Technology in World History: Cultures of Constraint and Innovation, Emulation, and Technology Transfers.[1]

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I. Introduction. Approaching Technology.

Of course there are many analyses of innovation that focus on its inducement through entirely non-cultural or seemingly a-cultural processes.[2] Here the focus has mostly been on economically induced technological innovation, normally operating through a change in relative factor prices or in demand. Thus historians have discovered stasis in early Chinese technologies due to a rising man/land ratio.[3] So too Ahmad's induced innovation hypothesis suggests that a decline in wages relative to land prices, say, would encourage technical progress that was biased in land-saving and labour-using directions through the multitudinous agency of profit-seeking individuals operating with good information in competitive market conditions, and much effort has gone into econometric testing of such theorising.[4] Historians of technology frequently come across such relations, although often extended to incorporate bias towards or away from certain priced materials or skills components – persistent technicians will spend much ingenuity in

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1 This paper was initially stimulated by my participation at the Lemelson Center Symposium, May 2005, Smithsonian Institution, Washington, on 'Cultures of Innovation' and further developed in my presentation of September 2005, 'Useful and Reliable Knowledge: Patterns, Contexts and Institutions', GEHN Panel on Regimes for the Production of Useful and Reliable Knowledge, Europäischen Kongress für Welt- und Globalgeschichte of the European Network in Universal and Global History and the World History Association, Leipzig, Germany. I would like to thank Patrick O'Brien, Kent Deng, Abdallah Daar, Robert Kargon, and Arthur Molella for their critical comments on its aspects.

2 H P Binswanger and V W Ruttan, eds *Induced Innovation*, Johns Hopkins UP, Baltimore and London, 1978.

3 Kang Chao, *Man and Land in Chinese History: An Economic Analysis*, Stanford UP, Stanford, California, 1986.

4 Syed Ahmad, 'On the Theory of Induced Invention', *Economic Journal* 76, 1966, 344-57.

substituting alloys or other metals or materials for copper or zinc that is rising in price. The need to exploit a potential asset at low cost might induce a search for new technique, as in the cyanide process for gold extraction in the late nineteenth century.[5] But such inducements seem to refer pretty much to switches within an existing technological or production system. In historical situations where such markets, agency and information may not be assumed away, and where much of the analytical problem lies with the manner in which knowledge develops and is brought to bear on production in some places and times (and not in other places or times) such analyses become less interesting and useful. Markets are themselves institutions with real cultural histories, and where markets are weak then a variety of cultural factors may intrude on the manner in which sensible private or public agents take up or entirely eschew technological innovation.

Cultural factors also loom the larger when we – as working historians – are forced to consider the whole range of Schumpeterian-style innovation, beyond mere product or machine/process innovations. This is partly just because cultures might retard technological innovation but at the same time may induce innovations in organisations, markets, and other aspects of technological change in the wider, Schumpeterian sense. We must - therefore - be prepared to at least consider the historical force of cultures of innovation in areas other than the strictly technological, for innovations in institutions (for instance) may have as great an impact on economic growth and productivity as any shiny new machine.[6]

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[5] Ian Inkster and Janine Todd 'The Support Structure for Australian Science circa 1851-1916', in R. Home (ed), *Australian Science in the Making***,** Cambridge University Press, Cambridge, 1988, pp.102-133.

[6] Douglass North, *Understanding the Process of Economic Change*, Princeton University Press, Princeton and Oxford, 2005, especially pp. 59-66.

II. Culture and All That.

Famously, Williams warned us all that the term ‘culture’ is amongst the most ‘complicated words in the English language’.[7] It seems that good old scare quotes remain appropriate. But it seems as apparent, that if we are to examine the relations between culture and technological change, then we need some limiting and working definition of the more doubtful of the two key terms. This is because any attempt at persuading historians of the material world that physical outcomes might be decisively and measurably determined by cultural elements peculiar to particular civilizations, nations, institutions, or sites, will encounter intellectual resistance. If such persuasions utilise terms that are clearly super-inclusive then they are that much more easily faulted. If we are not to confuse past culture with past life itself, then we must risk some charges of reductionism in favour of the greater certainty of a more outright dismissal.

Much of the observed *behaviour* that is attributed to such terms as 'values’ 'attitudes' and 'culture', is historically channelled and perceived through the workings of specific *institutions*. Although the field is a very large one, we might summarise that 'culture' is normally treated of as either an ideal type defined in terms of absolute or universal values; as the body of intellectual and imaginative work, the stock of recognised (not necessarily organised) knowledge, representing experience recorded; or as a social phenomenon expressive of meanings/values/ attitudes. That is, culture then broadly embraces the means of production of goods, services and knowledge, the structure of the family, the structure of institutions governing social relations and all forms of communication. Culture is, at even this level of analysis, institution-bound.

[7] Raymond Wiliams, *Keywords*, London, Fontana, 1983, p. 87. For earlier forays see in particular, A.L. Kroeber and C. Kluckhohn, ‘Culture: a Critical Review of Concepts and Definitions’. *Papers of the Peabody Museum,* Harvard, vol., 47, 1952.

