

Motivation and Achievement: Technological Change and Creative Response in Comparative Industrial History*

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Introduction: Generalisations and Treacherous Terms

People behave in context. There is a sense in which there is no such thing as the 'entrepreneur' (innovator, scientist) but there have been, certainly, clusterings of 'entrepreneurship' (innovation, scientism) throughout modern history. It is the periodic batching of entrepreneurial and innovative acts which generates the 'achievement' of total economic and technological systems, as in the industrial revolutions of Britain and Japan. But no industrial revolution repeats itself. What does this actually mean? Again, the link between motivation and achievement is, surely, lengthy and weak? It is not entirely facetious to claim that there is no such thing as

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achievement in its own time. An achievement may be taken as an individual or systemic action or recorded thought which is known to have been deviant in time X, to have influenced events in at least time X+i, and to be of continuing significance in time Xn, one of the times of its *recognition*. It may no longer be recognised in time Xn+i. A great writer, Adam Smith, nominated the rules for the industrial revolution in 1776, another great writer, John Stuart Mill, reflected upon the changing of the rules for achievement in 1848. But, between these two dates - the period of the classic industrial revolution - few great writers uncovered the achievement or the motives behind it. This, by the by, allows the possibility that the origins of achievement are mundane, for in economic history, achievement is an effect.

A selective comparative analysis of industrialisation in Britain and Japan may assist in clarifying this particular murky essence. The industrialisation of Britain developed within a *context* for investigation and entrepreneurship and experiment quite different from that of late nineteenth century Japan. Industrialisation was crafted of a complex of elements, some of them originating elsewhere than in England itself. In Japan, the break into industrialisation was ushered in by a new exposure to 'foreign' influence, which, ultimately, swamped all other motivations of either individuals and groups or of the increasingly national system of which they were part. In Britain, motivations prompted original industrialisation, in Japan motivations were forged within the process of technology transfer and imported industrialisation. It may be that the essential contrast of the two cases lies in the layers of differences between creativity and response. Much depends upon assumptions about effective context. The motivations of today's Japanese and American businessmen are, conceivably identical, but the measurable contrast in their behaviour and subsequent achievements may result all but entirely from the contrast in the contexts within which they effectively operate.¹

¹ Ian Inkster 'Made in America but lost to Japan : Science, Technology and Economic Performance in Two Capitalist Superpowers', *Social Studies of Science*, 21 (1991), pp. 157-78.

Such considerations are of pertinence to the exploration of cases of successful technology transfer, or in our terms, the cases of measurable economic achievement which are identifiably associated with an earlier or contemporaneous impact of advanced ideas/techniques/institutional arrangements from elsewhere. Yet technology transfer was important to the industrial achievement of our first modern case, Britain, and vital to the achievement of the Japanese economy during the Meiji era (1868-1912). What determines successful technological transfer from one technological system to another? Any such factor or set of forces almost certainly defined the dominant economic and political contours of modern history.²

Much is in the air. Much is amiss. And this is probably a Good Thing, even if it does often lead to unreflective analytical shifts. Economic historians searching for 'context' commonly leap upon culture as explanation, address the writers who at first glance have attacked the historical relationships between individual motivations, boundary conditions and system change. If the historian is searching for a specific sociopsychological cause of high industrial achievement which at once (a) helps to define achievement and (b) explores the potential causal links between individual motivation and cultural systems (value complexes) or influences, then there is a varied menu to choose from. Items on the menu range from the Weber-McClelland arguments on the psychological and ideational bases of action/achievement, through Everett Hagen's more specifiable, empirical and perhaps convincing accounts of loss of status respect within value systems and Joseph Schumpeter's focus on the socially-generated, institutionalised risk environment of the innovating entrepreneur/technologist, to the more historical, Landes type of tactic, which relies upon the emergence of fairly specific pairs of traits and institutions (eg. the Individual and the Market, Freedom

² Ian Inkster, 'Technology Transfer: The Historical Dimension in Detail', *Metascience* 8 (1990), pp. 12-19.

and the State) and to their at times liberating impact on the bounded rationality of key agents or groups or social classes.³

From any of these entrées we might arrive at interesting assertions. Achievement indisputably occurs when relevant risks are low, but Mary Douglas may or may not help us here. The social anthropology of the taking of risk may not be the appropriate key to the interpretation of the success of entire technological or social systems.⁴ The perception of risk is central, and this is perhaps entirely dependent upon the microcontext of action, which is mundane: what is being risked, how high is the estimated level of risk, what is the likelihood that the estimate of risk is correct, and how far down do the failures fall? Are there avenues for regaining status/information/wealth? The perception of risk relates directly to the amount of reliable and relevant information and its social location, and to the consequent bounded rationality of individuals and collectivities operating more or less coherently in existing, institutionalised systems. Thus Britain versus France in the late eighteenth century, Japan versus China in the late nineteenth century, South Korea versus Burma in the late twentieth century?

Finally, culture is the most treacherous of terms, an ideal type, a stock of recognised knowledge and achievement, experience recorded, a social phenomenon expressive of meanings /values/attitudes 'not only in art and learning but also in institutions and ordinary behaviour'.⁵ So, Japanese industrialisation was predicated on a reinvention of the past to fit the control needs of the new technological system: the Emperor

³ The references are wellknown, but see E.E. Hagen, *On the Theory of Social Change*, (Harvard, Illinois, Dorsey Press, 1964); Michael Argyle *et al.*, (eds), *Social Theory and Economic Change*, (London, Tavistock Publications, 1967); Lecture one of Alexander Gerschenkron, *Europe in the Russian Mirror*, (Cambridge, 1970); Talcott Parsons, 'Evolutionary Universals in Society', *American Sociological Review* 29, (1964), pp.339-57.

⁴ Compare with Mary Douglas, *Cultural Bias*, (London, Royal Anthropological Institute, 1978); Douglas and A. Wildarsky, *Risk and Culture*, (Berkeley, University of California Press), 1982.

⁵ Raymond Williams, *Culture and Society 1780-1950*, (Penguin, London, 1958), pp.16-18.

Movement, the samurai ethos and *shingaku* sprang not from 'the past' but from necessity.⁶ In contrast, China may well have represented an ideal type traditionalistic society, where culture was, in the anthropological sense, highly 'configured'. Individuals or collectivities settled within a highly configured culture may not, as it were, ignore or divest themselves of 'archaic' components, however much they or even their leaders may see such components as retardative of technological or other achievements, because either acceptance or applause would have convoluted impacts (extramural implications) throughout the social structure.⁷ This essentially prosaic feature may explain something of the differences in the modern economic histories of Japan and China. Japan was certainly no more 'creative' than China, it was certainly more responsive. The historical relationship between creativity and response is, thus, problematic.⁸

On the other hand, Needham has stated that in the case of China, 'however great the forces of conservatism there was no ideological barrier ... to the development of modern natural science and technology when the time was ripe'.⁹ Here there is clearly a distinction between conservatism as ideology and conservatism as a feature of the operation of bounded rationality. For instance, 'culture' in the Toynbeeian sense may have been of

⁶ The notion of re-invention of tradition in order to legitimise modernity may be found in V.G. Childe, *Social Evolution*, (London, 1951); for a summary of the Japanese case R.J. Smith, *Japanese Society, Tradition, Self and Social Order*, (Cambridge, 1983), ch. 1.

⁷ Ian Inkster, 'Colonial and Neo-Colonial Transfers of Science and Technology' in D. Kumar and R.M. MacLeod (eds), *Science, Technology and the Raj*, (New Delhi and London, 1995), pp. 25-50.

⁸ This may be seen as reflecting a structural-cultural position, rather than one espousing the actual 'content' of the value-system, a distinction confounding much so-called Weberian analysis eg. the complex of religious beliefs and the status of particular religious groups is of more importance than the 'content' of a religious belief.

