意外與阻礙

歐洲、中國與日本五百年科技之演變

Ian Inkster

摘要

本文企圖大膽建立一假設性理論，透過歷史上近五百年來有關文化、環境與資源等層面之檢視，分析其各自扮演之角色，闡明西方霸權與民族國家興起及機械生產等科技的獨特性是息息相關的，並主張世界歷史上所謂的現代實際上僅僅是項異常（abnormal）。這些理論明顯地是相當寬略的主張，以本文有限篇幅僅得作簡要的勾勒與說明。儘管歷史上有爲數衆多的事件得以引證，本文重點仍置於歐洲、中國與日本以利闡述一較普遍之過程。基本上，吾人將現代歷史與歐亞間之關係區分爲三個時期，一爲1450年到1700年「意外時期」（Age of Accident），一爲十八世紀的「科技轉變與系統性擴張時期」（Age of Technological Change and Systematic Expansion），以及十八世紀後到1960年代的「機械生產時期」（Age of Machinofacture），首先則由當代切入。

Accidents and Barriers:

Technology between Europe, China and Japan for 500 Years*

Ian Inkster**

Golden Ages and Climacterics

Those who reside in industrially developed Europe, inheritors of a multitude of earlier efforts and attitudes, often suffer from a certain myopia, a failure to recognise shifts in the global technological, economic and institutional systems which are climacteric in nature. Such shifts may represent a move away from earlier comforts and certainties as the older Western domination of the globe is replaced by a supernational dispersal of economic power, wherein a nation within Europe becomes merely one negotiator in a more complex, less geographically and historically determined world system. Because we were brought up in a Golden Age, we fail to perceive the present Climacteric. This has happened before. Most Europeans now alive grew up in a golden age lying somewhere between circa 1950 and circa 1973. In a last gasp of abnormalcy the world grew as never before, with growth in the developed nations taking place at around 4% per annum per capita, with export volumes growing at 9%. The post-war years were the Cold War years, where a series of bloody hot wars overseas replaced direct or imperial conflicts, and where Khruschev tactics of economic competition ('what kind of a communist society is it that has no sausages?'), won over Stalin more

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** Professor and Director of Department of International Studies, Nottingham Trent University, UK（英國諾丁漢全特大學國際關係所教授兼所長）。

bitter persual of military industrialisation and direct confrontation on European borders. The Golden Age exhibited firm Atlantic leadership, a group of legitimate nation states riding on the back of a range of international understandings, (Bretton Woods, the IMF, GATT etc) and prospering greatly from post-war recovery forces, superior technology transfers from the USA, increasingly associated with a newly dominant electrical technology, and a cultural, commercial l and military *Pax Americana* which yielded both coca cola and comfort. Within this prosperity no nation joined the Atlantic winners from elsewhere (as we shall see, Japan was already there), and there is no evidence of any significant closing of the large gap between the real incomes and consumption standards of the poor world and those of the rich. ①

There were, however, strong indicators of production and technique failure and of institutional and policy rigidities. Most of these were ignored in favour of more comfortable interpretations, those which pointed to marginal adjustments rather than any wholesale reforms. Thus Britain's economic failure set in during the *Golden Age* rather than much before it, a product of diminishing returns to institutions and a reflection of the ultimate failure of industrial liberalism to confront and defeat landed elitisms. A second large indicator was the low income and productivity growth of the world leader; America. Although catch-up growth was accruing throughout the OECD club, the source system grew at a rate no better than that of Britain, and well below that of such recovery systems as West Germany. Increasingly, downward rigidities in national welfare and defence expenditures matched the inefficiencies inherent in non-competitive market structures, and resulted in low overall economic growth in the giant nation at the heart of the global trading and investing worlds.

A third indicator related closely to the first two. For the first time it was clearly the case that even hegemonic superiority in the original creation of new scientific and technical advancements, was no guarantee whatsoever of dominance in industrial production or gains in overall productive efficiency. Technological change was yet

① Andrew Glyn et al., *The Rise and Fall of the Golden Age*, (WIDER Working Papers, Wider Publications, Helsinki: 1988); E.A. Brett, *The World Economy since the War: The Politics of Uneven Development*, (Macmillan, London: 1985)

characterised by automation, office technologies, oil and natural gas and petrochemicals, and the new electronics of the transistor and computation were the outcomes of research and development programmes at Bell Labs, USA, which went back to the years 1939-1947. But the Sony applications of such core breakthroughs during the 1950s and 1960s were reasonably clear harbingers of the technological things to come. And the speed with which newish ideas or early applications were emulated, adapted and made more cost effective was becoming more independent of the sites of original breakthroughs than had ever before been the case Finally, the exceedingly fast growth at full employment of the *Japanese* economy during the 1960s was a clear indicator that success could be achieved and sustained to globally competitive levels as a result of large supplies of labour, huge technology transfers in, and a government policy which set an environment for long term decision-making. ②

However, seldom was this perceived as a whole during the Golden Age, and this has resulted in a general failure to comprehend the dimensions of the present Climacteric period since circa 1971-73, the years during which official American trade policy began to admit to the impacts of the expanding Japanese economy, when revaluation of the yen became as important to American policy makers as had revaluation of the deutschmark, and when the group of oil-exporting nations (OPEC) first wielded their commer cial influence at a global level. From that point, the relatively rigid giant has absorbed the blows of enormous capital inflows, imports of high quality cheap products from developing Asia, and an increasing surge of high technology electronic consumer products, components and producer's equipment. By the early 1990s the USA was in massive trade deficit to Asia: annual trade deficits approximated at $60 billion with Japan (population 122m or 50% that of the USA), 25 billion with China (1072m or 435%), 11 billion with Taiwan (20m or 8%), 7 billion withThailand (54m or 20%) and 7 billion with Malaysia (17m or 7%). Although we may define the present climacteric as a global shift, resulting from the juxtaposition of diminishing returns to the institutions of advanced industrialism and modernity with rapid growth of nations in receipt of the technologies of the information age, there seems little reason to doubt the certain advances of East

② E. F. Denison and W. Chung, *How Japan's Economy Grew So Fast*, (Brookings, Washington: 1976)

Asia. ③

For the first time on such a scale, successful East Asian development arose from a series of institutional and political reforms which acted as necessary conditions for the full sovereign capture of Western capital and technologies. Following the earlier lead given by Japan from the 1950s, East Asian industrial economies reformed their public institutions and policies, gave greater attention to guidance than to autocratic planning, and prepared the way for greater Western involvement. Although this ocurred in nations from Indonesia to South Korea, the best known case of structural and institutional transformation was that of mainland China, particularly after the reforms of 1985. Here the size and importance of the nation encouraged a move to regional developments along the massive coastal provinces, in new free-trading zones and industrial cities. Although many Europeans still view such development as partial and temporary, in fact the size of the high-growth regions together is approximately equal to that of northwest Europe as a whole. Furthermore, there is little doubt about the historical and logistical relationship between institutional reform, regionalised industrialisation and foreign trading and capital importing. As Chyungly Lee has recently summarised in a very clear paper, total capital flow into mainland China increased enormously in the reform period, at absolute levels beyond those of previous historical examples. Foreign capital increased from a flow of US $ 2.74 billion in 1979, to 48.13 billion in 1995. Furthermore, the proportion of such foreign capital flowing as foreign direct investment, has risen from insignificance to around 80% of present totals. Accumulated FDI for the years 1979-95 reached US $ 133 billion. Most significantly for our purposes, the greatly increased private investment suggests that the flow is primarily a market response to Chinese institutional refiorms, and this is affirmed in the destination of such capital within China:

some 90% has gone to the fast-growing coastal regions, into the thriving industries and services of Beijing, Tianjin, Shanghai,

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③ The President's Commission on Industrial Competitiveness, Global Competition: The New Reality, (US Government Printing Office, Washington: 1985); M. L. Dertouzos et al., *Made in America: Regaining the Productive Edge*, (MIT Press, Cambridge MA: 1989); I Ian Inkster, 'Made in America but Lost to Japan:Science, Technology and Economic Performance in the Two Capitalist Superpowers', *Social Studies of Science*, 21 (1991), 157-78.