Whilst Bagby, Toynbee, and others have written variably successful meta-histories based on some combination of these approaches, the answers to more specific questions (e.g. Why technological success in Japan and why not in Indonesia?) may lie with a careful treatment of the most prosaic last level.[8] This does not entirely exclude the possibility of useful generalisation arising from more ambitious levels of analysis. Pitirim Sorokin's notion of a *traditional* culture as a casual conglomerate of values and attitudes appears to fit pre-Meiji Japan and may well be an explanation of that nation's industrial success. Japanese industrialisation was predicated on a recreation or reinvention of the past to fit the needs of the new technological system; the Emperor Movement, the samurai ethos and *Shingaku* sprang not from the past but from necessity.[9] In contrast, China and India may well have represented *traditionalistic* societies, in the sense that their 'cultures' were composed of logically interrelated components, or what A.L. Kroeber has termed 'configurations'. A highly configurated culture may not, as it were, divest itself of 'archaic' components - however much elites or others see these as retardative of technology transfer, modernised science, industrialisation or individual advancement - because this would have convoluted impacts throughout the social structure.[10] Hagerstrand long ago claimed that 'whether a particular trait is accepted depends not only on its utility to the borrowers but even more on whether or not it can be

[8] Arnold J. Toynbee, *A Study of History,* 12 vols., OUP, 1932-1960, vol. 12 especially; Philip Bagby, *Culture and History,* London, 1958.
[9] Pitirim Sorokin, *Contemporary Sociological Theories*, New York, 1928 and *Social and Cultural Dynamics,* 4 vols., NY, 1937-4; T.S. Lebra, *The Japanese Self in Cultural Logic*, University of Hawaii Press, Honolulu, 2004; I. Scheiner and T. Najita eds. *Essays in Tokugawa Intellectual History*, Chicago University Press, 1978; Fumiko Shiratori, *The Cultural Background of Japanese Economic Development*, De La Salle University Press, Manila, 1995.
[10] A.L. Kroeber, *Configurations of Culture Growth,* Berkeley, 1944; P. Sorokin, *Social Philosophies in an Age of Crisis*, Boston, 1951.

integrated into the receiving culture'.[11] In a highly configurated culture such integration is simply less probable, and this may explain something of the differences in the economic histories of Japan, China and India. At this big level culture does look deterministic.

As anthropologists have taught us, observing backwards from 'behaviour' to culture is fraught with danger. Historical or contemporary observation of minority groups (say 17th century English Calvinists) *within* a national framework might reasonably lead to statements of the sort that such groups are 'propelled towards seeking economic success in a way that distinguishes them from the rest'.[12] But statements derived from observations of the sort that some nations are 'not adaptable to economic change'[13] are less convincing. Boeke's study of Indonesia argued that the forces of growth fell on stony ground because of cultural factors. But 'failure' may well have reflected not the inherent workings of traditional culture but an understandable negative response to the clear subjugation of the economic and political system during the Dutch 'culture' period.[14]

Unexpected behaviour, and thus unplanned results, may have explanations that do not deny the existence of either 'economic man' or 'man responding to new circumstances'. First, behaviour may appear to be 'irrational' and culture-bound but in fact be economically rational, as in Elkan's example of African plantation workers who return to their villages, or in the more general phenomenon of the 'backward sloping' demand

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[11] Torsten Hagerstrand, 'The Diffusion of Innovations', *International Encyclopedia of Social Sciences,* Vol. 4, (1968), p.170.

[12] For an accumulation of neo-Weberianism on this theme see: Max Weber, *The Protestant Ethic and the Spirit of Capitalism,* (New York and London, 1950); Alexander Gerschenkron, *Europe in the Russian Mirror*, Cambridge, 1970; for approaches which identify a particular trait or historical occurrence as projecting deviant social change for the *whole* society, or for non-specified groups, see D.C. McClelland, *The Achieving Society*, London, 1961; E.E. Hagen, *On the Theory of Social Change*, London, 1964; M. Morishima, *Why Has Japan Succeeded?*, Cambridge, 1982.

[13] Elkan *Development Economics,* 1973, op.cit. p.35.

[14] J. Boeke, *Economics and Economic Policy of Dual Societies*, New York, 1953.

curve for labour.[15] Second, behaviour may be changed and directed by new institutions. Many of the latter (e.g. those linked to the socialization process) are more or less malleable, some are amenable to revolutionary change (eg. schooling, patenting). Third, it is possible that many values or culture traits that are indeed reasonably shown to be the basis of real behaviour are not immutable or traditional. In many cases such traits may be of recent origin, perhaps formed in reaction to an earlier period of formal colonialism. Extreme nationalism was one of the features of European nations at a time when Asia, Africa and Latin America knew little of nationhood.

Such room for doubt gives space to argue that economic development may arise as a result of explicit institutional reform. Change in institutions may well alter behaviour patterns - as in Meiji Japan or post-Maoist China. At the level of the international economy, reform may go beyond cosmetic tampering with market prices or currencies into a fundamental alteration in the manner in which major institutions (including trans-national corporations) are permitted to operate. If this should be characterised as 'radical institutionalism' then so be it. It is merely a moot point.

As a result of problems associated with advanced technologies in Europe, the US and Japan, several commentators have called for a shift in ultimate goals in or for the underdeveloped nations.[16] Environmental imperatives that have arisen in rich nations have been imposed as environmental limitations in poor ones. But have western analysts any particular right to assume, for instance, that poor people in poor nations

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[15] Walter Elkan, *An Introduction to Development Economics,* London, 1973, p.39; Elkan, *Migrants and Proletarians.* OUP, 1960; Michael. Lipton, 'The Theory of the Optimising Peasant', *Journal of Development. Studies,* 4 (1968).