⁹ Joseph Needham, 'Science, Technology, Progress and the Breakthrough: China as a Case Study in Human History' in Tord Ganelius (ed), *Progress in Science and its Social Conditions*, (Oxford, 1986), p. 14.

very little relevance compared with bureaucratic institutions in dampening the achievement of the Chinese technological system after, say, 1650 or 1700. But even this formulation requires some care and reflection. It is, for instance, well-enough known that Chinese technology transfer to Europe at an early stage left Europe remarkably changed, but that improved Chinese technique in China (composed of a series of certifiable Chinese 'achievements') or European technique in China left the latter remarkably undisturbed - specific micro-achievements led to little or nothing in the way of a systemic, macro-achievement. Achievements may be absorbed. Perhaps arguments designed to explain cognition/science are not appropriate explanations for artefact/technology? By the time of the European scientific achievement the new views and techniques were surely of practical relevance to China: mechanics for shipping, hydrostatics for water control. What of the existent non-cultural features of China which inhibited technology *diffusion* and therefore *systemic* achievement? In bureaucratic China little private return was to be gained through the introduction of superior technology. This approach is reflected in Needham's stress on the absence in China of a 'mercantile culture', but the actual focus is institutional ie. derivable from a far narrower conception of 'culture'.¹⁰ But, in fact, demand may have been absent for other reasons, amongst them the low cost of Chinese labour and the *relatively* equable distribution of income at the time compared to, say, North Western Europe or Tokugawa Japan. In particular, the *adaptive diffusion* of technique within Europe was central to its economic achievement, and some function of the *variety* of tasks which each technique could be applied to. In Europe, for instance, the water wheel was applied to grinding grains, fulling cloth, throwing silk and so on. In China the water

¹⁰ That is, if we define 'culture' as 'content' of attitudes/ideologies etc. then there was little in 'Merchant Culture' in early modern Europe that was actually exclusive to merchants. But merchant *life* threw up a complex of institutions invaluable to the improvement and diffusion of both science and technology.

wheel was mostly used for metal-making only, and there were many substitutes for metal in China.¹¹

Achievement is, patently, a function of acceptance (not merely production), and we must admit that this lies beyond economy alone. So the historian in search of 'achievement', even when that term is narrowed to potentially measurable, systemic technological progress, may move between culture and its economic context, structure and process, market and non-market institutions, especially those defining information, its status and social location, between individuals and systems, motivations and the effective boundary conditions of real action. Joel Mokyr is willing to allow that his path-making macroinventions 'are seeds sown by individual inventors in a social soil', this bringing together idea and artefact, individual and system, action and its consequence. On the other hand, and ultimately, 'it is hard to think of conditions that would be either necessary or sufficient for a high level of technological creativity'.¹² This may serve as our first text.

In looking very briefly at two cases of immense systemic technologic achievement, one basically organic, the other blatantly critical (Saint-Simon), we might uncloset some convincing simplicities. The last section of the paper begins to unravel the extramural implications of the case studies.

English Industrialisation: Problems of the Free Lunch

Those few historians who are brave enough, confident enough or merely established enough to surmount technical niceties, find that the 'extraordinary flowering of ingenuity' is a useful interpolation in

¹¹ The debate on such matters continues. For an early statement, H. Bourgin, *L'industrie et le marché* (1924) and for his reflections and modifications of this, Fernand Braudel *Civilisation and Capitalism 15th & 18th Century*, especially vol. II, *The Wheels of Commerce*. Fontana English edition, 1982, pp. 298-314. Braudel seems to come down in agreement with the established argument that China's failure to industrialise was some direct function of higher levels of bureaucratic statist rigidity and conservatism, which inhibited the key emergence of a 'multisecular and general movement of society', in contrast to Japan and Europe: see *ibid* pp. 585-601 p. 601)

¹² Joel Mokyr, *The Lever of Riches, Technological Creativity and Economic Progress*, (Oxford, 1990), p.299.

reflecting upon the major achievement of British industrialisation. Just as our introduction ends with the mundane, Deirdre McCloskey ends with 'ordinary inventiveness'. Of course there is a contrast: it is possible to explain the extraordinarily inventive in terms of the mundane, or explain achievement in terms other than that of extraordinary inventiveness.¹³ For McCloskey, it was a surfeit of ordinary things which allowed Britain to guzzle a massive free lunch between 1780 and 1860 whilst no one else was at table, though some were in the same room.¹⁴ Despite a little torture, even Nick Crafts is willing to refer to 'inventive activity' and 'better machines' and 'improvements', if not Ashton's schoolboy, in isolating the forces behind the growth of the British economy in the eighteenth century.¹⁵ And this represents a great return, even to the years before Ashton. In 1757 Josiah Tucker had argued that few countries were equal, 'perhaps none excel, the English in the number of contrivances of their machines to abridge Labour'.¹⁶ In 1919 a distinguished student of British industry, Alfred Marshall, had declared that the 'leading characteristic of English inventions has not been their ingenuity'.¹⁷ Admitting every hole in the econometrics, there yet seems to be no commanding argument which removes technology from the heart of English/British economic achievement in the years prior to 1850.¹⁸ The much-ignored H.L. Beales captured accurately and unpretentiously the more recently hard-won distinctions of Nathan

¹³ R. Floud and D. McCloskey (eds), *The Economic History of Britain Since 1700* Vol. 1, 1700-1800, (Cambridge, 1981). However, see essays 2 and 3 in the new edition, *idem*, (CUP, 1994), vol. I, pp 12-59.

¹⁴ Recently McCloskey has stated a Humean case for British industrialisation, in Deirdre McCloskey "1066 and a Wave of Gadgets: the Achievements of British Growth", in P. Gouk (ed.) *Wellsprings of Achievement*, Variorum, (Aldershot, 1995), pp. 113-132.

¹⁵ Crafts in *op.cit.* (footnote 13) pp.1-17; see also his 'Industrial Revolution in England and France', *Economic History Review* 30, (1977), 429-441. But also see NFR Crafts and C.K. Harley 'Output Growth and the British Industrial Revolution', *Economic History Review*, 45, (1992), pp. 703-30.

¹⁶ Josiah Tucker, *A Brief Essay*, (London, 1750), p. 124.

¹⁷ Alfred Marshall, *Industry and Trade*, (London, 1919), p. 73.

¹⁸ See chapter 3 of Ian Inkster, *Science and Technology in History*, (London, Macmillan, 1991).

Rosenberg (incrementalism)¹⁹ and Joel Mokyr (macroinventions and microinventions): 'The revolution in industry comprised a series of improvements rather than a series of startling inventions. The elaboration of large-scale manufactures necessitated the successive conquest of processes and parts of processes by machinery'.²⁰ Similarly, Raphael Samuel argues that mechanisation itself 'advanced by small increments rather than by leaps'.²¹ How did all this configure? Why Britain? More potently, why England?

England: David Hume and Trickling In

For David Hume, writing in the 1740s, it was easier to explain economic success than intellectual achievement, for whilst the first could arise from generalised avarice the other depended upon the inherent subtleties and fragilities of knowledge production. Hume had a clear answer to the problematic of Dutch rise and decline. If the achievement of the Dutch in the seventeenth century resulted from migration and other foreign influences, the nation subsequently never moved beyond the threshold for autonomous technological development: 'Multitudes of people, necessity and liberty, have begotten commerce in Holland: but study and application have scarcely produced any eminent writers'.²² Furthermore, the Dutch enjoyed 'no extent of land, nor possessing any number of native commodities, flourished only by their being the brokers, and factors, of others'. The Dutch may put back the evil day when others forge their own brokerage, for 'as all the transactions increase by the increase of industry in the neighbouring states, even people whose commerce stands on this

¹⁹ Nathan Rosenberg, *Perspectives on Technology*. (Cambridge, 1966).

²⁰ H.L. Beales, *The Industrial Revolution 1750-1850*, 1958 edition (of 1928 London), pp. 49-50.

²¹ Raphael Samuel, 'The Workshop of the World: Steam Power and Hand Technology in Mid-Victorian Britain', *History Workshop* 3, Spring 1977, p. 10.

²² The quotations and account are all drawn from David Hume, *Essays, Moral Political and Literary*, Edinburgh, 1741-42, and the *Political Discourses*, 1751, London. The quotations are taken from the essays as published as Vol. XXXIII of the *Works of David Hume*, London, Grant Richards, 1903.

precarious basis, may at first reap a considerable profit from the flourishing condition of their neighbours'. But, eventually, decreasing returns set in.

Although we must beware confusing contingency and cause, Hume was clear in distinguishing between cultivators and culture: 'it is impossible but a share of the same spirit and genius must be antecedently diffused throughout the people'. It followed that scientific if not technological achievement was not 'altogether a question concerning the taste, genius and spirit of a few, but concerning those of a whole people'. England possessed definite advantages, chief amongst them being freedom, the absence of which dictated the ultimate failure of the reforming Tsars of Russia, however science seeking they may have been. Intellectual creativity requires the Trinity, in proper chronology, of systemic law, thus systemic security, thus individualistic curiosity. More interestingly, Hume goes on to specify effective competition between systems: 'That nothing is more favourable to the rise of politeness and learning, than a number of neighbouring and independent states, connected together by commerce and policy'. The latter is important, for isolation and the subsequent undue potency of existing intellectual authority is 'destructive to the freedom of thought and examination ... the severest scrutiny which Newton's theory has undergone proceeded not from his own countrymen, but from foreigners; and if it can overcome the obstacles which it meets with at present in all parts of Europe, it will probably go down triumphant to the latest posterity' ie. our initial register of an achievement.

