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Technology and Values in Traditional China and the West: II

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Deciphering the Puzzle

In China the same values had far less dignity in the official scheme of things, and the prevailing Confucian idea of human nature had little to do with understanding, regulating, and exploiting physical nature. Moreover, the Empire was organized to preserve and extend balance and stability, not to stimulate change, technological or otherwise. The organizing power for centuries, rivaling the agricultural system and the written language as a key to China's continuity as a civilization, was the bureaucracy, the mandarinate, for which there is nothing comparable elsewhere. This historically unique class of Confucian managers and rulers was non-hereditary, non-titled, and non-specialized, mostly chosen through examination, mainly functioning to supervise the labor of a vast agrarian society, perpetuating themselves through a monopoly on education, and sharing the same worldview. They were the collective instrument of China's continuity as "a permanently bureaucratic society," and the main institutional obstruction to long-term, cumulative technological innovation. What we are looking for is a clue to "the something in Chinese society which continually tended to restore it to its original character, that of bureaucratic feudalism, after all disturbances." The non-economic, intellectual basis of their solidarity and role in subordinating change—technological or otherwise—to tradition was an ancient conviction about human nature and the purpose of knowing, which came from Confucius and his later interpreters, provided justification for a hierarchical society, reached definitive form in the Neo-Confucian synthesis of Chu Hsi.

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(1130-1200) in the Sung Dynasty, whose commentaries on the Five Classics and especially the Four Books and dominated the examination system in the Ming-Ch'ing period.35 The philosophical anthropology of the Confucian literati reached directly or indirectly into every cranny of Chinese society. Government through moral theory and edict was largely supreme.

The emphasis in Confucian moral philosophy was on proper conduct and the discrimination of right from wrong. The teaching of Mencius (371-289 B.C.?), the most influential early Confucian, was that human nature (jen-hsing) is naturally good, with the consequence that everyone starts from the same place and enjoys a certain status of natural equality.36 This assumption led to others. First, that the purpose of knowing is recognition of the proper from the improper so action may be rightly guided. Knowing how to behave is what knowing is all about. Second, that the instrument of knowing is the “evaluating mind that can assess the natural nobility or baseness, rightness or wrongness, propriety or impropriety of an object, act, position, or event.”37 Third, what determines the later inequality of men is the extent to which the evaluating mind is employed. That is, natural equality at the beginning is not incompatible with a subsequent hierarchy of status based on observable behavior and tested moral knowledge. Fourth, the evaluating mind can be cultivated by moral eduction, which is the key to harmonizing both the self and the world. Finally, the best evaluating minds, selected by competitive examination, should govern. Their role in society was to set a moral example, to rule benevolently, and by so doing to maintain harmony between Heaven, Man and Earth. A bureaucracy of chun tzu (superior man, gentleman, the “sage” of later Confucian thought), the finest evaluating minds in the land, make the world function less through causal action than through moral presence, example, and judgment.38 For the Confucian mind the purpose of studying nature was not to understand rationally and objectively how things work, or to design better mousetraps, but to do what is right. Achieving “rightness” in a universe that demands it as a condition for order and balance was the moral objective of public works and technology, not to master and control nature in Baconian fashion. The proper objects of study and inquiry were Confucian classics and moral examples of the past, not science and engineering. Intellectual or technical novelty had distinctly
subversive overtones. No wonder "the social and cultural milieu in Ming-Ch’ing China was . . . hardly conducive to scientific and technological inventions."  

There is no contradiction between this philosophical anthroplogy, with its highly specific claim of human natural equality, and the influential dictum of Mencius that "some labor with their minds and some labor with their strength," which means that some govern others and are supported by them. Practice in life reveals the activity of the evaluating mind and the degree of its self-cultivation and cumulative wisdom. Education can increase it and examination can identify it. The hierarchical class system—literati, peasants, artisans, merchants—was a result of the inequality which results from men realizing or failing to realize their naturally equal potential to discriminate and act on what is right. A two-class society was not the outcome of distinguishing brains from brawn. A social ideology based on the primacy of developing and recruiting into government service a body of evaluating minds helps to explain traditional China’s reluctance to mobilize technology in the service of modernization in the nineteenth century. 

