efficiency of technocratic system into legitimacy via the delegation theory of Latour. In this theory norms are delegated to technical devices. Even Latour's simple example of a device for automatically closing the door embodies such a norm. Much more than simple conventions are at stake when we move from a door-closing device to the organization of technical-social life in areas such as education, scientific training and practice, medicine and health-care delivery systems or public administration. The rise of technocracy and an elitist, hierarchical order is ultimately tied with a certain anti-democratic conception of development through technical progress (Khan 1997, 1998). In applying the theoretical framework developed above to understand the creation of technical modernity two approaches – both seemingly empirical – are contrasted. The first, national innovation system, approaches the problem of technology and development from above. Hence, it remains trapped in a technological determinism. The second, alternative approach, emphasizes the role of democratic struggles in choice, development and design of technology. Clearly, agency, conceived in a non-essential, heterogeneous way – particularly the agency of the non-elite, ordinary people – plays a key role in this alternative empirical approach to technology in developing societies. This approach, called POLIS (positive feedback loop innovation structure) is cognizant of the complex interactions among technology, economy and polity. Ultimately it emphasizes the teleological desideratum of equalizing social capabilities as the end of development. Given this end, technology is much more than an instrumental means. Depending on how the above relations are conceived,institutional structures can be judged as promoting more or less freedom in concrete historical contexts.

6. Empirical Approaches to Technology, Modernity and Development: A Critique of National Innovation Systems

One appropriate example – one might even be tempted to say, an exemplar – of the multiple contradictions between technology systems in a modernizing, development context and democratic norms of freedom is the idea and practice of national innovation systems (NIS). The concept of NIS, like many other concepts in the field of economics of innovation, was originally proposed for analyzing the advanced industrial countries (Freeman 1987; Nelson 1993; Lundvall 1992). As a systems-oriented, holistic way of thinking about technological change it has undoubted strengths. By identifying links between R&D, human resources development, formal education and training, as well as innovating firms, NIS presents an analytical schema for relating a cross-cutting array of activities that lead to a dynamic innovative economy. The proponents of this approach also advocate an 'evolutionary' as opposed to a mechanistic approach (based on classical physics-type study of equilibria) for studying the economics of innovation.

Given the obviously sincere and serious intentions of the theorists of NIS, and the intellectual break with neoclassical economics, the study of NIS held out promises of both retrospective understanding of economic history and a prospective, prescriptive approach to help countries innovate. Nowhere was this promise more eagerly believed than in the developing countries. No one was more excited by the prospects of NIS than the avid modernizers in their governments, universities and international organizations and think tanks. I have documented in great detail elsewhere (Khan 1997, 1998, forthcoming) the reach and sweep of NIS in newly industrializing countries such as South Korea and Taiwan.

Yet, so far the thinking about NIS, and its connections to modernity and development, have been entirely technocratic. The argument always proceeds in terms of the function of technologies and their role in increasing GDP-per-capita in the most efficient manner. The intense and

inconclusive debate raging with respect to whether East Asia has really grown because of a simple accumulation of labor and capital, or because of productivity increase through genuine technical progress and learning illustrates neatly this technocratic bias. Neither side is willing to step beyond the economic inputs and outputs, production functions and technology as a black box. It is, of course, important to know whether learning has taken place in, for instance, textiles or electronics sectors. But there is no recognition of the point made by Feenberg and others, namely that design ... incorporates broader dimensions about social values_ (Feenberg 1999: 86).

This "cultural horizon_ of NIS, which legitimately can be said to constitute a hermeneutic, interpretive dimension, should offer some interpretative flexibility. A recent paper by Murata (1999) illustrates the relevance and importance of such interpretative flexibility by simple but elegant examples such as the go-slow street barriers (to restrict speed) and harnessing the driver of a car to the key to prevent her from leaving it in the car in a fit of forgetfulness. When an underdeveloped economy accepts an NIS whose components come from abroad, a society-wide hermeneutic process is unleashed. Yet this is where the interpretative flexibility is frequently blocked by the closure imposed undemocratically over the rest of the population by the technocratic elite and their modernizing allies from the "west_.

