social sciences

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# Bending and Fitting: Disciplinarized Institutionalization of Modern Science in China during the 'Treaty Century'

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Received: 25 September 2017; Accepted: 14 December 2017; Published: 19 December 2017

**Abstract:** This article investigates how Western science established itself through disciplinarized institutionalization in China as the country entered the modern era, delineating China's science and technology (S&T) enterprises evolving within the social settings primarily decided by Confucianism doctrines including Scholar-bureaucrat virtue. Although the perspective of this study is mainly historical, I also adopt a sociological approach to scientific knowledge production in order to argue that, the socialization of Western science during the 'Treaty Century' (1842–1943) has shaped and channeled the growth of modern S&T as well as its governance in contemporary China in a normative manner. It is this sociological interpretation of the history of modern science in China that sheds new light on our understanding of scientific knowledge as a component element of belief system that crosses countries, social structures, and civilizations. The main findings also include the premises on which the S&T governance issues are explored in China's case, in particular, the increased social mobility at the intrusion of the Western.

**Keywords:** disciplinarized institutionalization; modern science; scholar-bureaucratic virtue; utilitarian view

## 1. Introduction

Science and technology governance, interpreted narrowly as S&T policy-making and implementation, is conventionally used as a synonym of science, technology and innovation policy, innovation policy, and technology policy (Gu 2001). It is widely accepted that the S&T policy of a nation is an outcome of its political system and it evolves as its economic structure, and social and cultural features change (Ergas 1987; Lundvall 1992). Indeed, this approach to S&T policy has put a nation's S&T governance into a wider, but more specifically, social and cultural context. However, the debates around the Chinese case tend to present an oversimplified view of the social context. Under such circumstances, the evolution of China's modern S&T enterprises was roughly correlated with various aspects of the social, political, and economical changes that China has experienced during the past century. These ventures sought to understand China's S&T enterprises in relation to China's recent transformation and development as a modern nation. Nevertheless, less attention has been given to the relationships between scientific knowledge production and the social context within which it has been largely influenced and shaped. Fortunately, some scholars have become aware of this lack of analytical work, and have probed the connections by which S&T enterprises have become involved with social factors in modern China (see Li and Handberg 2002; Shen and Williams 2005; Zhong and Yang 2007).

The social study of S&T requires a basis of historical and institutional knowledge (Barnes 1995). Admittedly, the historical influences of modern S&T streaming into China from Western countries constitute a vast terrain of a great variety and unexplored proportions. Moreover, China's modern S&T

evolution has outpaced its institutional history, as a result of the unstable social situation in modern China. A brief review of the history of China's modern S&T is appropriate in order to contextualize the accurate analysis of the trends that have emerged in China's approaches to S&T governance. The time frame covered in this article consists mainly of the historical stage, which witnessed China's journey in initializing and strengthening its modern S&T enterprises, namely the 'Treaty Century' covering the period (1842–1943). In this stage, China's social structure experienced the switch of two major dominant polities (from the late-Imperial period to Republican China). During the course, modern sciences have been progressively introduced in from Western countries, whilst China's S&T enterprises emerged and grew under the control of the heterogeneous S&T governance bodies.

This article examines the institutionalization of modern sciences in China and how it contributed to the increase in social mobility, with a focus on the development of scientific knowledge production following the disciplinary category. It is argued that the intellectual tradition, social structure of the academic community, and historical effects of polities, within which the trajectory of disciplinarized institutionalization was embedded, all need to be included to provide an adequate account of its development. These features, albeit significantly transformed, remain powerful influencing factors in the emerging transformation of China's contemporary S&T, as well as its governance.

## 2. Methodology

The long-established tradition in sociological study of science has produced important insights into the structural factors that shape scientific knowledge production and curation as a social process. Particularly, scientific knowledge is seen as cultural system achieving validity in social intercourses where the social credits emerge in structuring the social life. This article is to incorporate historical perspectives and those from Sociology of Scientific Knowledge (SSK) into understanding of modern science as it was socialized Chinese society. The specific steps include synthesizing data, ideas and findings across fields, and making new connections between depictions of modern science and analysis of social structure of late imperial as well as the Republic China.