[16] M. Abramovitz, 'Economic Growth and its Discontents', in M.J. Boskin (ed), *Economic and Human Welfare: Essays in Hon. of Tibor Scitovsky*, NY, 1979; T. Scitovsky, *The Joyless Economy,* NY, 1976.

value individual freedom above an increased income? Whether traffic jams in Bangkok represent the same degree of 'disutility' to the Thai citizen as traffic jams in New York to the US citizen is possible, unlikely and uncertain. An equality of dissatisfaction would require that both the traffic jams and their environmental setting were comparable and that immediate past experiences as well as present expectations were identical in both settings. This is certainly not to argue for relativism in everything, that we can play a culture game willy-nilly. Rape is as horrible in Thailand as it is in North America. But it is to warn against supposing that the task of development in underdeveloped nations is somehow less urgent merely because the overfed and under-exercised in advanced nations are at present having problems in fully participating in the historical benefits of higher technology. The latter may lead to the bomb, acid rain or global warming, but improved technology in India may still (and at the same time) be able to reduce starvation, population growth and other gross measures of stark inequality. Similarly, energy conservation is an unlikely policy tactic in a poor nation dependent on energy exports. In the long term we *are* all dead, but most people do want to live a little longer. Finally, I have little trouble in believing that people in societies of high GDP are generally happier than people in societies of low GDP. That they might not believe they are happier is a measure of their lack of imagination, not their state of happiness.

III. Cultural Constraints and Technological Change.

It might be possible to better forge an historical approach to culture and technology by focussing on cultural constraints, and in doing so distinguishing between *cultural constraints that act as productive channels* for technological progress, and *cultural constraint that stops or increases the costs of technological change.*

In this location it is perhaps fitting that I begin here with that great American, William James, who believed that invention and emulation were together 'the sole factors active in human progress'. James claimed forthrightly enough that mankind 'does nothing save through initiatives on the part of inventors, great and small, and imitation by the rest of us'.[17] The real world has been forged through processes of creative leadership and creative emulation. The latter – technology transfer - is without doubt the more powerful of the two processes at the level of long-term global history. Imitation is more common than creation, in technology as in so much else. So why is the whole world not modern and rich, the question that brought so many of us to the study of history in the first place?

But how are we to define or even recognise those Jamesian creative initiatives? The first patent awarded in the US in 1836 under the improved Act of that year was to John Ruggles, Senator from Maine on 13 July for a locomotive steam engine 'designed to give a multiplied tractive power to the locomotive and prevent the evil of sliding wheels'.[18] On 12 September 1961 patent number 3 million under that very same act of 1836 was awarded to Dr Kenneth R Eldridge staff scientist of Stanford Research Institute, Menlo Park California, assigned to General Electric's Computer Dept in Phoenix, Arizona for the invention of an automatic reading system, designed initially to process cheques for the Bank of America at 1200 per minute.[19] In terms of cultures of creativity what may we say of these two American patented inventions? Firstly, although both

[17] William James, from *The American Treasury*, Harper, NY, 1955, p. 719.
[18] Officially reorganisation was completed on 4th July 1836. But the fire of December 1836 delayed reorganisation and destroyed models and records, this affecting some 10,000 living American patentees each of whom was written to by the commissioners to encourage re-registration for diverse legal reasons! By January 17th 1838 some 2,000 patents had been renewed. Unfortunately, the fire destroyed all the papers that had been deposited by Robert Fulton. See *Report from the Commissioner of Patents, Doc 112 of 2nd Session, 25th Congress*, House of Representatives, Washington, 1838, pp. 2-5.
[19] Extensive Ceremonies to Commemorate 125th Anniversary of Patent Act of 1836, *Journal of the Patent Office Society,* XLIII no 10, pp. 663-700.

were decidedly American, they originated and operated in *distinctive inventive cultures.* John Ruggles operated in a world of partial information and in heroic isolation, aimed at one of the biggest technical headaches of the industrial revolution, gaining a patent of little private or social outcome based on an absence of any real scientific, technical or commercial test, suggesting the solution of one supposed evil by the introduction of a definitely greater evil, in a climate of bravado and infinite possibilities, if not yet very fast speeds. The three patents brought out concerning wheel carriages for the year 1836 that included Ruggles' efforts, were embedded amidst a host of individual claims representing the much boasted 'records of American genius'- numbering some 400 or so annually, but dominated by factory machinery (looms, ginning cotton, flax, hemp and manilla-grass separating, lathes and planing machines), calorific and steam apparatus (furnaces, boilers and engines), and mill machinery (cranks, chains, pulleys).[20] In contrast, Eldridge was part of a knowledge and information system strategically situated in a commercially sensitive information processing environ, aiming at an intellectually minor irritation, who secured a tremendous commercial outcome - by 1961 30 ERMA systems were processing 3 million chequeing accounts for the Bank of America every working night - utilising sophisticated sequences of technical and scientific components[21] that could not be even wildly conceived of in 1836, and that operated in an entirely different world from one in which cumbersome machinery may or may not slide down fruitless inclines left by spineless engineers employed by unscrupulous capitalists. But secondly, examples such as

[20] As listed in *A List of Patents Granted by the United States April 1790-Decemnber 1836,* Commissioner of Patents, Washington, 1872, pp. 762-805.

