

STATE SYSTEMS AND THE ORIGINS OF MODERN SCIENCE: A COMPARISON OF EUROPE AND CHINA¹

by

Graeme Lang

Introduction

Why did some societies or groups of societies produce the institutions of modern science and a rapidly growing body of scientific knowledge over the past three hundred years while other societies lacked such institutions until the 20th century? Sociologists and historians have addressed this question through studies of the rise of modern science in Europe and through comparative studies of civilisations which did not develop modern science but which produced some early scientific or proto-scientific work.

Some of these studies have tried to explain why Europe developed modern science while China did not. Joseph Needham posed this question in the late 1930s, after discussions with young Chinese scientists in England², and subsequently began his life's work on the history of science and technology in China. But he devoted most of his efforts to the study of developments in pre-modern China and largely abandoned the original question.

Other scholars continue to pursue the answer to Needham's question through comparative research. Their explanations can be classified according to the type of factor which each theorist believes is primary. Proposed causes or conditions for the rise of science in

¹ Paper presented in the "East-West Talks" series at the David C. Lam Institute for East-West Studies, Hong Kong Baptist University, February 1997.

² Needham, 1981:3

Europe, and for the lack of such a development in China, can be grouped into 'culturalist' and 'structuralist' explanations.

The most recent attempt to provide culturalist explanations for the growth or inhibition of science in various societies is Toby Huff's *The Rise of Early Modern Science: Islam, China, and the West* (1993). The most recent major structuralist analysis, attempting to explain the fate of science in terms of ecological conditions and the social and political structures which developed under various ecological conditions, is Harold Dorn's *The Geography of Science* (1991). Huff's culturalist approach is grounded in a type of analysis which goes back to Max Weber, while Dorn's structuralist approach is grounded in one which goes back to Friedrich Engels. Thus the classic debates of the last century with regard to the fundamental causes of social and cultural change are still very much alive in current studies of the rise of modern science.

I. Culturalist Theories

Culturalist explanations look for the causes of the differences between two civilisations in the realm of beliefs and values. The most common culturalist explanation for the failure of China to develop modern science holds that Confucianism is not compatible with the scientific approach to pursuing knowledge. Etienne Balazs expressed this idea as follows:

most probably the main inhibiting cause was the intellectual climate of Confucianist orthodoxy, not at all favorable for any form of trial or experiment, for innovations of any kind, or for the free play of the mind.¹

Culturalist explanations for the rise of modern science in Europe have referred to the effects of Christian or Puritan theology, the legacy of Roman law, and so on.²

¹ Balazs, 1964:22, quoted by Karp and Restivo, 1974:138.

² Merton, 1970; Huff, 1993.

There are several serious problems with culturalist explanations. Most social scientists do not view culture as a static set of ideas and rules somehow imposing itself on society. Culture is comprised of a multitude of images and ideas which are used selectively and often creatively to suit the needs of various groups. When it appears to be advantageous, a group may reinterpret elements of received culture to support their plans, or adopt new ideas from local innovators or from other groups, provided they have the resources and the freedom to do so. If scholars in China had wanted to do science, philosophy alone would not have been a serious impediment. Indeed, there were probably fewer ideological impediments to science in Confucian China than in Christian Europe.

II. A Structuralist Explanation

Structuralist explanations look for the causes of the rise of modern science in Europe, and its absence in China, in the ecological, economic, social or political formations which developed in the two regions. In this paper I offer a brief outline of elements of a structuralist explanation. (A more extensive analysis is contained in a longer article, in preparation). I do not intend to review all of the important factors here. For example, a number of scholars link the rise of modern science to the emergence of capitalism in Europe.¹ The emergence of capitalism, in turn, can be linked to some of the structural factors discussed below. Here, I will ignore the capitalism-science argument and focus mainly on the causes and consequences of differences in the state systems of Europe and China.

Most historians agree that the origins of modern science can be located in the 16th to 17th centuries in Europe, where we find the first full and explicit formulations of scientific method, the first recognition of the importance of demonstrating results to other investigators using repeatable methods - the crucial social aspect of modern scientific

¹ E.g. Zilsel, 1964; Ben-David, 1965; Needham, 1972

epistemology¹ - and the first organised forums devoted to critical assessment of the work of scientists², which could be called scientific societies.