The present methods involve systematic collecting and critical reading of publications and documentation pertaining to theoretical discussions on the development of China's modern S&T enterprise. The goal is to develop a general narrative about the historical events. It is furthermore tailored to a thick description of how modern S&T evolved in China's social setting, which features disciplinary institutionalization. Official documents relating to the disciplinary structure and governance of scientific research in China are carefully examined. There are also valuable sources of historical materials, detailing the evolution of modern S&T in China as well as its social background, notably, *the Science and Civilization in China (SCC)* series by Joseph Needham (Needham 1953, 1969, 1974, 2004) and his international team of collaborators at the Needham Research Institute, *The Cambridge History of China* series published by Cambridge University Press, and *China: A New History* by John K. Fairbank and Merle Goldman. In addition, online sources provide complementary yet invaluable records, such as the Chinese Educational Mission (CEM) Connections which revitalize almost forgotten endeavors in 'China's hesitant journey towards modernization' (Chinese Educational Mission CEM).

## 3. Modern S&T in China in Treaty Century

In his narrative of China's modern history, Fairbank regarded the period of one hundred years from 1842 to 1943 as the Treaty Century[1]. This labelling of Chinese history does provide a sound starting point for an investigation into the development of modern S&T in China, with the nation's experience of modernization as a broader context. It is important to note that the treaties within

[1] The 'Treaty Century', according to Fairbank and Goldman (1998, p. 204), started at the first treaty signed between China and Britain in 1842 and ended finally in 1943 when the United States and Britain formally gave up extraterritoriality as the linchpin of the unequal treaty system western countries had imposed mainly by force on China.

different (mainly Western) countries focus on various issues and were generally the outcomes of China's military struggle against its opponents (Song 2008). In many conflicts China was defeated due to backwardness in modern S&T capacity, specifically, the application of weapons technologies. Thus it is sufficient to assert that China's initialization of modern S&T was both rooted in a painful reality and bound up with the nation's survival during this historical stage.

It is conventionally accepted that Chinese society under either the late imperial regime of the Qing (清) dynasty before 1912, or the polity of Republican China (中华民国) before 1949, failed to provide a seedbed for the growth of modern S&T (Song 2008). Revolution, civil wars, and the Japanese invasion, with the associated damage to society, have been cited as impediments to the advancement of modern S&T in China. Indeed, launching China's modern S&T with an ambitious vision of technology transfer from the West was frustrated during the first half of the twentieth century by a succession of weak central governments, the Japanese invasion in the 1930s, and civil war which ended with the founding of the People's Republic of China (中华人民共和国) in 1949 (Hu 2008). Thus, within the broad terrain of China's history of modern S&T, the focus of the largest portion of contemporary studies of China's modern S&T, as well as its S&T policy, has been limited to the period of People's Republic of China, on the assumption that a serious move to develop modern S&T enterprises did not start until 1949[2].

In contrast to these prevalent views, in this article I illustrate that the confrontation, adoption, initiation, and finally the institutionalization of modern S&T in China during the treaty century provided the bedrock for China's contemporary S&T enterprises. The features embodied by the intellectuals, the academic community, and the governance bodies, together with the legacy of the evolution of China's S&T in this period, have largely shaped the contemporary development and transformation of China's S&T, as well as its governance. Specifically, I show, first, how a scholar-bureaucrat virtue was displayed by Chinese intellectuals as they confronted, in cultural terms, the modern S&T from the West. And the increased social mobility was achieved by nurturing a new group of intellectuals practicing production, application, and distribution of modern scientific knowledge Second, I describe the colonial status symptoms shown by China's academic community in the process of generating and structuring scientific knowledge production; and third, I discuss the utilitarian view[3] of S&T in a top-down mode, adopted by China's S&T governance bodies.