[21] An electronic information control using magnetic particles, a magnetic eye, a memory, and a unit capable of comparing current signals with images stored in the memory system and feeding this information into a computer – the demands of grammar require the imposition here of a sequence of words that yield an entirely false impression on the mind, for in fact all these accomplishments take less than a millionth of a second to complete.

these, 3 million patents apart, conjure up contrasting views of such a term as *creativity* or *creative innovation,* and they suggest differing micro-cultures of innovation. Within different local or historical cultures each of the two patents was creative, perhaps that of 1836 more so than that of 1961. Yet the economic outcome of 1836 was nil, that of 1961 was large and is measurable in cost-benefit terms.

It appears that when we think of cultures of constraint we are considering at least two historical processes. First we are considering cultures as possible constraints on acts of imagination, creativity, invention and emulation. The Old World with its ancient assets and mores may well have suffered greater problems in this regard than the ebullient New World, one that was altogether more prone to mingle folk and dispatch traditions. We shall return to this. But secondly we might be thinking of cultures as providing those constraining assumptions, institutional procedures, technical components, and informational resources - all touched on in our two cases above - that *increase* the likelihood of creative inputs having material outcomes by *directing them along productive trajectories*. In this sense the culture of British machinofacture from the 1830s or the culture of the American System of Manufactures from the mid-19th century, or the culture of the Japanese *kanban* and just-in-time system from the 1960s might all in their time have served as local cultures [cultures within cultures], the components of which acted as constraints on creativity, forcing certain trajectories that increased the likelihood of positive material outcomes, often with little reference to supposed linear models that neatly capture the happy sequence of information, idea, experimental application, time-and-money-consuming development and redesign, sales and profits. Such cultures of constraint might be quite local and specific.

So emerges the idea that in the historical leaders of technological change there are needed systems of information, of loose ties, of liberal

discourse, and that such cultures of constraint ensure that increasingly creative acts are likely to have accumulative material outcomes. Unfortunately, many of our political masters have misinterpreted this cultural component, translated it as one that directly creates insight and genius and innovation, rather than one that constrains it or fashions it along certain pathways. A result is our endless trans-Atlantic discussions about education, innovation, industrial retardation and falling behind, whether the British trailing those precocious Americans, or the Americans suffering the surprising Japanese, and so on.

IV. Strategies for Investigation. Cultures and the History of Technological Change.

This is a very big topic, but here I suggest some working notions that historians or others might bear in mind as they investigate the relations between cultures, institutions and processes or periods of significant innovation.

a) On Identifying Prohibitive Cultural Constraints:

Culture impacts on both original innovation and imitative/adoptive processes in a manner that is difficult to unveil with any convincing or final flourish. It should not be confused with resistance to new, for instance, scientific, ideas. Thus in the 'advanced' west, Darwinism may have been more resisted by intellectuals because of prior commitment to other intellectual and faith paths, but less resisted in Japan or China because elements of traditional culture were actually conducive to acceptance – so the Shinto conception that there is no clear demarcation between inanimate objects, or between humans and other creatures; or Buddhist notions that the quality of one's present life might determine the character

of one's rebirth, or to ingrained beliefs that the superior will always triumph over the inferior.[22]

Consider briefly several contrasting examples. During his campaign of 1536 against the Incas of Peru, Pizarro soon found how quickly Inca culture was attuned to the use of Western military technique, in a civilization hitherto unaware of either wheels or horses: 'It was impressive to see some of them emerge ferociously with Castilian swords, bucklers and morrión helmets. There was one Indian who, armed in this manner, dared to attack a horse, priding himself on death from a lance to win fame as a hero.'[23] The element of surprise may arise primarily from the Euro-cultural assumptions in Pizarro's mind, rather than from the actions of Inca warriors. Simple accounts of accumulative progress tend to assume or suggest an inevitable sequential logic, where the water-wheel must precede the steam engine and so on. This may of course often be perfectly appropriate, but when such sequential thinking becomes unquestioning assumption then it can miss the complexity of the global historical process. Thus when Pizarro invaded the Incas of Peru he brought to the enterprise a hugely superior military technology. Yet despite the entire absence of the wheel, maize had been introduced by the Incas from Mexico to complement the traditional potato and ensure a huge increase in irrigated cultivation and the intensified herding of the llama and alpaca. Despite no horses the Incas constructed immense and sophisticated road systems, cities and temples. Despite no written language they organized mass corvees of tens of thousands of workers for irrigation projects – this necessitating reliable supplies of meat, fish, and maize in huge amounts - and nurtured the skills required for the

[22] See for instance for relative ease of acceptance of Darwinism and social Darwinism in Japan from 1877, M Watanabe, *The Japanese and Western Science*, University of Pennsylvania Press, Philadelphia, 1976.

[23] John Hemming, *The Conquest of the Incas,* London, PanMacmillan, 2004, quote p. 215.

production of gold, silver, pottery and textile products, or to invent trepanning as a way of relieving brain pressure. So, quick indicators of a lack of such a basic technique as the wheel can be entirely misleading, for globally technology did not come in neatly accumulative sequences yielding readily describable packages of advancement that might provide evidence of levels of attainment in terms of a measure of modernity. A society might not yet have developed the wheel but nevertheless may have originated trepanning or constructed massive and sophisticated road systems, cities and temples.