If Hume had solved the Hollander problem, so too he makes little of my China problem (above)²³. There was little difficulty in China with the *stock* of knowledge, the drawback lay with the authority in which it was held, as in Needham, a feature of culture configuration:

China is the one empire, speaking one language, governed by one law, and sympathising in the same manners. The authority of any teacher,

²³ The reference is to Mokyr, *op. cit.* (12)

such as Confucius, was propagated easily from one corner of the empire to the other. None had courage to resist the torrent of popular opinion; and posterity was not bold enough to dispute what has been universally received by their ancestors. This seems to be one natural reason why the sciences have made so slow a progress in that mighty empire.

Paradigm-type intellectual achievements require 'interruptions' which would be 'rather favourable to the arts and sciences by breaking the progress of authority, and dethroning the tyrannical usurpers over human reason'. Hierarchy produced achievement only in the polite arts, democracy or the republic is the desideratum of science and the mechanical arts. Great systemic social distance and dissonance (eg. the hand-mind distinction exhibited between classes in most hierarchies) will generate polite learning but under such conditions 'no improvement can ever be expected in the sciences ... and scarcely in the manual arts and manufactures'. What Joel Mokyr has referred to as Cardwell's Law belongs, of course, to Hume: 'That when the arts and sciences come to perfection in any state, from that moment they naturally, or rather necessarily, decline, and seldom or never revive in that nation where they formerly flourished'.

Thus China. Thus Holland. Thus Britain. Thus the United States.... If Hume had gone no further this might have still been of real interest to us. But, in fact, he then takes up the theme of transfer between systems, and here he does begin to broach the essence of English achievement. If England's initial advantages lay in its sociopolitical system, a major force at work was not so much its endogenous creativity but its openness to other systems. At one point Hume postulated a global reciprocity: 'that where an open communication is presumed among nations; it is impossible but the domestic industry of every one must receive an increase from the improvement of the others'. But another slice of the essay, *On the Jealousy of Trade*, suggests that a certain asymmetry of advantage was being captured and systematised by mid-century:

Every improvement which we have since made [from 1500s], has arisen from our imitation of foreigners; and we ought so far to esteem it happy, that they had previously made advances in arts and ingenuity. But this

intercourse is still upheld to our great advantage: notwithstanding the advanced state of our manufactures, we daily adopt, in every art, the inventions and improvements of our neighbours. The commodity is first imported from abroad, to our great discontent, while we imagine that it drains us of our money: afterwards the art itself is gradually imported, to our visible advantage....

Openness prevented or at least held back diminishing returns. Continual advancement in England required some achievement elsewhere, for otherwise intellectual and natural exchange would halt and diminishing returns to *endogenous* creativity would set in. This is close to modern evolutionary approaches to the history of technical change.

In exploring the English case there are three possible reasons why diminishing returns did not set in prior to the mid-nineteenth century, and I believe that all three were in operation; England continued to be a major recipient of scientific and technical knowledge stemming from Scotland and Europe;²⁴ the reduction of social distance and the reproduction of social marginality induced dynamic 'trickling through' effects, producing new nodal points of innovation in the technological system; in addition, micro-and-macro inventions clustered and fed off one another within the technological system, countering the impact of diminishing returns in any one path of incremental innovation.

It must be stressed that such arguments relate to the dynamic of the English technological system as such. The exact relationship between this and overall productivity and economic growth is another matter, for this was dependent upon, amongst other things, the demand, scale and investment context of the inventive or innovative activity.

Britain: The Open System, William Hutton and Trickling Through

Although there is little real indication of any decline in the openness of England to intellectual and technical inputs from both Scotland and Europe in the later eighteenth century, it is quite

²⁴ Ian Inkster, 'Mental Capital: Transfers of Knowledge and Technique in Eighteenth Century Europe', *Journal of European Economic History* 19, (1990), pp. 403-411.

possible that diminishing returns to technological creativity would have occurred in the absence of the reduction in social distance and the associated emergence of an urbanised, increasingly institutionalised cultural movement which carried within it both science (as information)²⁵ and technology (as both information and physical artefact). In the same year that David Hume was beginning to earn some small recompense for his printed thoughts on the arts and sciences, the young William Hutton, apprenticed stocking weaver, arrived in the town of Birmingham. His reflection on 1741 (composed in 1781) serves as our next text. Hutton wrote that the city was composed of

a species I had never seen: they possessed a vivacity I have never beheld; I had been among dreamers, but now I saw men awake: their very step along the street showed alacrity: every man seemed to know and prosecute his own affairs: the town was large, and full of inhabitants and those inhabitants full of industry.²⁶

This notion of sub-mass-milling is repeated by many eighteenth-century commentators. There was 'a great deal of trick and low cunning among the Birmingham manufacturers in general' because they *were* low; 'the genius of Birmingham is not that of coffee houses'.²⁷ In 1767 T. Forster noted the reduction in social distance:

In England the several ranks of men slide into each other almost imperceptibly, and a spirit of equality runs through every part of the constitution. Hence arises a strong emulation in all the several stations and conditions to vie with each other; and a perpetual restless ambition in each of the inferior ranks to raise themselves to the level of those immediately above them. In such a state as this fashion must have an uncontrolled sway. And a fashionable luxury must spread through it like a contagion.²⁸

²⁵ For a recent overview and interpretation, J. B. Morrell, 'Bourgeois scientific societies and industrial innovation in Britain 1780-1850' *Journal of European Economic History* 24, No. 2 (1995) pp. 311-332.

²⁶ William Hutton, *A History of Birmingham to the Year 1780*. (Birmingham, 1781), p. 44.

²⁷ W. Thompson, *Tour of England and Scotland*, (London, 1788), p. 11.

²⁸ T. Forster, *An Enquiry into the Causes of the Present High Price of Provisions*. (London, 1767), p. 41.

Thus Hägerstrand-like “neighbourhood effects”,²⁹ increasing levels of derived demand for technique, information flows both horizontal and vertical. Furthermore, as a variation on Hume, emulation derived from reduced social distance fed back into intersystem relations:

The Advantage of Commerce is evident to all Mankind; the wisest, the politest Nations on Earth now court her ... Before we were a Trading People, we were, it is true, subsisted by the natural produce of the Island: Our Manners were Rude, our knowledge of the World trifling ... But we no sooner became a Trading People, than the Arts and Sciences began to revive, and polished us out of our domestic simplicity and ignorance.³⁰

Individualism plus market expansion plus knowledge allowed the technological system to push ‘to the utmost the principle of the division of labour, calling on all the resources of scientific research and mechanical ingenuity’.³¹ Once the system employed and rewarded trade skills and tacit knowledge, future development was inevitable, for as Adam Smith recognised, there was ‘scarce a common trade which does not afford some opportunities for applying to it the principles of geometry and mechanics, and which would not therefore gradually exercise and improve the common people in those principles’.³² The availability of specific scientific and technological information throughout the social system was perhaps key amongst several intricate force conjunctions of the industrial revolution.

Arguments from derived demand, which ignore or discount knowledge supply, fail to recognise that applications, when sought, are seldom found. David Landes wanders uneasily between conventional demand arguments and less-conventional supply-side arguments. Thus, aspects of the social system may have provided

²⁹ Torsten Hägerstrand, “The Diffusion of Innovations”, *International Encyclopaedia of Social Sciences* 4 (1968), p.170.

³⁰ R. Campbell, article under ‘Merchants’ in his *The London Tradesman*, London, 1747.

³¹ *Report for the Committee on the State of the Woollen Manufactures of England*, London, House of Parliament, 1806.

³² Adam Smith, *The Wealth of Nations*, (London, 1776), Book V (1936 ed.) p.267.

greater opportunity for social mobility and experiment and risk-taking, may have offered greater rewards to inventors, or may have involved less in the way of institutional barriers (eg. guilds) than in other European nations. As in Sidney Pollard's more recent treatment, the social and the regional are then combined in the hypothesis, 'was it not only that the English atmosphere was more favourable to changes, but also that special experience in certain areas provided unique facilities for training?'³³ Drawing on the earlier work of Musson and Robinson,³⁴ Landes points to specific micro-environments of skill, adaptation and innovation, which favoured system achievement. But in the end 'the pressure of demand ... called forth the new techniques in Britain'.³⁵ This ambiguity is understandable within such a large and classic scape, but it remains unsatisfactory.

Information for decision-making and risk-taking was continuously trickling in from Europe and across from Scotland. A complete approach requires an independent argument for the flow of scientific and technical inputs into England from Scotland, and there is still a great deal of debate surrounding the issue.³⁶ If Nicholas Phillipson is basically sound in judging that the sustenance of the Scottish enlightenment lay less in the 'democratic intellect' than in an ideology of improvement, then we may go on to postulate that the cultural and institutional effects of socio-economic peripheralisation within Britain may lie at the heart of the matter.³⁷ The outside sources fed the further growth of the English

³³ David S. Landes, *The Unbound Prometheus*, (Cambridge, 1969), p.63; see generally the early pages in S. Pollard, *Peaceful Conquest*, (Oxford, 1981).