The development and institutionalisation of modern science depended on a number of factors, some of which were present in both Europe and China (for example, a writing system, extensive division of labour, and so on), and some of which were present only in Europe. In this paper I would like to begin with one of the most important of these factors: the existence of a number of relatively autonomous nodes of inquiry where investigations into nature could occur without undue ideological or political interference from conservative authorities.³ Such nodes were provided by the universities which proliferated in Europe from about the 12th century C.E. They served as incubators of rationalistic inquiries into nature for several centuries prior to the emergence of what we now call modern science in the 17th century.⁴

In China, there were no such nodes of inquiry. Universities comparable to those in Europe were absent, and there was no other social structural location within which science could develop. The so-called Imperial University in Beijing, during those few periods when it was fully operational, was too close and too vulnerable to the imperial authorities to serve as an incubator of rationalistic inquiry, and was in any case periodically closed and the scholars dispersed. The private academies which operated throughout the empire during the Ming and Qing periods were, during most of this time, hardly more than cramming schools for the imperial civil service examinations.⁵ Why did universities develop in Europe, but not in China?

¹ Schmitt, 1994

² Goodman and Russell, 1991; Garber, 1995

³ Huff, 1993

⁴ Goodman and Russell, 1991; Gascoigne, 1990

⁵ Blunden and Elvin, 1981:145

III. Ecology

A key factor was the ecology of the two regions.¹ In Europe, rainfall agriculture provided no early role for an intrusive state. The agricultural revolution of the 6th to 9th centuries provided the economic basis for the growth of relatively autonomous towns, the private control of tradeable surpluses, and locally autonomous institutions in these towns prior to the rise of centralised states in Europe in the late Middle Ages (which was accomplished largely as a result of developments in military technology). Universities established in these European towns prior to the rise of the centralised states acquired a degree of legal autonomy unknown among the towns and municipal institutions in China.

The ecology of the most productive agrarian regions in China - the major river valleys - was quite different and evidently favoured a much more intrusive state. This idea was proposed by Engels² and was developed into a major comparative thesis by Wittfogel.³ Despite the widely noted flaws in Wittfogel's work, it appears that 'hydraulic' civilisations did indeed develop in particular kinds of geographical settings - those in which large-scale agricultural engineering works such as dams, dikes, and canals could be used to increase the security and productivity of agriculture and avoid famines and ecological disasters.⁴ The Chinese state engaged in major water-control projects to generate the agricultural surplus with which the state further aggrandised itself, and which required a more coercive role for the state than in Europe. Towns grew up in China in those regions where intensive hydraulic agriculture supported a dense and growing population, but these towns were primarily nodes of the state administration rather than nodes for the production and exchange of privately-held tradeable surpluses as in most of Europe.

¹ Karp and Restivo, 1974; Dorn, 1991

² Marx and Engels, 1980:278

³ Wittfogel, 1957

⁴ Dorn, 1991

But relatively autonomous nodes of inquiry alone will not produce modern science without some social and material rewards for success in investigations into natural phenomena. The motive force and social reward for such investigations resulted, in part, from the presence of numerous contiguous states in Europe in the late Middle Ages, and the growing perception among state authorities that investigations of natural phenomena could provide a competitive advantage in the growing military, maritime and commercial competition among these states. A number of the states in Europe tolerated and eventually patronised relatively independent nodes of inquiry partly for this reason. At the same time, the rapid communication of new ideas throughout Europe by travellers and by the transportation of printed works across national boundaries stimulated inquiry and comparison of results throughout Europe.

The existence of numerous contiguous states in Europe also provided a refuge for scholars threatened with repression in conservative regions.¹ A relatively short journey could take them into a different and independent legal jurisdiction, beyond the reach of hostile officials in their home state. By the late Middle Ages, no single authority was able to impose ideological hegemony throughout Europe. There were of course agencies and regimes in Europe which wished or attempted to maintain the kind of ideological hegemony and control exercised by the imperial regime in China. The Catholic Church, in particular, attempted to control belief throughout Europe, by threat of trials and executions if necessary, and exercised considerable political power over rulers in some of the states. However, the rise of the nation state with its own universities and its communities of relatively protected intellectuals eventually doomed the efforts of the Church. The Reformation was not so much a cause of the rise of science² as a good illustration of the liberating effects on intellectuals of political fragmentation.

¹ Wuthnow, 1980

² Mason, 1964

In China, by contrast, the state system for virtually all of the past thousand years consisted of a single vast empire with no contiguous competing states which could have induced a sustained competition among the states to produce better science and technology. Instead, the imperial state in China was preoccupied much of the time with maintaining social and political control over a vast area. This social and political control was fostered partly through the imperial examination system¹, which began during the Sui dynasty (589-617), became the standard method of selecting bureaucrats during the Song (960-1275), and was revived in the Ming (in 1382). This system enforced a single state-serving ideology on all those who would seek a career through learning² and provided great rewards to all who succeeded in mastering this ideology after years of study of the Confucian corpus and the approved commentaries.³ At the same time, the state was capable of pursuing and punishing dissident scholars anywhere within the empire using its network of imperial officials.