In the 1590s John van Linschoten, a Dutch spy concluded from personal observation that the Japanese were 'cunning workmen of all kinds of handy works, they are sharp witted, and quickly learn anything they see'.[24] In Madagascar in the 1820s the skilled artisans may not have possessed the saw but nevertheless worked well and efficiently with plane, hatchet, wedge, and rule.[25] In 1885, an engineer working on projects in British India stressed how the 'natives take kindly to new inventions, particularly to mechanical ones calculated to save labour or increase production. All articles of hardware are universally patronised, while improvements in household furniture and in equipage find favour amongst the wealthier classes' and in industry referred to recent innovations and mechanisations in civil engineering structures in Calcutta, fibrous plant processing, tobacco, indigo, weaving and spinning: 'improvements in simple dredging or irrigation appliances would prove highly valuable' and clearly envisaged no cultural inhibition to technological progress on the sub-continent.[26] Technological cultures

[24] John Huighen van Linschoten, *His Discours of Voyages into ye East and West Indies*, London, John Wolfe, 1598, p. 45 (1974 edit.)
[25] *Account of the Conquest of Mauritius with some Notices of the History, Soil, Products, Defences by an Officer*, London, T. Egerton, 1811; Samual Copland, *A History of the Island of Madagascar*, London, Bruton and Smith, 1822.
[26] Henry.H. Remfry, 'On India as a Field for Patents', *Transactions of Institute of Patent Agents*, 3, 1884-5, pp. 150-54

possessed inner logics, just as did the wider cultures in which they were more or less embedded.

Yet none of such casual cultural pronouncements were accurate indicators of the subsequent history of technology in the Americas or Africa or Japan or India. One reason for this might lie in the huge range of cultural inhibitors, much of which lies beyond the ‘attitudes’ or ‘capabilities’ of artisans, warriors, or forced labourers. Chart 1 attempts to sketch in a blatantly general approach that derives from a broad, Schumpeterian view of technological progress.

Chart 1: Cultural Resistance and a Typology of Innovation (Schumpeter)

Assume innovation takes the form of any of –

(a) **changes in production technique** (PT);
(b) **new product technologies** (NPT);
(c) **conquests of new markets** (CNM);
(d) **novel organizational methods, esp. re. distribution** (NOM);
(e) **new legal devices** (NLD).

CORE IDEA	resistance	BEST PRACTICE	resistance	ADAPTIVE DIFFUSION/TRANSFER	
PT* =>	A* =>	PTi =>	Ai =>	PTn	
NPT* =>	B* =>	NPTi =>	Bi* =>	NPTn	Raised
CNM =>	C =>	CNMi =>	Ci =>	CNMn	Average
NOM =>	D* =>	NOMi =>	Di* =>	NOMn	Practice
NLD =>	E* =>	NLDi =>	Ei* =>	NLDn	Result

* Points at which culture might most likely be seen as the operating element, frequently invoked by historians.

If this makes any sense, then historians of technology might acknowledge that technological change may be inhibited or halted by a huge variety of elements operating on different aspects of a complex process. Before any society may reap the social and material benefits of new technology there must clearly have been some process of application, diffusion, and possibly of transfer from one market region to another. As the asterisks indicate, historians often invoke culture as an inhibitor of original creativity (at PT and NPT above), initial applications (the 'Luddism' of A and B above), socio-spatial diffusion of best practice (at Bi above), and so on. But any one of these asterisks might be challenged – upon examination much 'Luddism' was directed against modes of application in new institutions rather than machines themselves,

and more opposition to the locomotive system arose from landowners and canal proprietors with vested interests than from intellectual or folk resistance. As historians of China have recently emphasised, isolating a 'cultural' inhibition is a difficult task. In a period of violent loss of power and wealth, late nineteenth century Chinese authorities were wary of western railways as means of ultimate technological invasion, but they welcomed and built western steamboats as useful technologies firmly within their control.[27] Is culture operating at all within such a distinction?

b) Initiation - Micro-cultures and the notion of Proximity:

When thinking of classic cases of technological innovation it might be better to identify proximate micro-cultures or particular sites within larger cultures.[28] In many instances of historical technological change, national cultures appear to have been of less importance than were proximate environments for innovation. All vicinities or sites of technological and other changes contain representations of a larger, perhaps national culture, but they are not themselves representative of such entire cultures. The proximity of innovative sites to the location of useful and reliable knowledge becomes crucial to the wider process of technological progress. This may help with both accuracy and incipient Whiggism. Thus, rather than assuming the inevitably progressive character of Enlightenment thought when locating James Watt's invention

[27] Nathan Sivin and Z. John Zhang, 'Steam Power and Networks in China 1860-98: The Historical Issues', *History of Technology,* 25 (2004), pp. 203-11.