Shandong, Guangdong and Hainan. There is little that is accidental here, the flow of capital, and the intellect embodied in new technologies, being outcomes of a planned liberalisation of the political economy of China. ④

So, there is much interesting news from the Golden Age and the Climacteric. The rest of this lecture reflects upon such changing relationships and quantities by arguing that they might represent some return to normalcy after a rather long phase of abnormal Western dominance. We suggest furthermore that there seems to be no sturdy arguments which sufficiently explain European dominance in the centuries prior to the technological and industrial transformations of the eighteenth century. We go on to argue that the maintenance of Western dominance over Asia in the years to circa 1950 was one result of a complex of factors surrounding the progress and transfers of Western technologies. Although other processes were involved, we suggest that Western mach inofacture technologies served as an effective barrier to Asian development rather than as an avenue of escape, or an 'engine of economic growth' or a 'window of opportunity' or any other of those benign expressions which often flow so glibly from many an academic pen. The Asian economic miracle awaited the shift from **machinofacture** which began to occur with the electronics and new materials of the *Golden Age.*

The 3 Rs Approach and Accidental Europe

The dominance of Europe began in the early 1400s, when Portugese sailing ships began to move down the Western coast of Africa, for reasons initially weak but later firmed up in the search for a supply of gold not dependent on continental, Saharan traders, for slaves, and for souls. From the Guinea and the gold coast the voyages continued, Diaz rounding the Cape in 1486, Goa secured as a base in 1510, Macao during the 1550s. ⑤ At some such narrative

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④ Chyungly Lee, 'Foreign Direct Investment in China: Do State Policies Matter?', *Issues and Studies, A Journal of Chinese Studies and International Affairs,* 33 no.7 (1997), 13-29.

⑤ C. R. Boxer, *Four Centuries of Portugese Expansion, 1415-1825: A Succinct Survey,* (Witwatersrand University Press, Johannesburg: 1968); S. Subrahmanyam, *The Portugese Empire in Asia 1500-1700.* A Political and Economic History, (Longman, London: 1993).

point the overwhelming temptation of most Western historical accounts is to resort to a version of the Three Rs Approach-- European expansion was an outcome of the Rennaissance, the Reformation and/or the Scientific Revolution. (See Chart 1) The first generated new freedoms, ambitions and imaginations, the second invoked a movement of energies from the old Meditteranean city states towards the nation states further north and west by challenging traditional, supernational and at least nominally spiritual powers, whilst the subsequent advances in the natural sciences offered up a novel elegance of argument and demonstration which, emanating as it did from the hardier nations along the maritime seaboard, provided the appliances of global expansion. Out of this conjunction of skills and imagination sailed the many masted caravel, the 20-gun naos; the 19 ship expedition from England to Mughal India in 1685 included vessels of 70 guns and 700 tons. These were the armed enclaves of a superior Western civilisation, which through the subsequent long years defeated other civilisations through persuasion and emulation as well as through brute force.

The Three Rs Approach is attractive because it invokes a large and colourful history, but it is not convincing as a sufficient explanation of the pre-eighteenth century period of Western domination. (See Chart 2)

The so-called Portugese *caravel* and its descendents were at most only partially 'European'. They were rather a confused product of Atlantic and Meditteranean shipping traditions, in which the components of the latter were themselves derivatives of cultural passages between the Eastern and Western Empires over a considerable time, in which influences from Arabia and Asia intermingled. More clearly differentiated inputs from Asia included the astrolabe (a primitive sextant used to derive the position of the heavenly bodies), the compass and such basic shipbbuilding elements as the use of watertight bulkheads and the stern post rudder. ⑥ Secondly, there is very little evidence that expansion called upon the resources of the Three Rs to any great extent - that is, the growth rate of European expansion and dominance was not clearly dependent upon the growth of

⑥ U. Lamb ed., *The Globe Encircled and the World Revealed*, (Variorum, Aldershot: 1996); M. Adas ed., *Technology and European Overseas Enterprise*, (Variorum, Aldershot: 1996).

Chart 1

The Three Rs Approach

The Renaissance	Freedoms Imaginations Ambitions Princely Competitions
The Reformation	Challenges National Competition Scepticism Energies
Scientific Revolution	Methods/Experiments Generalisation Efficiency Simplicity Elegance

Producing the imagination and skills out of which sailed the many-masted Caravel, the 20-gun *Naos* etc, the power of the Indian Ocean and beyond.

Inter-European competition then provided impetus.

And Finally in the Eighteenth century a *4th R*

The Industrial Revolution	Resources Technologies Interests.

Chart 2

Failures of the Three Rs Approaches

True Origins* of Expansion mechanisms.

The Portugese Caravel from Meditteranean via Arabia/Asia
astrolabe (Arabic)
compass (Chinese)
shipbuilding
watertight bulkheads (China via
stern-post rudder Arabia)

Resources of the 3 Rs (previous panel)
Character of Iberian Peninsula
Of Lisbon and Seville
Of 'grummits'* on India voyages
Of Companies (not Nations) 1530-1750
Muscovy 1554
Baltic 1579
Levant 1581
East India(s) from 1600

Of Incomes - Iberian and
Maritime incomes
well below those of Western Meditteranean

The Clash of Civilizations?
The 'Military Revolution'* (***5th R***) Thesis (1560-1660)
Ease of Defence of China Coast
Manning of Portuges Empire by 17thC - 10,000 people

Chart 3

European Accident: The Indian Ocean

The Indian Subcontinent (Boxer, Broeze, Moreland, Sangwan)

Efficiency of Indian Shipping
- cabling
- rabetting
- 16thC Europe. borrowings
- iron nails,
- sheathing
- anchors,
- rigging

Avoidance of Armaments
- Aurengzeb and 'soft rule'*
- independent merchant shipping

Ottomans and Muslims of Egypt

- culture of horsemanship and land siege
- northwards view (Constantinople 1453)
- blockage of land routes by warfare of Turkey and Persia
- timber starvation along Red Sea and Persian Gulf

The Chinese Empire and the Great Retreat (1433,1449,1452)

- note, just prior to Vasco da Gama the huge Chinese armed fleets on the African and Indian Coasts
- Ming reunification and expansions of control, Manchuria and the Steppes of Central Asia- attention inland
- foreign trade? revenue % down to 5%, drew attention to problems of
  - piracy
  - tax evasion
- no question of 'threat'* from Indian Ocean

Thus, no 'Clash of Civilisations', no great 'Theatre of Operations'. All forces at work were independent of each other and of Europe, yet all worked in Europe's favour, without recourse to Three Rs resources.

resources associated with the Three Rs thesis. The Iberian centres of expansion, the cities of Lisbon and Seville, were hardly centres of new thought or new aesthetic or intellectual products; the capital and the adventurers of such places were escaping from the Renaissance, not its better representatives. The grummits, who manned and made possible the great India voyages of 1550-1750, lived in appalling conditions for even that time, and hardly reflected the newer artisanal and technical skills of the more independent craftsmen found throughout other European locations in this period. ⑦ Nor were the voyages, on the whole, great 'national' efforts, but more often sporadic outcomes of intermittent jealousies and piracies. The most systematic and well resourced forrays were probably those of the profit seeking, adventuring merchant companies, the Muscovy of 1554, the Baltic of 1579, the Levant of 1581 and the several East India companies from 1600. Expansion was produced almost as an incidental outcome of events marginal to the major thrusts of the Three Rs, even if at a later period the physical and mental products of such expansion fueled further intellectual and commercial developments within Europe itself: in the earlier years Iberian and Maritime incomes were lower t than those of the Western Mediterranean. ⑧

Thirdly, there is very little solid evidence of a sustained 'clash' of Civilisations in the grand manner of the Three Rs approaches. The exact delineations of the much vaunted 'Military Revolution' (with the Industrial Revolution, we now have no less than 5 Rs), of the years 1560-1660 were hotly debated during the 1960s and 1970s. One strong conclusion was that of P, J. Marshall, who judged that despite the various labels attached to the period prior to 1660, 'in Maritime Asia innovations were never on such a scale that some Asian states could not adopt them themselves', and went on to argue that in even the European successes of the 18th century 'there is no uniform pattern of success and they are not necessarily the occasions in which differences between the two societies manifest themselves in inevitable European triumph.' ⑨

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⑦ Fernand Braudel, *Civilization and Capitalism, vol II The Wheels of Commerce*, (Fontana, London: 1985); Daniel J. Boorstin, *The Discoverers*, (Random House, New York, 1983).

