I. Framing the Issue – The Relationship of Governance to the Production of Science and Technology

The question of how science and technology (S & T) should be governed is an issue that has received considerable attention in advanced industrial societies. Interest in the subject rose rapidly in the aftermath of World War II and the development of nuclear weapons, with the impacts of scientific and technological advances becoming a central focus of science governance. Growing concerns for environmental and safety risks furthered this focus on impacts and the need for regulatory controls.

At the same time, the ever-increasing importance of science and technology for the well-being of modern societies, especially with regard to national defense and economic competitiveness, has also led to sustained concerns for ensuring that national policies and institutions are suitable for building and enhancing national scientific and technological capabilities. This has called attention to the challenges of understanding the complex ways in which S & T interact with society, as well as the social complexities of research and innovation themselves. Science and technology, in the first instance, have deep relations with the modern state, which both seeks to exploit technical knowledge for its many ends and, in most countries, supports aspects of scientific and technological development on behalf of society as a whole. Science and technology have clearly become central to the economic success of modern societies as well, and are therefore supported by private economic actors and shaped by market forces. But, in addition, science and engineering can also be thought of as distinct social institutions, with varying degrees of institutional autonomy, having their own mechanisms of self-governance and regulation. Discourses about the governance of science and technology therefore reflect variously theories of politics, theories of economics, and theories of social institutions.

Economic analysis offers an especially powerful and parsimonious initial approach to thinking about S & T governance. Much of science policy in advanced capitalist societies is built around the parsing out of a proper role for government in scientific and technological development in the face of the failure of market mechanisms to supply socially optimal levels of new knowledge. Government, therefore, has an important role in seeing to the provision of knowledge as a public good, and in doing so introduces a variety of policy measures shaping the governance of science.

In normative theory, an extensive role for government has been most readily justified in
the area of basic research and in those areas of applied research and development that serve most directly the needs of government missions. As one moves toward more applied research and development not related to government missions, the role of government - and hence the nature of regulatory mechanisms - becomes more contested in the face of varied understandings of market and state capabilities and, in the opposite vein, market and state failures.\footnote{Fred Block and Matthew R. Keller (eds.). \textit{State of Innovation: The U.S. Government’s Role in Technology Development}. Boulder and London, Paradigm Publishers. 2011.} This is especially pertinent for consideration of the role of S & T in industrial catch-up and in charting a course for science and technology as part of a national industrial strategy for knowledge intensive industries.\footnote{Joseph Wong. \textit{Betting on Biotech: Innovation and the Limits of Asia’s Developmental State}. Ithaca. Cornell University Press. 2011.}

While economic theories, built around notions of public goods and market failure have had a profound influence on thinking about the governance of science and technology in capitalist countries, we should not overlook the ways in which political forces shape understandings of the proper forms of governance – consider the growth of regulations intended to insure accountability in the uses of public funds\footnote{Tobin L Smith, Josh Trapani, Anthony DeCrappeo, and David Kennedy. “Reforming Regulation of Research Universities.” \textit{Issues in Science and Technology}. Summer, 2011. pp. 57-64.} – and the importance of professional norms and practices as well. Thus, in most capitalist societies we see a variety of normative blends and regulatory mechanisms shaping the governance of science and technology - norms of the political system, of the market, and of professional organizations - manifest in a great diversity of institutions with varying relationships to the state, institutions such as universities, government laboratories, industrial laboratories, startup companies, and NGOs. Efforts to understand the complex interactions of these diverse regulatory impulses often build on the concept of “innovation system,” a concept which has been applied most frequently to the national level, but also increasingly to the international and subnational levels. As countries in Europe, North America, and East Asia attempt to redefine the role of the state in the governance of science and technology, the innovation system tradition is a reminder that innovation typically involves the systemic interactions among a variety of state and non-state institutions - for R&D, finance, manufacturing, education, etc. - to form \textit{networks} of innovation. A proper role of the state, therefore, is increasingly associated with its potential for fostering an ecosystem for network formation and the need to overcome what some have referred to as “network failure.”\footnote{Christopher Newfield. “Avoiding Network Failure: The Case of the National Nanotechnology Initiative.” In Block and Keller. Pp 282-299.}

