A Cultural and Institutional Study of Useful and Reliable Knowledge: the Case of Traditional China

[Discussion paper][1]

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Recent scholarship on global history (e.g., Pomenranz 2000; Bin Wong 1997) has criticised the Eurocentric portrait (e.g., Landes 1998) of the long-term backwardness of 'the East'.[2] For more than a millennium, China had been more economically advanced than Europe with periodic 'efflorescences', especially in the Tang (618-907AD) and Song (960-1279AD) dynasties. The 'great divergence' only occurred later, around 1800. In the field of science and technology, the work of Needham has also shown that China had been ahead of Europe before 1500. It may well be that a climacteric in the generation and diffusion of 'useful and reliable knowledge' (URK) occurred in the Ming dynasty (1368-1644AD), and the shift in the locus of the generation and application of URK may be crucial to the reason and timing of the subsequent 'great divergence'. If so, perhaps the reasons for the divergence of the development paths between China and Europe were not simply a matter of 'luck', as the revisionists have in fact argued. However, discussions of URK are currently missing in 'the great divergence' debate.

URK: definition and criteria from the European perspective

URK is often regarded as amorphous and hard to measure compared with economic factors such as labour inputs and incomes. Indeed each of the words 'useful', 'reliable' and 'knowledge' needs further clarification.[3] It is also difficult to define the

[1] In our URKEW (Useful and Reliable Knowledge in the East and the West) group workshop in mid-April 2010 at Cambridge, we explored five issues: 'Useful and Reliable Knowledge' (hereinafter URK), elites, institutions for higher education, relations between science and technology, and comparisons in global history. In my paper, I trace the Chinese conception and understanding of useful knowledge historically through examining the connections between useful knowledge and science and technology, the institutions, and the roles of the elites in the Chinese context. I thank Professors Patrick O'Brien and Mark Elvin and Dr Kent Deng for reading this preliminary draft. The paper is not for citation in its present incomplete form.

[2] Neither 'the East' nor 'the West' is a homogenous entity. In this paper, 'the East' refers to China, Japan, India and Isladom. 'The West' refers to Europe, especially Western Europe.

[3] For example, in a discussion with Professor Mark Elvin on 17th March 2010 at the LSE, where he

scope of URK, and indeed it is often simply equated with science and technology. Joel Mokyr's work has been path-breaking by showing the close linkage between URK and economic progress -- useful knowledge is the knowledge that could promote economic growth. Going beyond science and technology, Mokyr's approach has stressed the roles played by culture and institutions in the generation and diffusion of URK. For example, Mokyr argues that technology is 'epistemological in nature', and 'technology change should be regarded properly as a set change in our knowledge' (1990: 276). Flows of Knowledge are influenced by institutions and incentive structures[4] (1990: 277-302). For Mokyr 'useful knowledge' is knowledge that deals with natural phenomena that potentially lend themselves to *manipulation*, and includes artefacts, materials, energy, and living beings' (2002: 3, italicised emphasis added). He excludes from URK knowledge associated with the human mind and social institutions. This kind of knowledge is not necessarily 'true', but it is (close to) practical (2002:2; see also Gaukroger, 2006: 36). In his recent work 'The Enlightened Economy' Mokyr extended one of his several definitions of 'useful knowledge' to include 'social relations' such as trust and authority (2009: 12).

To facilitate our comparison of the differences in the generation and diffusion of URK between China and Europe, it would be helpful if we could be more specific about imprecise words such as 'useful' and 'reliable' by developing some criteria for their content. Mokry (2009), for example, gives three criteria concerning useful knowledge generated by the Baconian program, namely, knowledge that is 'cumulative, consensual and contestable' (p. 42). URK from the European point of view should be: *contestable* (the knowledge is subject to adversarial practice, disputation, criticism and competition[5]); *accessible* (the public can get access to knowledge, and cost of access should be gradually reduced); *transmissible* (individual efforts could be

raised his doubts about the concept of 'useful' and thought that it was a dangerous criterion. He suggested using 'realistic' instead of 'useful' and 'reproduceable' instead of 'reliable'. From the perspective of economic history, useful and reliable knowledge should have economic utility or potential commercial utility. 'Useful' thus means commercially saleable.

[4] See e.g., North and Thomas (1973); Jones (2002).

[5] For example, publishing in scientific journals since the time of Newton has been a typical activity of competition and establishing the priority in the research field.

transformed into collaboration, and knowledge could be passed on from generation to generation and therefore a collective enterprise); *economically motivated* (with commercial incentives and the belief that such knowledge may enhance efficiency and economic profits). Generally speaking, the generation of the stock of useful knowledge should be linked quite well with the effective diffusion and utilisation of such knowledge. But we may ask: what constituted useful knowledge in the context of traditional China?

URK: the European criteria and the Chinese context

Scholars (especially those working in the field of history of science) often equate URK with science and technology. So, let us start with a brief review of the discussions on Chinese science and technology. Ever since Joseph Needham's voluminous work demonstrating that Chinese science and technology were ahead of Europe before 1500,[6] narratives that assumed the superiority of Western science and technology look dated. Instead, concern has been diverted to 'Chinese sciences'. Needham argued that although there had been 'primitive science' in ancient China and Greece, 'modern science' originated in 'the West', Chinese science has contributed significantly to what he called 'universal science'. Nathan Sivin disagreed with Needham's approach, which amalgamated science and technology, and argued that Chinese superiority in technology should not be equated with a more advanced state of Chinese science. Science and technology should be treated separately. Technology was produced by craftsmen, and science was the preserve of a minority of educated people (Sivin, 1982). Sivin's work has been developed by Elman. The latter argued that there were longstanding Chinese interests in the natural world, especially in the fields of astronomy, geography, mathematics, and medicine and that the native Chinese sciences continued to evolve from the 16th to the early twentieth century under the influence of the Jesuits and Protestant missionaries (Elman, 2005, 2006). The Chinese produced 'modern science' 'on their own terms'. But Elman does not

[6] Needham argued that 'between the first century B. C. and the fifteenth century A.D., Chinese civilization was much more efficient than occidental in applying human natural knowledge to practical human needs' (1969: 190).

really give an answer to the puzzle -- if the development of Chinese science proceeded at the same, or even a higher level as that of Europe in the period 1400-1800, why an Industrial Revolution did not take place in China, and why did a great divergence occur ca. 1800? Moreover, if we assess the state of science and technology in traditional China in terms of the criteria mentioned above, we will see that science and technology in China do not meet the standards developed in Europe.