⑧ Ian Inkster, 'Global Ambitions: Science and Technology in International Historical Perspective, 1450-1800', *Annals of Science*, 54, (1997), 611-22.

⑨ Quoting Marshall as in Adas op. cit. (footnote), 50-51; see also, G. Parker,

Of even greater significance was the relative absence of significant opposition. Not one of the three major civilizations, of the Indian Subcontinent, the Ottomans and Muslims of Egypt, nor the Chinese of the Ming dynasty, was at that time operating on a large scale in the potential theatre of conflict, the Indian Ocean. This must surely be the Great Accident which ushered in the modern era? (See Chart 3) As CR Boxer, WH Moreland, Frank Broeze and more recently Satpal Sangwan have argued in their different ways, the Muslim India of Aurengzeb was just then formulating a position of 'soft rule', of negotiation and mild taxation, rather than confrontation with external interests. This was no case of backwardness, of European militant shipping defeating the forces of India. The two civilisations did not confront each other. Indian shipping was particularly efficient, demonstrating its own superior techniques of 'rabetting' (a substitute for caulking) and cabling, and showing an innovating flexiblity in its adoption of the European technologies of iron nails, anchors, sheathing and rigging. But such technique was carried by merchants, acting pacifically and quite independently of any state ambition. ⑩ Similarly, Muslim power was focussed on the culture of horsemanship and the land siege, the 'feudal' techniques chosen to attack Constantinople in 1453, from which time the Ottomans' ambitions moved for ever northwards. In addition, incessant warfare between Turkey and Persia blocked other land routes, whilst the timber starvation which set in on the Red Sea and the Persian Gulf forbade development of ocean shipping at precisely that time.⑪

But perhaps the most global and profound of events, was the retreat from the Indian Ocean of Ming China by the enactments of 1433, 1449 and 1452. There could be no more precise a retreat, even if the overt intention had been to allow a European global expansion! Yet, China's policy was perfectly rational and had nothing

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The Military Revolution: Military Innovation and the Rise of the West 1500-1800, (Cambridge Univesity Press, Cambridge: 1988).

⑩ For summaries see chapter 3 of J. A. Hall, Powers and Liberties, (Penguin, London: 1985) and chapter 2 of K. N. Chaudhuri, *Asia Before Europe. Economy and Civilization of the Indian Ocean from the Rise of Islam to 1750*, (Cambridge University Press, Cam mbridge: 1990).

⑪ Chaudhuri ibid. chapter 1; Hall ibid. chapter 4, and Part II of Richard Hall, *Empires of the Monsoon. A History of the Indian Ocean and its Invaders*, (Harper Collins, London: 1996).

Chart 4

Turning Point: The Eighteenth Century

Six Vital Factors (relationship to three RS?)

1) From the Dutch to the British model (a la David Hume)

2) Growth of Northwestern Europe
GNP and population grow at x2 the rate of 1500-1700
income and nutrition out-distancing China

3) Harnessing of Craft Skills to formal knowledge
breakdown of hand-mind distinctions in NW Europe
practical enquiry and innovation environments

4) Institutional Advances
Example of Lombe Silk Factory to Arkwright Mill
Property Rights
Labour Control

5) Irreppressible Technology Transfers
urbanism and chance meetings
migrations eg Huguenot
Statist competition and inducements
The Enlightenment and the Public Sphere

6) Politicisation of European Expansion (1764-1804)
The Mercantile State Overseas
Statist well-resourced voyages Byron
Wallis from 1760s
Cook
La Parouse of 1780s

3 Measures: Nation replaces Trading Companies
Increase in output of Arms and fall in Shipping Costs Amassing of arms and money in European bases in Asia.

whatever to do with Europe as such. Just prior to the explorations of Vasco de Gama, large Chinese fleets had voyaged and traded through the African and Indian coasts, and would have been far more than a match for European challenges. But precisely at that time a series of forces peculiar to China, brought the fleets back home to coastal waters. The inland expansions of the Chinese Empire had vastly increased its size, and brought threats of invasion ad loss of border controls in Manchuria and the Steppes of Central Asia. As with the Ottomans, circumstance forced the Chinese rulers to think in terms of large land masses, and there was, rightly, little notion of any threat from the Indian Ocean which could touch the real life of China. Again, territorial expansion and Ming reunification and an increased tax base from a consequently larger internal trading, meant that during the early sixteenth century the ratio of foreign trade tax revenue to total government revenue dropped from its high point of around 20% to something in the order of 5%. Such shrunken returns made it far less likely that the Chinese authorities would continue to tolerate the problems relating to trade tax evasion and piracy. There was little to be gained from an explorative foreign trade, and from around this time the very motif of the sea begins to disappear from Ming porcelain, as if by decree. ⑫

Although the details may remain in dispute, the main point is clear enough. At the time when a minimally resourced European expansion was underway, a series of utterly independent and exogenous factors ensured that resistance, too, was minimal. The Indian Ocean then became a theatre of European competition, in which the Dutch and then the English benefitted, but it was not an area of European-Asian competition, in which the cultural, commercial and technological resources emanating from the '3 Rs' ousted non-European civilisations. At this time, the Indian Ocean was not the Theatre of Civilisations, not a scene for the setting of Toynbee's great historical drama of mimesis, response and reaction.⑬

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⑫ See references at footnotes 9-11 above and Jung-pang Lo, 'The Emergence of China as a Sea power during the Late Sung and early Yuan Periods', *Far Eastern Quarterly*, 4 (1955), 489-503; Mark Elvin, *Patterns of the Chinese Past*, (Stanford University Press, Palo Alto: 1973).

⑬ For an excellent contextual summary of the Toynbee approach see volume 12, Reconsiderations of Toynbee's *A Study of History*, (Oxford University Press, London: 1961).

And Then Something Happened

The eighteenth century is a different matter altogether. The historiography of Europe alone is immense, and the century has been a major source of basic methodological and ideological disputation amongst historians since before the year 1800. Indeed, it is precisely Enlightenment thought which provides the core for most subsequent notions about the century. For our purposes we might hazard just six major analytical claims of special relevance to our wider concerns here. (See Chart 4) First, the north western European system appears to have moved from the Dutch model with its high trade/production ratios and emphasis on innovations in mercantile institutions, towards the British model of increasing manufacturing/agricultural ratios and emphasis on innovations in production techniques. As an ideology of production began to gradually oust an ideology of mercantalism, so too Britain out-performed advanced Europe; at the beginning of the century incomes per head in Holland might have been some 40% above those of Britain, by its end British income outmatched that of the Dutch. Furthermore, this British takeover was associated with a faster growth of Northwestern Europe overall; both population and national incomes grew at some twice the rate of the two previous centuries. If Chinese incomes and consumption of nutrients per head had previously outmatched those of Europe as a totality, industrial, agrarian and commercial growth in much of the north west had almost certainly brought Europe to leadership by the later years of the eighteenth century. ⑭

Thirdly, whereas hand-mind distinctions based upon demarcations of social class existed throughout the world, in Europe such dichotomies were more broken down and there was far more evidence of the regular and casual harnessing of a variety of craft skills to formal knowledge in the pursuit of improvement. There is no clear theory as to why this became the case, nor when it was that slight tendencies became great enough to exert an impact upon

⑭ See chapters 2, 3 and 9 of Ian Inkster, *Science and Technology in History. An Approach to Industrial Development*, (Rutgers University Press, New Brunswick: 1991); for an unusual and interesting interpretation, volumes I and II of Michael Mann, *The Sources of Social Power*, (Cambridge University Press, Cambridge: 1986 and 1993).