China’s experience reflects patterns common to non-Western developing countries, especially in East Asia, patterns that reflect pragmatic developmental and national security experiences as much as normative theory. Starting along a path of S & T development, countries generally find themselves with weak firms and weak professionalization of science. The absence of alternative nodes for S & T development almost inevitably means the state will be a key actor in providing direct policy supports. The question then becomes, as a country travels up the development trajectory, when does the state step out – or retreat to the use of more indirect policy tools - and to what degree? When firms and markets develop, and the professional community becomes strong enough, the state’s role is often expected to evolve considerably. In South Korea, for example, the government facilitated the development of the research and

innovation capabilities of chaebol and a university system that would become the basis for its move, in the 1980s, to redefine its role substantially. Research and development that had been led by government research institutes and 60-70% funded by the government in the 1970s and 1980s, had, by the 1990s, become more of a private sector function, with 70-80% of the nation’s R&D now coming from Korean corporations.\(^5\) Redefining the role of the state involves further challenges as countries seek to go beyond “catch-up,” as South Korea and the other Asian NICs also illustrate.\(^6\) Thus, governance of science and technology in any country, including the PRC, presents myriad choices and dilemmas as to how to build networks and make them work. These involve decisions about the role of the state versus non-state actors, the level and proper distribution of state and private resources, the incentives provided for scientific development and for scientists themselves, and the development of professional norms in the scientific community. In China, the government, reflecting its own goals but also the pressures and opportunities of globalization as well as market forces, had to face these dilemmas.

As we discuss in this chapter, enormous changes have occurred in the governance and regulation of science and technology, but the state-of-play in China also reflects its distinctive historical, development, and political path. By considering a series of factors affecting rewards and incentives, personal mobility, communications, and project selection, control and evaluation, we explore how three approaches to governance (guanzhizhili) in China - bureaucratic, professional, and commercial norms - interact to produce governance mechanisms which have facilitated the country’s S&T development but which are also increasingly matters of concern. In doing so, we focus principally on mechanisms used to promote science and technology, but we are also concerned with emerging efforts to control the negative externalities, or “public bads,” associated with scientific and technological development. China’s efforts to devise new regulatory institutions in this area further highlight its challenges.

The choice of mechanisms for the governance of science and technology has become a major policy issue in today’s China. The fact that dramatic increases in national expenditures for research and development have produced disappointing results has led the Chinese leadership to give changes in the governance system high priority attention, as seen in the July, 2012 national conference on S&T reform discussed by Simon, and the subsequent release of new policy guidelines for reform by the Party Central Committee and State Council.\(^7\) These latest initiatives come after more than 25 years of S&T reforms, in rough conjunction with economic reforms, intended to transform China’s science and technology institutions into an innovation system compatible with an evolving “socialist market economy.”

II. Science and Technology Governance in China – from Mao to Market Reform.

Chinese thinking about the governance of science and technology prior to the 1970s, was strongly influenced by the ideological formulations of Marxism-Leninism-Maoism, and by the institutional model offered by the earlier Soviet experience. In this tradition, questions of regulating market failures were largely considered irrelevant. Under socialism, the state was


\(^{6}\) Wong. Betting on Biotech.

expected to promote the development of science and technology in a rational manner through central planning. Economic, social, and national defense needs would be identified through the bureaucracy’s planning process, and would then form the basis of research and development activities in centralized research institutions. In principle, this system was to produce effective networks of innovation. But, in actuality, the innovation systems of centrally planned economies were plagued by weak network formation except in areas of intensely managed national security missions.

During the early years of the People’s Republic, most of China’s leading technical personnel had been socialized into Western professional norms and took to the Soviet inspired approach of bureaucratic governance with considerable uneasiness. Nevertheless, by the mid-1950s an accommodation of views had begun and a “bureaucratic-professional” model of governance was beginning to emerge.\(^8\) This model was characterized by the direction of the R&D system by politically accountable officials (e.g., Nie Rongchen) who developed a sensitivity to the culture of science, and a technical community which was willing to acquiesce to the loss of autonomy in order to gain access to resources needed to support national development and defense. The onset of Maoist inspired radical politics in 1957 attenuated this approach. In spite of the reemergence of the bureaucratic-professional model in the early 1960s, the Cultural Revolution further disrupted its development, led to widespread disruptions of research and educational activities, and produced a governance environment that was antithetical to scientific and technological development. The extent to which the Cultural Revolution set back Chinese science and technology became apparent in the early 1970s as China’s East Asian neighbors began to demonstrate their own capacity for technological progress and as Chinese scientists and engineers began to interact with foreign counterparts in an expanding agenda of international exchanges.