Such premature closures can certainly produce success stories in modernist technological terms. In Taiwan, for example, NIS has succeeded to the extent that it has been able to capture worldwide market shares in several high technology areas. The Taiwanese manufacturers' swift capture of the lion's share of world information technology hardware markets is nothing short of amazing. In most relevant product categories Taiwan has greater than 50 percent market share. In some categories such as scanners it has almost cornered the whole market. In many other high

technology areas also companies based in Hsinchu Science Park have been quite successful. Yet, this very exporting success may have forced the Taiwanese companies to seek a closure that largely excludes the domestic constituencies.[xiv] The preferences of the technical, business and bureaucratic elites, only, are reflected in the design and development of technology in the Taiwanese NIS. A more detailed empirical analysis can substantiate this critique.

The key conceptual term in my critique of the NIS is the idea of a positive feed back loop innovation system (POLIS).POLIS can be seen as both a critique and an extension of NIS. Like NIS, POLIS also emphasizes the salience of institutional structures, both economic and non-economic, in the creation of positive feedback loops in terms of technical progress and productivity increase.However,going further, POLIS connects such technical progress as may occur also to the normative issues of enhancing freedom in all spheres--- economic, political and cultural. Using the terminology introduced earlier, we can say that POLIS enhances both economic productivity and social capabilities.

Taiwan: Building a POLIS?

In this sub-section, the theoretical model developed above informs an analysis of a leading East Asian ‘miracle_ country -- Taiwan. The history of development of Taiwan shows a greater reliance on direct foreign investment, more direct government ownership of enterprises, and the greater role of small and medium enterprises in the manufacturing sector than the other large East Asian “miracle_ economy, South Korea.

The early development policy in Taiwan was aimed at increasing agricultural output, developing an infrastructure, and promoting light manufacturing industries. Import-substitution was pursued till the mid-1960s. U.S. foreign aid played a crucial role in financing imports and

early capital formation. Even though the theoretical thrust of aid was to help the country modernize, a curious silence pervaded the technical analyses when it came to structures of authority. In fact, quite often, anti-democratic structures were strengthened by such aid.

Taiwan's switch to a regime of export promotion took place in the mid-1960s, as in South Korea. Initially, the government backed exports of the light manufacturing industries such as textiles and consumer electronics. At the same time, Taiwan pursued a long-term strategy of building a more complex industrial structure including steel, petrochemicals, machine tools and electronic equipment.

The new outward-looking strategy was accompanied by a series of financial and fiscal measures to facilitate export financing and to help establish export processing zones. From the beginning, Taiwan made a special effort to promote high technology sectors through publicly funded research laboratories. Later, an industrial park at Hsinchu was created specifically for high technology industries.

In the wake of the 1973 oil crisis, the government introduced a policy of major infrastructure projects and subsequently promoted , the capital goods producing sectors. As a result Taiwan broadened its export base to include machinery and related equipment. The second oil shock led to substantial changes in Taiwan's industrial policies. The country's overcapacity and the lack of competitiveness in a number of firms were addressed by a strategy of scaling-down industrialization plans. Strategically selected firms, however, still received special grants and loans. Foreign investment in capital-intensive sectors was encouraged further to effect a transfer of technology and knowledge.

A new orientation in the 1980s emphasized high technology and skill-intensive activities. Specifically, three areas -- information, electronics, and machinery -- were identified as

strategic. Products targeted for special treatment included precision instruments, machine tools, VCRs, telecommunications equipment, and computers.