European industrialisation. It is possible that we require different approaches for different nations within Europe, and that in particular we might distinquish between advanced and lagging or colonised regions.

A fourth notable characteristic of the century was the manner in which significant productivity gains were derived from new combinations of institutions and techniques. European, and especially British supremacy is often described in terms of improvements of machine technique alone. But the competitive sites of new manufactures seem to have been most associated with novelty of organisation. ⑮ For example, in the first half of the century the English manufacturing silk industry gained great advantages over European regions, even though the basic techniques had been transferred out from Italy at the beginning of the century and despite the obvious climatic limitations on either rearing or processing the raw materials in Britain. The one outstanding feature of the early English system was the organisation of centrally powered mills in which the machinery of Piedemont or elsewhere was juxtaposed with other machinery, run at greater speeds with improved gearing and braking devices and with a more efficient overshot water wheel. It would appear that mutual machine improvement came about as a natural process, with incremental changes occuring in the process of running shifts and repairs. Thus the English mill became a productive technology incorporating a range of known but slightly improved machine techniques.

A fifth element in the European changes was the notable politicisation of the expansion process between 1764 and 1804. Despite Adam Smith admonitions of 1776, the mercantile European state engaged in a search for markets and trading posts which became increasingly colonial in character. In contrast to their decreasingly frequent predecessors, the great voyages of Byron, Wallis, Cook and La Perouse involved the deployment of large physical and intellectual resources and the interests of the State. Expansion was now characterised by three elements: a great increase in the output of arms and a fall in transport costs, the taking over of the great trading

⑮ Ian Inkster, 'Sites and Agents: Aspects of Technological Progress in World History' in the forthcoming eighteenth century volume, editor Roy Porter, of *the new Cambridge History of Science*, (Cambridge University Press, Cambridge: 1998)

companies by direct state organs, and the amassing of arms and money in many European bases in A Asia. ⑯

Finally, perhaps the most obvious characteristic of European dynamism was the acceleration of technology and information transfers between nations, a process that could not be stopped by war or legislation. Sites of significant applications were not necessarily sites of original technical ingenuity or initial advantage. A fruitful chaos of migrations, associations, translations, encyclopaedic encapsulations and statist military requirements, ensured that information, skill and machinery flowed between sites of increasing density but decreasing social distance. In England the insidious inducements of guild membership, premiums and intermarriage served to gain the skills and capital of the Huguenot diaspora. In crisis-ridden, relatively backward technological systems, such as that of Tsarist Russia, the activities of the state were somewhat more intrusive and expensive - forced labour, tax concessions and freedom of worship were added to the assortment of instruments designed to seduce skills and capital to St Petersburg or to the metallurgical projects of the more distant Urals.

The grand result of all this was frequent and very expensive failures in both military and civilian technology transfers and projects, alongside the development of an increased number of competitive sites of technological endeavour. ⑰

Capture and Escape

Several questions now arise. Why did the ferment in Europe fail to spread? Was there something in the cultures or political systems of Asian and other regions which prohibited technological advance and escape from European dominance? Did the large overall advancement of Europe in the Three Rs create such a development gap that no culture could follow, whether through peaceful emulation or aggressive competition? Why did European dominance last so long, conceivably into the middle of the twentieth century?

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⑯ Parker op cit., (footnote 10); part III of Eric R. Wolf, *Europe and the People Without History*, (University of California Press, Berkeley: 1983).

⑰ Ian Inkster, 'Mental Capital: Transfers of Knowledge and Technique in Eighteenth Century Europe', *The Journal of European Economic History*, 18 (1990), 403-41.

Chart 5

The Great Escape: Meiji Japan 1868-1912

Powerful Mundane Features

Large densely situated population (30 million)
Sankin kotai and Urbanism and improved Transport System
Islands with no obvious resources to capture
Location - the breathing space
Urban social change of Tokugawa re-value changes

Consequent Dynamic Factors

Technology Transfers and enforced Government Activity
Cultural Engineering
Institutional Innovation
Human Capital Formation
Prolonged Treaty Port Interactions under Japanese Control

Note : Rejection of simplistic cultural argument
Rejection of **both** of the two opposing Public Sector Arguments
Government activity increased the cost of success
or Japanese government was far-sighted and innovative compared to Chinese and other governments.

Alternative argument: the combination of mundane factors with cultural engineering gave power to government which it used to instigate and monitor the industrialisation program, providing the conditions for the emergence of private sector activty from around 1885.

We might usefully begin with the great case of Imperial China and the positions established by British liberal writers from David Hume in the 1740s, Adam Smith in the 1770s, to J. S. Mill in the 1840s and Karl Marx from the 1850s. ⑱ The Great Liberal Perspective would have it that Western military and commercial defeat of China from the late eighteenth century was a normal, expected outcome of interaction between industrial market capitalism and imperial state centralism. Chinese culture and its social institutions condemned China to economic backwardness until such time as the traumas of technological and ideological intrusions shocked the system into some form of positive response. Chinese culture served as the sufficient barrier to economic success, and gunboats, opium and civil war were mere reflections of this, not causal to it. This approach from entrenched liberalism, therefore, neglects the obvious locational, geographical and climatic constraints faced by China (imagine a national mobilisation compared to that of relatively compact, densely populated and borderless Japan), the effects on the budget and on tax receipts of the multiplexity of foreign interventions, and fails to identify non-cultural elements in the forging of China institutional structures. As to the latter, whilst elements of Confucianism without doubt tallied as a **legitimation** of centralised authority structures, the reasons for the long tenacity of both may have lain in the logistic control problems of a sophisticated hydraulic society, where maintenance of fabulously expensive irrigatio on systems in regions far from central control required the periodic raising of large amounts of corvee labour along border areas, where waterborne disease, barbarian invasion and great human debility coalesced. More importantly, even radical liberalism tends to underplay the dynamic negative impacts of Western machinofacture technologies when allied to a loss of internal economic sovereignty. ⑲

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⑱ For brief exemplars see John Stuart Mill, *Principles of Political Economy* (1848) 7th edition, the last by Mill, 1871, book 1 chapter 7, 100-103; S. Avineri, *Karl Marx on Colonialism and Modernisation*, (Collins, New York: 1969). For a critique of the conventionalism of radical liberalism see Ian Inkster, 'Technology in *History: Case Studies and Concepts circa 1700-2000*', in R. Narasimha and J. Srinivasan eds., *Engineering as a Human Enterprise*, (Harwood Academic, London: forthcoming 1998).