By the early 1980s, it was clear to China’s leaders that China’s future wealth and power was intimately tied with its ability to build scientific and technological capability. The modernization of science and technology was identified as one of the “Four Modernizations,” and as foundational for the other three modernizations of agriculture, industry and national defense. Yet the institutional arrangements that would best promote the “modernization” of S&T were not clear. For some, a return to the pre-Cultural Revolution experience, built around the bureaucratic-professional model of the 1950s seemed the right way to go. This involved raising once again the status of trained scientists and engineers, a step towards greater professional governance, but also involved reestablishing bureaucratic structures and planning mechanisms that had had prominent roles before the Cultural Revolution. However, as exposure to the capitalist world grew, so too did the appeals of Western institutions and regulatory mechanisms for science and technology.

The new exposure to the West led to a wide range of reforms such as the initiation of the patent system, the introduction of competition in the awarding of government research support, the use of peer review mechanisms for judging that competition, and requirements that research institutions should face market forces in building their research portfolios. Such changes were captured in the important S&T reform of 1985 which attempted to overcome some of the “iron

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\(^8\) On the bureaucratic-professional model, as counterposed especially to mobilization models of the 1960s, see Richard P. Suttmeier, Research and Revolution: Science Policy and Societal Change in China (Lexington, MA: Lexington Books, 1974).
rice bowl” features of the inherited bureaucratic-professional model by adding competitive, market regulation elements and a greater role for professional judgment into its science and technology system. In doing so, it led to the slashing of guaranteed research budgets, or block grants, to institutions but also introduced more targeted national research programs, such as 863, inspired by the successes of the strategic weapons program, arguably the manifestation of the bureaucratic-professional approach at its best.

The insertion of principles of competition into a newly developing market system raised its own difficulties, however. For example, the early appeal to market forces in the late 1980s generally did not have the desired effect of stimulating the flow of Chinese-developed technology to industrial users, largely because of the immaturity of technology markets and the lack of managerial experience in both research and production enterprises. Market forces did, however, encourage Chinese enterprises to meet their technological needs by tapping into international technology transfer channels that were becoming more readily available, but this frustrated attempts to build stronger research to production linkages in China in spite of the fact that the scaling back of government support for research forced research institutes and universities to seek support from commercial interests. This left a legacy of commercialism in Chinese universities, but arguably, may have also worked against the development of a strong basic science tradition to serve China’s longer-term needs.

Throughout the 1990s, the search for the right formula for blending state initiatives with market forces persisted, and by the middle of the decade the formula, wenzhu yitou, fangkai yipian (“anchor one end securely, free up the other”) was taken as a guide to policy. While intending to legitimate a new balance between state (the anchoring mechanism) and market forces, the formula was not without its ambiguities. With the growing influence of the literature on national innovation systems, by the end of the decade China had convened a national conference on innovation in 1998 and began to show a new awareness of the importance of commercial innovation activities and the role of indirect policy instruments (as opposed to direct state support for R&D) in encouraging these. Yet, the persistent weak R&D capabilities of Chinese firms, and the growing influence of foreign corporations on China’s technological development, meant that basing hopes for the national innovation system on Chinese firms in the free market entailed undesirable risks. Thus, the complexities and unexpected consequences from reform initiatives again buttressed the position of those calling for a strong leading role for the state but also did not remove the fundamental question of the nature of the state’s role in supporting research and innovation.