## 4. Scholar-Bureaucrat Virtue

During the Han (汉) dynasty (206 B.C.–A.D. 220), Confucianism was adopted by the state as the dominant ideology, and the Confucian doctrine of scholar-bureaucrat linkage became a critical part of the Confucian values and beliefs subscribed to by most of the intellectuals in traditional China (Kim 2000). Initially serving as an educational slogan, this linkage convinced Chinese intellectuals that he who excels in study can follow an official career (*xue er you ze shi*, 学而优则仕, see (Jin 2004, p. 233)), which inspired young scholars to become scholar-bureaucrats (*shi*, 仕) so as to serve the country as well as get themselves recognized. As the imperial autocracy rose to its climax in the Song (宋) dynasty (960–1279), the scholar-bureaucrats within the imperial system were well established as playing the dominant roles in all aspects of Chinese society. The civil exam testing knowledge of Confucian classics finally became the only entrance requirement for intellectuals seeking power (Kim 2000). The social openness of the civil exam system had effectively guaranteed social mobility till late imperial China, according to (Ho[1967] 1980, p. 107), given an overwhelming proportion (50% in the Ming and 37% in the Qing dynasties, respectively) of *jinshi* (进士, the highest degree in civil exams) and many (45% in the late Qing period) *juren* (举人, the second highest degree) came from "commoner" families. This imperial-Confucian mode of knowledge speaking to power has been deeply rooted in

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[2] Further evidence of this trend can be found in Yu (1999), Du and Sun (2006), Zhong and Yang (2007), to name just a few.

[3] In this article, 'utilitarian' is used to illustrate a perspective of being mission-oriented and troubleshooting in a more practical sense.

Chinese intellectuals' minds as the guideline for their career development. Moreover, the mode is ultimately conceived of as a scholar-bureaucrat virtue, and was embodied by the academic community in the evolution of modern S&T during the treaty century.

In spite of the historical achievements achieved over the course of the longest tradition of successful imperial autocracy on this planet, China had been overtaken by the West in modern S&T. In his landmark work on China's science and civilization, Needham raised the puzzle since known as 'Needham's Grand Question' which centered on 'the failure of China to give rise to distinctively modern science while having been in many ways ahead of Europe for some fourteen previous centuries' (Needham 1974, p. xxiii). In the late stage of China's imperial autocracy, starting from the end of the sixteenth century, Western S&T began to penetrate into China, from missionaries from Western countries, primarily through the Jesuit China Mission (JCM). Although it was through the missionaries that the Chinese began to encounter modern S&T (Waley-Cohen 1993), the serious introduction of modern S&T into China started only after the Opium Wars (1839–1842, and 1856–1860) as China moved into the treaty century.

It is noteworthy that the intellectuals' devotion to bureaucracy manifested itself first in confrontation with and later with the introduction of modern S&T around the beginning of the treaty century. Among the Jesuit missionaries who adopted the accommodative approach to fulfil their missions, by arousing the interest of Chinese literati in Western S&T knowledge, Matteo Ricci (1552–1610) was conspicuously successful (Ma 2009). With the intention to gain access to China's elite and its imperial court, Ricci introduced to China aspects of modern S&T knowledge, with a focus on planar geometry (and other mathematical concepts), geographical knowledge, and techniques of cartography in a decade-long collaboration with Chinese intellectuals—primarily with Xu Guangqi (1562–1633).

Xu Guangqi, however, had different motivations for collaborating with Ricci to translate part of Euclid's Elements (*jihe yuanben*, 几何原本). He identified the social functions of geometry (*jihe*, 几何, the characters Xu Guangqi coined together with Riccci) and other modern scientific knowledge by applying them to the Chinese social context. The special purpose of his dedicated efforts in introducing and applying modern mathematics was statecraft. Specifically, the knowledge of modern celestial geometry with its higher level of precision qualified Xu to greater powers, and consequently he was appointed by the Emperor as the official in charge of improving the accuracy of the Chinese calendar (Stone 2007). Although a degree holder already, Xu and his followers practicing modern scientific knowledge or technological equipment were provided with better chance to be successful in career ladder.

Due to the convention of scholar-bureaucrat virtue, traditional Chinese intellectuals aspired to speak to power through expertise principally in Confucian. Unsurprisingly, modern scientific knowledge, conventionally termed as 'Western learning' in traditional China (Mullaney 2007), had been included in the expertise, which Chinese intellectuals endeavored to master in order to facilitate entering or upgrading their official careers since its first cultural confrontation with Chinese society through the JCM. Furthermore, the impact of this scholar-bureaucrat virtue upon the Chinese localization of modern S&T took an upward trend as China entered the treaty century.