³⁴ A. E. Musson and E. Robinson, *Science and Technology in the Industrial Revolution*, Manchester UP, Manchester, 1969. But see also important modifications to the argument in P. Mathias 'Who Unbound Prometheus? Science and technical change 1600-1800' in P. Mathias (ed) *Science and Society 1600-1900*, Cambridge University Press (Cambridge, 1972), pp. 54-80.

³⁵ Landes, *op.cit.* p.77.

³⁶ See H.R. Trevor Roper, 'The Scottish Enlightenment', *Studies in Voltaire and the Eighteenth Century* 58, (1967); N.T. Phillipson and R. Mitchison (eds), *Scotland in the Age of Improvement*, (Edinburgh, 1970).

³⁷ N.T. Phillipson, 'Culture and Society in the Eighteenth Century Province', in L. Stone (ed), *The University in Society*, Princeton, 1975; T.C. Smout, 'Scotland and England: Is Dependency a Symptom or a Cause of Underdevelopment?', *Review* 3 (1980).

information system, as did the continued reproduction of social marginality in new urban settings. Much of T.S. Ashton's little classic is postulated on this; 'there was much coming and going between the laboratory and the workshop.... Inventors, contrivers, industrialists and entrepreneurs ... came from every social class and from all parts of the country'.³⁸ The price of information *fell*. Thus social (not economic) forces generated information, scientific and technical networks were constructed for social purposes, and this represented an information pool or stock which could be drawn upon by producers of goods and technologies.

In a sense, England derived its large free lunch from a combination of three contrasting sources, each of which was inherently systemic. Much of the knowledge or technique which flowed from Europe was generated under the auspices of the state.³⁹ In Scotland, economic peripheralisation led to an elitist ideology of improvement which generated institutions and attitudes which, through diverse channels, flowed into the English technological system. Thirdly, within England itself information was disseminated within a provincial, urban culture which was in many ways anti-establishment. Neither the state nor the English elite were, at that time, prominent members of the new scientific and technical information systems. And we might remember that, unlike other factors of production, information expanded with use.

British Achievement: Motivation in Context

Both *homo economicus* and *homo creativus* abounded in the British industrial revolution. They did not operate in strongly configured blocks of the social system. There was a process of mass-milling. Hume's and Forster's stress on 'emulation', 'contagion' and 'imitation' sits happily alongside Hutton's and others' repeated reference to a 'new species', 'restless ambition' and 'men awake', to the growing qualities of vivacity, alacrity and novelty. Whilst breakthrough technology requires spurts of insight

³⁸ T.S. Ashton, *The Industrial Revolution 1760-1830*, (London, 1948), quote pp.16-17.

and creativity and serendipity, the sustained progress of industrialisation, the achievement of total economic systems, requires the systemic repetition of the everyday, the pragmatic, the honest, the mundane.⁴⁰ The ordinariness of invention was some function of both external sources, which provided information, skill and competition, and the internal reduction of social distance. Genius was present in both England and Scotland, but in the latter it could not be contained. Genius was present in both Britain and France, but in the latter it could not readily be diffused as average practical technique.

So far so good. There appears to be a Humean-Rosenbergian interpretation for the achievements of the British technological system prior to the sustained growth of industry in the nineteenth century. Motivations were a little different than in France (Hume), the boundary conditions of the two systems were greatly different eg. the definite contrasts of spatial and social distance, the contrasting levels and locations of specific skills (containing tacit knowledge), degrees of openness to outside influence and so on. Furthermore, in Britain the physical complementarities between large technical innovations and subsequent chains of incrementalism sustained the system and countered the impact of diminishing returns to any one path of technical progress. Here, the strong information culture was of quite vital importance.

It is just conceivable that we have now presented - if anything - an overdetermined theory of technical achievement in Britain, which is either inherently confused as to the role of individual and group motivation or is independent of an *explicit* or *special* argument from motivation. Humean factors may or may not suffice to explain the large breakthroughs, Rosenbergian factors related to induced demand, localisation of skills and machine complementarities may well explain the stupendous outpouring of

⁴⁰ There are, of course, procedural and conceptual problems associated with such distinctions as "creative technological breakthrough" and "mundane incrementalism"; see Ian Inkster 'Discoveries, Inventions and Industrial Revolutions', *History of Technology*, 18 (1996), pp. 39-58.

minor inventions. Thus the latter may well immediately obey the rules of the economists, but, as Mokyr has emphasised, they suffer diminishing returns if not punctured by breakthroughs. Mokyr is tempted to explain the puncturing of equilibrium in terms of an evolutionary approach, we are inclined towards a systemic approach specific to our needs.⁴¹

The advance of diminishing returns inhibits *systemic achievement*. What we require, in all probability, is another level of input and argument, relating to institutional change. If, as we began, people behave in context, that context may be best defined in institutional terms rather than in factorial terms ie. we might try to go beyond inducements to action/achievement stemming from Humean and Rosenbergian forces, into the motivations of individuals as formed, expressed and rewarded within the institutions of the social and technical systems.

It must be recalled that, in the end, Max Weber explained technological achievement of the British type primarily in terms of explicit institutional breakthroughs, systemic inducements from international competition, deforestation, reverse salients,⁴² the independent English city, the increased 'union with science' and the forward movement provided by increased complementarities.⁴³ In this reading of Weber, the history of context - mainly in terms of institutions - bore the brunt of explanation of specific technological achievement, not motivation. The latter was forged within British (or European) institutions.

More recently, for Nobel prize-winner Douglas North, the industrial revolution was an acceleration of the rate of innovation associated (more than contingently but less than causally?) with better specification of property rights, which improved and stabilised

⁴¹ See Mokyr, *op.cit.* (footnote 12) with particular regard to the last interpretative sections.

⁴² W.E. Bijker, T.P. Hughes and Trevor Pinch (eds), *The Social Construction of Technological Systems*, (Cambridge Mass.), 1987.

⁴³ Max Weber, *General Economic History*, (New York, 1966), pp.224-33. Originally delivered as lectures by Weber during 1919-20 under the title 'Outlines of Universal Social and Economic History';

market forces (and thus motives relating to profit) and certified risk. Early-phase institutions served primarily to define property rights, later-phase institutions served to reduce the higher transaction costs which stemmed from Smithian division of labour. Such institutions included the factory itself. North's chain of causal regress is quite clear, organisational change being a function of the *intent* of key managers of the technological system, and these institutional innovations 'had the consequence of radically lowering the cost of innovating at the same time that the increasing market size and better specified property rights over inventions were raising the rate of return on innovation. It was this set of developments which paved the way for... the wedding of science and technology'.⁴⁴ The mixture of system and intention is troublesome indeed, but it is fairly clear that North's approach to the role of institutions in systemic achievement fits easily into (and possibly adds very little to) a Humean-Smithian perspective. This approach seemingly does *not require* an explicit linkage between individual/sub-system *motivations* and system *achievement*. Motivation may be assumed fairly constant or universal, action is constrained by institutional boundaries. Achievement - a clustering of successful commercial and technological activities - results from a removal or loosening of the boundaries. Perhaps the good life is also thereby redefined. Motivation is at all times lying in wait upon institutional innovation, and this seems to come from key system managers whose explicit aim is to redefine the boundaries of action. Again, the impact of actual technical change, especially of the breakthrough type, is similarly contained by institutions as well as by cruder economic forces and by the absence or availability of essential technique inputs. Thus North and Mokyr have a very similar view of the 'enabling' power of Wilkinson's boring machine ie. that it 'allowed' or 'permitted' Watt to bore precise cylinders, hence the actual technological achievement of the steam engine.⁴⁵ For Mokyr, indeed,

⁴⁴ Douglass C. North, *Structure and Change in Economic History*, (New York, 1981), p.159.

⁴⁵ *ibid.*, p.163; Mokyr, *op.cit.*, (footnote 17), pp. 88, 103-105, 183, 241.

Wilkinson 'made the difference between Watt and Trevithick on the one hand and Leonardo Da Vinci on the other'.⁴⁶

From Margaret Jacob to Joel Mokyr, the new interpretative historians of British science and technology have more to say about attitudes, motivations and impacts than they have to say about the institutional context within which all such were manifested.⁴⁷ They would certainly admit to the crucial importance of the complex of formal and informal institutions which carried science and technological *information* (or, in Jacob, *method* too), and this is a focus of an extensive industry of scholarly production.⁴⁸ But do features of this institutional complex also provide clues to motivation, particularly to the motivation of individuals employed in systemic technological advance? Obviously, the social distance argument may be reworked for this purpose. In England more than anywhere else, advanced information or innovative activity led potentially to both social *and* economic rewards. Social marginality was a feature of both social restrictions and relative liberalism, and was played out in institutions. In the absence of Liberalism (again Hume) all radicals and dissenters would have ended up in the colonies or in Europe. Most did not. They emerged rather as innovating, institutional activists within the fast-emerging urban cultures of London, Birmingham, Manchester or wherever. Disaffection within this particular institutional setting was what led to the claiming of an audience; the urban associations of science and technology were essential to the gaining of power and respectability at a time of formal political exclusion. Quite clearly, the motivating or sheer energising of such key collectivities itself gave rise to further

⁴⁶ Mokyr, *ibid.*, quote pp.103-04.