First, most Chinese scientific discoveries and technological innovations were not 'contestable'. Secondly, in traditional China there seems to be less effective conduits through which scientific discoveries could be transformed into technological innovations. Throughout Chinese history, there were many examples of scientific discoveries, but few were economically motivated or applied to technological improvements. As Eric Jones has argued, 'Chinese experience reaffirms that the nexus between scientific discovery and technical advance was really quite weak', and in his view China lacks 'a sharp-edged experimental approach of the type that really may lead to better technologies'(1988: 75). Thirdly and most importantly, China lacked institutions to promote the transfer of science and technology from generation to generation. Even Needham himself admitted that there were barriers to the development of Chinese science such as the Confucian approach to nature, the lack of an autonomous merchant class, and the entrenchment of the Ming bureaucracy. Elvin (1973: 315) argued that the power within society that might encourage creativity and innovation was in the hands of conservative bureaucrats. Mokyr (1990: 233-236; 2002: 223) has pointed out that the state played an important role in the generation and diffusion of innovations in China before 1400, because the landed gentry and educated elites were not interested in these matters; when the support from the government withdrew, there was no replacement and the innovations declined. There was a huge gap between the *propositional* knowledge embodied in educated elites and craftsmen with *prescriptive* knowledge.[7] Qian (1985) argued that China rarely

[7] Compare the European situation. In Europe, engineers, inventors and merchants seldom belonged to the ruling class, and the situation was more or less similar to China. But the landed aristocracy did not

provided the necessary 'software' (that is, political-ideological conditions) to sustain intellectual creativity and innovation and cultural pluralism, even though examples of 'hardware' (e.g., paper, printing, gunpowder, and magnetic compass) appeared much earlier in China than Europe. Qian used the term 'inertia' to describe the non-development of Chinese science.[8]

Furthermore, let us probe a little more into the argument that China had developed its own 'modern science'. The idea that China had developed its own 'modern science' since the seventeenth century is often focused on the Chinese 'investigation of things' (*gewu* 格物). This linkage was drawn by the Jesuits between *gewu* and European higher learning *scientia*[9] at the beginning of the seventeenth century (Elman, 2005: 4). But if this linkage existed, it is then hard to explain why certain Western knowledge such as medicine, anatomy or physiology, mechanics, botany, agriculture or architecture were seldom transferred by the Jesuits to China. One possible reason is that there was hardly any demand in China for the transfer of certain kinds of knowledge. This indicates that the linkage may be quite weak, partly because of the ambiguity of the meaning of *gewu*. More importantly, this linkage ignores the cultural and institutional foundations (neglecting differing views on nature and its relations with humans) of *scientia* in Europe and *gewu* in China. The European system of knowledge was shaped by the interactions between Christianity and science: 'Christianity set the agenda for natural philosophy in many respects and projected it forward in a way quite different from that of any other scientific culture' (Gaukroger, 2006: 3).[10]

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resist new technology, as their interests were not harmed. See Mokyr (1990: 236-258). See also Qian (1985: 105).

[8] On discussion of a paradox for China between development and stagnation, see Deng (1999).

[9] The earliest uses of the Latin *scientia* in more or less the sense of 'science' go back at least to the 12th century with various adjectives including 'experimental', 'natural', 'practical', and 'secular'. See Latham (1965: 424). Thanks to Professor Mark Elvin for drawing my attention to this reference.

[10] Gaukroger summarises some Weberian approaches to stress the 'differences': the bureaucratic structure of Chinese society, adherence to tradition, tendency of self-effacement and avoidance of contentiousness, lack of adversarial model and corporate entities (Gaukroger, 2006: 33-34). But Gaukroger (2006: 35) does not think that these are the core issues to explain the rise of a scientific culture in the West. He argues that 'if we confine our attention to two issues—the existence of a neutral space for enquiry, and the role of an adversarial culture—we can glimpse the extent of the challenge'.

In Europe Aristotelianism was incorporated by Christianity and was extended to cosmological inquiries -- so that its students were doing the God's work in exploring and potentially manipulating the nature.[11] But in China religion could not play the same role as Christianity, and in many respects Confucianism is not a religion at all. Chinese philosophy draws close to ethics. Although Confucianism absorbed certain elements of Daoism and Buddhism in the early stage of its development, it eventually became secular. Therefore in China there was no equivalent to the philosophy of science as found in the European context. Sivin's has noted the diversity of knowledge in China, although he has labelled various forms of knowledge as 'sciences':

> In China there was no single structure of rational knowledge that incorporated all the sciences. Knowing was an activity in which the rational operations of the intellect were not sharply disconnected from what we would call intuition, imagination, illumination, ecstasy, aesthetic perception, ethical commitment, or sensuous experience. The various sciences, unlike those of Europe, were neither circumscribed by the philosophies of their time nor subordinated to theology (which did not exist in East Asia) ….There is an obvious contrast with the educational institutions of Europe, from Plato's Academy and Aristotle's Lyceum to the medieval and early modern universities, in which the natural sciences were kept subordinate to philosophy' (Sivin, 1990: 169).

Thus, within the Chinese system, there must have been diverse forms of useful knowledge. For example, for the Chinese elites, knowledge that could be considered useful and practical should concern good order or solutions to social problems such as agriculture, military issues, and medicine). Many useful inventions were not diffused and were soon lost or forgotten. There was a cleavage between knowledge held by the elites and the knowledge held by technicians, craftsmen and common people. To borrow Professor Mark Elvin's metaphor of 'branches' and 'trunks' of the tree to describe the system of useful knowledge, if intellectual culture is the tree, 'science', 'technology' and other forms of useful knowledge are branches growing off the same

[11] See e.g., Stark (2003), especially chapter Two 'God's Handiwork: The Religious Origins of Science', pp. 121-200.

cultural trunk rather than separate trees.[12] Moreover, there is a hierarchy of the 'branches'. Some branches were growing higher than 'science' and technology. Our task is to identify: what is the 'cultural trunk' and what are the 'higher branches' than science and technology?