III. Three Approaches to Governance and Regulation

As is evident from this brief review of the history of the PRC’s S & T governance, the experience of recent decades has left China a legacy of competing governance approaches. We

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shall see that the governance system for China’s S & T system has become a highly variegated and messy hybrid of these approaches, a system which defies simple characterization, but which nevertheless maintains a strong leading role for the state. 12

Several themes related to the sources and results of this complexity run through this chapter. First, as will quickly become clear, it is in some ways a fiction to treat each approach separately; they overlap substantially. 13 In particular, it is evident that, in all countries, state S & T policy provides a framework for enabling technical professionals and market actors, not simply restricting them. The pertinent questions are: what are the right proportions in the mix and what proportions produce the desired results? To analogize, while state planning and free markets are two ideal visions for economic activity, all economic systems are characterized by some mix of the two. Second, while aspects of the approaches overlap and can be combined to good effect, it often has proven difficult in China (and elsewhere) to reconcile the varying goals inherent in the three approaches to governance. In particular, a continuing strong need for scientific practice to meet state-directed goals set by national programs, the control and management of which remains top-down, may not sufficiently foster bottom-up commercial innovation, despite efforts to encourage commercialization of technology. Finally, efforts to improve the institutional design of S & T governance can itself create problems. The Chinese government, as noted, has engaged in extensive reform of the S & T system. And yet reforms often are additive; market-centered reforms have been layered onto the bureaucratic-professional model, without far-reaching efforts – or success – at replacing the old model. 14 This exacerbates the well-documented fragmented and “stove-piped” nature of the Chinese bureaucracy. Indeed, fragmentation occurs despite extensive efforts to coordinate policy at the highest levels through plan-set goals (such as the 12th Five Year Plan) and institutional coordination as discussed in the chapters by Simon and Miller. This problem is far from unique to China, but is perhaps more pervasive.

A. Bureaucratic-Professional Governance

In ideal terms, bureaucratic-professional governance involves a process of determining and accommodating national interests (civilian and military), bureaucratic interests, and professional norms and the career interests of members of the research community attached to the state. The state is the decision-making principal, and often the manager or the agent as well. Incentives for scientists are designed to meet state goals. Generally, the direction of energy is top down. As the above description of the post-1949 S & T system makes clear, this bureaucratic-professional approach has dominated in the PRC even as it evolved over the years to meet a changing


14 The additive nature of regulatory reform is not unique to the S & T arena. In the area of industrial regulation, see Margaret M. Pearson, “Governing the Chinese Economy: Regulatory and Administrative Reform in the Service of the State,” Public Administration Review (Vol. 67, Issue 4, July-Aug. 2007).
environment. Certainly, during the reform era, the combination of marketization and internationalization have changed the way bureaucratic and professional values and procedures have been understood and expressed. Yet at the same time, certain enduring features of the Party-state have ensured that the realm of change is limited.

The source of authority for the Chinese state-directed regulatory environment begins with major pronouncements about the direction of science and technology from the political elite, with Deng Xiaoping, Jiang Zemin, and the Hu-Wen leadership all issuing important instructions. Typically, these pronouncements are short on specifics and must then be interpreted by relevant ministerial level bureaucratic entities. As the chapters by Miller and Chen point out, efforts to provide policy focus and ministerial coordination are centered in the Science and Education Leading Group under the State Council. An additional source of authority, the “Law of the People’s Republic of China on Progress of Science and Technology” (hereafter, “S&T Progress Law”), was adopted in revised form by the Standing Committee of the 10th National People’s Congress and promulgated in July 2008. The Law lays out the broad outlines of the state’s responsibility for science and technology, and as with all leadership directives, allows for more specific regulations from other entities.

A fundamental tenet of China’s approach is that the research system should be guided by national plans in which efforts are made to integrate national needs and objectives with scientific and technological development opportunities as seen by the technical community of scientists and engineers. The more important of these plans, of course, are the five-year plans and the special science and technology development plans that have been introduced at various times over the past 60 years. At present, the planning environment is defined by the Medium to Long-Term Plan (MLP) (2006-2020), the 12th Five Year Plan for National and Social Development, the 12th Five year Plan for National Scientific and Technological Development, and the 12th Five Year Plan For the Development Of Strategic Emerging Industries. Although scientists and engineers play active roles in the development of these plans, in essence, this planning tradition reflects a belief that national scientific and technological development can be left neither to the vagaries of market forces nor to the governance procedures of the technical community. Instead, in this view, when properly done, planning can rationalize the integration of ends and means and provide the basis for mobilizing resources for a comprehensive development strategy. Thus, the plans for S&T are complemented by plans for talent development, education, intellectual property development and management, etc.