A physical crisis for the Chinese state was not an invitation to seek greater sufficiency and control over people or nature through improved technology, but rather an inducement to moral self-examination and reform shaped by judgments about what is morally right. Drought, famine, flood, rebellion, and invasion all had their moral dimensions. Correlative thinking, which viewed every element of existence as connected in some way to every other, taught that harmony in the whole was determined by moral and not physical criteria, the most central being the emperor’s benevolence and officials radiating Confucian virtue. In China, it was not, as in Europe, the rule that “fear of disaster preceded each of the major advances in economic growth over the centuries)and technology always came up with the answer.” 

Chinese correlative thinking and numerology, based on elaborately formulated correspondences between Yin-Yang, the Five Elements, and domains of man and nature, persisted despite its intellectual exhaustion and heavy criticism of its contradictions and absurdities by scholars of the Ch’ing dynasty. It was never replaced by an alternative cosmological scheme during the imperial period because it did not serve as a framework for scientific
inquiry and had no serious rivals. It was a scheme for organizing moral judgment and understanding moral relationships, not merely a stubborn expression of Chinese inertia or ruling class perversity and self-interest. The scholar Tai Chen rejected numerological cosmology on the grounds that it was based on an outmoded calendrical system, and the Chinese even had their own Battle of Ancients and Moderns in early Ch'ing times, with some participants concluding that “the science of the moderns was necessarily superior to that of the ancients.” Such boldness came to little because, with all its “modernity,” the protest was marginal in a social order governed by moral thinking referred to historical examples and models, and to cosmic correspondences.

Much the same kind of thinking prevailed in the West into the 18th century. Western literature and thought were suffused with ideas of a Chain of Being along which all existence was strung in hierarchical order, of correspondences between macrocosm and microcosm in which man summarized the universe in himself, and of existence reflected in symbolic and allegorical metaphors. Symbolic numerology was rampant. This way of thinking also became too ripe, played out, and entered a deadend, provoking criticism and satire, but the outcome was its replacement by an alternative cosmology, that of Copernicus, Kepler, Galileo, and Newton. Rational criticism rather than moral exigencies carried more weight in the West, where a “causal or genetic attitude” came to displace the symbolist attitude.

Needham believes “it is precisely in the inhibition of the rise of merchants to power in the state that we have to look for the reasons for the inhibition of modern science and technology in Chinese culture.” Mechanisms of inhibition might be sought in the oppressiveness of bureaucratic policy in relation to merchants by means of confiscations, heavy regulation of capital accumulation, and monopolies of salt iron, tea, wines, and foreign trade, all of which appears in Sung times to have nipped proto-capitalism in the bud, and continued to dog copper mining as well as salt and iron production in the Ming-Ch'ing era—enterprises able to stimulate applications of old and new technology. Merchants responded to constraints by investing surplus capital in extravagant living and by preparing their sons for a shot at the triennial examinations. Initiation into the literati class was far preferable to being rich, for the definition of status was social and not
economic. In the 16th century one Chang Shih-i became a tradesman to avoid poverty and to educate his sons. When one of them succeeded in the examinations, he said: “now we can get ourselves out of this trade business.” Conditions were never consistently good for risk taking, entrepreneurship, capital accumulation, competitiveness, legal protection for investment and property, joint stock companies, or government support for business and technological innovation—all the kinds of things which flourished in the West and led the European bourgeoisie from economic to political power.