In spite of its openness, flexibility, and strategic vision, the Taiwanese economy has yet to create a well-balanced POLIS. The predominance of small firms is a handicap where high-tech ventures require large R&D expenditures. The strategic complement of R&D -- skilled human components -- may also create a bottleneck in some sectors. More importantly, a hierarchical, authoritarian managerial and financial control structure may prevent a democratizing move toward equalizing capabilities. Both within the enterprises and at the macroeconomic level the task of making power responsible has been very difficult. Thus, whether Taiwan has succeeded in creating a POLIS is a non-trivial question. However, there is one particular sector -- electronics -- in which Taiwan has achieved a mature capability to innovate. A discussion of the electronics sector can serve as a prelude to a discussion of an economy-wide capability to innovate.[xv] Even here, the detailed empirical investigation will expose crucial areas of difficulty in making innovation and control genuinely democratic.

The Electronics Sector in Taiwan

From humble beginnings in the 1950s -- when Taiwan first started producing transistor radios --, the electronics sector has grown to include many advanced products. Among them are the various components of personal computers, advanced work stations, and other microelectronic products. Companies such as Tatung and ACER have sales exceeding one billion dollars. A number of small firms such as Sampo Corporation and United Microelectronic Corporation have shown tremendous growth in recent years. The share of foreign-owned firms also declined during the 1980s and 1990s. However, even now foreign-owned firms account for more than 25 percent of the electronics industry's output.

Small- and medium-sized firms (defined as firms with less than 300 employees) dominate the industry. This means that innovation in Taiwan unlike South Korea occurs in relatively small firms.

Table 2 shows the plans for the year 2004 for the electronics industry.This can be compared and contrasted with the situation in 1990. In 1990,Nearly US$ 6 billion of total computer production was exported, with information products leading the way. Of this 40 percent went to North America and 41 percent to Europe. Japan imported only 2 percent of the computer exports; but Asia-Pacific accounted for about 14 percent.

Table 2: Electronics and information technology, production values and forecasts (US$ billions)

	Output 1990	Forecast 2004	Average annual growth (%)
Information products	6.9	34.0	15.1
Automation	2.8	12.0	13.5
Consumer electronics	2.3	6.5	7.0
Telecommunications	1.9	10.2	16.0
Semiconductors	1.5	8.0	14.8
Total	15.4	70.7	

(Source: Hobday 1995: 100; 2004 estimates by the present author)

Although the take-off in the electronics sector appears to be a market phenomenon, government policies played a key role. In May 1979, the Executive Yuan put forth the Science and Technology Development Program, which identified information technology systems as an area of emphasis for future R&D. The idea for an Institute for Information Industry also emerged during this period.

The Ministry of Economic Affairs moved quickly. In July 1979, the implementation plan for computer technology was contracted out to the Industrial Technology Research Institute. The Council for Economic Planning and Development prepared a ten-year plan, 1980-1989, which provided targets for R&D expenditures and human capital supply. The Electronics Research Services Organization took charge of coordinating the transfer of technology from foreign companies. These responses were technocratic and frankly authoritarian. No democratic pretenses were expected or offered.

By all indicators the ambitious plans succeeded for the most part. Many new companies, such as the success story Datatech, were started in the 1980s. By the 1990s Taiwanese firms were among the world's innovative designers of PCs, electronic notebooks, and circuit boards. During these years Taiwan also surpassed Great Britain to become the world's fifth largest producer of semiconductors.

Under an overall imitative strategy (Chiang 1990) Taiwan decided to follow the leaders in already established technologies and to compete by cutting costs through production efficiencies. The government has taken the responsibility for acquiring technology from abroad. It has also fostered advanced research. The government-supported research institutes, utilizing skilled scientists and engineers, have conducted the research, and the results are then transferred to the private sector. Furthermore, economic incentives are provided to the strategic sectors. In terms of complementary human capital accumulation many Taiwanese went abroad to acquire advanced education and skills in science and technology. A number of local employees were also trained in the foreign multinationals where they were employed as engineers, technicians, and managers. Lucrative financial incentives were offered to attract skilled Taiwanese living abroad.