⁴⁷ Margaret C. Jacob, *The Cultural Meaning of the Scientific Revolution*, (Philadelphia, 1988); for contrast, but covering a later and limited task, M. Berman, *Social Change and Scientific Organisation, The Royal Institution 1799-1844*, (London, 1978).

⁴⁸ For examples of which see A.E. Musson and E. Robinson, *Science and Technology in the Industrial Revolution*, (Manchester, 1969); A.E. Musson (ed.), *Science and Technology in the Eighteenth Century*, (London, 1972); Ian Inkster and Jack Morrell (eds.), *Metropolis and Province*, (London, 1983).

institutional changes, information dispersal and reductions of social distance. The resulting availability of packets of scientific and technical information, transmitted through a collectively constructed network, may well have been a necessary factor in contributing to informed empirical technical research and invention. The gross availability of such information amongst diverse social groupings and between diverse localities may be what finally distinguishes the British case from that of any other.

Japanese Industrialisation: Problems

Given the apparent need for large-scale initial investments, the high cost of motive power and transport, the lack of worker and management training, the relative absence of an entrepreneurial culture, the historical internalisation of (Needham's) merchants and the unsettled nature of the political system, how was it that late nineteenth century Japan emerged as by far the greatest achiever outside the pale of the Atlantic economies? Compared to the case of Japan, Landes' problem of the spread of industrialisation in Europe and to America appears eminently solvable. There is no convincing argument from indigenous creativity. The Japanese were happy with the 'ready made' if attuned to 'accurate and detailed investigation'.⁴⁹ It is true that Weber distinguished Japan from his 'oriental system' as a 'product economy' similar to that of Western feudalism, with 'proprietaryship' through 'enfeoffment'. On the other hand, he had no actual explanation of how the dissolution of 'proprietary rights' during the 1860s, led to the emergence of a class of Japanese 'capitalists'.⁵⁰ In contradistinction to Humean openness and minimal social distance was late Tokugawa's relative isolation, clannism and social hierarchy. Eric Jones turns such features to his own advantage in espousing the position that Japan's success floors all attempts to equate 'political liberty and economic progress', and thereby severely reduces the potency of the Humean perspective as

⁴⁹ *Japan Weekly Mail*, 25 June 1870.

⁵⁰ Weber, *op.cit.*, (footnote 43), pp.61, 84.

a global explanation.⁵¹ But Jones does not pursue his advantage, and he offers no real argument to explain the technological achievement of Japan prior to World War One.

The early years of Meiji - ones of definite industrialisation but only dubious overall economic growth - were characterised by a large transfer of foreign knowledge and technique and a wholesale reinstitutionalisation, the latter stretching from new training and knowledge-dissemination mechanisms to land reform (taxation and property rights), political reform (towards a Prussian-style civil code and constitution) and social reform (towards a legislated reduction of social distance). Why? (not What?) is the initial form of the question.

The basic character of the overall systemic dynamic is not questioned: productivity gains in both agriculture and industry arising from the transfer of advanced technology into Japan were the essential determinants of the eventually achieved high rates of both industrial and economic growth.⁵² government interventionism - basically inefficient in short-term, cost-benefit aspects - was central to institutional change as well as to the transfer process itself. Ohkawa and Rosovsky explicitly link technological and institutional change: the process of technology 'absorption' and the required investment pattern promoted 'the development of specific institutions that facilitated the entire' process.⁵³ For Mokyr, such a nexus was created in the realisation by government (the legitimate system builder) that 'technological backwardness itself constituted a threat to the regime'.⁵⁴ Such views represent the advocacy of a classic feedback mechanism, whose

⁵¹ Eric Jones, *The European Miracle*, (Cambridge, 1981), p.158. Hopefully Jones is not at his most serious when he summarises that 'in certain respects Japan was as 'European' as if it had been towed away and anchored off the Isle of Wight', (p. 159). Anyhow, just precisely *how* European (or even British) were the Shetland islanders of the eighteenth century?

⁵² See K. Takahashi, *The Rise and Development of Japan's Modern Economy*, (Tokyo, 1969); and for a very brief summary, chapter 30 of Benjamin Higgins, *Economic Development, Problems, Principles and Policies*, (New York), revised edition, 1968.

⁵³ K. Ohkawa and H. Rosovsky, *Japanese Economic Growth*, (Stanford, 1973), quote pp.218-19.

⁵⁴ Mokyr, *op.cit.*, (footnote 12), quote p.181.

dynamics start with elements exogenous. For Reischauer, the cognition and determination of system-builders was the initial point from which all else dynamic followed:

the Japanese studied, borrowed, and gradually assimilated those elements of Western civilisation which they chose to adopt.... The Japanese determined to learn from each Western country that in which it particularly excelled.... They saw at once that a technically competent populace was a prerequisite for a modern power.... Western science and cheap oriental labour made an excellent combination for low-priced production.⁵⁵

This pleasant recipe may serve as our next text. It does not take a sociologist of knowledge to see that problems abound. It does not take a geographer to see that some thirty million people could not have been all at once so abundantly engaged in the process of industrial modernisation.

Japan: The Controlled System and Tricking In

Under the prevailing conditions of the late nineteenth century, the character and extent of trickling-in was determined by the nature of the commanding technological imperatives (eg. of scale, skill intensity etc.), indirect and direct transfer mechanisms and selection processes, and relevant internal boundary conditions relating to finance, physical and social space, existing skills and knowledge, and political stability.⁵⁶ Much of this is relatively unproblematic - and only imperfectly related to the eighteenth century liberalism identified by David Hume! Indeed, from Japan, it might reasonably be argued that successful trickling-in demanded a systematic rejection of Humean liberalism. Given the legitimation of the new systems builders after the Restoration of 1868, what mattered was retained sovereignty and this required the effective operation of a series of control mechanisms. The resulting continuity and risk-reducing context stimulated rampant institutional and technological incrementalism (emulation,

⁵⁵ Edwin O. Reischauer, *Japan. Past and Present*, (London, 1964).

⁵⁶ See chapter 7 of Inkster, *op.cit.*, (footnote 18).

adaptation) rather than breakthrough innovations. Achievement, therefore, arose from the ability of the system to responsively retain its sovereignty and to continuously select and diffuse foreign know-how and technique. Diminishing returns resulting from a relative absence of breakthrough technological advance within the system was seemingly adequately countered by new mechanisms and levels of transfer as well as truly innovative institutional response and adaptations.

This sort of formulation posits a bunch of contrasts between the British and Japanese cases; endogenous prime movers versus exogenous impacts: initiation versus reaction and response; a multitude of 'blind-watchmaker' system builders, versus centralised, goal-orientated system building; organic change across a wide front leading to critical dynamics, versus critical impacts absorbed by deliberate institutional adjustments; extended motivation resulting in inchoate individual actions reflecting social tension and marginality, versus compacted industrial drive resulting from centralised responsiveness reflecting a perception of sovereignty at bay.

An important similarity between the two cases was the sustenance of 'trickling in' during systemic change. In the case of Japan, the continuation of this technological process was almost certainly determined in the institutionalisation of socio-political control.⁵⁷

It may be quite conventionally argued that in such a case of relative technological backwardness, a strong 'industrialising élite' may transcend socio-cultural 'barriers' to change, both through overt controlling activity and through the creation of institutions (business, legal, police, administrative etc.), functioning so as to substitute for the Humean-type prerequisites of the eighteenth century early starter. If so, in such a case the process of industrial achievement may be somewhat detached from 'underlying' social values and

⁵⁷ Ian Inkster 'Culture, Action and Institutions: On exploring the Historical Economic Success of England and Japan' in P. Gouk (ed.) *Wellsprings of Achievement: Cultural and Economic Dynamics in Early Modern England and Japan*, (Variorum, London, 1995), pp.239-266.

traditional institutions.⁵⁸ If system building requires social engineering, the Kerr, Dunlop *et al.* formulation seemingly holds:

If the dynamic elite is the prime mover towards industrialisation, as in Japan during the Meiji restoration, many of the traditional values will be preserved while others change. The authority of superiors stemming from the restoration of the emperor, was maintained ... the Japanese did not hesitate to adopt modern technology ... the traditional culture favoured the dynamic elite as the prime movers toward industrialisation, and this elite in turn preserved as much of that culture as possible.⁵⁹

Once more the cognition, intentions and power of system-builders dominate the explanation, this time qualified by an argument from culture. Tradition and its manipulation becomes a tool of change, but change incorporates cultural selection as certain key (functional?) values and institutions are preserved and highlighted by system builders. Thus viewed, culture is both a resource and a product.