A partial explanation is that the Confucian evaluating mind saw a flourishing merchant class, like a too powerful military establishment, as a threat to social balance and cosmic harmony. Moral discrimination told the bureaucratic sage (no doubt self-interest intervened as well) that it was not “right” for one class to overwhelm others, especially one that had no direct productive function and was guided by calculation and the lust for accumulation. Perhaps the literati understood than an unfettered market economy tends to extend itself ruthlessly into every sphere of life, substituting economic values for all other values. The idea of merchants linking up with the military to bring about the kind of commercialization of war that triumphed in Europe was even more repugnant. After all, soldiers did not have a place in the social hierarchy, being regarded as necessary evils. Sellers of goods and lenders of money had no moral credentials, and hence could not guide society as a whole or maintain harmonious relations with Heaven and Earth. Their very station in life was evidence of defective evaluating minds. Confucius, perhaps the ultimate sage, said: “A gentleman takes as much trouble to discover what is right as lesser men take to discover what will pay.” Furthermore, “gentlemen never compete,” except, of course, in the state examinations. The preservation of social values required leaders who cared more for rectitude than profit. The Marxist temperament will, of course, see all of this as ideological rationalization of the dominant class in an agrarian mode of production, and critics of China’s old regime will spotlight the corruption in high places. On the other hand, it is not implausible that many Confucian officials were at least as sincere and morally zealous as 17th century Calvinist entrepreneurs who believed themselves to be members of the Elect doing God’s work.
The artisans who created and applied China's technology were far removed from the sphere of degree-holding scholars and in the official histories craftsmen "hardly appear at all." In the voluminous body of surviving histories, monographs, encyclopedias, and local gazetteers, all of which was written "by officials for officials," there appears to be limited space for technics and mechanical arts, mainly having to do with hydrology, transport, and canals, the sorts of things an official would have to be conversant with in his role as a guardian of society's agricultural foundation. Amidst Chinese encyclopedias and compilations there is nothing in scope and purpose quite like the eighteenth century French Encyclopedie, which included volumes of exhaustively researched engravings, accompanied by descriptive articles, to illustrate, clarify, and promote technical arts. Thus Diderot himself wrote fourteen columns on "Agriculture," and took into account the latest discoveries of improving landlords like Jethro Tull. Diderot gave as much space to mechanical arts as to philosophy, literature, and the fine arts, and aimed to change the way all educated people thought about the world by encouraging a spirit of criticism and judgment based on experience. His hope was that entire technologies could be reconstructed from the Encyclopedie if they were ever lost in some catastrophe. His inspiration was the Baconian vision of technology transforming and improving conditions of human life.

It is instructive to compare the content, intention, critical spirit, and readership of Diderot's volumes with a noted work on technology of the Ch'ing Dynasty by Sung Ying-hsing, first published in 1637, the closest approximation perhaps to a Chinese Encyclopedie. Needham refers to Sung as the "Diderot of China" and his book as "China's greatest technological classic." Sung had the standard classical education and was a district education officer when he wrote the book. We learn from Sung's Preface that his motive, like Diderot's, was to change the way of thinking among literati ignorant of natural phenomena and aloof from practical crafts: "A person who is endowed with intelligence and possesses a knowledge of the natural world is much respected by the multitude of ordinary folk. Yet there are those who, not being able to distinguish between jujube flowers and pear blossoms, would prefer to indulge in speculations about the water plants of Ch'ü." He was one thoughtful official concerned about re-
medies for the ills and ineffectiveness of the late Ming (the Manchus toppled the dynasty seven years after Sung's book came out). His book appeared about the time Chinese technology had peaked, and its eighteen chapters touch on major industrial techniques of the time, from agriculture, textiles, mining, metallurgy, and chemical engineering, to the building of boats and the manufacture of weapons. His main interest, however, is traditional agricultural technique rather than metallurgy and weapons, judging from the allotment of space to various subjects in the same 310 page volume. Under "Casting" we find bells with a page and a half, cooking pots with three-fourths of a page, and cannon with only five relatively useless lines. Sung's Preface is revealing about the limitations of technological inquiry and enterprise in seventeenth century China. He complains about a lack of funding to acquire artifacts for close study, his inability to consult knowledgeable people for confirmation of detail because of "no meeting place for such conferences...", and the probable irrelevance of his labors to the educated class, for "an ambitious scholar will undoubtedly toss this book onto his desk and give it no further thought: it is a work in no way concerned with the art of advancement in officialdom." The educated were not interested. The craftsmen who might have been interested could not read. The Chinese Diderot sank into virtual oblivion after 1644 while his European counterpart proceeded a century later to change the general way of thinking and contribute to a revolution in thought and politics.