It was not until the Opium Wars that public awareness in China acknowledged the importance of modern S&T. The need for modern S&T, specifically powerful firearms and strong gunboats, manifested itself as Britain bombarded the closed gate of the Qing Empire, breaking China's image of itself as the 'Central Kingdom' and center of civilization[4] (Song 2008). Thus, modern S&T was recognized by the Chinese as a means both defending and strengthening the nation. As a result, the ruling class in

[4] The civilization in traditional China reflected its illusion of being the 'Central Kingdom' ('*zhongguo*', 中国) or the 'Celestial Kingdom' ('*tianchao*', 天朝) in the propaganda by the ambitious throne and the lack of global geographic knowledge. One of the vestiges of this assumption, more relevant to the current topic, is the world map by Giulio Aleni (1582–1649), the other outstanding Jesuit missionary, who introduced Western science to China after Ricci, published in 1623 in Chinese. In the

China began to seek modern scientific and technological expertise. The academic community thus consolidated the position of modern S&T knowledge in realizing their scholar-bureaucrat aspirations, while maintaining a strong desire to preserve China's cultural identity of Confucianism (Fairbank 1994). This was well articulated by one scholar-bureaucrat in late Qing dynasty, Zhang Zhidong (1837–1909), as the 'foundation-practicality' ('*ti-yong*', 体-用) dichotomy of attempting to adopt modern S&T (Western learning, *xixue*, 西学) for practical application, whilst retaining Chinese learning for fundamental principles (Yuan et al. 1998).

Consequently the more progressive scholar-bureaucrats advocated a movement of 'Self-strengthening' (*ziqiang*, 自强) focused on adopting Western S&T. In this movement, extensively importing and applying modern scientific knowledge was taken as major self-strengthening measures to save the society from danger of collapse, and engagement with modern science has offered individuals a way of acquiring higher social status. As early as 1863, Zeng Guofan (1811–1872) summoned Rong Hong (1828–1912), China's first scholar to have graduated from a US university, for an interview on modern weapon machinery. One year later, Li Hongzhang (1823–1901) explained to the Qing throne the superiority of Western weapons, so as to rationalize the need for China to take up western approaches to S&T, including the training of Chinese personnel, in order to strengthen itself in this area. The memorandum to recommend the scheme of sending youths to be educated in America, as drafted by Rong, was jointly signed by Zeng and Li, and finally presented to the Throne in 1871. Official approval was secured in the next year (Fairbank and Goldman 1998). This first overseas study programme known as the Chinese Educational Mission (CEM 1872–1881) sponsored large numbers of China's young students to be fully immersed in the education and training of modern S&T for the first time (LaFargue 1942; Shi 2000; Ding 2007; Saari 1990). As summarized in Li's memorandum to the Throne, 120 CEM students had been sent to the United States between 1872 and 1881 before the programme was aborted (The Chinese Association for History Zhongguo Lishi Xuehui, 中国历史学会). According to Xu and Mao (2005) investigation of the career experiences of the returned CEM students, the largest portion (58%) were engaged in the fields practicing modern S&T for the needs of the nation. The expertise of modern S&T that this first generation of intellectuals educated abroad possessed, however, played an even more critical role in realizing their scholar-bureaucrat aspirations and setting good examples for the following students.

Altogether, 63 out of 99 returned CEM students, as presented in Table 1, succeeded in fulfilling their scholar-bureaucrat aspirations and held varied official positions. Moreover, intellectuals from this portion of slightly higher than 63% were well represented in the 58% who engaged in applying modern S&T after their return. Table 1 highlights the close relationship between modern S&T application and the governmental departments, which recruited most of the returned CEM students in terms of number, namely the telegram bureau, military enterprises, and the railway bureau.

In this respect, the subject of the relation between modern S&T expertise, and the aspirations of intellectuals entering official careers in China, can be seen as having played an important part in the evolution of modern S&T in China since its very beginning. It serves as a critical constituent element of the social context within which the disciplinarized institutionalization of China's modern S&T was initially conceived, and has deeply shaped the development and transformation of contemporary S&T enterprises in China. To a larger extent, studying and practicing modern S&T also served to supplement the civil exam system in facilitating the social mobility and therefore the stability of late imperial China.