In fact, internal control during the crucial early Meiji years required far more than such 'soft' techniques. The overt political violence and intellectual debate of the 1870s must be stressed in any worthwhile account of Meiji technological achievement.⁶⁰ Conflict-containing institutional developments included the popular assemblies and the constitutional reform, new media and communications structures, the 'party' movement as well as all those institutions within which dissenting opinion could be gainfully employed ie. absorbed within the very process of change itself. This latter point is perhaps of greatest importance in understanding system-maintenance during Meiji technology transfer. The Meiji oligarchy speedily created a meritocracy based on the new universities, ministries, agencies and bureaux, within which milled the *ōyatoi* (foreign) technological experts and the

⁵⁸ Ian Inkster, *Japan as a Development Model?* (Bochum, 1980), pp.64-68.

⁵⁹ C. Kerr, J.T. Dunlop, F.H. Harbison, C.A. Myers, *Industrialism and Industrial Man*. (London, 1962), p.87.

⁶⁰ Ian Inkster, 'The Other Side of Meiji: Conflict and Conflict Management', in G. McCormack and Y. Sugimoto (eds), *The Japanese Trajectory: Modernisation and Beyond*, (Cambridge, 1988), pp.107-128.

foremost Japanese intellectuals.⁶¹ The treaty ports became focal points of influence. Together with the removal of the means of diffusion of radicalism and the selling-up of government enterprises during the late 1870s and the 1880s, the new employment outlets and information channels defined the character of a new bounded rationality in Japan.

Finally, and of undoubted importance to any understanding of successful technology transfer under conditions of relative system backwardness, the level and nature of conflict and opposition were strongly conditioned by the *specific nature of the commanding technological imperative*. System builders did not focus entirely on the best from the West - in labour-intensive manufactures and throughout agriculture quite mundane, incremental changes to both technique and its organisation were central to economic achievement. This reduced the political impact arising from extreme cognitive dissonance. For instance, the business elite was incorporated fairly smoothly amongst the system-builders because the comparatively simple level of even 'best technique' enabled them to move from their traditional mercantile/commercial functions to a more modern manufacture/management function. At the level of overt opposition, the nature of imported and adapted technology was such as to minimise the 'displacement' effects of unemployment, and to permit new skills to develop just as many other skills found new rewards. The subsequent emergence of dualism of scale, skills and organisation between and within particular industries during the 1880s further permitted a continuity of economic activity in older industries (eg. textiles) and newer leading sectors (eg. mining) and maintenance of non-urban social institutions. Much of new manufacture was, in fact, rural. It seems that the 'technological imperative' was of such a kind as to dampen the politico-economic tensions which arose during the technology

⁶¹ For meritocracy and mass milling respectively, B.S. Silberman, *Ministers of Modernisation*, (Tucson, 1964), Ian Inkster, *Science, Technology and the Late Development Effect: Transfer Mechanisms in Japan's Industrialisation circa 1850-1912*, (Tokyo, 1981).

transfer process in such countries as Tsarist Russia during the de Witte industrial programme of the 1890s.⁶²

Japan: Creative Response as Institutional Innovation

Writing out of European-based backwardness, such otherwise very diverse thinkers as Trotsky, Veblen and Strumilin identified the essential links between relative backwardness, threat, technology transfer and institutional change.⁶³ If an advanced core technology or set is to be transferred without paradigmatic modification in the short or medium term, then the greater the discrepancy between systems the greater must be the extent to which ancillary technique, knowledge and institutional components are transferred alongside the core. Given great discrepancy (as we have here), either blueprint transfer fails, core technology must be significantly adapted prior to transfer, or core technology must be transferred alongside ancillary physical and service facilities and contingent changes in institutions.⁶⁴ All of this may be witnessed in Japan. The American agricultural blueprint for Hokkaido failed dismally. The Japanese were adept at adapting technologies, particularly to labour availability, existent skills and raw material supplies. Ancillary services were imported in the manner of the *ōyatoi*, (honourable hirelings), the treaty ports, key skilled workers,

⁶² Ian Inkster 'Technology Transfer and Industrial Transformation. An interpretation of the Pattern of Economic Development circa 1870-1914' in Robert Fox (ed.) *Technological Change*, (Harwood, Oxford, 1995) pp. 177-200; *idem*, 'Late Development Revisited: Aspects of International Technology Transfer and Russian Industrialisation prior to 1914' in S. V. Ustiantsev *et. al* (eds.), *Russia and West Europe: Interaction of Industrial Cultures 1700-1950*, (Ekaterinburg, 1996), pp. 7-16.

⁶³ B. Knei-Paz, *The Social and Political Thought of Leon Trotsky*, (Oxford, 1978); T.G. Veblen, *Imperial Germany and the Industrial Revolution*, University of Michigan, 1966, original 1915; J.P. Diggins, *The Bard of Savagery*, (Harvester Press, 1978); R. Hutchins, *Soviet Economic Development*, (Oxford, 1971).

⁶⁴ Illustrated in Inkster, *op. cit.*, (footnote 24); more generally, Nathan Rosenberg, *Inside the Black Box*, (Cambridge, 1982), contentiously, Hing Ai Yun, 'Science, Technology and Development', *Journal of Contemporary Asia* 16, (1986). and Ian Inkster, 'Structural Change, the Multifunction Polis and Japanese R+D for Australia', *Journal of Contemporary Asia* 20, (1990), and very specifically and convincingly, J.A. McGaw, *Most Wonderful Machine; Mechanisation and Social Change in Berkshire Paper Making 1801-1885*, (Princeton NJ, 1987).

organisational know-how. But, more than this, the Japanese system-builders invested in institutions which together created an environment for selection, innovation and service.⁶⁵ To the 1873 Vienna Exposition were sent no less than seventy Japanese delegates, including twenty-four technical workers from the private sector whose task was to search and purchase appropriate techniques. From Austria the group brought back the latest textile looms, which were then tested and leased to various provincial entrepreneurs after regional public display.⁶⁶ Established by government, the Akabane Engineering Office (1874) was designed to construct selected and tested machinery for purchase by private Japanese enterprise. Innovation awaited institutional diffusion. Thus the *kyosbinkai* (cooperative - competitive exhibitions) were established from 1879 for the spread of *existing* best technique and during their peak in the 1880s successful exhibitions might last from 30 to 100 days. In 1887 alone, 317 exhibitions were opened for the combined total of 2410 days, involving 180,000 producers displaying 430,000 articles before an estimated audience of 2 million people.⁶⁷ The *ōyatoi* hiring policy of the *Kobusho* (Ministry of Industry) centred on infrastructure formation; during 1872, 80% of its 800 foreign employees worked on transport, communication and mining projects.⁶⁸ The bureaux in charge of metrication, standardisation and clearer specifications in government contracts hastened the process of technology diffusion. The establishment of hundreds of trade associations under official auspices from 1884 were designed initially to control product quality, but they soon

⁶⁵ For such categories see R.R. Nelson and S.O. Winter, 'In Search of a Useful Theory of Innovation', *Research Policy* 6, (1977); F.R. Bradbury, V.T.P. Jervis, R. Johnson, A.W. Pearson, *Transfer Processes in Technical Change*, (Rijij, Netherlands, 1978); B.J. Loasby, *Choice, Complexity and Ignorance*, (London, 1976).

⁶⁶ Japanese internal exhibitions of industry began around 1877 and by the 1890s were attracting over 1 million visitors. From 1867 to 1910 Japanese delegates participated in at least 38 major international exhibitions.

⁶⁷ A.E. Burks (ed.), *The Modernisers: Overseas Students, Foreign Employment and Meiji Japan*, (London, 1985); H.J. Jones, *Live Machines*, (Vancouver, 1980); Henry Dyer, *Dai Nippon*, (London, 1904).

⁶⁸ N. Umetani, *The Role of Foreign Employees in the Meiji Era in Japan*, (Tokyo, 1971.)

developed as regional technical extension centres. The newly established, patent system worked asymmetrically in Japan's favour - thereby Mitsubishi gained ownership of the Parsons turbine and Shibaura obtained entry to General Electric's manufacture of heavy electrical equipment.⁶⁹

In addition to protection of innovative behaviour and stimulation of social mobility, new Western systems of commercial law and practice hastened the occurrence of individual entrepreneurship; that is, a group of 'derived' systems builders emerged during the 1880s and 1890s.⁷⁰ In addition to such quite specific, targeted legislation as the Promotion of Navigation and Shipbuilding laws there was also a series of important incremental enactments encouraging innovative behaviour amongst smaller enterprises in the more traditional industries.