[28] After all, this is merely asking historians to think in terms commonly found in business, as with the present emphasis on innovation-clustering and innovation relay systems for sharing of ideas and experience within the European Community. The historian would be more prone than today's private and public agents to focus on issues of social and cognitive knowledge-proximities, and less on financial support systems and other such matters that appear to absorb all of the energies of such projects as Paxis and Gate2Growth: see *European Innovation*, July 2005, pp. 22-23. For examples of a large project initially intended to create micro-cultures for incubation, see Ian Inkster, *Clever City. Japan, Australia and the Multifunctional Polis*, Sydney University Press and Oxford University Press, Melbourne, 1991.

of the separate condenser and the improved steam engine, we might consider the proximate micro-culture in which he was more effectively embedded – the Glasgow university workshop, the shops and workshops of the Salt Market and by 1763 the Trongate, the *savant* nexus of the Lunar Society, the routines and challenges of the travelling surveyor, and the Soho connection forged in summer of 1768.[29] And when we consider proximity we might think beyond geography to social distance as well. If we are to hitch something called culture to something termed technical innovation, then we must deal with all of proximity by which I mean at least its temporal geographical, social, and cognitive dimensions, which together may reveal the cost aspects of proximity within any one national culture.

Here – much more broadly - we are reminded of the old notion of 'hand-mind distinctions', which appear ingrained in many traditions throughout the world, where scholar gentry and artisans live in exclusive social and cognitive worlds, where problems of application are not shared *between* such groups but only *within* them. Did Imperial examination systems merely mark the social fault-line between hand and mind? It has been claimed, for instance, that Tokugawa Japan (1603-1868) could not have harboured a scientific revolution because of such distinctions prevailing between samurai, merchants and artisans.[30] A huge amount of evidence is now available that demonstrates that such dualism had broken down in many European places well prior to 1700.

We may draw from Kirzner[31] the idea that an essential dynamic of capitalism is entrepreneurial alertness, a concept itself drawing from

[29] J.P. Muirhead, *The Origin and Progress of the Mechanical Inventions of James Watt,* vol. 2 London, 1854; R.E. Schofield, *The Lunar Society of Birmingham,* Oxford, 1963.
[30] James Bartholomew, 'Why was there no Scientific Revolution in Tokugawa Japan?', *Japanese Studies in the History of Science* 15, 1976, 111-25.
[31] I.M. Kirzner, *Discovery, Capitalism, and Distributive Justice*, Blackwell, Oxford, 1989, e.g. see p. ix, 22-33, where discovery is seen as associated with a particular alertness, subsequent developmental problems as more products of sequential logic, something that could be 'turned over, in principle, to a computer for their solution'.

Joseph Schumpeter and similar perhaps to recent approaches by Mokyr and Jacob.[32] We would argue that such extra quotas of 'alertness' were products of site characteristics rather than original attributes of total 'cultures', and were bound to the proximity of useful and reliable knowledge on several levels, as in the Watt example above. For Kirzner the discovery has no significant prior history, for me that history is compounded of a local environ or culture of inducement, the availability of useful and reliable knowledge and specific site characteristics – inducement may lie beyond a specific site. We might usefully distinguish discovery that arises directly from a prior search process, from that which does not or which arises by accident when searching for something else!

Innovation occurs in some specific site or other, and at a subsequent period passes between sites. How can we enlist culture in examining what determines these two processes? With reference to temporal proximity, it would appear that quite long time periods may indeed be concerned - Tokugawa Japan's mathematics and science, somehow incorporated at least elements of the European scientific revolution into a Meiji industrial revolution So, we might conclude that cultural suasion over technological innovation or transfer does not require temporal proximity – in *Annales* terms, cultural causation may exert itself strongly across very different conjunctures. Geographical proximity is a different matter and is surely of far greater saliency. Watt operated within an actual site rather than in some vaguely defined culture or system, and the culture of the site is what may have determined Watt-like outcomes. In the case of social proximity, so often ignored or assumed away, the case is even firmer. An excellent illustration lies with the clear infirmities

[32] Joel Mokyr, *The Gifts of Athena. Historical Origins of the Knowledge Economy,* PUP, Princeton, 2002; Margaret Jacob, *Scientific Culture and the Making of the Industrial West,* OUP, New York, 1997, p.1.

of the Weiner approach to Britain's economic decline.[33] However much we may argue that the intellectuals and the poetry of the romantic reaction was not conducive to innovation and technological change in 19th century Britain, the harnessing of this seeming 'cultural' argument to material effects is marred and in the end entirely spoilt by a failure to illustrate social proximities. The sites of the innovators were not those of the romantics and it took a foreign intellectual to state the case clearly.[34] Where they did coincide or overlap, as in the case of the later 19th century move to arts and crafts and art nouveau, then the elite romanticism bowed entirely to the real machinofacture of the industrial innovators, utilising the most recently patented breakthroughs as the very basis of the mass production of a new aesthetic of consumption.[35] We may conclude that a good deal of both social and geographic proximity is required if we are to argue from culture to innovation, and that this almost certainly applies to both cases of cultural inducement and cultural constraint.

c) Culture and the Location of Useful and Reliable Knowledge.