As the planning structure becomes operational, bureaucratic interests and procedures pertaining to program and project selection, budgeting, personnel, and evaluation emerge as key elements of the governance system. As the chapter by Zhi Qiang illustrates, with regard to

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18 While we rightly often think of pervasive bureaucratic intrusions into the Chinese research environment, other countries are not without their “regulatory burdens.” Discussions in the US, for instance, have identified excessive regulatory requirements faced by US universities on such matters as human subjects, animal research, export controls, level of effort and financial reporting, conflict of interest and research integrity, use of toxins and
project selection and program definition, the relationships between scientists and bureaucrats has varied over time, with the role of the former being expanded somewhat since 2000. At the Chinese Academy of Sciences (CAS) and the leading universities, for instance, scientists play an important role in shaping the research environment. Yet the context of their work is strongly influence by national plan objectives and bureaucratic rules and incentives, with research personnel subject to regulations issued by MOST, the NSFC, and the Ministries of Finance and Personnel. In spite of opportunities for bottom-up initiatives, overall, the Chinese research system thus reflects the dominant influences of bureaucratic structure and procedures which are strongly biased towards top down direction of the national research agenda. Below, we explore these bureaucratic influences in the key issues of personnel, budgeting, and evaluation. In all three realms, recent reforms have attempted to bring norms more associated with professionalism and market-oriented models – competition, workforce mobility, etc.- to the bureaucratic model. It is also evident that these reforms have not been a panacea, and problems remain.

**Personnel.**

The PRC government has made extensive efforts over the past 30 years to upgrade bureaucratic capacity throughout the political system, with the need for technical expertise in the S&T sector getting special attention. Trained scientists or technical experts have been recruited into all levels of government positions, and since 1984, the four ministers of Science and Technology (Song Jian, Zhu Lilan, Xu Guanhua and Wan Gang) have all been scientists in contrast to their predecessors (Nie Rongzhen and Fang Yi) both of whom had mainly “revolutionary” credentials. In MoST, competitive recruitment and promotion have been institutionalized in recent years; positions ranging from entry level to departmental level are open for competition. Moreover, hierarchies within an institution, and across institutions, have been rationalized and promotions based on objective merit criteria have been introduced. In particular, all potential candidates were required to meet requirements set at a particular “rank” (jibie), or to have recognized professional titles (zhicheng). However, as in other Chinese organizations, despite the adoption of modern bureaucratic procedures, the management of civil servants ultimately remains under the control of the CCP. “Party Control of Cadres” (dang guan ganbu) remains a main principle in personnel management, as stated in the Civil Service Law (Article 4). In practice, potential candidates should first be examined by the relevant CCP committee; indeed, political control over the bureaucracy has become stronger in recent years.

While changes in the civil service have led to more professionalized staff in government agencies administering S&T programs, most scientists and engineers who work for public research institutes (PRIs) or public universities are not, strictly speaking, considered civil servants. In China, both the PRIs and public universities are categorized in the Chinese

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hazardous materials, many of which have become more demanding in the post-9/11 security environment. See, Smith, Trapani, DeCrappeo, and Kennedy, “Reforming Regulation of Research Universities.”

19 Article 13 of the S&T Progress Law thus calls for active participation of the professional community in policy development, but also stresses the importance of “macro control” by the state.


institutional order as *shiye danwei* (public service units) as opposed to Party or government entities (*dangzheng jiguan*), state owned enterprises (*guoying qi ye*), and state-sponsored social organizations (*shetuan*). In 2011, there were some 1.2 million *shiye danwei*, of all types, employing 30 million people, including approximately 47% of China's professional manpower. The staffs of *si

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e danwei* participate in the same civil service system as civil servants with regard to recruitment, pensions, health benefits, and basic salary, but they are also eligible for other sorts of income which are formally denied civil servants. These entities are subject to the general personnel policies made for *shiye danwei* by Ministry of Human Resources and Social Security.