In terms of our specific analysis and focus, the institutionalisation of the scientific and technological enterprise is also of interest as a component of systemic institutional adaptation. Despite the strong thin line of *Rangaku* (Dutch Learning) there is little good evidence of any transforming intellectual or technological revolution either prior to or immediately after the Meiji Restoration.⁷¹ Scientific (knowledge) or scientific (role) transition was not a wholesale intellectual or cultural phenomenon but a matter of counting heads and new organisations.⁷² The essential epiphenomenality of Western science in both Tokugawa and Meiji Japan is not seriously doubted, and this helps to explain the obvious emphasis on the role of Japanese

⁶⁹ W.D. Wray, *Mitsubishi and the N.Y.K. 1870-1914*, (Harvard, 1984).

⁷⁰ I take this as especially potent given my assumption that innovative activity is stimulated by proximate economic circumstance, rather than by historically entrenched values, at least in the great majority of cases of measurable systemic achievement.

⁷¹ Grant G. Goodman, *The Dutch Impact on Japan*, (London, 1967); D.E. Smith and Y. Mikami, *A History of Japanese Mathematics*, (Chicago, 1914); J.R. Bartholomew, 'Why Was There No Scientific Revolution in Tokugawa Japan?', *Japanese Studies in the History of Science* 15 (1976), pp.110-125.

⁷² M. Yuasa, 'The Scientific Revolution and the Age of Technology', *Journal of World History* IX, (1965), pp.187-207 and his 'The Growth of Scientific Communities in Japan', *Japanese Studies in the History of Science* 9, (1970), pp.137-158.

students abroad and the internal and immediate impact of foreigners prior to and during Meiji.⁷³ The scientific transition may, therefore, be interpreted as formally institutional and some function of 'substitution' rather than cultural reformation. The great Japanese intellectual Fukuzawa Yukichi could declare just how futile it was to 'allow wild guesses about moral relations to distort the laws of physics',⁷⁴ perhaps because there was no prohibiting commitment to established intellectual systems. This may well represent an intellectual wing of the traditional (Japan) as against the traditionalistic (China) social system. Against mere ad hocism, the laws will convince. It is true that at various points Fukuzawa and other influential intellectuals were forced to realise the incommensurability of 'science' with many traditional modes of *operation*. In his own case, the changed tactic was to press for reform or removal of the *latter*, especially focusing on improved education and information.⁷⁵ It is true, however, that the non-bureaucratic or non-system-builder's support for new 'science' was bound to be weak and confused when some opinion (represented for instance by the *Jōi* group)⁷⁶ could reasonably consistently opt to protect such 'moral relations' and abandon any search for the 'laws of physics'.

In short, the formation of science in Japan is a story about institutions.⁷⁷ Outstanding characteristics of institutionalisation include the focus on applications, the pivotal importance of ex-samurai (*shizoku*) trained in European laboratories and at the

⁷³ For worthy examples in English, Masao Watanabe, 'American Science Teachers in the early Meiji Period', *Japanese Studies in the History of Science* 15 (1976), pp.127-44; Yoshio Hara, 'From Westernisation to Japanisation: The Replacement of Foreign Teachers by Japanese Who Studied Abroad', *The Developing Economies* 15, ('977), pp.440-61.

⁷⁴ Carmen Blacker, *The Japanese Enlightenment: A Study of The Writings of Fukuzawa Yukichi*, (Cambridge Mass., 1969), p.11.

⁷⁵ See Inkster *op.cit.* (fn. 60) especially pp. 121-23.

⁷⁶ For *Jōi* see *ibid* p.121; Joseph Pittau *Political Thought in Early Meiji Japan 1868-1889*, (Camb. Mass, 1967); Delmer Brown, *Nationalism in Japan*, Berkeley, 1995.

⁷⁷ J.R. Bartholomew, *The Formation of Science in Japan*, (New Haven and London, 1989); Ian Inkster, 'Catching Up and Hanging On: The Formation of Science in Modern Japan', *Annals of Science* 47, (1990), pp.393-406.

Imperial University in Tokyo, the influence of Germany on specific Japanese research programmes (bacteriology, stereochemistry, metallurgy, theoretical physics), the wide-ranging engagement of the new Japanese scientists and technocrats in consultancies, public services and commissions and as full-time bureaucrats (one becoming Minister of Education), the adaptation of European institutional modes and the relative paucity of instrumental basics: 'no books, no equipment, no specimens, nothing'.⁷⁸ In his thorough treatment, James Bartholomew reconstructs the taut distinction between the 'Western scientific norm' and Japanese traditions of 'loyalty to mentors' and argues that although such dualism might be found in any 'receptor' nation, it was 'particularly salient for Japan because the formal structures of Japanese feudalism, samurai privileges, had disappeared so recently and because the experience of studying abroad had exposed Japanese scientists to the ethos and values of the Western scientific tradition'.⁷⁹ What this sort of treatment does not easily permit is an understanding of the historical relations between indigenous (endogenous) mentalities and foreign (exogenous) imports, whether these be traced through cognition or role playing. As with institutionalisation and achievement more generally, there seems to still be a major problem in defining the basic resources upon which system builders (initial and derived) drew. If they were clearly not those of David Hume, then where do we go?

Japanese Achievement: Motivation in Context

Amongst other things we have suggested that Japan achieved success because transferred technology was 'appropriate' on various levels, but primarily because it served to absorb into systemic change large numbers of indigenous workers and intellectuals and did so without confronting or creating wholesale social, cultural or geographic barriers. In turn, this may have been a

⁷⁸ This the President of Kyoto University, quoted in Bartholomew, *ibid.*, p. 109.

⁷⁹ *ibid.* quote p. 162.

result of the operation of institutionalised mechanisms or substitutions which served and mediated the foreign influence. Such institutions also served to replace or by-pass the personal communication systems of the existing social system. We are then left with a somewhat more complicated explanation of achievement than that emanating from Everett Rogers or other exemplars of the 'norms of inventiveness' school of thought.⁸⁰ Certainly, any emphasis on reorientation of the systemic cultural norms and social values of today's poor nations as a technique in aid of technological achievement or industrialisation is not given support through experience from the Japanese case. In Japan, technological transfer and diffusion was by no means equivalent to acculturation.

If the roots of Japanese achievement during Meiji did lie in something called Japanese traditional culture, may this latter be specified in formal institutional terms? In this case, if we wish to explain and ascribe motivation to those beyond the ken of the initial or derived systems builders, then a Weberian approach is fraught with difficulty. This is so even when a simplistic or reduced version - the 'ethos' as an ideological orientation tending to lead those who embraced it to an entrepreneurial mode of behaviour - is upheld. The theory is easily misapplied as well as mis-specified, and here McClelland is as guilty as any.⁸¹ Even when more carefully approached, the Weberian schema is too often broached on the motivational side at the expense of the more mundane but possibly trenchant and gainly influence of institutions. As Robert Bellah nicely expressed it, however important 'motivational factors may be they have proved time and again to be highly sensitive to shifts in institutional arrangements'.⁸² Thus the inherent ambiguities of the Japanese case; whatever the *motivation* of the samurai, their innovative,

⁸⁰ Everett M. Rogers, *Diffusion of Innovations*. (New York, 1962).

⁸¹ David C. McClelland, *The Achieving Society*. (Princeton, 1962). see pp.369-70 etc. where he misleadingly identifies the Meiji *samurai* as followers of Zen Buddhism. See also Kurt Samuelson, *Religion and Economic Action*. (New York, 1962), for mis-readings and the far more thorough and applicable Nakamura Hajime *Toyōjin no Shitō Hōbō*, (Tokyo, 1949), 2 vols.

systemic actions awaited the new institutions of Meiji; and so on.

Now our text becomes that of Bellah: 'it would be advisable to consider motivation in close connection with institutional structure and its historical development'.⁸³ As I have already foreshadowed, and as Bellah confirms, this is not uncomplementary to at least one reading of Weber himself.⁸⁴ Hagen pushes this fractious arena aside somewhat by concentrating only on the motivation of system builders: 'A world view assuming the capability of intervening directly and successfully in physical processes is essential for technical innovation'.⁸⁵ If external circumstances (eg. the opening of Japan to foreign influence) are such as to provide new rewards for hitherto subordinated groups, 'then economic growth is apt to begin'.⁸⁶ Developing internal social tensions during the Tokugawa era plus the challenge of the barbarians led to the rejection of old views by a hitherto subordinated elite (mainly but not wholly *samurai*) who exploited the growing perception of imminent systemic humiliation:

The nature of the humiliation made it clear that technological progress was the only possible road to the restoration of national dignity, just as the internal situation made it clear that economic prowess offered the greatest opportunity for the subordinated groups. Because they offered strength, and because they were an honoured indigenous group, the nation followed them. With every circumstance favourable, Japan entered upon continuing technological progress⁸⁷.

A group subordinated but honoured, a system following its builders; a recursive loop! At any rate, from what has gone before this seems far too simplistic and, regardless, it is clear enough that

⁸² R.N. Bellah, 'Reflections on the Protestant Ethic Analogy in Asia', *Journal of Social Issues* 19, (1963), quote p.54.