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map titled 'Complete map of all the countries' ('*wanguo quantu*', 万国全图), the Chinese Empire was located at the center, reflecting in its Sino-centric configuration Chinese demands. See more work on Aleni in Pan (1994).

**Table 1.** Official Positions Held by the Returned CEM Students (in total 99).

| Official Position | Number of Returned CEM Students |
|---|---|
| Prime Minister | 1 |
| Foreign Minister | 2 |
| Minister | 2 |
| Diplomatic Official | 12 |
| Customs Officer | 2 |
| The Chief of Railways Bureau | 3 |
| Railways Officer | 5 |
| Telegram Bureau Officer | 16 |
| Customs Commissioner | 1 |
| Admiral of the fleet | 2 |
| Naval officer | 14 |
| With other official title | 3 |
| Total | 63 |

Source: adopted from Gao (1980) translation of LaFargue (1942) and Xu and Mao (2005)[5].

## 5. Colonial Status Symptom

The development of modern S&T in the late Qing dynasty, starting with the introduction from the West by Jesuit missionaries and military aggression, leading to the adoption of S&T by progressive Chinese intellectuals, paved the way for the growth of modern China's S&T enterprises. The evolution of modern S&T in China during the late Qing dynasty, however, was still in a pre-disciplinary development stage. Admittedly, it is clear that a large portion of modern science subjects and disciplines were adopted into the curriculum of the institutes and colleges set up during the 'Self-strengthening' movement by the scholar-bureaucrats in order to train Chinese modern S&T personnel. Yet modern science subjects were generally categorized as 'Western Learning' ('*xixue*', 西学), 'Western Techniques' ('*xiji*', 西技) or '*Gezhi* (格致)'[6], with the exception of Mathematics and Geography (Liu and Yang 1994, pp. 359–60).

The disciplinary development of modern S&T in China was not effectively promoted until the beginning of Republican China in 1912. Based on the detailed studies of the personnel configurations, groups, factions and cliques that advanced modern S&T in Republican China, I argue from a sociological approach to scientific knowledge production, that the colonial status symptom, being dependent on international community and resided within the local backwardness, was represented in the growth of the Chinese academic community. The major constituents of the academic community involved in the development of modern S&T enterprises in Republican China were the students returning from the Western countries, primarily the United States, Britain and Germany.

These roughly 20,000 students were a remarkably small but potent group in China's intellectual society. Having received modern S&T training and education in the West in the twentieth century, they found themselves in a two-front struggle in promoting modern S&T in China (Sun 1986). On the one hand, they were connected to their studies abroad, where they received their education and training, and to which they tried to contribute even after their return to China. On the other hand, they simultaneously faced the task of localizing their newly gained knowledge into China's intellectual and cultural community, thereby introducing scientific thought into the life of the Chinese people, and attempting to reduce the 'backwardness' of the nation. This conflict is also a critical indication of the

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5 In Xu and Mao's study, the total number of returned CEM students is 106, a figure that includes both the 94 students who returned in 1881, as narrated in Li's summarizing memorial, and others who returned earlier. However, 7 students in unclear categories have been excluded from my analysis of career experiences of returned CEM students; so the total number in my consideration is 99.

6 'Gezhi' was the Chinese version of 'science (*kexue*, 科学)' before the term was borrowed from Japanese by Kang Youwei (1858–1927) in 1897 (Yang 1981; Fan 1988; Xi 2005).

nationalist perspective through which modern S&T was viewed. The traits of both dependence on the Western scientific community and the backwardness of their own nation were stigmatized by Buck as symptoms of a colonial status (Buck 1980). Those symptoms were rooted in the social background of Republican China. They were imprinted onto China's academic community, and thus deeply shaped its institutionalization of modern S&T. In this section, a brief examination of modern S&T in Republican China is to focus primarily on the academic community's efforts in founding and reforming modern Chinese universities, and constructing the national institutes of modern S&T research on a nationalist basis, as the major steps of institutionalization.