Mokyr's definition looks useful for an analysis of the importance of knowledge to the economic and industrial development of Europe. For him URK helped created the material culture and paved the way for the First Industrial Revolution, especially in Britain from 1700 to 1850. But Mokyr's definition of useful knowledge (setting aside human mind and social institutions) may be too narrow to comprehend useful knowledge as conceived, valued and embraced by top-level elites in pre-modern China. They saw governance, education and the moral transformation of both individuals and society as the priority for their society and empire. What constituted the most useful knowledge in the thought of the Chinese top-level elites may be fundamentally different from that of their European counterparts -- the Confucian elites characterised such knowledge as '*xiu qi zhi ping*' (修齐治平) namely, self-cultivation, family management, national administration and the maintenance of the whole social order.[13] Thus an examination of useful knowledge in traditional China should also include discussions of law, ethics, bureaucracy, and organisation of society. I will come back to this point shortly.

Thus a wholistic conception of URK is not universal. It is depended upon or embedded in its cultural and institutional contexts. We need to think: in China was there a kind of knowledge embodied the potential to lead elites to think systematically and persistently about the nature of the natural world and ways of manipulating? More importantly, we may ask questions: what factors decide whether knowledge was

[12] Elvin (2004: 56: '…we have also to consider whether 'science' and 'technology' in this age [1600-1800] were more like branches growing off the same cultural trunk than separate trees'.
[13] Knowledge on good governance is uniquely Chinese (*xiu qi zhi ping*). This was determined by China's non-feudal tradition. Under European-Japanese feudalism, there was no special need for good governance. China was an empire, run by bureaucrats (not aristocrats) who had no 'birth right' to rule. So, good governance was vital for them to hold office. Thanks to Dr Kent Deng for raising this point.

'useful' or whether certain kind of knowledge was more useful than others and therefore got diffused more easily? We need to consider the cultural and institutional factors behind the generation and diffusion of URK. I will examine the questions above through an analysis of the institutions of 'higher forms of education' and the roles of the elites in the context of traditional China. Specifically, I will trace the historical origins of '*gewu zhizhi'* and '*jingshi zhiyong'* as other traditional Chinese forms of useful knowledge that transcend science and technology.

'Useful knowledge' in China: the institutional context

Since the cosmological and intellectual spheres are often considered amorphous and intangible to comprehend, we need to approach the differences between China and Europe by constructing some 'comparative engines'. Institutions come to mind, because useful knowledge is embedded in or closely related to formal (or informal) institutions such as universities, academies, networks of intellectuals, libraries, markets, the legal systems, notion of trust, civil society, the publishing industry and the trade of books etc. Such observable institutions provide spatial and social sites for the generation and diffusion of useful knowledge.[14] Thus I will now focus on the educational system as it operated in traditional China. This is an important institutional dimension within which to examine the kind of knowledge and the manner in which was generated, shared, accessed and diffused.

In traditional China, education (*jiao* 教) was closely linked to governance (*zheng* 政) Education and governance complemented each other. Education was established to sustain an ideal social order. Governance did not just mean governmental administration, but more importantly, it embodied a mission of 'rectifying thought and regulating conduct' (Liu, 1988: 37-38). To fulfil the purpose of governance, education was not limited to teaching and schooling, but meant more broadly 'instilling and perpetuating a moral standard of social order' (Liu, 1988: 38). Moreover, education

[14] See Inkster (2006).

helped ‘transforming’ (*hua* 化) as shown in the compound *jiao-hua* (educating and transforming 教化) (Liu, 1988: 38). Therefore, as Liu summarised, ‘the ideal of Confucianism as it evolved through the centuries was to fulfil all these functions--governing, educating, improving, and transforming individuals, society, and rulers’ (1988: 38). The conception of useful knowledge in pre-modern China is thus closely related to how to govern, educate and transform both individuals and society.

The oldest form of higher education in traditional China could be traced back to the Xi Zhou (Western Zhou) (1046-771BC), the ‘feudal’ period of China. Schools were mainly established for the nobility in the capital of the Zhou. The curricula were consisted of the ‘six arts’ (*liuyi* 六艺): *li* (ritual 礼), *yue* (music 乐), *she* (archery 射), *yu* (charioteering 御), *shu* (literacy and calligraphy 书) and *shu* (mathematics 数). But unlike the ‘seven liberal arts’[15] in Europe, the learning of ‘six arts’ did not lead to more specialised studies. The schools for the nobility were publicly run and were called official schools (*guanxue* 官学). The decline of the central control and the emergence of ‘a hundred schools’ made the Dong Zhou (Eastern Zhou) (770-256BC) the most intellectually creative period in traditional China. Among these schools were Confucianism, Daoism, Mohism (which contributed to technological development), and Legalism. Confucius and his disciples actively established private schools, and other groups also set up teaching institutions.[16] The Han Dynasty (202BC-AD220) abolished a hundred schools of thought including Mohism and worshiped Confucianism. While private schools were maintained, the official Imperial University (*taixue* 太学) was set up. The classics became the core of the curriculum, but music, ritual, and archery were still included. The Directorate of Education (*guozi jian* 国子监) was established in the Sui (581-618AD) and Tang (618-907AD) dynasties, and performed the functions as both an education administration authority and a higher education institution. The Imperial University was administered by the

[15] Grammar, rhetoric, logic, arithmetic, astronomy, music, and geometry.
[16] See also Randall Collins (1998: 142-146).

Directorate of Education.[17] Large-scale private academies (*shuyuan* 书院) emerged in late Tang and flourished under the Song.[18] They approached the prominence in the Southern Song (1127-1279AD). The Ming banned private academies many times. In Qing times private academies were gradually incorporated into public schools. Along with the process of the institutionalisation of official schools and private academies, the civil service examination system emerged under the Sui, was developed in the Tang, institutionalised in the Song and was only abolished in 1905. Therefore, in order to understand 'higher forms of education' in traditional China, we need to study public schooling (including the Imperial University, the Directorate of Education, various specialised schools and local schools), private schooling and the civil service examination system, especially the curriculum shifts which show the transformations in the classification of knowledge in these institutions.