This state system also blocked several other conditions for the rise of science. For example, to incubate the rise of science, a society must be capable of tolerating a critical approach towards received theory. Otherwise, science will be inhibited, in proportion to the degree of repression. In addition, the society's educational system must be capable of assimilating advances in knowledge produced somewhere within the society, otherwise there is likely to be little progress as each generation is socialised anew in the old received theory. The imperial state in China was relatively intolerant of heterodox philosophies, and the examination system forced educators to teach the traditional corpus of received theory without critical analysis. The multi-state system in Europe, by contrast, contained a diversity of educational institutions, and some of these institutions allowed critical analysis of received theory because there was no single ideological authority which could control all of them.

¹ Elvin, 1973

² Qian, 1985

³ Lin, 1995

But why was the state system in Europe throughout most of the past thousand years characterised by numerous contiguous and competing states increasingly preoccupied by competition with each other, while the state system in China during the same period included only a single vast empire preoccupied mainly with political hegemony?

The hydraulic agriculture explanation cannot explain the dominance of a single state in China throughout the entire landmass of the empire, since hydraulic agriculture or major water-works occupied only a relatively small area around the major river systems in north and central China. The regions of the empire to the south and southeast were as large and as populous as most of the countries in Europe. But agricultural infrastructure in these regions - mainly wet-rice works such as paddies, dykes, and sluices - was developed and maintained locally. There was no significant direct role for the state in this type of agriculture, nor did the state build major water-works or canals in the south comparable to the Grand Canal system for transportation of grain from the Yangzi region to the imperial capital.¹ Much of the labour involved in water-control for wet-rice agriculture in southern China was organised and controlled at the village level², as critics of the 'oriental despotism' hypothesis have pointed out. So we must ask: why did these regions not develop their own state systems separate from the state system which evolved in the regions of hydraulic agriculture? The repeated conquest and reunification of the entire area of what is now China had enormous implications for intellectual life in China. Why did the state which developed in north and central China come to dominate such a large region despite the lack of any coercive role throughout much of this region in the production of greater agricultural surplus?

I do not believe that the answer to this question can be found in the realms of ideology, ethnicity, language, or culture. The diversity of local and regional languages was certainly as great in China as in Europe, reflecting the existence of populations which preserved their ethnic distinctiveness into the twentieth century. Instead, I suggest that

¹ Blunden and Elvin, 1983

² Merson, 1989:28

this radical difference between China and Europe ultimately has its roots in geography.

IV. Geography

Europe is comprised of a number of geographical subregions, each of which is relatively protected by substantial geographical barriers such as mountain ranges, major rivers, bodies of water or dense forests. Within these regions, separate languages and ethnic cultures evolved. These ethnically diverse regions were relatively difficult to conquer and hold within a unified empire. With rainfall agriculture throughout most of Europe, and no role for the state in producing surpluses, most of these regions developed their own local political institutions, which formed the basis for resistance to later attempts by imperialistic states or agencies to impose control over them. Most of these ethnic regions eventually developed into nation states. Thereafter, potential conquerors were deterred, or defeated, partly because geography provided numerous natural defences against conquest and prolonged centralised control over the whole region.

In another paper, I will elaborate by describing the geographical routes through which the subregions of China were invaded and controlled and the geographical difficulties which led to failures or inhibition of conquest and control in Europe. Here only a brief sketch can be attempted. However, we may note that the British Isles were surrounded by water; France was partially protected by seacoasts, the Pyrenees, the Alps and the Rhine; Spain was protected on three sides by water and on the fourth by the Pyrenees; Italy was protected similarly by water and by the Alps; and Germany was partially protected by a patchwork of mountains, rivers and dense forests in the south and southeast, and by the seacoast in the northwest. None of these areas was immune to invasion, and all have been successfully invaded at one time or another during the past two thousand years. But since most of the states in Europe presented such difficulties, no state was able to dominate and conquer nearly all of the others and thus

achieve the power to concentrate all the resources of the region to bring the last recalcitrant state back into a regional empire. States also formed alliances to protect each other from invasion by other states, which further inhibited regional unification. The few temporary empires quickly disintegrated under the difficulties of holding the entire region under a single imperial system.

In China, by contrast, imperial control over the entire region was maintained for most of the past one thousand years, and was repeatedly reconstituted by military conquest whenever the empire disintegrated due to internal rebellions or invasions from the north or northwest. None of the temporary states which coalesced during the intervals between disintegration and reunification were able to survive long enough to acquire their own distinctive intellectual or political traditions, although some regions nurtured memories of their temporary independence.¹ Regions such as Lingnan could never find military allies to help protect themselves from invasion by sea or by land and were always reabsorbed.