The technological interests of the *Encyclopedie* were the culmination of a tendency among literate European craftsmen and their admirers from the Renaissance on to discredit the bookish mind as barren and establish the dignity and even nobility of making useful things. The artisan's virtues were "collaboration, progressiveness, perfectibility, and invention," which were defended by Francis Bacon, who also viewed mechanical arts as "a model for culture." Two great ideas became associated with mechanical arts—progress and truth. The first repudiated the authority of the ancients and proclaimed the superiority of modern invention. One 16th century writer believed "the art of printing alone would easily be able to match all the inventions of the ancients." The second idea held that a useful invention was both a form of truth and a generator of truth. Utility and truth could not
be separated. Francis Bacon proclaimed "the identity of knowledge and power..."\textsuperscript{58}

To the Confucian literati, all of this would have seemed subversive at worst and unintelligible at best. Craftsmen made useful things but did not do so by exercising the evaluating mind. What they did had social utility without moral significance. Thus it would make no sense to say a better paddle boat is in some way "truthful," since truth had meaning only in reference to correct perceptions of right and wrong in social contexts. It is the case that hydraulic engineering was especially smiled upon by Confucian bureaucrats, in large part because it was intimately connected with the agricultural base upon which the entire social system rested, but also because of the geographical fact that hydraulic works cut across boundaries and automatically placed power firmly in their hands.”\textsuperscript{59} But the truth value of hydrology was not a common theme for celebration in treatises and histories.\textsuperscript{60} The only kind of "progress" that mattered to the individual and to society in this frame of reference was deeper powers of benevolence, reciprocity, and propriety, and conscientiousness in all three, attained through self-cultivation and the study of virtue in past models. A preoccupation with ingenious machines, like a fever for profit and material success, could eclipse the evaluating mind, stultify moral growth, and was best kept firmly in its place.

\textit{Time and Values}

The divergent value systems of traditional China and the West are well manifested in the fate of mechanical clocks in the two civilizations, a fitting example with which to conclude. The mechanical clock, according to Joseph Needham, was a seminal invention, one of the most important turning-points in the history of science and technology.” He assembled with others an exhaustive book on China’s astronomical clocks, concentrating on the huge virtuoso device completed by the official Su Sung and his collaborators in the year 1094 A.D., and presented to the emperor along with a treatise on the device. The clock was an observational armillary sphere designed to mimic the motions of sun, moon, and some stars and driven by a water wheel. Needham argues convincingly for Chinese priority in developing such a mechanism, and less so for its transmission to the West. Moreover
there were precedents for the Su Sung adventure in astronomical clockwork, indeed, "a long tradition of astronomical clockmaking in China between the seventh and fourteenth centuries A.D." Needham is insistent that it is a "devastating misjudgment" that the Chinese were indifferent to time measurement. They divided day and night into 12 equal double hours and 100 quarters. Matteo Ricci (d. ca. 1610) and his companions, earnestly trying to convert China to the Catholic faith from the top down, noted the use of sand, fire, water, and sunlight to mark off time intervals, but had the impression that mechanical clocks were unknown in the Ming court. As it turned out, the Su Sung clock was lost physically, and then in memory, along with the treatise which contained a review of clock making in the previous six hundred years. The enterprise was carried off on the initiative of a few curious, gifted men with official support, but had no lasting impact on the configuration or values of Chinese civilization. The treatise was recovered briefly in the seventeenth century, fell from view, surfaced again in the nineteenth century, fell from view, and finally depended on a scholar from Cambridge University to bring it to light again. No one after Su Sung tried to duplicate his towering feat. There was no body of craftsmen ready to improve and extend the technology as was the case with portable time pieces in sixteenth and seventeenth century Europe, and no expansive market of people eager to regulate their lives by improved time reckoning. Even the well-informed, technologically aware Ricci and his colleagues knew nothing about it and expressed a low opinion of Chinese time keeping methods.