The Tang was a time when the dominance of the medieval aristocracy of China came to an end. The Northern Song (960-1127AD) marked the rise of meritocracy by the continuing development in the civil service examination system and bureaucratic government. The Southern Song (1127-1279AD) also deserves special examination as it is the period in which Neo-Confucianism became a powerful school of thought. Neo-Confucianism is often called the 'Cheng-Zhu school': Cheng refers to the Cheng brothers -- Cheng Yi (程颐 1033-1107) and Cheng Hao (程颢 1032-1085), northern Song intellectual 'pioneers', while Zhu refers to Zhu Xi (朱熹 1130-1200),[19] a southern Song synthesiser of thought. The scope of neo-Confucianism is a matter of some debate. This study adopts the more narrow definition, that is, neo-Confucianism which refers to Zhu Xi school of thought, or *lixue* 理学, also known as the school of principles. Generally speaking, *li* refers to the principles that give all things their form.

[17] But in the Northern Song 960-1127AD, the Directorate of Education was established before the Imperial University.

[18] On private academies, see e.g., Grimm (1977).

[19] There are debates over Zhu Xi's historic role, see e.g., Qian (1985: 117-118). Joseph Needham thought highly of the role played by Zhu Xi. Needham compared Zhu Xi with Leonardo da Vinci (*The Great Titration*, p. 149) and even regarded Zhu Xi as a Chinese equivalent to Thomas Aquinas (*Within the Four Seas*, 1969, 66). For other scholars, Zhu Xi's marks the retrogression of Chinese intellectual creativity. See e.g, (Hartwell, 1971).

But, again, there are differing understandings of the concept of *li* 理.[20] *Lixue* was also called *daoxue* 道学 (the school of 'the Way') in the Northern dynasty. '*Dao*' 道 originates from Daoism (*daojia* 道家), and its definition is fluid.[21] To search for the *li*, a Confucian needs to examine himself inwardly so that he could further understand the outside world. Therefore, in the concept of *li*, as Nakayama (1973: 40) has argued, 'moral issues and the law of nature remained undifferentiated; thus it played an inhibitory role in the development of the modern way of thinking'. Li or *tianli* (天理 the principles of universal heaven/heavenly principles) is thus not just a purely philosophical, abstract, and metaphysical system but includes moral, social and political concerns.

The Song was a most developed bureaucratic state, and it pursued a policy of treating its bureaucrats well (Liu, 1988: 90). Officials were trained and selected by means of a system of civil service examinations. The method of selection was reformed in the Northern Song when the anonymous examination procedures were introduced in order to promote fairness and suppression of 'nepotism' in selecting officials. However, the new procedures were criticised by Confucians for not taking virtue into account. The critics argued that morality was ignored by students as they set their sights on examination success rather than pursuing 'the Way' (Chaffee, 1995: 17). While the Northern Song reformers advocated an empire-wide school system[22] but were disappointed by the misconduct of the students, including a tendency to cheat in the exams. In contrast, southern Song Neo-Confucians emphasised self-cultivation and argued for a clear separation between education and examinations (Chaffee, 1995: 17). The teaching of Neo-Confucianism was through lectures, dialogues and discussions, and private teaching (especially in private academies) which proliferated in the Southern Song, with an emphasis on self-cultivation rather than preparation for the

[20] See Qian (1985: 117).

[21] Confucianism is not exclusive to other groups of thought and ideas, rather it had acquired 'a host of eclectic components' that are practical and acceptable (Liu, 1988: 39). Many elements of Buddhism and Taoism were absorbed by Confucianism.

[22] In the late Northern Song, governmental schools spread to most prefectures and counties and education was made more accessible. Landholding and the development commerce provided the economic base for an increase in governmental schools. See Chaffee (1995: 16).

exams.[23] The teaching of Neo-Confucianism lacked formal organisation, instead, a proper curriculum was set out by a good master starting from the Confucian classics of the 'Four Books' (*sishu* 四书) -- the *Great Learning* (*daxue* 大学), the *Analects* of Confucians (*lunyu* 论语), and the *Mencius* (孟子), *Centrality and Commonality* (*zhongyong* 中庸) (Liu, 1988: 138-139).[24] Nevertheless, Neo-Confucianism was eventually incorporated into the state orthodoxy and thus become a rigid doctrine, especially under the Ming (1368-1644AD). Taken together, as Chaffee (1995: 142) argues, 'the cultural unity created, in large part, by schools and examinations was an important contributing factor to the political unity of late imperial China'. Nevertheless, that unity was one in which 'the moral and natural realms were merged' (1995: 19).

In terms of curriculum provided by the public schools and especially for the purposes of the exams, there were differing views about the relative value of 'specialised expertise' and 'general education', especially during the Song. In the Tang, the mainstay of the examination content was to be qualified as 'metropolitan graduates' (*jinshi ke* 进士科) which involved extensive study of the classics for the purpose of choosing officials, but the curriculum also included various specialised subjects such as legal knowledge (*mingfa* 明法) as well as mathematics (*suanxue* 算学) and medicine (*yixue* 医学). However during the Song, specialised subjects were virtually abolished (Song and Wang, 1999: 312, 429). Among the debates over a curriculum for higher education there were two major schools of thought -- Wang Anshi's (王安石 1021-1086)[25] utilitarianism and the school of the principles led by Zhu Xi. The reforms of Wang Anshi in the Northern Song emphasised a detailed knowledge of

[23] However, we will see in my proposed later chapters that although private academies were initially established in rural areas, the locus was gradually shifted to urban areas. Private academies were also incorporated by official schools, and the aim of teaching and learning was for the preparation of state examinations.

[24] They are all Confucian classics. Zhu Xi took the *Great Learning* and the *Centrality and Commonality* out of the *Book of Rites* and combined them with the *Analects of Confucians* and the *Mencius* as the 'Four Books'. Zhu Xi suggested that the study should start from *the Great Learning*, and then follow the orders of the *Analects of Confucians*, the *Mencius* and the *Centrality and Commonality*.