As Hobday (1995) points out, there are at least five types of strategic firms in the electronics industry. These are: foreign corporations and joint ventures; the major local manufacturing groups; high technology start-up firms; government-sponsored ventures; and the traditional small and medium enterprises that cluster together in special market niches. Strategic interactions among these actors resulted in the industry's rapid growth and expansion as a whole even as some individual firms declined. There is an almost classic Schumpeterian 田reative destruction_ scenario. It is also classically undemocratic -- a phenomenon not noticed by technocratic analysts such as Hobday.

Hobday (1995) has discussed the role of the major private manufacturing groups and government-sponsored start-ups in Taiwan. The following brief discussion highlights the actions of these diverse economic agents in creating the conditions for a 哲IS_ (but not 撤OLIS_) within the electronics sector, and, through its linkages, in the broader economy.

The Electronics Sector: Firms

The progress of the industrial group Tatung, according to Hobday, is representative of the entire electronics industry in Taiwan. In the 1970s, electronics became the industrial group's largest operation. The electronics maker began to produce black and white TVs by 1964, VCRs by 1982, and fourteen-inch color monitors for computers by the early 1990s (see table 3). The company currently produces a range of household electronics and electric goods in its manufacturing plants around the world.

Table 3: Tatung's Progress in Electronics

Product	Introduction date
Black and white TVs	1964
Color TVs	1969
Black and white TV picture tubes	1980
VCRs	1982
High resolution color TV picture tubes	1982
PCs	mid-1980s
Hard disk drives	mid-1980s
TV chips/ASICs	late 1980s
Sun workstation clones"	1989
Fourteen-inch color monitors	1991

Tatung, like the typical South Korean *chaebol*, first gained its manufacturing knowledge through technical cooperation deals. By investing capital in joint venture projects with foreign companies, the Tatung group participated in licensing agreements while learning technological

skills through original equipment manufacturing_ (OEM) deals. Tatung absorbed and adapted foreign technology, learning to modify, re-engineer, and re-design consumer goods to fit customer needs. While initially production involved little R&D, by 1990 the group employed more than 500 R&D staff. However, the job of this staff was mainly in advanced engineering rather than 'blue sky_ research. Finally, by the mid-1980s Tatung was transferring its production technologies to its subsidiaries in lower cost East Asian countries.

ACER is representative of the high technology start-up companies which began to appear in Taiwan in the late 1970s and early 1980s. For years, ACER relied on product innovation and original equipment manufacturing (OEM) with experience gained by individuals who had worked overseas in U.S. firms or universities (see table 4). Many of the other recent start-ups, like ACER, have used OEM to some extent, and most were unknown outside of Asia despite brand name sales.

Table 4: ACER: Behind-the-Frontier Innovations towards an NIS

Year	Innovation
1984	Developed its own version of the 4 bit microcomputer (later followed by 8 bit, 16 bit and 32 bit PCs)
1986	Launched the world's second 32 bit PC, after Compaq but ahead of IBM
1988	Began developing supercomputer technology using the Unix operation system
1989	Produced its own semiconductor ASIC to compete with IBM's PS/2 technology
1991	Formed a joint company with Texas Instruments (and the Taiwanese government) to make memory chips (DRAMs) in Taiwan
1992	Formed alliances with Daimler Benz and Smith Corona to develop specialist microelectronics technology
1993	Produced a novel PC using a reduced instruction-set (RISC) chip running Microsoft's Windows NT operating system
1993	Licensed its own US-patented chip technology to Intel (in return for royalties)
1993	Received royalties from National Semiconductor, Texas Instruments, Unisys, NEC and others for licensing its PC chipset designs

ACER, according to many observers, exemplifies the strengths and weaknesses of Taiwan's high technology start-ups. ACER started with only 11 engineers in 1976; its total sales reached some US$1.4 billion by 1993. ACER lead the local computer industry in the 1980s with 60 percent of sales being name brand through "own-brand manufacture_ (OBM). The company began to distribute

directly to customers abroad in this decade to challenge other brand leaders and move beyond OEM. However, the company retreated from this forward strategy after heavy losses between 1990 and 1993.