The irony is that Jesuits brought mechanical clocks with them to China which were "instrumental in opening the gates of the Imperial Palace at Peking..." It was the chimes and bells that fascinated. The emperor K'ang Hsi (1662-1722) even had a clock workshop organized to turn out bell ringing time pieces in quantity, which he distributed to his children and court favorites for amusement. In short, Su Sung's epic creation had been forgotten by his own fellow mandarins, and when the mechanical clock reappeared to the Ming and Ch'ing courts in the hands of foreigners, it was viewed as a diverting toy, not as a practical device to be copied, produced, and used. While Chinese may have gestured at keeping time, they were not, like Europeans, obsessed with time measurement. For most Chinese purposes, exact hours and minutes were unnecessary.
Time keeping in the West became a preoccupation in the fifteenth and sixteenth centuries. The Renaissance *uomo universale* (1404-1472) Leon Alberti set the tone with a “time discipline” and “time thrift” that was to engulf Europe: “He who knows how not to waste time can do just about anything; and he who knows how to make use of time, he will be lord of whatever he wants.” European time consciousness, and the determination to divide time lines into ever more discrete increments, added up to a passion for efficiency, control, and profit. Merchants grasped the connection between time and money. For religious folk to waste time was sinful. To know the time, to keep time, to be on time, to anticipate time with precision was to be master of one’s own fate and perhaps the fate of others. Monastic clocks summoned the faithful to prayers in the fourteenth century. The tower clock summoned townspeople to work in the fifteenth. Clock time became indispensable to commerce and industry, to transportation, and to the military—all requiring measures of efficiency. In the sixteenth century the miniaturization of timepieces ordered the lives of individuals rather than whole communities. Thus “privatization . . . of time was a major stimulus to the individualism that was an ever more salient aspect of Western Civilization.”

The clock transformed western consciousness and became the ultimate metaphor of cosmic order. In China, it was always a device peripheral to both thought and society. In European experience the structure of the clock suggested a mechanical mode of explanation, which already had its lineage in Greek astronomical systems—Eudoxus, Hipparchus, Ptolemy—whose geometric detail permitted the construction of working models. In the sixteenth century there were celestial globes driven by clockwork which replicated the movements of Ptolemy’s universe with precision. Most striking is the prevalence of clock metaphors in western literature, something for which there is no counterpart in the Chinese tradition. The regularity of clock motions suggested the “harmony and orderliness” of divinity. The analogy of clock motions with the seasons and celestial cycles suggested God as a clockmaker and the world as His mechanism. The analogy of the world with the clock’s regularities implied a world governed by mechanical laws. The harmonious working together of numerous parts, each fulfilling a specialized function in a larger effort, generated the idea of a system, which, in turn, suggested the effi-
ciency of parts organized around a central authority, a model of hierarchy radically different from the chain of being, and one vindicating a division of labor that maximized efficiency of all the parts. Henry Ford would have recognized the principle and smiled approvingly.  