[25] Wang Anshi (1021-1086), chief councillor and reformer in the Northern Song dynasty

institutions and economics. Practical subjects such as law, military affairs, and medicine and a little later, mathematics, were added to the examinations. But Wang's reforms failed, and the generalist approach to curriculum setting prevailed, putting more weight on morality (Chaffee, 1995: 19). The curriculum underwent important changes with the rise of Neo-Confucianism (that is, the school of principles). The generalist style curriculum created 'uniformity' not only in subjects to be learned but also in modes of thought, for example, the attitudes toward authority such as classical texts. The Song educational system became a model for the institutional foundations for systems for the Yuan, Ming and Qing dynasties. For example, in the Yuan dynasty (1271-1368AD), the regulations for the civil service examination in 1313 decreed that the answers to the Four Books were to follow the commentaries by Zhu Xi. *Sishu Jizhu* (四书集注 Collected Annotations of the Four Books) (written by Zhu Xi) thus became the official reference for the candidates taking the civil service examination. In the Ming, Zhu Xi's version of Neo-Confucianism was established as the orthodoxy by Ming emperors. Furthermore, all candidates had to write their examined essays by following a rigid structure—the eight-part essay (*bugu wen* 八股文).

Different levels of Useful knowledge: the role of the elites

Mokyr argued that 'for better or for worse, the history of the growth of useful knowledge is the history of an elite: the number of people who augmented the sets of prepositional and prescriptive knowledge is small' (2002: 291). Elites are important as they are the agents who either promote or restrain the generation and diffusion of useful knowledge. In traditional China, the people who could be characterised as members of an 'elite' are very diverse. Their status was closely related to the levels of education they had received and their success in examinations.[26] 'Elites' may include literati and gentry (*shi* 士), although there are no clear boundaries between the two.[27] Literati mastered classical studies and held knowledge of lineage ritual. They were land-holding but did not necessarily hold official positions. Gentry enjoyed a

[26] Elites were also engaged in other diverse activities included poetry composition, art appreciation, philanthropy, the patronage of intellectual networks or associations and local governance.
[27] On the literati or the gentry (*shi*), see e.g., Deng (1993: 18-28).

Confucian education in the classics but also held power as governmental officials at local and central levels usually through passing civil service examinations or upon by way of recommendations from senior officials. As such, gentry (also called scholar-officials) constituted the ruling class (Elman, 2005: xxi; Liu, 1988: 14). There were no clear boundaries between literati and gentry, but their social and cultural status was depended on whether they passed the civil service examinations. From the Sui onwards, civil service examinations were gradually integrated into the elite culture. Although holding land secured the financial sources and paved the way for the preparation of examines, it did not carry the same weight in access to political power, higher social status and prestige of learning (Liu, 1998: 15). As gentry elites were both scholars and officials, their intellectual and political activities were intertwined (Liu, 1998: 15). This also gives rise to the question on the definition of 'intellectuals' within the elite group. An intellectual had acquired a record of a both outstanding scholarship and a governmental post. His concern for universal values of the state and society could exert profound influences on trends in thoughts and public affairs (Liu, 1988: 15).

There was, moreover, a hierarchy within the elites. For example, if we consider literati without official appointments as being the lowest status group and the gentry as being an intermediate level in the group, then intellectuals were the top-rank of the elites. Although different groups of elites all played important roles in education and acted as controllers and mediums for the transfer of knowledge,[28] they might prefer and promote different forms of knowledge. For example, they often placed more weight on statecraft, while their emphasis on universal values often led them to downplay the specification in academic learning. They accordingly paid attention to agriculture, military affairs, medicine as well as mathematics and astronomy. Thus there was a hierarchy of knowledge in traditional China which corresponded to the hierarchy within the status of elites. Different forms of knowledge did not however necessarily exclude each other, because they were produced and located under an overarching

[28] See e.g., Deng (1993).

institutional framework as discussed in Section Three. Although different groups of thought did emerge from the orthodox Confucian way of thinking or the state ideology, there were all constrained by an entrenched institutional framework which closely linked to the civil service examination and bureaucracy. As an example, I will take the roles played by Xu Guangqi (徐光启 1562-1633) in the generation and diffusion of knowledge as an example and compare it with the examples of other lower-status elites.

Xu was vice-president of the Board of Rites and stood at the top of the elite. In collaboration with the Jesuits such as Matteo Ricci (利玛窦 1552-1610), Xu translated many Western works on maths and astronomy into Chinese. He even converted to Christianity. Xu was the author of the *Nongzheng quanshu* (农政全书 a complete treatise on agricultural administration)[29] and the compiler and translator of the *Taixi Shuifa* (泰西水法 Water methods from the West, finished in 1612) written by Jesuit Sabbathinus de Ursis (Xiong Sanba 熊三拔). He became to advocate for 'concrete studies' (*shixue* 实学[30]). Subjects such as agricultural administration and water control were regarded by Xu as 'concrete knowledge' that could bring tangible general benefits. Western learning conveyed by the Jesuits was seen by Xu as solid learning, as the way they produce knowledge could be verified by proper methods. Xu's own work on agricultural administration reflected his experimental attitude towards the accumulation of knowledge. But for Xu, subjects such as agriculture, water control were 'useful' because they were relevant to statecraft and could contribute to the welfare of the state and the livelihood of the people (*guoji minsheng* 国计民生).[31]

One of the important ways through which the gentry contributed to the generation and

[29] The writing of the *Nongzheng* quanshu was a group enterprise, as it was completed, revised and edited by young scholars after Xu's death. See Francesca Bray and Georges Métailié, 'Who was the author of the *Nongzheng quanshu*?', in Jami (ed.) (2001: 323).
[30] *Shi* 实 could be translated into English as solid, practical or concrete.
[31] On Xu Guangqi, see e.g., Jami (ed.) (2001).