⁸³ *ibid.*, quote p.55.

⁸⁴ As detectable in Bellah, *Tokugawa Religion, the Values of Pre-Industrial Japan*, (New York, 1957); Clifford Geertz, *The Religion of Java*, (Glencoe Illinois, 1960) and the interesting treatment of The Old Believers by Gerschenkron in reference cited footnote 3 above.

⁸⁵ E.E. Hagen, 'How Economic Growth Begins: A General Theory Applied to Japan', *Public Opinion Quarterly* 22, (1958), quote p.375.

⁸⁶ *ibid.*, quote p.383.

⁸⁷ *ibid.*, quote p.389.

the 'broadened scope of experience' gained by the several generations of the subordinated elite must have been pursued and nourished within explicit institutions.

Detailed examination suggests that most Japanese religious groups and popular sects taught a 'virtually identical ethic'.⁸⁸ Yet several so-called psycho-social approaches - such as that of Hagen above - in fact subsume a theory about group power and strategic institutions; the hitherto dispossessed somehow had the political resources to become both negators of the old ways and system builders for the new. Even the fairly sophisticated, and certainly determined, approach to motivation and achievement, which revolves around the unique attributes of Japanese Neo-Confucianism, fails to adequately address the success of intention, of the actions of the motivated - precisely how did Neo-Confucianism not only motivate but *empower* system builders?⁸⁹ On the other hand, approaches to the 'nation' as a whole neglect obvious self-interest and rely upon stereotype; of national character, loyalty to conservative groups, dependency within primary groups and selfless service to them.⁹⁰ The 'group model' is often called up to emphasise harmonious followership. Based on the psychological notion of *amae*, where a person in a lower social position seeks emotional satisfaction by dependency on his/her social superior, the group approach has a paternalistic leader at its peak.⁹¹ If Japanese

⁸⁸ See Bellah, *op.cit.*, (footnote 84), pp.98, 183. This last point may not stand up easily: R.E. Mouer, 'Conservative and Radical Approaches in the Literature on Japanese Society', paper delivered May 1978 to Convention of the Asian Studies Association of Australia, University of New South Wales, Sydney.

⁸⁹ M. Morishima, *Why Has Japan Succeeded?*, (Cambridge, 1982). For other problems with this sort of approach, Ian Inkster, 'The Massage and the Message: The Mythology of Japan's Industrialisation' in A. Rix and R. Mouer (eds), *Japan's Impact on the World*, (Nathan, Australia, 1984), pp. 18-29.

⁹⁰ From which arise theories of the Japanese firm etc.; M.Y. Yoshino, *Japan's Managerial System*, (Cambridge Mass., 1969); Hanami Tadashi, *Rodo Sogi: Roshi Kankai ne Miru Nihonteki Fudo*, (Tokyo, 1974).

⁹¹ Doi Takeo, *Amae no kozo*, (Tokyo, 1971), later released as *The Anatomy of Dependence*, Tokyo, 1973. The group translated into a formal institution then is characterised by *marugakae* (total embracement), which adds something to the notion that leaders may change systems at will.

institutions are, effectively, agglomerations of such groups, then it might be possible to explain Meiji achievement in terms of the power of leaders to change institutions according to circumstances which only *they need* to perceive and act upon eg. elite response to a threat to sovereign Japan stemming from without. Although this consensual view of 'Japan' may be applied to explain Meiji technological achievement through wholesale followership, it does not fit comfortably with abundant evidence of vital systemic conflict in the 1870s (above). Furthermore, Japanese history is replete with episodes of exploitation, brutal repression and radical resistance, ranging from the agrarian revolts (*hyakushō ikki*) and police repression of the Tokugawa era to the anti-war movement of the Taishō years.

Perhaps in the generic case of successful technological transfer under conditions of relative economic backwardness, of which Japan is our exemplar, a political economy of institutions is a better bet? An institutional approach may permit us to more properly or consistently distinguish between challenge and response, initial and derived system builders, and motivation and action.

The Power of Historical Context: Motivations, Institutions and Response

Let us be naive but brave. We may be prepared to allow that, in the main, scientific discovery or advance is neither heroic nor spontaneous nor obvious, but a product of substantial effort, incremental insight and collective judgement. Laboratories are social settings and findings are negotiated within them and without them.⁹² Scientific achievement is somehow 'recognised' *ex post* but not *ad hoc*, for it is perceptible only within a frame set by key components of the existing socio-intellectual system. If scientific 'discoveries' are best thought of as constructions overtly forged within specific social systems, so too are technological achievements induced by commanding technological regimes. Technological multiples occur

⁹² B. Latour, *Science in Action*, (Milton Keynes, Open University Press, 1987); W.E. Bijker, T.P. Hughes and T.J. Pinch, *The Social Construction of Technological Systems*, (Camb. Mass., 1987); Steve Woolgar, *Science: The Very Idea*. (London, 1988).

daily and diversely because the wider technological regime inhabits a system which is at once social, intellectual, technological and economic, even if only loosely configured. If Edison evidenced much perspiration, it was a similar effort which measured the difference between Watt's initial insight and Watt's steam engine. And without such subsequent effort there was and would be no achievement measurable in *that* location at *that* time.

On the other hand, Edison's 'bugs' are *not* equivalent to Medawar's 'extramural implications'.⁹³ We *may* interpret the chain of incrementalism following Watt's insight - flywheel, governor - as analogous to the perspiration which follows inspiration. But with technique, motivation and insight are progenitors of not only effort but physical resources, which are or are not systematically available: an innovative achievement is measurable only after certain difficulties and scaling-up problems have been 'solved', and in our case this required (actually necessitated) *both* Watt's time and talent and Matthew Boulton's money. Now, the latter required Matthew Boulton's proximate existence, and such proximity to the insight is definable, it seems at least in our earlier Humean sense, only in broader sociological or system terms. In France or Hungary at this time, Boulton may not have existed, as it were, on the same terms.

Perhaps Rosenberg and others, however, have provided historians of technology and industry with a more secure historical analysis for the relations between incrementalist assemblage processes and sporadic 'bursts' than have the prevailing analyses of the history of science? But this in turn would strongly suggest that at this fairly conceptual level there is something which distinguishes the label science from the label 'technology', and the reductionist flavour of such a formulation is worrisome. I don't know that this is reduced by exposing the peculiarity of retrospection, even though we accept the latter.

My own temptation is to not seek out any sort of covering law about science/technology distinctions or collapses but to investigate

⁹³ B. Medawar, *Induction and Intuition in Scientific Thought*, (London, 1969), p.50.

the historical contexts in which, in some cases, science and technology are merely indistinguishable within clearly achieving systems (the Humean English case) whilst in other cases systemic achievement seems to result either despite or because of a distinct detachment between acts of science and the process of technological achievement (the non-Humean Japanese case). Analyses which seek a global account of industrial achievement based on a universal account of the science-technology relationship are bound to fail on a lot of grounds, but in particular because they cannot and do not generate any explanation of the process of technology transfer. As has been quite strongly suggested already, the most immediately identifiable *modus operandi* of modern economic history is not technological creativity but technological transfer. In the process of technology transfer, the potency of the historical context of the existent technological system is all important. My most generic statement would be that technology transfer and subsequent technological achievement is at least explicable in terms of (and quite probably actually determined by) the nature of the juxtaposition between the relevant systems and the character of the institutions within the receiving system in particular.

Finally, the extent and character of institutional response may be quite substantially explicable in terms of the global political economy of industrialisation itself. That is, industrial revolutions do not repeat themselves - thus the resources of technological achievement alter form - not merely because all nationally bounded systems differ, but because all nationally defined systems face a set of exogenous imperatives which have evolved systematically. Some key internal systemic features (eg. space, social structure, human resource formation) may explain the observed differences between the technological achievements of late Tsarist Russia under de Witte and those of Meiji Japan, but the contemporary global political economy forged the obvious similarities between them.⁹⁴ The outstanding

⁹⁴ Alexander Gerschenkron, *Economic Backwardness in Historical Perspective*, (Cambridge Mass., 1966).

contrast between the technological achievements of Japan and the 'failures' of China and India in the late nineteenth century are more readily explained in terms of different global imperatives stemming from the core achievers than in terms of variations in religion or social structure. For reasons primarily external, India's and China's sovereignty of decision-making was destroyed, Japan's sovereignty was at bay. Institutional innovation was possible in the latter case, highly improbable in the former cases.⁹⁵ The differential impact of evolving, systemic global imperatives, then, is what 'created' both achievement and 'failure' in technological systems once the first, Humean case of industrialisation was off the ground?

⁹⁵ Ian Inkster, 'Prometheus Bound: Technology and Industrialisation in Japan, China and India prior to 1914 - A Political Economy Approach', *Annals of Science* 45, (1988), pp.399-426.