The above discussion suggests the uncertain position of companies like ACER. On the positive side, these companies were able to benefit tremendously from the improving technological infrastructure and established market channels; they were able to bypass the "consumer_ electronics phase of the 1970s and to enter the market at a higher technology level; and they have benefited greatly from managers and engineers educated abroad. On the other hand, these companies have encountered many difficulties as latecomers. For ACER, the company sustained heavy losses in own-brand sales. This forced the company to retreat to its earlier OEM strategy, once again making ACER dependent on the global leaders of core technologies. Unless and until these latecomers develop in-house technologies, they will be unable to compete with the global leaders on an equal basis.

The final grouping to be discussed here is the government-sponsored start-ups. Table 5 shows the companies working at the government-developed Hsinchu facility and their relationship with international companies. With these special start-ups, the government has taken a "hands on_ approach offering direct and indirect assistance, including tax incentives and loans, and the use of science park facilities at Hsinchu to entice overseas Taiwanese to return to Taiwan. In one case, MTI, a telecommunications equipment maker, the government was greatly responsible for initiating this firm. In another instance, the government arranged for technology transfers for Winbond Electronics Corporation. Winbond's founder and eventually many of its employees came from the Industrial Technology Research Institute, a state-controlled organization that trained engineers in advanced semiconductors. With government-sponsored technology transfers, Winbond was able to compete not only locally but internationally as well. However, problems with shortages

in investment capital, poor brand name recognition, and uncertain distribution arrangements kept the company dependent on international leaders for technological innovation and capital goods.

Table 5: High-technology Start-ups in Hsinchu Science-Based Industrial Park during the 80s

Firm	Start date	Sector	Sources of senior staff, technology and training
Microelectronics Technology Inc.	1983	Telecom	HP, Harris, TRW
United Fibre Optics Communications Inc.	1986	Telecom	Sumitomo, Philips, AT&T, STC (UK)
TECOM	1980	Telecom	Bell Labs, IBM
Macronix	1989	Semiconductors	Intel, VLSI-Tech
Winbond Electronics Corp.	1987	Semiconductors	RCA, HP
Taiwan Semiconductor Manufacturing Corp.	1987	Semiconductor foundry	Harris, Burrows, RCS, Philips, IBM

(Source: Hobday, 118)

The United Fibre Optic Communications Inc (UFOC), despite an auspicious start, faced many of the same problems of other late-coming start-up companies in Taiwan. The government, specifically the Ministry of Economic Affairs Industrial Development Bureau, felt that Taiwan

needed an indigenous fiber-optic producer. This ministry called together the four largest copper producers within Taiwan and the local telecommunications operator to form a joint venture company, UFOC. The new venture sought licensing agreements with four other international companies, finally deciding on AT&T. Faced with the difficult choice of continuing to purchase its know-how from international competitors or investing heavily in its own in-house technology, these companies have typically relied on the former for continued learning and technology. This suggests some of the difficulties of latecomers in overcoming the OEM path to further development (Hobday 1995). The underlying problem, from the point of view of creating a POLIS, is that neither the state policies nor the private enterprises attempt to directly address the question of creating social capabilities. It is as if the battle for economic gains has crowded out all other considerations. Economic models, no less than technological systems, are path dependent, too.