One of the more characteristic ingredients of any such micro-culture relates to the supply and adaptation of Useful and Reliable Knowledge (URK). Any universal approach requires that we abandon Euro-centric definitions of 'science' and look for discrete supplies of the knowledge that was actually brought to bear on the process of technological innovation. Was URK available in a form or forms that could

[33] Martin J.Weiner, *English Culture and the Decline of the Industrial Spirit 1850-1980,* Cambridge University Press, Cambridge, 1981.
[34] Karl Mannheim, *Diagnosis of Our Time. Wartime Essays of a Sociologist,* Routledge and Kegan Paul, London, 1943.
[35] S. Smith, 'Art, Technology and Science: Notes on their Historical Interaction', *Technology and Culture* 11, (1970), pp. 493-549; idem., 'Metallurgical Footnotes to the History of Art', *Proceedings of the American Philosophical Society*, 116, April 1972, pp. 97-135; Ian M.G.T. Quimby and Polly A. Earl eds., *Technological Innovation and the Decorative Arts*, Winterthur and the University Press of Virginia, Charlottesville, 1974.

either be immediately used by technicians and artisans, or translated into use at low opportunity cost? In seeming contrast to other great systems such as those of India or China, 18th century Europe was flooded with publications designed to de-mathematise, translate and simplify, bring into diagram and perspective forms, lower the cost of and synthesise the more abstract aspects of the URK that flowed from the earlier intellectual breakthroughs of the scientific revolution. Such materials were debated, doubted, reported and reconstructed in a plethora of associations and networks that grew at a rate far faster than population ever could.[36] Can the same or functional equivalents be found elsewhere? An aspect of even rudimentary intellectual property systems of the type developing in Europe that has been neglected by historians of technology is the role they were now beginning to play in the specification, testing and codification of innovative knowledge and recipes concerning new techniques. Such activity served to increase the cognitive proximity of URK and technique across many sites and agencies, an URK-supply feature of McCloskey's 'ordinary inventiveness'.[37]

[36] For details see A. and N.L. Clow, *The Chemical Revolution*, The Batchworth Press, London, 1952; A.E. Musson and E. Robinson, *Science and Technology in the Industrial Revolution*, Manchester University Press, Manchester, 1969; W.H.G. Armytage, *A Social History of Engineering,* Faber and Faber, London, 1961; S. Pollard, *The Genesis of Modern Management, A Study of the Industrial Revolution in Great Britain*, Edward Arnold, London, 1965n and more recently Arnold Thackray, 'Natural Knowledge in Cultural Context: The Manchester Model', *The American Historical Review,* 1974; R.J. Evans, *The Diffusion of Science: The geographical transmission of natural philosophy in the English provinces,* PhD thesis, Cambridge University, 1982; Simon Schaffer, 'Natural Philosophy and Public Spectacle in the Eighteenth Century', *History of Science,* 1983, 1-43; Ian Inkster 'Potentially Global. A Story of Useful and Reliable Knowledge and Material Progress in Europe circa 1474-1914', *International History Review*, XVIII, [forthcoming, June 2006].

[37] Deirdre McCloskey 'The industrial revolution 1780-1860: a survey' in D. McCloskey et al., eds., *The Economic History of Britain since 1700,* vol 1, 1700-1860, Cambridge, CUP, 1981, 103-127, quote p. 117 The danger of the phrase lies with the economists' tendency to see technology as automatically induced by demand and capital, and to thus assume away the actual complexity and fractious character of technological change.

d) Adoption - the Role of Enclaves and Avoidance Systems:

Similarly to the above cases, transfer and adaptive adoption of advanced technologies does not occur in national cultures but in *nurtured sites* within nations. In their very different ways and places Henry the Navigator of Portugal and Frederick the Great of Prussia both took the tactic of deliberately fostered micro-sites in their efforts to transfer the Best of the West unto themselves. The vision of Meiji Japan, a nation of over 30 millions of people, somehow accepting western techniques at once and wholesale is ludicrous – technologies in fact transferred into prepared spaces, replete with appropriate institutions and flexible supplies of useful and reliable knowledge. An outstanding example in this case was the Yokosuka arsenal of the 1870s - financed by the government with an initial outlay of $2.4 million, French leadership and expertise, skilled Japanese employees on high salaries with a quality training establishment within its precincts, various model factories, foundries and fitting shops, linked to local villages for vital upstream supplies and so on – this was not representative of Meiji industrial culture *per se,* despite the cultural engineering that I have elsewhere emphasised.[38] Indeed, we might well argue that the speedy construction of such technological enclaves represented **policies of cultural avoidance** – in Meiji Japan there was little of any Huntingdon-style 'clash of civilisations' in the processes of technology transfer and settlement.[39]

In a sense we must also challenge the idea that 'culture' exists as a given entity, the nature of which is either encouraging or inhibitory of innovations from the individuals located in such culture. Industrial Revolutions, from that of Britain to that of Japan, have depended on

[38] Ian Inkster, *The Japanese Industrial Economy. Late Development and Cultural Causation,* Routledge, London, 2001; on Chinese arsenals see Benjamin Elman, *On Their Own Terms; Science in China 1550-1900*, 2005, pp. 355-95

[39] Samual Huntington, *The Clash of Civilizations and Remaking the World Order*, New York, Simon and Schuster, 1996.

dynamic and more-or-less purposeful processes of **cultural engineering**, which have in turn influenced the extent and pattern of innovative activities and products. Under what conditions is cultural engineering a salient element in explanations of technological success?