Which brings us back to Su Sung's “heavenly clockwork.” Why did the Chinese decline to develop and exploit such advanced technology, which we admire at a distance of more than seven centuries? Because everything that clocks meant to the West was anathema to the Confucian evaluating mind, and because the emperor, the Son of Heaven, was, in the final scheme of things, “the master and regulator of Time.” Time available to the Empire belonged to him as did virtually everything else. He could be as late as he wished for any occasion, and no one would complain. Hundreds would wait for hours in the courtyard of the Forbidden City, in driving rain or blazing sun, if he chose to delay a ceremonial. His officials could cool their heels in the ante-room for days for all he cared, because their time did not belong to them. If he did, he would be recognizing time as a form of private property. Time was really important for the calendar, which is the main reason astronomers and mathematicians had a place in the bureaucratic system. Imperial ceremonies, like periodic sacrifice to Heaven and Earth at the Temple of Heaven, had the function of holding off “the possibility of cosmic disorder.” The job of the emperor was to regulate and renew space and time. He accomplished this through the power of virtue, with some help from the calendar. Manifest virtue—produced by the Confucian evaluating mind, symbolized in the emperor as the hinge between Heaven and Earth, and objectified in a meritorious bureaucracy—was more important than exact time keeping. It mattered far more than anything else for the ceremonies to be executed with propriety and rightness. It was the ideal of moral power and not clock power that ordered the world of traditional China.

Continuity and Change in Perspective

Chinese civilization in its last six hundred years was a more or less steady state society whose economic, institutional, and philosophical arrangements favored a complex homeostasis. This
pattern of equilibrium was based on agricultural resources sustained and renewed by the photosynthesis of green plants, an eco-technical tradition, a minimally combative relationship with nature, a conception of human nature which stressed the primacy of a morally evaluating mind over a rationally calculating mind, and institutions which assured the primacy of that type of mind in the hierarchies of political power and social position. Within such material limits, harnessed to a status society rationalized by the Confucian evaluating mind, the Chinese reached acknowledged greatness in art, literature, thought, empire, and technology, and an historical longevity rivaled only by ancient Egypt. The industrial societies of the West, committed to the pursuit of power, wealth, and scientific knowledge, have also achieved cultural greatness and a global influence in which western political forms and ideas as well as technology have become nearly universal. But the western prospect is far more uneasy and ambiguous than China's ever was. Industrial civilization is only a century and a half old. Undeniable prosperity and military power have been accompanied by rapid, unpredictable, destabilizing change. History's most destructive and all-encompassing wars have been ignited by Europeans. Mass consumer societies expecting unlimited economic growth have squandered non-renewable resources and undermined the global ecosystem with industrial and urban pollutants. Market economies promoting material self-interest as the highest good, and premised on autonomous individualism as the best measure of social meaning, have dulled the minds of millions to any responsibility for past or future generations. The heritage of the past and the unspoken needs of the future are swept aside to satisfy the "rights" and desires of the present generation. The "language of individualism" and "the lifestyle enclave" have largely displaced "communities of memory" and ideal of civic virtue. Whatever the positive legacy of western culture, no form of civilization was ever in a position to destroy so much in so brief a time. Traditional China was never able, like the West, to foreclose the future with nuclear war or global eco-catastrophe. Chinese homeostasis limited destruction in war and was no threat to the ozone or the oceans, and the meaning of individual life had a larger context than personal success and pleasure.

Traditional Chinese civilization ran its course in the nineteenth century, a process accelerated by violent contact with the West.
But the game is not yet played out. It remains to be seen if the West will hold together as well as China did for so long a stretch of time, bequeath a comparable legacy of wisdom and beauty to unborn generations, and pass along a diverse and livable world in which those generations can realize their aspirations. After all, if longevity and survival, as well as high achievement, are tests of civilizational success, then China's traditional arrangements and values may have an ironic last word as industrial civilization runs its course.

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NOTES

33. Etienne Balazs, Chinese Civilization and Bureaucracy, Trans. H. M. Wright (New Haven: Yale University Press, 1964), pp. 13-19. Balazs says outright that "it was the state that killed technological invention in China," which might have reached "the threshold of the industrial age," except for "an atmosphere of routine, traditionalism, and immobility, in which any innovation or initiative not demanded and sanctioned in advance is regarded with suspicion..." Ibid., p. 11. Balazs tends to share Qian's "stagnation" hypothesis without, however, sacrificing historical perspicuousness.