As scholars of technology have pointed out, initial disputes and controversies about technologies and their characteristics are "closed_ by making one configuration the privileged one (van den Belt and Rip 1990), or using Kuhn's later terminology, an exemplar. The exemplar then defines the boundaries of discourse, establishing the standard way of seeing both problems and solutions. This paradigmatic artifact and associated procedures establishes a "technological frame_ (Bijker et al. 1987: 167-87). The world of technology and people are, to a significant degree, perceived only within this frame. The faltering attempt to build a POLIS in Taiwan shows how the elite-based model of NIS has served as a systemic exemplar.[xvi] One might speak of a "development frame. "

As I have argued elsewhere, in the case of the so-called developing countries the debate on what 'development frame_ to choose was foreclosed very early on (Khan 1997, 1998). After WWII, the two dominant paradigms of development – western capitalism and Soviet-style socialism – both

advocated large-scale, heavy industry. The role of technical elites was paramount in either case. It was only through the 'deviations' of Chinese socialism in the countryside in the 1950s and 1960s, and the revolt against technology in the west in the late 1960s, that technocracy came to be questioned. Yet the seeming triumph of capitalism globally in the last two decades, and the imposition of a neoliberal order through the structural adjustment programs, narrowed the debate once again to state vs. market, technological learning vs. factor accumulation, and other oppositional terms.

What needs to be done in the way of posing a theoretical challenge is to bring the normative issues connected with freedom as social capabilities raised earlier to the fore in discussing the creation of a NIS in an economy and society. In Taiwan NIS has apparently succeeded. But the normative issues are still very much contestable areas of discourse, as indeed are the technologies and practices themselves. As Taiwan matures as a polity and society such contests are likely to be more visible. The refractive relexivities of modernity will manifest themselves, as they already are to some extent in the sphere of ecology, through a complex set of social, economic and political struggles that cannot be predicted in advance.

It is in this context that I have proposed replacing the idea of the national innovation systems with a new concept that recognizes the connections – often suppressed or ignored – between technology, on the one hand, and the culture and politics of modernity, on the other. Coining a new abbreviation for the "positive feedback loop innovation structure_ or POLIS,[xvii] I wish to draw attention precisely to the political and cultural aspects of NIS.Normativity of social life and struggles for freedom are paramount aspects of this complex concept. Furthermore, replacing the word 'system' with 'structure' is signals the contradictory elements within the 'innovation systems'

and the society where these are to be implanted. There are many concrete aspects of NIS that appear in a different light when we think of them as part of a POLIS. Two examples will suffice.

First, NIS in the developed countries embody assumptions regarding citizen's rights, environmental regulations, and the needs of at least the higher categories of workers (for instance, the so-called knowledge workers)[xviii]. By contrast, the NIS –as they exist – in developing countries would often exploit child workers and women, turn a blind eye to environmental degradation and violations of citizen's rights. When these are pointed out, the response – not too infrequently – is that these are the necessary prices to pay for development and modernity. Conceptualizing the innovation process as a POLIS, on the other hand, immediately draws attention to the lack of congruence between technology and social capabilities, including the suppression of democratic freedoms. Future empirical work along these lines of actual development processes can reveal these contradictions and perhaps suggest various democratic ways of resolving them, at least partially.

My second example has to do with information technology as a component of NIS and POLIS. The standard NIS approach is to see information technology as the harbinger of a new era in a globalized economy. If this is so, IT will certainly result in a new technological regime, as Rip and Kemp (1998) have defined it.[xix] Again, since such regimes make up the totality of technology_ and pre-structure the the kind of problem-solving activities that engineers are likely to do_ there is a huge component of path dependence at issue. Without quite recognizing it, we may well be choosing the contours -- the structures that enable and constrain -- our future society.

If IT will result in a new technological regime in this sense in developing societies some socially relevant questions must be asked. A perspective of POLIS leads to such a set of critical questions. For example, what are the social values at stake here? Are we going to emphasize efficiency in hierarchically organized production as the prime value, or will we think of

citizenship, social communication, creation of public sphere as equally important? Who will define the 'technical code'? How will these codes be institutionalized? How will IT be codified in the developing societies when the codification is already under question in the 'west'? Will the progressives, including scientists, engineers, students, intellectuals and ordinary people in these "modernizing_ societies join with the critical-minded progressives from the 'modern' west? Or will they simply follow the "imperatives_ of the computer, software and telecommunications companies and their own modernizing impulses? Or, will they turn their back completely to modernity, counter-culture fashion?