⑲ Ian Inkster, 'Prometheus Bound: Science, Technology and Industrialisation in Japan, China and India - A Political Economy Approach', *Annals of*

In seemingly stark contrast to the case of China, nineteenth century Japan pursued the task of separating out Western **intellect**, in the form of imported machinery, institutions and ideas, from Western **capital**. (See Chart 5) Although the purposeful entry of the government into industrial policy has most commonly been explained in terms of the need to create an efficient production and export system in the face of enforced free trade (whereby a series of unequal treaties had imposed upon the Japanese a threshold 4% tarriff protection at a time of increasing global protectionism), a more complete interpretation would put at centre stage the need to introduce, promote and diffuse Western techniques whenever possible. In the absence of foreign entrepreneurial agency, the Japanese government erected a platform for technology transfer which maximised the use of Japanese resources of labour and handicraft skills by harnassing them to model enterprises, training institutions, information systems, new political arrangements and the employment of a variety of Western experts in and around the treaty ports.⑳

Of course, other nations had attempted something similar, not only within Asia but in the Middle East, South America and elsewhere. Why was Japan the only significant and sustained example of development outside the Atlantic industrial club during th he long era of machinofacture? How was it that the great publicist of the Japanese way, Nitobe, could predict with such confidence that 'we shall likely get richer, uglier and noisier for a long while to come'?

A series of powerful, mundane features must be emphasised as yielding the effective physical context of success, necessary but insufficient in themselves to explain the uniqueness of Japan. Foremost amongst these were the very large population size o of around 30 million combined with dense settlement patterns centred on main island alluvial plains. This provided ready defence systems, quick response, effective flows of goods, men, arms and information, and immediate urges of competition and emulation within Japan itself. The obvious contrasts here are with the great alternative contenders,

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Science, 45 (1988), 399-426.

⑳ Here there is a massive literature in English alone. For summary analyses see Frances Moulder, Japan, China and the Modern World Economy, (Cambridge University Press, Cambridge: 1977); Ian Inkster, 'Meiji Economic Development in Perspective: Revisi ionist Comments on the Industrial Revolution in Japan', *The Developing Economies*, 17 (1979), 45-68.

India and China.

In addition, location and earlier policies together ensured that Japan was not situated along any fault line of global ambitions; compared to the other great systems, Japan was unknown and relatively unwanted. This offered a breathing space in which there was room to manoeuver, perhaps especially around the period of the first Opium Wars and the Tempo Reforms, which from very different directions provided late object-lessons in the need for control and the rewards of self-reliance. Finally, a massive building boom in the early seventeenth century had, over time, forged an inverted urbanism: Where extremely large urban centres had been created for reasons of regime stability but had effected a seperation of important upper social groups from the land; the growth of centres of conspicuous consumption generating cultural formations and social sites whose characters were ultimately at odds with many of the assumptions of the traditional systems of obligation and reciprocity; and the sophistication of by-employments and commercial agriculture to levels well beyond anything found in the far reaches of the state. For such relatively mundane reasons, dynamic in their interactions, Japan joined the small group of industrial modernisers prior to 1914. ㉑

Why did the many levers of Western machinofacture not move the world? Answers addressing the continued European dominance range from Marxian arguments concerning capital, through Leninist theses concerning imperialism, to theories of overarching conspiracies or notions of cultural retardation. There is probably something to be said for bits of all of these under different, complex historical circumstances. Here we argue that the technologies and associated institutions of machinofacture naturally created barriers to the spread of industrialism and industrially grounded military power to nations

㉑ For varied approaches to Japan see G. McCormack and Y. Sugimoto (eds), *The Japanese Trajectory* (Cambridge University Press, Cambridge: 1988); J. W. Dower (ed) *Origins of the Modern Japanese State* (Pantheon, New York: 1975); Ian Inkster, 'Eikoku to Nih hon no Sangyo Kakumei ni Okeru Gijutsu Henkaku ni miru Shakaiteiki Haikei ni tsuite no Hikaku Kento' (Comparative treatment of the context of Technological Change during the industrial revolutions of Britain and Japan), in International Institute for Advanced Studies (ed), Bunka no Hon'yaku Kansei, (IAR, Tokyo: 1993), 134-46; W. J. Macpherson (ed), *The Industrialisation of Japan*, (Blackwell, London: 1973).

beyond the winners' club. This requires a diversion.

Barriers, Constraints and Resistances

A major historiography assumes that industrial success occurs for good reasons at particular sites, reasons which may be cultural, social, political or economic. It fails to spread universally because there are barriers over which it may not pass, such barriers being composed of cultural, social, political or economic elements inherent to the failing system. Those who believe this would also write of the failures of liberalism, the seeming impossibility of removal of such barriers through Western intervention, the expensive inadequacies of the efforts of large successful systems such as those of Britain or USA to move the barriers and thereby the world. This latter position might be that of radical liberalism. A more sophisticated approach requires that we distinguish between barriers, constraints and resistances. (See Chart 6)

Resistances are best perceived when substantial system change begins, especially if the change is initiated through interactions with other, initially distant systems. Thus, the intrusion of Western technologies into traditional economies may threaten the existing, previously gained, assets of several interests. Landlords might face invasions of privacy, threats to tenants or other income sources, revaluations of real estate which bring to new riches social groups who were before designated as of lowly status. Commercial agents may face the removal of established patterns of indebtedness through which they have previously prospered, whilst powerful religious groups might be seriously offended by specific transgressions of mining or commercial interests, as well illustrated in disputes over burial grounds and sacred structures or areas. Workers of many sorts may be stripped of their assets of skill, tools and neighbourhood as imports outcompete their own handicraft productions or new techniques redefine their value as producers. Whether resistance halts an attempt at industrialisation is another matter. This will depend upon the power of the industrialising elite or regime to control dissent, on the nature and extent of the assets held by classes and groups, and on the availability or otherwise of alternative avenues whereby assets may be reutilised or redefined, as in technical training programmes for skilled workers, or in financial schemes which assist producers to scrap old techniques as they invest in the new.

Chart 6

The Barrier of Machinofacture

Resistances]
Constraints] **The Maintenance of European Control**
Barriers]

Machinofacture-as Barrier

Metallurgy and Mining- measuring-
Construction fixing
Inorganic Chemicals sliding
Transport Systems re-locating

Standardisation — Urban Expertise
Precision — Technique Public
Sphere
Interchangeability **MODERNITY** — Expert Systems
Incrementalism — Polytechnical
Training

Efficiency]
Good Order]
Competition] Equipoise
Individualism]

New Sites of Modernity
Patent offices and patent agencies **MACHINFACTURE**
Professional Associations
Industrial Laboratories

By circa 1870, transferring modern techniques from machinofacture culture meant transferring much else, inculding, workpractices, work understandings, engineering-legal institutions, work practices, work processes etc. It was this package that was not transferable except under extremely favourable assumptions, thus acting as a prime Barrier to Asian or other entry into Industry Modernity.

More interestingly, new advanced techniques from outside may convert wastes into assets, (of minerals and fuels, timber and so on), the added value of which might compensate for losses or threats suffered elsewhere. Clearly, the existing stage of development matters, but not in an unambiguous way. Thus, already existing cloth manufacturng may become a mere cost if the difficulty of scrapping and retooling in new circumstances ushers in a phase of resistance by both producers and workers. More significantly, much also depends on the exact, technological character of the new industries and projects. Large scale and capital intensive industries such as rail roads, other forms of transport, cotton spinning, metallurgy and so on, all at the hub of nineteenth century **machinofacture**, may have more of an immediate negative impact on workers, their tools and their livestock than would a technological rejuvenation of existing handicrafts and rural industries - a small electric motor or an old truck may bring joy to a rural industrial site, textile mills may generate only resistance amongst urban textile workers. All of this means at least two things - the extent of resistance is no good measure of the 'backwardness' of a culture, and resistance may be overcome either through investing in assurance and cultural engineering or in selecting and adapting techniques from the array of technologies available.