34. Needham, Science in Traditional China, pp. 121-122. A useful effort has been made to quantify China's technological development in relation to dynastic shifts. Four categories of technology—agriculture, unifying technology, handicraft, and medicine—are addressed. The category "unifying technology," which included transportation, communication, weaponry, calendar-making, large-scale building, and other technological modes that would "demonstrate the majesty of imperial power," peaked when a dynasty was strong and dipped when it came unraveled, and was always in the service of maintaining the integrity of a unified feudal and bureaucratic society supported by a landlord economy. Jin Guantao, et al., "The Evolution of Chinese Science and Technology," in J. T. Fraser, et al., (eds.), The Study of Time V (Amherst: University of Massachusetts Press, 1986), pp. 172-173. Technology "transfer" across a chaotic moment in the dynastic cycle was seriously impeded. "Whenever a dynasty collapsed, the net increase of technological level dropped sharply and many successful results became lost in the turmoil... Inside a closed technological system, no matter how advanced a technical invention was, it would meet immense difficulties when it came to transferring it to other economic sectors." Ibid., p. 179. In Europe, on the other hand, technological innovation and its transmission were not prevented by civil or international wars or the rise and fall of states.

35. On principles of Confucian doctrine and the hierarchy deter-


37. This argument is developed in Donald Munro, *The Concept of Man in Early China* (Stanford: Stanford University Press, 1969), pp. 11-29. The Confucian tradition is a complicated historical phenomenon, but with all the transformations from Confucius and Mencius to Tung Chung-shu to Chu Hsi to Wang Yang-ming, the connecting, visible thread is "the evaluating mind," which should be viewed as a Weberian "ideal type" with heuristic value rather than as an oversimplified abstraction. Ambiguity in the ideal must be noted. Confucian ideas were not monolithic and were commonly stretched between polarities of knowledge/action, self-cultivation/ordering the world, and the like. See Benjamin Schwartz, "Some Polarities in Confucian Thought," in D. Nivison and A. Wright (eds.), *Confucianism in Action* (Stanford: Stanford University Press, 1959), pp. 52-58. The ideas of Wang Yang-ming (1472-1529), the most eminent Ming thinker, defend the evaluating mind by seeking "to redress the Confucian balance in the direction of moral cultivation in practice, as opposed to cultural activity and the accumulation of learning." Wm. Theodore de Bary (ed.), *Self and Society in Ming Thought* (New York: Columbia University Press, 1970), p. 10. In Wang, "practice" means looking after society "rather than in the development of a thoroughgoing empiricism in either the physical or social sciences." Ibid., p. 23. Behind all the theory, Confucian moralism was balanced in historical reality by moral failure, social horror, and preventable suffering. See Jonathan

38. The moral point of view dissuaded officials from integrating mercantile interests into the fiscal management of the state, because "it would have been necessary to accept property rights as supreme . . .," and "that would have run counter to everything the bureaucrats had learned from the *Four Books."* Huang, 1587, *A Year of No Significance*, p. 147.

39. Ho, *The Ladder of Success in Imperial China*, p. 259. Indeed, a gentleman's virtue took precedence over creative ability, and "what had not been done before should never be attempted. Not infrequently a technical innovation simply incited charges of immorality." Huang, 1587, *A Year of No Significance*, p. 215. Qiu Renzong argues that only two kinds of "knowledge" held sway in traditional China—knowledge of the Confucian classics and craft knowledge. The latter which includes "the body of ancient Chinese science," was controlled and put in its limited place by the former. "Cultural and Intellectual Attitudes That Prevented the Spontaneous Emergence of Modern Science in China," *The Study of Time V*, pp. 182-183.