transmission of useful knowledge in China is in the *nongshu* (农书 treatise on agriculture),[32] because the gentry treated agriculture as the root (*nongben* 农本) of practical knowledge that could benefit the social order. The *nongshu* writing was (one kind) of statecraft writing, and top-level elites like Xu Guangxi wrote *nongshu* from the perspectives of public servants in order to instruct the administration of officials.[33] That is why Xu's *Nongzheng quanshu* received the patronage from the 'Chongzhen emperor' (Chongzhen 崇桢 is the reign-title of the Ming emperor Zhu Youjian 朱由检 r. 1627-1644) who gave orders to print and disseminate the book (Bray and Métailié, 2001: 355). We can compare the works of Xu with that of a lower-level literati Song Yingxing (宋应星 1587-1666?) in the Ming dynasty. Song became an 'advanced scholar' (举人) through examination at the county level but failed subsequent higher-level exams many times. At the age of forty seven, he eventually became a minor official in the county in charge of education. Song's work *Tiangong kaiwu* (天工开物 *The exploitation of the works of nature*) was first published in 1637and included not only discussions of agriculture but also descriptions of important forms of commodity production including sugar, textiles, ceramics, salt, colas, and various metals and precious stones. In his work he stressed the importance experiments in the investigation of things. However, unlike the *Nongzheng quanshu* and the *Qimin yaoshu*, the *Tiangong kaiwu* was not included in the '*Siku quanshu*'[34] (四库全书总目提要 The Annotated Catalogue of Books in The Comprehensive Library in Four Classes) compiled by the order of the Qianlong emperor (乾隆 r. 1735-1796), and failed to be widely disseminated, and was subsequently got lost.[35]

The context for Chinese science and technology: *gewu zhizhi* and *jingshi zhiyong*

Gewu zhizhi

Gewu zhizhi (格物致知 investigating things and extending knowledge), an important

[32] On the *nongshu*, see e.g., Deng (1993).
[33] Bray and Métailié (2001) made a distinction between writing *nongshu* as a public servant and as a private landlord.
[34] The compilation of the 'siku quanshu' started from 1773 and lasted for ten years. It was the largest scale official book compilation in Chinese history.
[35] In the 1920s China got copies of the book from Japan. Later the Beijing Library recovered the original copy from a private collection of books.

concept in the Confucian thought, is often regarded as the Chinese equivalent to 'Western science'. In Western- style schools set up in the late Qing, subjects such as physics and chemistry were often called *gezhi* (格致), a name derived from *gewu zhizhi*. However, the conception of *gewu zhizhi* transcends science and technology. To understand the meaning of *gewu zhizhi* correctly we need to trace its historical origins. The term *gewu zhizhi* is originated from the *Great Learning* (*daxue* 大学 written ca. 500 B. C. E) and is pregnant with complex meanings. The *Great Learning* was part of the *Book of Rites* (*liji* 礼记) and provides eights steps (*bamu* 八目) for the cultivation of the elites according to classical ideals of higher education, each in turn a precondition to the next: investigating things (*gewu* 格物);extending knowledge (*zhizhi* 致知); making their thoughts sincere (*chengyi* 诚意), rectifying their mind (*zhengxin* 正心), cultivating the self (*xiushen* 修身), regulating their families (*qijia* 齐家), governing the country (*zhiguo* 治国), and making the whole social order tranquil and happy (*pin tianxia* 平天下) (Daxue, section 1 in Zhu Xi's rearrangement of the text). Nothing in the *Great Learning* defines *gewu*. Once the concept was taken out of the *Book of Rites* and rearranged as one part of the Four Classics by Song Neo-Confucians, the real meaning of *gewu* has been subject to various explanations. It would be easy to fall into a trap by regarding *gewu zhizhi* as an equivalent to scientific investigation and a top priority in these eight sections and to ignore their interrelations and social and moral contexts. The Book of *Great Learning* is a treatise in moral philosophy that includes and seems inseparable from reflection on nature and natural phenomenon. For example, it says: 'Things have their root and their branches, and affairs have their end and their beginning' (*wu you ben mo, shi you shi zhong* 物有本末, 事有始终), the root and their branches of things should follow the order of the mind (*xin* 心), the self (*shen* 身), the family (*jia* 家), the country (*guo* 国) and the whole social order (*tianxia* 天下) with the mind as the foundation, while the beginning and end of affairs should follow the order of investigation (*ge* 格), extension (*zhi* 致), sincerity (*cheng* 诚), rectification (*zheng* 正), cultivation (*xiu* 修), regulation (*qi* 齐) and governance (*zhi* 治), with maintenance (*ping* 平) and the tranquillity and happiness of the empire as the ultimate end. Thus we should read

gewu by emphasising its moral and social messages. The ultimate goal is to govern the empire and maintain the social order through cultivation of the self. Therefore within the eight steps, *gewu* is inferior to other steps and considered 'the inferior study' (xiaxue 下学) by the top-level elites.[36] In my discussion below, I will sketch out some main schools of thought on the explanation of *gewu*.

The meanings of both *ge* and *wu* also subject to various explanations. In Chinese *ge* could mean: to arrive at, to correct, to oppose or to categorise. For example, Sima Guang (司马光1019-1086) in the Northern Song explained *ge* as 'to oppose'. For him, *gewu* is to guard against things, that is, to oppose to one's desires excited by material things (Graham, 1958: 74). In his translation of the *Four Books*, James Legge (1815-1897) translated *gewu* into English as the 'investigation of things', and his translation is adopted by many scholars. In the Cheng brothers Cheng-Yi and Cheng Hao's accounts, *ge* means 'to arrive at' (*zhi* 至), and all things should contain principles (河南程氏遗书, 卷二上). Thus their underlying explanations of *gewu* shifted the emphasis from 'investing things' to 'fathoming principles'. For the Cheng brothers *gewu* meant as 'to reach to the utmost principles of activities and things' (穷至事物之理) (四书集注・大学章句). Here *wu* refers to both 'objects' and 'affairs'.[37] *Gewu* included the studies of both natural phenomenon and ethics. Principles are seen as the guidance for moral actions including the investigation of things as a kind of moral activity. But what 'principles' means seems quite obscure and abstract. Compared with moral principles, the study of natural phenomenon look less important, although references were made to the study of natural phenomenon in the dialogues of the Chengs and Zhu (see De Bary, 1975: 377; Graham, 1958: 79). For Zhu Xi, intellectual learning and self-cultivation should be combined, that is, an integrity of 'abiding the reverence' (*jujing* 居敬) and 'searching for the principles' (*xiongli* 穷理)

[36] For example, even Xu Guangqi who was deeply influenced by western science still considered western science 'the inferior study' (*xiaxue* 下学) as '*gewuqiongli zhixue*' (格物穷理之学) in his works (《徐光启集·几何原本杂议》,《徐光启集·泰西水法序》)

[37] On things as phenomenon, affairs and events see also Elman (2005: xxix-xxx).