In imperial China, formal and informal institutions including government schools, community schools, and private academies provided aids for exam candidates that facilitated social mobility under the civil service exams (Jiang 2012). Since 'Self-strengthening' movement, however, universities and higher education organizations were also to create, import and disseminate modern S&T, which became a central focus of the republican government of China. Two days after the foundation of the Republic of China, on 1 January 1912, a provisional government appointed Cai Yuanpei (1868–1940), a student who returned from Germany as the general governor of education. One week later, on 9 January 1912, the Ministry of Education was established. The leaders in the development of higher education, with Cai as their representative, immediately responded to the need for scientific expertise in an extraordinary time for Republican China. They confronted the necessity of grafting modern S&T together with its institutional achievements in affecting the wider society, so as to save China from its backwardness as a nation and to essentially catch up with the West. Consequently, the conscious aim of their collective efforts was to imitate foreign models, specifically the American and European university curricula, textbooks and systems of instructions within a modern disciplinary framework, while adding their own input to the educational transformation.

One typical outcome of this trend was the reshaping of Beijing University as a national university. Established in 1898 by the Qing regime, the Metropolitan University (*jingshi da xuetang*, 京师大学堂) was initially designed to re-educate some of the Qing scholar-officials so that they would be reasonably knowledgeable about affairs and conditions of the modern world. It was, therefore, taken as merely a ladder for intellectuals with scholar-bureaucrat virtue to enter or upgrade their official career. This preparatory-school atmosphere remained, even after the institution was renamed National Beijing University in 1912. After Cai was appointed Chancellor in 1916 he, together with his peers, succeeded in placing the university under the direct jurisdiction of the Ministry of Education (Sun 1986, pp. 368–72). Plans for the university's re-structuring were drawn up in 1918, to establish programmes following the modern disciplinary structure of the humanities, science, social science and law. By the early 1920s, as the first of the national universities[7], the National Beijing University had come to represent a curriculum organized along the disciplinary lines common in modern sciences education, which was also required to meet the disciplinarized institutional standard set by law.

Alongside the development of modern higher education organizations so as to consolidate the national base for adopting modern S&T in China, the academic community in Republican China also underwent self-structuring in accommodating modern scientific knowledge production based on the disciplinarized structure of Western S&T practice. As early as 1914, the Chinese Association for the Advancement of Science (CAAS, '*Zhongguo Kexue She*', 中国科学社) was established by Ren Hongjun (1886–1961), Zhao Yuanren (1892–1982) and their fellow Chinese students at Cornell in the United States. Echoing AAAS (American Association for the Advancement of Science), CAAS set itself as the exemplar in structuring China's academic community, as it developed in the evolution of modern S&T in Republican China (Zhang 2007). Significantly, the symptoms of colonial status were visible from the very beginning, when China's academic community adopted a contradictory dualism in aiming to

[7] The first modern university in China, however, was the School of Chinese and Western Learning (*Zhong Xi Xue Tang*, 中西学堂) which was established 3 years earlier than the Metropolitan University, in Tianjin by Sheng Xuanhuai (1844–1966). In 1903, it was renamed the Beiyang University, and now is called Tianjing University (Liu and Yang 1994).

promote and spread scientific knowledge. On the one hand, the academic community promoted the production of scientific knowledge, but on the other hand it insisted on regenerating China's entire society and cultural tradition on a nationalistic basis. They imitated the common practice of Western S&T, with the institutional structure following the modern disciplinary system, including publishing the journal Science (*Kexue*, 科学), and holding meetings for the presentation of research papers, and so forth. Meanwhile, conflicts between the nationalist perspective and their dependence on western S&T became inevitable[8].