41. Braudel, *The Structures of Everyday Life*, p. 435. In the litany of Confucian virtues, the notion of reciprocity (*pao*) in human relations corresponded to a cosmic reciprocity between the parts of nature. See the essay by Lien-sheng Yang in Fairbank (ed.), *Chinese Thought and Institutions*, pp. 296-298.

42. Henderson points out that "most Ch'ing cosmological criticism was focused rather narrowly on the faults of particular schemata . . ." *The Development and Decline of Chinese Cosmology*, p. 178. On the range of criticism of correlative cosmology, see Ibid., chapter 7.


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46. Balazs, *Chinese Civilization and Bureaucracy*, pp. 10, 44-51. Huang notes that the excellent Chinese general Ch'i Chi-kuang, “when in charge of army training in the 1570’s, found that the weaponry of his own command was not standardized, and complained frequently of projectiles that did not fit the gun barrels, and gun barrels that tended to explode. The Ming government’s manufacturing enterprises were actually even more backward than their critics had imagined.” *Taxation of Governmental Finance in Sixteenth-Century Ming China*, pp. 320-321. Private industry, commerce, and associated technology for the Ming Dynasty were marginal in government finance. Confucian economic theory required that income originate in agrarian contexts. Consequently, “the bureaucrats could no longer stimulate and develop the more volatile sectors of the national economy,” which would have resulted in a different system of management and political philosophy, and “when an economic activity produced social consequences that the government could not handle, it had to be abandoned.” *Huang, 1587, A Year of No Consequence*, p. 144.

47. Ho, *The Ladder of Success in Imperial China*, p. 27. Chinese social novels are rich in examples of such elevated status. Ibid., pp. 42-46.


50. Ibid., pp. 136-139.


52. Sung Ying-hsing, *T’ien-Kung K’ai-Wu* (The Creations of Nature and Man), trans. E-Tu Zen Sun and Shiou-Chuan Sun (University Park: The Pennsylvania State University Press, 1966). There were two editions of this work before 1644. It dropped out of sight until 1914, probably because of remarks in it regarded as subversive to the Ch’ing Dynasty by Manchu watchdogs, although parts of the text appeared in encyclopedias and in the Gazetteer of Yunnan Province. The 1914 version was a collation of a Japanese copy with some material preserved in a Chinese encyclopaedia, while the two original Ming copies lay in, of all places, the Bibliothèque Nationale in Paris. The first of the Ming editions was published in 1959, a mere 322 years after its initial appearance in 1637. See the Translator’s Preface, Ibid., pp. ix.

53. SCC, IV, 2: 171-172. There were other technological manuals as


55. Ibid., pp. 160-166.

56. Ibid., p. xiv.

57. Paolo Rossi, *Philosophy, Technology, and the Arts in Early Modern Europe*, trans. S. Attanasio (New York: Harper & Row, 1970), p. 86. It should be said that Rossi is one of those scholars who believes the relationship between technology and the scientific revolution was intimate. Ibid., p. 31. See also Francis Haber, “Time, Technology, and Productivity Values in Early Modern Europe,” in J. T. Fraser, et al. *The Study of Time V*, pp. 79 ff, which explores the religious basis of values in the Christian West which justified improvements in manufacturing, technology, and economic productivity.

58. Ibid., pp. 75, 151.


60. There are exceptions. For example, the square-pallet chain pump, a device for raising water, was extolled from time to time in Chinese literature. *SCC*, vol. 4, pt. 2: 346-347.


62. Ricci said “all such instruments are very inaccurate.” Quoted in Cipolla, *Clocks and Culture*, p. 80. In fairness, there were Chinese officials who held the same view of western clocks and thought them extravagant to boot. Landis, *Revolution in Time*, pp. 47-48. On the fate of the Su Sung clock, see Ibid., pp. 33-35.

63. Cipolla, *Clocks and Culture*, pp. 82-89.

64. Landes, *Revolution in time*, p. 92.

65. Ibid., p. 89.