These are complex questions that force us to confront a complex reality. Will the Latourian "parliament of things_ arrive in both East and West thus erasing one of the invidious distinctions between these two equally imaginary (in the Lacanian sense) entities, or will the status quo continue? It can, of course, get much worse than that. Positive feedback loops accentuate precisely and remorselessly the initial differences between the advanced and the backward regions -- unless countervailing action is taken. Perhaps a new internationalism from below will recognize and strengthen the actor network that can realize a reflexive modernity (which, of course is also refractive at the same time) with progressive technological structure leading towards increasing at least some of our salient social capabilities. However, at this time, it is not clear what particular social and political conditions can make such an internationalism from below a real historical prospect.

7. Conclusions

The social and political failures of "successful_ information technology and other high technology firms in Taiwan and elsewhere in developing countries are empirical data that need to be taken seriously in science and technology research. So long as one focuses on narrow economic costs and benefits, tidy indicators of success and failure can be constructed. Part of the point of this paper has been to warn the readers against such narrow interpretations of success and failures.

Broadening our criteria, however, means questioning modernity and development in the specific contexts of technology policies. A critique of national innovation systems is an example of such a contextual approach. Contrasting NIS with POLIS reveals the technocratic bias and non-democratic framing of technologies even in technologically modern and economically successful developing countries. This is far from an accidental -- though by no means inevitable -- result. It is rooted in the historical development of imperialism, and the attendant international division of labor. Ironically, achieving technologically based modernization, viewed through the uncritical lens of NIS is usually misconstrued as the inevitable necessity of constructing an NIS in a world that is really the result of a series of concrete historical contingencies. Clearly, this epistemological gesture cannot envision a process of development where technology can be designed and controlled through a deep democratic process.

An economic (and perhaps even technological) determinist position argues that first the poor countries must grow rich by adapting an elite-defined NIS and other policies for economic growth. Only later, when the country is more affluent can the people afford luxuries such as democratic freedoms and ecological consciousness. This position ignores both the real historical democratic tradition and ecological awareness in indigenous peoples' cultures because its modernist bias and determinism will not allow such 'anomalies_ to enter into the modernization paradigm. Yet, as Latour has so acutely observed, the current collective global situation will not allow

such easy recipes for success. Attitudes and practices must change – in the "east_ as well as in the "west._ Ironically, it may be more difficult, as the empirical study of Taiwan here illustrates, to recover and extend democratic freedoms and transform the NIS into a POLIS when too much economic "development_ has already taken place. Only a series of further negotiations within the economy, civil society and state -- the outcomes of which are far from transparent -- can determine whether the move from the NIS to POLIS can be made by the newly industrialized economies. However, this future, though far from completely open, is not simply one inscribed by a closed national system of innovation. But such critical alteration through the creation of a POLIS will require the transformation of the machines of dominance -- to use an expression close to Deleuze and Guattari's usage -- into a trnsformed politics of fluid democratic rhizomes, as opposed to the biopolitics of a society of discipline and control.

FOOTNOTES

[i] I would like to thank Karin Hillen and Gyeong Jei Lee for excellent research assistance. Pat Baysa also provided valuable assistance. Comments from David Hess, Michiel Korthals and other workshop participants -- Thomas Hughes, Arie Rip, Tom Misa, and Philip Brey in particular -- were very helpful in preparing the final version. All remaining errors are my own.

[ii] E.M. Forster, *A Passage to India* (New York: Grosset, 1952; first published 1924), pp. 251-52

[iii] This idea is elaborated on later; here it can be thought of as somewhat akin to 'the seamless webs' described by Bijker, Hughes, and Pinch (1987: 9-15), or more particularly of Callon in the same book. It should be clear, however, that my epistemology and ontology are firmly non-relativistic, yet postmodern.

[iv] Pinch and Bijker (1987: 39).