When does a protective and useful enclave become part of an underdevelopment process i.e. negative? Perhaps when it is not planned as a controlled interface but rather develops as a non-integrated resource-swallowing enclave, as in Tsarist Russian metallurgical projects.

e) Cultural Intrusions - Impacts of Exogenous Institutions on Innovation Followers:

Eventually the cultures that constrained technological innovation into the development of progressive industrial systems forged sophisticated institutions - from patent systems to trans-national corporations - complex systems that *are now themselves* proximate micro-cultures, that bring fragments of other cultures into the cultural systems of receptor or adopter/adapter nations, often with disastrous results.

Now, it would be tempting to argue that native, traditional elements of receiver or indigenous cultures retarded, halted, or resisted emulation when all the creative hard work had been done amongst such 'leaders' as Britain, Germany or the US, and hence the tragedy of the 20th century and the problems of the present. This was indeed an argument of the mid-20th century and can still be found. It represents an essential conservatism that lies in the background of all the post-modern rhetoric that argues that culture is all-important and encompasses all those other old [Talcott] Parsonsian structural-functional elements of our advanced society. A more radical alternative argument is that the nature of the commerce and capital that exuded from these very areas of technological creativity and advancement also excluded technical capability and choice

in receiver nations. Foreign capitalists became foreign owners, became foreign decision-makers, became foreign 'cultures of constraint' on technological development in poor nations. This too was the common enough cry on the radical side of the mid-and-later 20th century, many of us remember, some of us took part, others continue to develop the argument.

A third possibility has been neglected by analysts [forgivably] but also by historians [unforgivably]. The possibility here is that the very technologies of advanced economies and the local cultures that they inhabit and depend upon, are themselves cultures of *inhibitive* constraint in/on receiver nations. Now we are referring to the immediate institutional and cognitive clashes that occur as two or more technological systems meet, periods in which time itself speeds up and in which all the possibilities seemingly inherent in the notion of late development lie waiting. We might wish to reflect on this possibility, departing with a consideration of resistances to technological innovation, which allows us to approach perhaps a more conventional notion of cultures of constraint. A thesis worthy of refining and testing is that cultural resistance to emulation has been a major determinant of the patterns of world material development since circa 1870 - a year by which such late developers as Germany, the US and Japan (just) had passed into the pale of modern technological advancement - and has arisen not from nativity or indigenous superstitions and irrationalities but as rational reaction to the local institutionalised culture of advanced technologies, rather than as reaction to the technologies themselves.

To end with the patents that we began with – intellectual property rights are now so vehemently condemned by third world nations just because they act as cultural systems that serve to swamp poor nations in their attempts at some technological independence, secure monopolies of useful and reliable knowledge, reduce the effective proximity of

nourishing micro-cultures (e.g., small workshop conglomerations) and effect a nexus of investment, institution and technology that serves to exclude the wider national cultures from effective acts of innovation, technological or otherwise.[40]

IV. Concluding Thoughts:

As most of the presentations at this **Conversation** appeared to focus on contemporary issues, I did range rather far as a historian in order to set up some categories for our debates. It is easy enough to use systematic data to show how the world divided technologically between rich and poor in the 19th and 20th century, utilising international measures from the Renaissance to the 20th century.[41] But one of our tasks was to illustrate the limit or extent of 'cultural explanations' for this divergence - this is where it gets really tricky. A commanding notion for the conference was 'cultures of innovation', my particular argument here being that, in successful economic systems, culture *constrained or channelled* technological innovation into industrial progress. In many of the poor nations of the world – in contrast - culture *constrained* innovation in such a way that industrial surges ultimately failed, whether they be Tsarist plans for heavy industry and railroadisation in Russia during the 1890s or Indian 5-Year planning in the 1960s. However, those cultural constraints did not arise merely within the cultures of the poor nations, but stemmed also from the institutional mechanisms and influences of the

[40] Commission on Intellectual Property Rights, *Integrating Intellectual Property Rights and Development Policy*, Report of CIPR, London 2002; Kamil Idris, *Intellectual Property. A Power Tool for Economic Growth*, WIPO, Geneva, 2003; Curtis Cook, *Patents, Profits and Power*, Kogan Page, London, 2002.
[41] Ian Inkster 'Patents as Indicators of Technological Change and Innovation – An Historical Analysis of the Patent Data, 1830-1914', *Transactions of the Newcomen Society,* 73 no.2, 2003, pp. 179-208.

successful nations themselves (from patent systems to trans-national corporations). This seems like a nicely closed case?

It is, unfortunately, complicated by a subsidiary argument: That it is all but impossible in most instances to isolate a decisive cultural constraint indisputably acting as an innovation restraint or prohibitor **-** non-cultural elements interact with conceivably cultural processes, and in such conjunctures causation is more than difficult to pinpoint.

Terribly, I have suggested a second complication! Not all innovation is strictly technological, and economic and industrial progress and efficiency has historically often been hugely increased by innovations ancillary to the *technical,* such as changes in markets (American exports of cotton to the British), institutions (patents) or within production organisations (the Japanese *kanban* system for instance). Thus most famously, some 50 years ago Moses Abramovitz showed that study of US efficiency growth during 1870-1950 could only reflect the 'measure of our ignorance'.[42]

[42] Moses Abramovitz, 'Resource and output trends in the United States since 1870', in *Thinking About Growth, and Other Essays on Economic Growth and Welfare,* Cambridge University Press, Cambridge, 1989 (first published 1965), 127-147, quote p. 133.