How far resistance can be overcome at low cost will depend on the character of constraints, our second analytic category. Thus it may not be possible at any reasonable cost to utilise rural based, low technologies as a resistance-reducing tactic : Transport facilities may be inadequate, skills may be insufficient (a pre-industrial system may appear to be in labour surplus, underutilising labour at different parts of the year, but it may be that specific skills are rare or that general labour may not be permanently removed to other industries without increasing the price of labour at periods of high demand, such as harvests), raw materials may restrict the range of applicable techniques in particular industries, and so on. **Constraints are those features of a system which do not necessarily first appear at the initiation of change but which do subsequently act to increase costs.** Clearly, an absence of certain raw materials would act as a constraint, but rarely as a **barrier**, to the successful utilisation of the techniques of machinofacture. But the manner whereby such a constraint would work is nor readily predictable. So, shortage of timber could be overcome in eighteenth century Britain through importation from Scandinavia, but also by internal technique changes which shifted industry and

household usage from a dependence on charcoal towards the use of coal and then coke. Constraints may, it seems, affect the costs of industrialisation as well as its trajectory. Again, the Japanese successfully penetrated the machinofacture mode, despite an absence of many key natural resources and in the face of high transport costs, resulting from locational factors as well as lack of sovereign control over shipping. Such constraints undoubtedly imposed costs and strains on Japan, but yielded the advantage of her appearing as a nation unattractive to either imperialist intruders or profit-seeking Western capitalists, and instigated an industrial program which maximised the use of rural skills and cheap female urban workers. In a sense, raw material constraints forced the Japanese to substitute their own **intellect** for their own or others' **capital**.

In contradistinction to resistances and constraints, **we define barriers as those elements which halt the entry of new players onto the stage of machinofacture.** From the above, it may already have become clear that here we do not discover barriers in the vagaries of nature, or even in the machinations of evil agency, but in the natural associations and contingencies of machinofacture itself. We mean by **machinofacture** that form of metal-using, inorganic chemical production and transportation which dominated modernity into the 1950s, but is perhaps best represented in later Victorian Britain. When we think of the greatness of the British production system we might recall Henry Perkin and his analine dye of 1856, Bessemer steel process patented in 1855, or Brunel **Great Eastern** of 1858. But these major technological events occurred within a stream of manufacturing improvement centred on machinofacture processes of measurement, fixing, sliding, turning and re-locating, of true flat and cylindrical surfaces and of screw threads, which together created a total system based on standardisation, precision and interchangeability, production requirements which became the very symbols of social and cultural **modernity**. [22] This was also the centre of the great surge of industrialising modernity which occurred in the second half of the nineteenth century, a first climacteric which embraced much of North West Europe,

[22] Ian Inkster 'Technology Transfer in the Great Climacteric. Machinofacture and International Patenting in World Development circa 1850-1914' , forthcoming in the Collection de travaux of the International Academy of *History of Science, 1998-2000, vol l.XV Engineers and Engineering*, eds., M. C. Duffy and A. Grelon.

North America and Japan, and which demanded and produced new institutional relations between technique, work and legal regimes. ㉓ As early as the years 1877-1894, the number of patents granted in Britain alone totalled 266,000, whilst the three industrial: leaders of Germany, America and Britain together produced 782,275 patents in these years. By 1900, British annual patenting reached 30,000, 60% that of the US gross figure, but greater in per capita terms, and twice that of the French. ㉔ It was this metal-bedded technique which produced the super-modern culture of patent agency, urban technical association, professional expert systems and polytechnical training. In the newer industrialising systems and in the culture of machinofacture resided, were nourished and developed, notions of efficiency, good order, competition and individualism, elegance and simplicity and new combinations of knowledge and skill. Perhaps thus the equipoise, the containment and the great social compromises of industrial capitalism. In London, power still resided in old places, but much had shifted to Southamton Buildings, to Chancery Lane and to Warwick Court, the several sites of technological congress and negotiation. This was modernity epitomised. Machinofacture gave to industrial modernity its professionalism, expertism, scientism and a arrogant urbanism, and thus too produced a deep imbeddedness of machine technologies at little cost to government but of profound importance to all systems beyond the pale of success. If in the eighteenth century, European supremacy was based on technological breakthrough, in the nineteenth it was maintained through the barrier effects of the national cultures of machinofacture.

The period from around 1870 has sometimes been referred to as that of the Second Industrial Revolution (yet another 'R'!), where technology was increasingly based on new materials, electronics, new consumer products and services and closer links between scientific knowledge and industrial applications. Why was this not a sufficient technological shift to allow the entry of new players in the industrialisation game? Apart from the fact that new technologies were

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㉓ P. Bairoch, 'International industrialisation levels from 1750 to 1980', *Journal of European Economic History*, 9 (1982), 280-96; C. Trebilcock, *The Industrialisation of the Continental Powers 1780-1914*, (Longman, London: 1981).

㉔ Ian Inkster, 'Discoveries, Inventions and Industrial Revolutions: On the Varying Contributions of Technologies and Institutions from an International Historical Perspective', *History of Technology*, 18 (1996), 39-58.

indeed associated with greater levels of industrialisation within the Atlantic System, the new techniques of these years were, fundamentally, highly innovative extensions of machinofacture, still based primarily on coal, steam, metal and heavy chemicals. The core developments of this first **Climacteric** were the steam turbine, improved steels and alluminium, the telephone, electrical generator and electric light, the internal combustion engine and automatic machine tools. The processes and the products were extensions of machinofacture such as s automobiles, tractors and trucks, coal remaining the major source of energy, (in 1900 providing 92% of global energy, and the mining of which was now through steam-powered coal cutting machinery), with electric power stations an increasing consumer of it. The electrical components in mechanical devices allowed greater efficiency and speed using smaller units.

So, there was certainly a basic transition from purely mechanical devices to electromechanical devices, such as the automatic switching and safety systems of locomotive railway systems. At the same time, the electric motor encouraged the emergence of new small engineering shops in which skills were highly developed, and at the level of the large enterprise new techniques demanded the formalisation of scientific technical skills in areas such as industrial chemistry and electronics. None of this threatened or operated outside the rationalities of machinofacture. Although the new materials from the chemical industries, such as celluloid, bakelite, plastics and artificial fibres were creating new industries, in terms of overall production the dominant techniques were Bessemer and other steels production, reinforced concretes and the development of electrical energy. New techniques flowed into existing industries more commonly than they created new ones: thus the electric arc furnace, refrigeration on ships and railways, the use of new steels in construction work, the massive engineering feats of the Panama Canal (1879-1887), the Brooklyn Bridge the Saint Gothard Tunnel (Switzerland, 1882), the Eiffel Tower, the Danube-Black Sea Canal, and the Firth of Forth Railway Bridge (1889). With the new machinofacture improvements of machine tools, electric welding and mechanised gear cutting, came a range of new consumer and commercial products, from cash registers, comptometers and typewriters to bicycles, roller skates, and sewing machines. When added up in such a list, the impression is certainly that of a paradigmatic shift in global technology. In fact, the First Climacteric represented an Atlantic-based incorporation of

electrical technologies into a basic machinofacture frame, one which certainly might be interpreted as moving technological change onto a trajectory which would *eventually lead* to the true paradigm shifts of the Second Climacteric, from circa 1970. ㉕

This is one reasonable explanation of the dynamic underdevelopment of the twentieth century. Despite the labours of many and the theories of a few, the institutions of planning and the industry of foreign aid, industrialisation did not arise at new points on the globe as long as machinofacture remained the dominant technical mode. The second climacteric, ushering in the erosion of the abnormality of modernity, awaited the shift from machinofacture into pure electronics, biotechnologies, new transport and communication systems and their associated new industries.