[v] On this, see Lyotard (1979, 1988, 1993), Derrida (1981,1988), Rorty (1989). In Khan (1998) I have tried to move the modern/postmodern debate beyond the rather sterile terminological controversies about high, late, advanced, neo (and other) types of modernity. Reflexive modernity (Beck 1992; Bourdieu and Waquant 1992; Beck, Giddens and Lash 1994; Giddens 1991) is another fruitful point of entry into a similar set of issues.

[vi] On this see the very illuminating *Orientalism* and *Imperialism and Culture* by Edward Said. See also Hay (1970).

[vii] Even Derrida has been moved to remark: "A few moments ago, I insisted on writing, at least in quotation marks, the strange and trivial formula, 'real-history-of-the-world', in order to mark clearly that the concept of text or of context which guides me embraces and does not exclude the world, reality, history. Once again … as I understand it (and I have explained why), The text is not a book. It is not confined in a volume itself confined to a library. It does not suspend reference - to history, to reality, to being, and especially not to the other since to say of history, of the world, of reality, that they always appear in an experience, hence in a movement of interpretation which contextualizes them according to a network of differences and hence of referral to the other, is surely to recall that alterity (difference) is irreducible. Difference is a reference and vice versa." (Derrida 1988: 137)

[viii] The distinction between formal and deep democracy (Khan 1998) is important to keep in mind here.

[ix] This is one of the important points made by Latour (1993). See especially the chapter on Revolution and his discussion of the "Principle of Symmetry Generalized".

[x] It should be clear to the reader that I do not object to 'collectives' as ensembles of human and non-human agents or even 'actants' as explanatory categories. However, the issue of becoming human remains salient. I do not think that Latour's 'anti-humanist' position would reject this. However, to the extent that certain anti-humanist positions do reject the salience of 'becoming free human being', I am willing to part company with them without getting back into the fold of 'classical humanism'.

[xi] Feenberg (1999: 15). Feenberg shows that many thinkers who try to think of technology critically may nevertheless fall prey to this tendency. His list includes Heidegger, Borgmann, and Habermas, among others.

[xii] Feenberg (1999: 194) refers to the power of disclosure (*Erschlossenheit*) in Heidegger.

[xiii] See Khan (1998), Chapter 6 and Appendix 6.2 for a discussion of the 'cluster conditions' for deep democracy. See also Gilbert (1990).

[xiv] Of course, it could be argued that to the extent that the closures abroad embody progressive social values such export dependence is a good thing. There are several problems with this argument, however. First, the closures abroad may not be that progressive. Second, even if they were, there is still the question of *agency* of the domestic producers, designers and users. To what extent this *agency* problem is solved is vital to the assessment of specific technologies as well as the NIS of which these are a part.

[xv] Of course, it is not being claimed that having an apparently self-sustaining innovation structure in one sector is sufficient for a POLIS. For this we must examine the economy-wide linkages.

[xvi] In a recent paper Rip and van der Meulen (1996) argue that research systems also shift over time. In their view research systems are moving from a modern to a post-modern framework with potential for less steering and more aggregation. Unfortunately, it would seem that the theorists and policymakers in the LDCs are still in the thrall of a modernist NIS. The Taiwanese case is an all-too-clear and disturbing example.

[xvii] It is important to realize that being nationwide is not a necessary condition for POLIS. It could very well be regional, or even confined to a city. For a beautiful example of a city-wide POLIS, in Boston, see Hughes (1998). At the other extreme a POLIS could in principle be supranational.

[xviii] For example Feenberg (1998: 90-91) discusses reflexive design and his own experience in studying groupware.

[xix] They define "regime" as follows: "The whole complex of scientific knowledge, engineering practices, production process technologies, product characteristics, skills and procedures, and institutions and infrastructures that make up the totality of technology. A technological regime is thus the technology-specific context of a technology which prestructures the kind of problem-solving activities that engineers are likely to do, a structure that both enables and constrains certain changes." (Rip and Kemp 1998, quoted in Feenberg 1999: 88)