(see also De Bary, 1975: 14). For Zhu Xi, knowledge should be socially relevant and his commentary became the orthodox interpretation of *gewu*.

The Ming philosopher Wang Yangming (1472-1529) had a different reading of *gewu*. Wang's thought was close to that of Lu Jiüyuan (陆九渊 1139-1192) of the Song dynasty, who preferred the subjective approach to *gewu*. Wang's views should be understood in relation to the intellectual context of the late Ming when there was a revival of Chan Buddhism (see Kengo, 1975: 39-66). When Wang was young, he tried to investigate bamboo and to fathom the principles by following Zhu Xi's guidance, but he failed and became ill. He rejected Zhu Xi's doctrine that principles could be found in things 'outside there', instead principles only existed in the mind, although he agreed with Zhu that *gewu* was a kind of moral conduct. The principles of things could not be separated from the mind (see Wang Shouren,传习录, *Instructions for Practical Learning*). Wang's should also be understood in the social context at that time. Wang was worried about the chaos in the social order and emphasised 'good conscience to show one's inner goodness' (*liangzhi* 良知). Wang then developed a study of the mind (*xinxue* 心学). For the extension of knowledge, Wang emphasised making the thought sincere and rectifying the mind in the *Great Learning*. Wang also disagreed with Zhu about the relations between 'knowledge'/ 'good knowing' (*zhi* 知) and 'practice' (*xing* 行). [38] He proposed a synthesis of 'good knowing' and practice (*zhixing heyi* 知行合一) (Shen and Wang, preface to the Collected Works of Wang Yangming, 1992, p. 27). That is, principles are not static and could not be pursued just through object things, rather principles dynamically exist in the mind and should be pursued by a combination of good consciousness and practice. As Shimada Kenji has argued, the thought of Wang Yangming freed the autonomy of the self from the entrenched Confucian doctrines and functioned as 'a potent concept and force for rationality in the Weberian sense' (cited in De Bary, 1975: 5). But unlike the school of

[38] Zhu Xi said that 'knowing' (*zhi* 知) should come first before 'practice' (*xing* 行), and principles existed before material objects'.朱熹说："知行常相须，如目无足不行，足无目不见。论先后，知为先；"未有物，而已有物之理"，"理在物先，理在事先"。Zhuzi Yulei: Zhu Xi.

Zhu, Wang's thought was not accepted by the state as orthodox.

The late Ming scholar Fang Yizhi (方以智 1611-1671) divided knowledge into three categories: the first type deals with what is material (*zhi* 质) and is concerned with the principles of things (*wuli* 物理), the fields of learning include studying the *Book of Change* (*yijing* 易经), calendar, music, and medicine; the second deals with specific ways of governing and educating that is concerned with principles of social order (*zaili* 宰理); the third category deals with specific ways of comprehending (seminal forces)' (*tongji* 通几) that is concerned with the extended principles of things (*wu zhi zhi li* 物之至理).[39] Fang proposed a combination of 'material investigation' (*zhice* 质测) and 'comprehending seminal forces'. According to Fang things is not just a product of mental processes. For him things are at least external to the mind. To comprehend extended principles of things, we should investigate various kinds of *wu* (things), 'ranging from epochs of time down to plants and minute insects, by categorising their characteristics, assessing their merits and defects, and determining their changes and constancies' (物理小识・自序).[40] Fang's method to knowledge could be seen as an embryonic combination of 'science', philosophy and an analytical approach. Fang Yizhi was 'offering to his contemporaries a mode of endeavour which was parallel to the secularisation of natural philosophy in seventeenth-century Europe' (De Bary, 1975: 400). But in Fang's work there is not much discussion about the *manipulation* of nature. Fang also accepted portions of knowledge conveyed by the Jesuits, but drew a distinction between the scientific teaching and the religious teaching of the Jesuits. He declared: 'The knowledge from the Far West which entered [China] in the Wan-li period is detailed in 'material investigations' but deficient in speaking of 'comprehending (seminal) forces' (quoted in Peterson, 1975: 398-399). 'Ke wu [gewu] for Fang I-chih [Fang Yizhi] could thus serve as a form of intellectual self-discipline and moral training, as in Wang

39 '考测天地之家，象数、律历、音声、医药之说，皆质之通者也，皆物理也。专言治教，则宰理也。专言通几，则所以为物之至理也'。(《通雅・文章薪火》)
40 '寂感之蕴，深究其所自来，是曰通几；物有其故，实考究之，大而元会，小而草木蠢蠕，类其性情，征其好恶，推其常变，是曰质测'。 (物理小识・自序)

Yang-ming's interpretation, but directed at that which is external to our minds, as in Chu Hsi's [Zhu Xi's] interpretation' (De Bray, 1975: 399).

jingshi zhiyong

Fang Yizhi advocated a method of acquiring knowledge that differs from the moralist approach of Zhu Xi and the introspective methods of Wang Yangming. Fang Yizhi can be seen as a predecessor of the school of evidential research (*kaozheng xue* 考证学) that was pioneered by Gu Yanwu 顾炎武 (1613-1682) and others in the early Qing and which flourished in the Qianlong(乾隆 r. 1735-1796) and Jiaqing (嘉庆 r. 1796-1820) periods especially in the Jiangnan region (including areas such as Suzhou Changshu, Songjiang, Wuxi and Zhejiang). Fang and Gu shared the view that knowledge of the world could be carefully and impartially observed and verified by (textual or historical) evidence. Although they both recognised the significance of the meaning of the words as the medium for knowledge transfer thus paid less attention to the words themselves. Differences between Fang and Gu can be found in their conceptions of *wu* (including objective things and human affairs). For Fang, 'things' meant *physical objects and natural phenomenon*; For Gu and other scholars involved in the school of evidential study 'things' are understood primarily as *human affairs*. For them, useful knowledge really meant statecraft or knowledge that could be useful for a properly governed empire. To pursue such knowledge, the school of evidential study was devoted itself to the historical and textual studies (see also De Bary, 1975: 400-401).