Nations and Technologies

But there are even wider concerns here. **We may note the seeming feedback relationships bewtween European dominance, machinofacture and technique advance, and the rise and sustenance of the nation state. Modernity was closely aligned with all of these elements. Similarly, as a new technical paradigm emerged with the electronics of the second Golden Age, followed by the information industries of the second Climacteric, so too European dominance and the primacy of the nation state have both been seriously challenged.**

From the later eighteenth century, much of European industrialisation may be explained in terms of local competition with Britain. In a Europe of close communications and a multiplicity of foreign traders, superior technologies spread out from Britai in and other advanced centres to create a European technological system based on mining, metalworking and new forms of motive power. Thus the culture of machinofacture spread. The modern climacteric has witnessed the rise of the Japanese economy at a far faster rate than that of the British economy, two hundred years ago. In the British case there had been some dependence at an early stage upon transfers of

㉕ For detailed notions of climacteric and twentieth century applications see Ian Inkster, 'Into the Twentieth Century: Patterns in the Relations between Science, Technology and the State during the Early Industrialisation Process', in Martine Barrere (ed), *Sciences et Developpement*, (Orstom Editions, Paris: 1996), 67-96.

better techniique from the Continent of Europe, but these had easily been equalled by important t transfers in the reverse direction. In the case of Japan in the golden age of the 1960s and 1970s, an overwhelming amount of new industrial growth was directly dependent upon transfers from Europe and the USA, this aided by institutional reforms instigated within Japan by the foreign Occupation Powers headed by the USA. As is indicated briefly below, it was in the climacteric years, from the 1970s onwards, that Japan began to exert its own technological style and creativity more obviously, and this was s precisely the period when Japanese development began to impinge upon the East Asian economies to a far greater degree than ever before.

No doubt, much of earlier East Asian development might be attributed to the combination of very cheap labour with medium-level technologies imported from throughout the industrial world, but especially from the USA after 1945. At that point, the continuing predominance of the older machinofacture technologies prohibited entry to Asian nations, in a manner indicated above. Temporary development of new nations would decline as costs rose or the price of staple exports fell, or because the advanced techniques of the West within the machinofacture paradigm, continually replaced the raw materials and foodstuffs of the poor nations with the synthetics and new materials of machinofactures. [26] But the exception was Japan, for as we have seen it began its initial industrialisation under unique conditions at a much earlier time. So, the 1970s witnessed both a movement of the Japanese towards a far greater degree of expansion outwards (accelerating after 1985) and an increasing movement towards new technologies in new industries, and away from the capital intensive metallurgies of the old machinofacture. This juxtaposition was at the very centre of the new climacteric and the rise of East Asia. After the revaluation of 1985, which lowered the price of Asian assets in Japanese terms, the export of capital from Japan rose to levels never before witnessed in world history, whether under the earlier British commercial hegemony or through the auspices of the

[26] Of theories of twentieth century underdevelopment there are as many as cases, see however R. B. Sutcliffe, *Industry and Underdevelopment*, (Addison-Wesley, London: 1971); M. Caldwell, The Wealth of Some Nations, (Zed Press, London: 1977); A. Y. So, *Social Change and Development*, (Sage, London: 1990).

USA's Marshall Plan. Japan was a nation which saved $400 million per day more than it needed to replace existing investments at home! Although the details remain in dispute, it seems to have been the case that Japan became a new centre for the export of **intellect** and **capital** at precisely the point when a new technological paradigm was emerging - a series of global industries far less dependent than ever before on the traditional imperatives of large investments, machine skill, factory production, single urban sites, large tran sport systems and centralised hierarchies.

With the rupture of the old machinofacture paradigm had come a new agent of change, outside of the Atlantic system, although dependent on it for core technological breakthroughs (see below). Where before, successful industrial growth had been sustained only in Japan or in relatively small economic systems such as those of Singapore, Hong Kong, Taiwan and Korea, now industrial growth through new technology was taking place much more widely. By the early 1990s the World Bank figures were showing rates of GDP growth of over 8% per annum in Thailand, Malaysia and South Korea, over 6% in the giant and difficult case of Indonesia, and of up to 10% for mainland China, where growth was spreading from areas such as Shanghai or Guandong to increasingly interior provinces. In other words, earlier success in industrial growth through technological transfers were now being followed by surprisingly good overall economic growth, a reasonable definition of industrial revolution. Accumulatively, in advanced nations such as Japan and Korea, growth was now coming from microelectronics, biotechnologies, marine technologies and even robotics.[27]

And what of the decline of modernity and the new technologies? The so-called 'European' advances of the early-modern period were in fact Moorish, Islamic and Jewish, as much as quintessentially European - that is, Christian, scientistic, nationalist and so on. Any shift in the technological mode is partial and fragmentary and often ill-noticed, and this is evidenced in the shifts both to and fro machinofacture.

Yet Bill Gates has replaced Henry Ford. Microelectronic fusions

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[27] Lester Thurow, Head to Head, (Morrow and Co., New York,: 1992); P. L. Berger, *The Capitalist Revolution*, (Wildwood House, London: 1987); H. Patrick and L. Meissner (eds), *Japan's High Technology Industries*, (University of Washington Press, London: 1986).

and genetic manipulations have challenged the automation and office technologies of the Golden Age. It is true enough that newer **climacteric** technologies yet emerge mostly from companies such as Xerox,(Ethernel); IBM,(laser technology applications, the 801 project, DOS in 1981); Bell Labs,(charge-coupled devices in astronomical telescopes, alloptical processors in 1990); Intel, (the Pentium chip in 1993); Hewlett Packard,(RISC processor 1990); Microsoft(1977); and Texas Instruments (the speech synthesiser chip in 1978). Institutions such as the US National Academy of Science still grab the headlines, and Western research teams are associated with major technological breackthroughs - primary climacteric-era instances being the British antibody team and monoclonal antibodies (1975), the large US program on fibre optic cables (1977), the French construction of commercial fast breeeder reactors and the joint European and US team applications of DNA sequencing to markers for genetic diseases,(1978). Core changes come from British, French and US research teams, from the universities of Dundee, California and Geneva, just as **applications and adaptations** to cost and circumstance tend to be elaborated elsewhere, in Japan and East Asia, within enterprise structures that Henry Ford would not have prized. Thus the Casio electronic typewriter with memory (1978), NEC voice data input terminals (1978), the invasion of the global computer memory market from 1981 by the Japanese 64 kilobite computer chip, and the further improvements of Hitachi (1990) and Fujitsu (1993).

If the second group of items reads more like a shopping list than the first, this is almost as true of government or official programs of applied research. The major early climacteric projects in the West were perhaps best represented by NASA's space shuttle system from 1972, the EEC solar furnace project (1981) and the US government's much-vaunted SDI project from 1983. More representative of Japanese projects were those that sought, however clumsily, to merge government facilities and guidiance with enterprise commercial expertise, leading examples of which were the Fifth Generation computer program (that is, artificial intelligence, using Prolog, from 1982), MITI's Sixth Generation program using neural networks (with initial costings of $26 billion), the combined enterprises project to develop the 64 megabite D-RAM memory chip from 1991, and the establishment of the MITI laboratory for Fuzzy Engineering research in 1989. So, a rather unusual juxtaposition of public and private institutions in the latest of the machinofacture industrialisers,

Japan, serves to allow that nation technological system to both absorb and redirect core techologies from the advanced technological centres, and to transmit a post-machinofacture paradigm to newly industrialising nations at the end of the twentieth century.

Prior to the eighteenth cetury, how noticeable was the similar movement of core techniques from China and elsewhere into new commercial and workshop enterprises in early modern Europe at the outset of modernity, the nation state and machinofacture? What would have been the pattern of European development without Eastern printing, gunpowder, double-entry bookkeeping, clockmaking and other techniques, in the absence of the Persian screw or the horizontal windmill?

Conclusions: The Accident of Modernity

In his introduction to the Cambridge Modern History of 1896, Lord Acton hoped that it would be a hart' for the new century. One hundred years later we know that it was not. It was a history which predicted very little, which ignored most of the world other than as colonies, a history in which even Russia only appeared because of Peter the Great's "Westernisation" program. During the early twentieth century, historians such as Trevelyan rejected the notion of forecasting from history, intellectuals became sceptical of 'historicism', that is, the belief that the development of a phenomenon sufficiently defines that phenomenon. Stories of causality are now done away with in favour of interpretations in which contingency and conjuncture figure largely. At this level we can sketch in some conclusions.