It is possible that during the Song dynasty, and particularly during the southern Song (1126-1279), parts of the area under Song control were developing a form of civilisation which might have incubated both capitalism and modern science. The wealth and influence of merchants was evidently growing, as was the reliance of the imperial treasury on the taxes and revenues which could be extracted from their activities, including overseas trading, after the loss of much of the agricultural land north of the Yangzi to the Jin Tartars.² Meanwhile, a relatively more cosmopolitan and relatively more empirical intellectual culture was developing in the cities. China during this period may have been approaching the threshold of a systematic experimental investigation of nature, particularly with regard to medicine and pharmacology.³ If this is the case, then the Mongol conquest and reunification of China was unfortunate for science. The Ming conquest and reunification produced an even more despotic and conservative

¹ Lary, 1996

² Merson, 1989:60-61

³ Elvin, 1973:178, 188-190

regime. The technological and intellectual stagnation of China began, according to some scholars, in the Ming.¹

The principal significance of the political reunifications, however, was not in the particular character of each regime, but in the impact of reunified and centralised imperial power on intellectual developments within the Chinese landmass. Although some of the dynasties were more despotic and repressive than others, all of the dynastic regimes pursued a policy of ideological control for the sake of political stability, and all of them were able to identify and punish dissidents and free-thinkers anywhere within the empire.

The geographical limits to the expansion of this empire have been apparent in the history of attempts by the various Chinese imperial regimes to conquer and hold neighbouring regions. Vietnam and Korea were near the limits of the imperial regime's ability and determination to surmount geographical obstacles to achieve political control, and although northern Vietnam was under Chinese rule for a long period, both areas have managed to escape the imperial embrace for the past thousand years. In part, the independence of Korea and Vietnam is not purely a matter of geographical barriers alone, but a result of the costs of surmounting such barriers relative to the benefits for the empire of doing so. If China-based empires could have reaped large benefits (political, financial or military) from conquering and holding Korea or Vietnam, there is little doubt they would have done so. Unsuccessful and costly invasions of both regions, however, demonstrated to various imperial regimes (both Mongol and Chinese) that there was not sufficient benefit from such conquests to justify the high costs. For the same reasons, Mongol attempts to conquer Japan were ultimately abandoned.

At the same time, none of these regions presented any serious threat to the imperial regime until the 20th century, and thus they did not provide the stimulus of chronic military and commercial competition, largely because China was simply too vast and its population too numerous to be seriously challenged by the weak and remote minor

¹ Huang, 1988

states on its periphery (except of course by land in the north and northwest, where the terrain provided no natural barriers and offered an easy route of invasion for cavalry). China was relatively isolated from other potential major competitors by high mountains and vast deserts in the west and southwest, by jungle and mountains in the south, and by a vast ocean on its eastern seacoast. Once it had reached the practical geographical limits of its territory (given current military technology and the nature of the populations on its periphery), the empire could concentrate on political stability, with the means to pursue heterodox thinkers and dissenters anywhere within the vast geographical scope of imperial control.

V. Conclusions

Differences between Europe and China in ecology and geography help to explain the very different fates of science in the two regions. First, agriculture in Europe provided no role for the state, which remained far from local communities most of the time, and when the agricultural revolution in Europe produced a growing agricultural surplus, this allowed the growth of relatively autonomous towns along with urban institutions such as universities prior to the rise of the centralised states in the late Middle Ages. Agriculture in China, by contrast, favoured the early development of intrusive and coercive states in the major river valleys, while towns and their institutions never achieved the degree of local autonomy found in Europe.

Second, the geography of China, unlike that of Europe, did not favour the prolonged survival of independent states. Instead, China's geography facilitated eventual conquest and unification over a vast area, followed by long periods of relative stability under imperial rule. The resulting state system suppressed most of the conditions required for the emergence of modern science, particularly the existence of relatively autonomous jurisdictions and nodes of inquiry in which critical analysis of theories about the world could occur without control or repression by centralized authorities. The imperial state system also never generated

the kinds of competition among states which occurred in Europe and which helped to provide some of the motivation and material reward for scientific investigation.

The explanation outlined above is certainly oversimplified. However, one of the advantages of this kind of account is that it escapes the circularity which often creeps into explanations which do not go deeper than social or cultural differences between Europe and China. Such explanations can always be challenged with the further question: Why were Europe and China different with regard to those social or cultural factors? Explanations rooted ultimately in geography and ecology, however, have reached bedrock. Using the work of a number of structuralists, this paper has proposed a relatively simple explanation for the rise of modern science in Europe and the lack of such a development in China.

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