There were few events in the treaty century as influential as the creation of the Academia Sinica. It served not merely as a central research academy of Republican China, but for the administrative organization of the nation's S&T research, as well. Thus, its establishment also marked the institutionalization of modern S&T in China. It was initiated in 1927 by Cai and other leading Chinese intellectuals, after building up modern higher education institutes in the previous years. As the Nationalist government came into being in 1928, the country experienced a rare period of relative peace. One immediate aim of the new government was to express China's newly ascendant nationalism in building a fully sovereign nation. The academic community was inspired to establish, in China, government-financed modern scientific research at advanced levels. Consequently, the Academia Sinica (*zhongyang yanjiu yuan*, 中央研究院) was officially founded in Shanghai on 9 June 1928, with Cai as its first government-appointed president. Placed directly under the supervision of the central government, the academy comprised the individual research institutes, primarily in the natural sciences, with clearly articulated disciplinary identities, a substantial portion of scientists previously involved in the work of CAAS were enrolled at Academia Sinica (Tao 1978; Sun 1986).

An outstanding feature of disciplinarization of scientific knowledge is that it can also be identified as the symptom of colonial status, as represented by intellectuals in Republican China, being dependent on Western science, as well as its institutional embodiment in affecting wider society. As can be seen both in the development of higher education for S&T personnel training and in the creation of national scientific research institutes, the institutionalization of China's S&T was inscribed by the leading educators, science practitioners, and government with disciplinary identities. Specifically, higher education in universities was to be conducted in disciplinary departments by both the Faculties of Letters and of Science, with a combination of Law, Business, Medicine, Agriculture, Engineering, and other professional disciplines (Sun 1986; Zhang 2000). Disciplinary identities were further formulated in their generic terms by professional societies, conferences, periodicals and chairs, which served as the conventional insignia of a discipline. Although a full picture of the disciplinary structure of China's S&T can only be sketched clearly about half a century later, the evolution of S&T in Republican China provides a preliminary starting point.

## 6. Utilitarian View in S&T Governance

Over the course of these two historical stages, a conspicuously strong role in S&T governance was held by the government, both of the Qing regime and that of Republican China. On the one hand, this deeply shaped the development of China's S&T enterprises; on the other it provided another dimension through which to address the issues with regards to social context, as well as the power configuration in China's S&T development during the treaty century. Within this dimension, I argue that a utilitarian view was universally adopted by the S&T governance bodies, which resulted in priority being given to the disciplines of engineering and technological applications, these having more direct relevance to the nation's need in defending and strengthening itself, and providing more

[8] Ironically, the nationalist trend rose as the academic community in Republican China expanded, and one of its outcomes was to seek independence of the nation from western influences, including the scientific expeditions directed by western scientists in China (for more details on this conflict between nationalism in Republican China and western scientific expeditions in China see *Nature*, (Anonymous 1931)).

attainable social esteem and prestige to individuals in performing the social function of modern S&T in China.

For the first time, adopting modern S&T became a governmental issue when the Qing rulership finally realized the power of modern S&T or, more precisely, modern weapons technologies and their applications. Meanwhile, the loyalty of traditional Confucian scholar-bureaucrats was believed to be the final hope of the regime, especially as it was under double threat from both foreign aggression and civil rebellions in the last half of the nineteenth century. In combining modern S&T and traditional scholar-bureaucrats, the strategy proved itself effective. One supporting fact is that the throne relied on the traditional Confucian scholar-bureaucrats (with Zeng and Li as representatives) and the powerful 'Ever Victorious Army' ('*changsheng jun*', 常胜军), equipped with Western guns, in rooting the rebellions out of their fortified strongholds (Fairbank and Goldman 1998). Furthermore, the Bureau of Foreign Affairs (BFA, *Zongli Yamen*, 总理衙门) was opened in 1861 as the special administrative department under whose governance foreign works on modern sciences, including mathematics, mechanics, geography, history and international law, were translated to spread knowledge of Western techniques. Meanwhile, colleges with specialities in modern technological applications were established nationwide. Notably, the overwhelming majority of these efforts were inspired by a utilitarian view of modern S&T, specifically, scientific expertise directly related to military training, weapons manufacturing, mining, engineering, modern communications and foreign affairs, took priority over all other sciences. Plenty of examples of this can be seen in works on BFA's measures in promoting modern education and S&T, by Liu and Yang (1998) and Chen (1994).