If modernity is European, statist, industrial and progressive, then it came about as a massive contingency. Stories of causation resting on the traditional templates of Rennaissance, Reformation and Scientific Revolution, are in fact inadequate as sufficient accounts of European expansion into Asia and elsewhere. They are even more inadequate as explanations of the continued power of Europe from the eighteenth century to the present day. Here we have suggested that the earlier expansion of Europe wa as principally a function of accident in a global context of near-zero competition. A very small edge, an increment of directed energy, was sufficient to create original changes in the earthly balance of power and influence. We agree, that such power was then furthered by the subsequent competition

between the European powers overseas, the outcome of which may well have related to greater levels of technological development along the maritime cultures of northwestern Europe. We then argue that in the eigh teenth century something happened which rendered more systematic the European lead over other advanced cultures. But even in the eighteenth century, it was not so much a unique genius as a combination of spatial and social factors which gave rise to a more advanced technological system in Europe; thus, the exact role of seventeenth century scientific advancements in the later industrialisation of Europe is debated, and if such a role was indeed greatly significant it was almost certainly mediated by a conjunction of social forces. In all this, the competition amongst nation states was of certain importance. Finally, and equally contentiously, we suggest that from that point the continued dominance of the European and Atlantic system was a function of several factors, prominent amongst them being the insidious and complex impacts of machinofacture, the overwhelming technological paradigm of the modernised world until around the 1960s.

If we have tried to avoid *cultural determinism*, we have hopefully not fallen into the trap of a covert *technological determinism*! To around the year 1700, independent, perhaps mostly exogenous events, induced the expansion of Europe: technology does not figure largely in any causal sense. In the eighteenth century an increased range of resources, including technologies, were focussed on the process of conquest or expansion, but at most technology acted as a vehicle rather than as a prime mover. Furthermore, technological change in Europe was itself induced by other factors. An element of techological determinism might be credited to the story after circa 1800. We argue here that the abnormal modernity of the following two centuries was sustained through the unplanned and unforecasted (and usually unnoticed) operation of the culture of machinofacture, which acted as a principal barrier to industrialisation from beyond the Western pale. But, note, that machinofacture was not a solely technological phenomenon, and arose in Europe for reasons non-technological. Consistently, we argue that the one case of Asian industrialisation under the auspices of machinofacture and modernity, that of Meiji Japan, may not be explained in especially technological terms.

Small beginnings may create new ages. Who would have spotted as 'winners' such systems as England circa 1650, America circa 1750,

Japan circa 1850 or China circa 1950? The criticisms of today's East Asian achievements as derivative, partial and temporary do not address the historical record. Such attitudes tend to be politically archaic, technologically inept and culturally credulous. Such attitudes were expressed about Germany in the 1870s and about Japan in the 1950s, and were better commentaries on the relations of late development to democratic institutions than they were accurate forecasts of the tenability of such economic systems in the longer run.

It is fitting to conclude with a further commentary on the 'Asian turn'. With historical perspective this might be seen as integral to a **Climacteric** switch in technological possibilities and associated institutions, in which the abnormality of Western dominance, machinofacture and the nation state, and the virulence of the feedback relations between them, are irretrievably weakened. (See Chart 7) If so, then we are at the very beginning of a long process of replacement, associated with a greater supra-nationalism, new technologies and industries, and a movement away from dominance by the West to either dominance by Asia or the Asian-Pacific region, or towards multi-leadership focussed on such regions as the Japan Sea - the latter now targetted by J Japan's MITI as the next focus of global growth, where meet the great historical systems of China, Japan, Russia and Korea. Much here will depend on the productivity of commercial linkages between key strategic players and possible intermediaries. Regional developments such as that which increasingly link Taiwan with Xiamen, might be so succesful and so inevitable as to greatly reduce diplomatic, political and military conflicts or tensions between the major elements composing the twenty-first century's s geopolitical jigsaws. ㉘

Modernity has been composed of succeeding leaderships, beginning perhaps with the great Catholic powers of Spain and France, moving towards the Protestantism of The Netherlands and Britain, to the migrant cultural mix of the United States, to the climacteric shift of the East Asian Edge. In the years of modernity, a leading commercial system has always also apprehended the most sophisticated technologies of the world, as well as the ancillary institutions, from accountancy and bookkeeping, through the factory and the

㉘ Oi Luo, 'Foreign Direct Investment and Industrial Restructuring in Xiamen', *Issues and Studies, A Journal of Chinese Studies and International Affairs*, 39 (1997), 62-76.

Chart 7

The Modern Climacteric and the Fall of Machinofacture

1) Modern Climacteric (1970 to present-time)

Breading of Machinofacture Paradigm

Environmental industries	Microelectronics
Health industries	Robotics
Information industries	Biotechnologies
Transport systems	Genetic engineering

Decrease of Nationalism

Regional Associations
Global Solutions
TNCs
pollution
Global mass media
energy

Decrease of Western Dominance

EastAsia Edge
(Confucian Rennaissance
Or 6th R ?)

2) Fetures of Post-modern Technology Paradigm

Compared to Machinofacture it is less:

	urban biased
	Site-dependent
Smaller gestation periods	Capital-intensive
Smaller sunk-costs	Energy intensise
	Scale dependent

Such technology is thus easier to transfer and utilise in a multitude of social and institutional settings.

3) Implications : **it is now less easy to capture and maintain leadership there are now more points of entry global reversion to system prior to The Great Accident of 500 years ago is less national states, fluctuating leaderships thus, the Exit of Abnormal Modernity and of European Dominance.**

American System, to flexible production sites. But the pattern of *leadership, spread*, and *limitation*, seems to have been peculiarly modern, nationalist and European-dominated. A new technological paradigm associated with a geographical shift, does not necessarilly impell a new leadership. The present climacteric might be the beginning of a move towards regional rationality, with a consequent decline of modernist nationalist urges and identities. It should be noted, that there is no feature of the historical perspective of the present paper which leads to a claim that such super regionalism or even globalism will measure a superior or progressive political or moral outcome in the long term. Historically, modern democratic instititutions arose within firmly sovereign nation states. It may well have been that confident sovereignty was a requisite of sustained liberal democracy. It may even have been the case that the most notable threats to democracy after circa 1789 took place most often amongst idealogues who espoused internationalism rather than nationalism, that the terrible emotional rhetorics of racism, for instance, were and are more naturallly internationalist than nationalist. But such reflection should better act as a warning to millenial-minded internationalists and globalists than as a denial of reasonable historical analysis. ㉙

It is sincerely hoped that readers of the present paper will discern this important distinction. The electro-information age of the present climacteric allows greater entry (requiring less fixed assets), at the same time as it produces diminishing returns to the institutions and behaviour patterns associated with Western machinofacture; something predicted in, admittedly, other terms by David Hume in 1741. The Asian turn is not, in other words, a mere change of location. The Confucian Renaissance (perhaps our 6th R?), is clearly not the Protestant Ethic revisited, and the new assimilations and exploitations of novel core breakthroughs may best be occuring in decision-making systems straddled between the older 'private' and 'public' sector distinctions. Just so were the European institutions of

㉙ For recent reflections which are of especial importance to all students of international forces, see in particular John Laughland, *The Tainted Source. The Undemocratic Origins of the European Idea*, (Warner Books, London: 1998); Samuel P. Huntington, *The Clash of Civilisations and the Remaking of World Order*, (Touchstone Books, London: 1998); John Gray, False Dawn. *The Delusions of Global Capitalism*, (Granta Books, London: 1998).

the joint stock companies, of factories and accountancy, and of mercantilist interventionist policies, seen as novel and foreign to the older structures of early modern Europe.