Thus there were two major areas that scholars involved in the evidential research movement could conduct their objective investigations—the natural phenomenon and textual and historical document related to human affairs and society. If research had been done in both areas, the new research scholarship in the seventeenth century might have been transformed into 'modern science'. But for several reasons this did not happen. First of all, we need to consider the whole intellectual environment in that period. The knowledge system in the late Ming and early Qing could be characterised

as *jingshi zhiyong* (经世致用) – that is, to say its primary concern was to govern the world through the study of the classics. Trying to reconstruct 'true knowledge' or sagehood that was thought to be lost or distorted for centuries, scholars delved into the study of subjects included philology, epigraphy, palaeography. This returned to the texts of the Song dynasty which advocated the study of the practical issues related to society, politics, and economy through the exegeses of the classics so as to achieve the aims of social reform. For example, Lü Zuqian (吕祖谦 1137-1181) in the school of Jinhua (金华学派) had emphasised the study of classics and history (*jingshi* 经史) in order to solve practical social problems. The Southern Song scholar Ye Shi (叶适 1150-1223) and other scholars in the school of Yongjia (永嘉学派) had argued that *jingshi zhiyong* should be combined with utilitarianism and they were critical of the school of principles. They also argued that the state should pay attention to commerce. The study of *jinshi zhiyong* achieved its prominence in the late Ming and early Qing. The pioneers in this study included Gu Yanwu and Huang Zongxi (黄宗羲 1610-1695). Their research areas included politics, economy, military affairs, law, geography, local custom as well as natural phenomenon. But they accorded the highest priority to statecraft within a framework of political ethics, and their ultimate goal was to find a proper social order and governmental format to benefit the national welfare and the people's livelihood. That is why the knowledge of construction and expansion of canals, irrigation works and public granaries became so important for them.

Moreover, the conduits for the transfer to China of Western sciences -- the Jesuits -- were expelled from China after the 'Rites Controversy'.[41] More importantly, as discussed above, the scholarship that investigated the natural phenomenon was often considered 'inferior study' by the Chinese scholars and elites.[42] Also, given the strict

[41] The Kangxi emperor (康熙 r. 1662-1722) himself took a great interest in scientific study and the knowledge conveyed by the Jesuits. But in 1704 Pope Clement XI issued a decree and officially condemned the Chinese rites, forbidding all Catholics in China from participating in Chinese ancestor worship. The Kangxi emperor was dissatisfied with the Papal stand on this Chinese rite and issued an order and banned those missionaries who followed the Pope's ruling in China in 1707.

[42] It is also worth noting that the majority of the scholars involved in the school of evidential research

ideological control on Chinese literati and the terror of literary persecutions in the early Qing, it would be much safer if scholars devoted their research to historical classics (Liang Qichao, 2004 reprinted: 20-22). So the 'new' thought in the seventeenth China should not be regarded as an era of the rise of 'empiricism, scientific criticism, and materialism', as has been characterised by many Chinese scholars (e.g., Hou Wailu 1956; see also De Bary, 1975: 4).

Concluding remarks

If we take useful knowledge as a homogenous entity that is only confined to science and technology, we will find that the conceptions of useful knowledge and its applications in traditional China do not match the criteria of URK as derived from the European perspective. But this paper has attempted to show that beyond science and technology, there were indeed other diverse forms of knowledge that existed in traditional China. The forces which decided whether knowledge was useful or certain kinds of knowledge were more useful than others and got diffused more smoothly lie in the institutional and cultural spheres. For the Chinese top-levels elites, useful knowledge really referred to knowledge that is practical and morally, socially and even politically relevant and that would bring general benefits to the welfare of the state and the livelihood of the people. For the Chinese elites disciplines that could be characterised as 'sciences' such as such as astronomy, hydraulics, mathematics, and geography really meant techniques of statecraft.

We need a proper conceptual and analytical framework to examine the system of useful knowledge, and to thereby also explain 'the great divergence'. Economic historians often emphasise the economic factors and downplay the cosmological factors that are thought to be hard to define, whereas cultural historians stress the cultural and institutional reasons in their explanations. But these socioeconomic, cultural, political and institutional factors are not really so easily separated, at least in

were not degree-holders, although they did get patronage from the top-level elites (Elman, 1984: 8). They also received financial support from merchants in the lower Yangtze River Basin marked by its commercialisation and urbanisation.

the case of traditional China. The approaches taken by Elvin (1973), Lal (2001) and Goldstone (2002) emphasising 'an equilibrium' are useful steps towards establishing a useful analytical framework. Once a certain socioeconomic order (or the material environment as in Lal 2001) is established, it tends to remain stable and is likely to create an equilibrium that is difficult to break through unless some political upheavals or cultural and institutional innovations emerge. But cosmology is not likely to rapidly adapt to the changes in the material environment especially when it is confined in an entrenched political and institutional framework. In traditional China the civil service examination system and the bureaucratic structure left little room for cultural and institutional innovation. The pattern of Chinese culture was not stagnant, it did get renewed and from time to time and new groups of thought did grow out of the state orthodoxy, but the changes were all constrained by the political and institutional framework. As such the Chinese developed a different view towards nature that shaped its knowledge system from that of medieval Europe. As Elvin (1973) argued that the 14th century might be a turning point. The further institutionalisation of the examination system and bureaucracy in China made Chinese society 'inward-looking' (Elvin, 1973: 204). The change towards nature led to two different views of the world—'the mechanical view of the world' in Europe vs. 'the organic view of the world' in China (Needham, 1969: 21). In China, nature never became an autonomous sphere that is to be manipulated by humans. All in all, the equilibrium maintained by the cultural and institutional framework played an inhibitory role in the development of science in China, and it also explains why a great divergence occurred after 1800 between China and Europe. Subsequently, the locus of the generation and application of URK shifted from China to Europe.

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