In spite of the great efforts made by the revolutionists led by Sun Yat-sen (1866–1925) and the Nationalist Party in overthrowing the imperial autocracy of the Qing throne, and in building a new, fully sovereign nation since 1912, this utilitarian view was largely inherited by the disciplinarised institutions of modern S&T in Republican China. Moreover, Shen and Williams (2005) proposed that this utilitarian view of S&T deeply shaped contemporary China's S&T enterprises, from the perspective of Social Shaping of Technology (SST). The new policy of the Republic was to 'invite in Mr. Science ('*sai xiansheng*', 赛先生) and Mr. Democracy ('*de xiansheng*', 德先生) to rescue China' (Hu 1981). By the 1920s, it became a commonly accepted article of faith for both scientific expertise and governmental power to view the outlook of modern S&T in China as an instrument for dismantling the traditional order and opening the way for China's attainment of modern nationhood (Sun 1986). To a large extent, this utilitarian view on modern S&T opened up an unusual window of opportunity for Republican China's academic community to promote modern S&T, for instance, to build up higher education and to create research institutes at national levels. Shortly after the Republican government established the Ministry of Education, with Cai as the first minister in 1912, a guideline for the development of China's modern higher education was formulated, to bring scientific knowledge production within an integrated national system to a modern standard. Moreover, higher education was conceived as an indispensable component of the task of national reconstruction, as it served as the S&T training ground for future leaders and generations to come. Following such a guideline, the Republican government officially announced the Law Governing Colleges and Universities ('*daxue ling*', 大学令) in the same year. Rather than to generate scientific knowledge, the objectives of the university were articulated by the Law as to train students with modern scientific expertise, and thus to meet the needs of the nation (Liu 2009).

## 7. Conclusions

During the treaty century, the evolution of China's S&T enterprises and their governance, in spite of having been slow-paced and on a limited scale, embodied a complex configuration of social settings. These included, most notably, cultural tradition, power hierarchies, and interactions between powers and expertise. Furthermore, the features that have come to define China's intellectuals, its academic community, and the S&T governance bodies, were integrated into a powerful stream in the growth of China's modern S&T, in which highly influential actors were gradually enrolled. The stream flowed

into the development and transformation of S&T enterprises in contemporary China. It shaped the sciences, practitioners, S&T policy-makers, and S&T institutions, and therefore shaped scientific knowledge production, despite the country has undergone massive changes. While modern science became increasingly institutional and diversified China's ruling class, those who pursued careers in Western science found their places with a noble but long neglected side stream of earlier Chinese culture of science and technology. Their social function of integrating society relied upon largely, but not limited to, how effectively they were able to materialized scientific knowledge so as to be ready for military utilization in removing social upheaval and resisting humiliation, and later on, industrial exploitation. On the other hand, the emergence of such a group of intellectuals contributed to the social mobility, albeit to a rather limited extent.

This article points to how the social context of power and Chinese cultural heritage are important to an understanding of how modern S&T established itself in China during the initial stages of the country's modernization. Out of a careful examination of China's S&T evolution and governance in the stages, three historical and cultural traits as main findings become evident. The traits with far-reaching influence in the social settings of the S&T governance in contemporary China emerged as scholar-bureaucrat virtue, colonial status symptom, and utilitarian view in S&T governance. Shaped by these factors, the discipline-based institutionalization of modern S&T was initialized out of the unstable social conditions, which eventually provided a guiding disciplinary frame for the development of modern S&T and its governance in China[9]. Over the course, the various status groups involved, namely China's intellectuals, the members of their academic communities, and governance bodies, have strongly shaped China's subsequent market-based, commercially driven model of scientific knowledge production as widely adopted in contemporary China (Baark 2001; Wang et al. 2009).

**Acknowledgments:** The funding from Exeter University in the United Kingdom (Exeter Research Scholarship, ERS), China Postdoctoral Science Foundation (2014M560518), and University of Science and Technology of China (the Fundamental Research Funds for the Central Universities, WK2110240007) are acknowledged. The study presented in this article formed part of Ph.D. research programme at ESRC Centre for Genomics in Society (Egenis) at Exeter University, I appreciate the guidance and comments from John Dupre, Barry Barnes, Claire Dunlop, Sabina Leonelli and Maureen O'Malley. Thanks also go to the anonymous reviewers for their careful reading and insightful comments and suggestions.

**Conflicts of Interest:** The author declares no conflict of interest.

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