Since the initiation of market reforms in mid-1980s, the *shiye danwei* have posed particular difficulties. Attempts at reform have been motivated by the desire to reduce the size of the state, and have been built upon distinctions between the provision of public and private goods. As of 2005, the state was funding approximately 40% of *shiye danwei* budgets, with most of the rest coming from service fees (hospital fees, university tuition, etc.). As incentivized by the current system, individual researchers often seek to achieve a “public service post” (*shiye bianzhi*), which guarantees them a lifelong position at a single institute, discourages their moving to other organizations that might better utilize their talents and capabilities, and promotes the quest for a higher rank within the hierarchy, so as to obtain more power and resources. However, salaries of researchers in public universities and PRIs are significantly lower than those for scientists and engineers in enterprises. It has proven difficult to keep the salary of PRI and university researchers at a level commensurate with their skill and education because the salary scale is set for *shiye danwei*, in general (including, for instance, elementary school teachers in rural areas). Thus, personnel policies associated with China’s categorization of institutions have created perverse incentives which have worked to promote income and power enhancement, and against the pursuit of research excellence.

In recent years, efforts have been made to improve the status of public R&D personnel. For example, since 2006, a “post appointment” (*gangwei pinren*) system has been implemented to standardize personnel management and to increase the mobility of S&T workforce. In this system, positions are open for competition, and researchers are to meet the requirements of these positions to obtain the posts. In addition, several national programs such as Recruitment Program of Global Experts (i.e. the Thousand Talents Program; *qianren jihua*) were developed to attract high-level talent worldwide. Especially important is that the Chinese government has recognized that the key personnel management problem is the “administrativization” (*xingzheng hua*) and bureaucratization of PRIs and public universities. Thus, it was proposed in the National Medium- and Long-Term Plan for the Development of Talents (2006-2020) that the government

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24 World Bank. p. 3

“gradually abolish the administrative rankings of public universities and PRIs, and overcome the tendency of administrativization.”

However, the issue is still being debated. In March, 2012, new guidelines for reform were introduced for a gradual transformation of the shiye danwei over the next five years. The key provisions of the guidelines call for a redefinition/reclassifications of diverse shiye danwei, for a change in the pension system which would put employees on a universal social security system (rather than a system maintained by the work unit), and for introducing a performance-based salary structure. According to the guidelines, those shiye danwei which are performing government functions should be integrated into the government agencies, or abolished. Shiye danwei capable of becoming self-supporting would be pushed into the market as enterprises. Those providing public goods, and which rely on government expenditures to function, would be subject to major reforms in management and structure, including the changes in pensions and performance-based remuneration.26

Absent effective reforms, confusion over the future of shiye danwei can also be expected to affect the behavior of individual researchers and research organizations as they seek to satisfy evaluation criteria and secure the resources necessary to do so. Thus, some of the problems with research administration, alluded to above, and the subject of current reform proposals, are really larger systemic problems stemming from uncertainties brought about by complex institutional categorization and resulting confusion. One of the more important objectives of the "Knowledge Innovation Program" of CAS, discussed in the chapter by Suttmeier and Shi, was to reform the management structure in ways that reduce many of these ambiguities.

**Budget and Finance**

Budgeting is a major tool of bureaucratic governance, and has a strong impact on the S & T research environment in China. The budget process in the Chinese government follows the procedure known as “two up two down.” Firstly, the budget units, i.e. central departments, submit an initial draft budget request to Ministry of Finance (MoF) (the first “up”). In the budget draft, the departments are to provide detailed information about proposed activities and relevant costs, and to justify all the programs included as fully as possible. The MoF reviews the requests and sets an upper limit budget number (yusuan kongzhishu) for each department (the first “down”). Based on the number, the central departments should revise and resubmit a second draft budget to the MoF (the second “up”). At that point, the MoF will assemble all the budget requests from different departments and submit the integrated budget proposal to the State Council and then the National People’s Congress (NPC) for approval.27 After passage by the NPC, the MoF will send the final budget resolution to each budget units (the second “down”).

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27 Before the PRC budget reform initiated in 1999, the government budget was compiled based on functions of expenditures without being broken down by department details. What’s more, there existed a large amount of extra-budget income that were collected by departments to directly meet their needs, income that was beyond the supervision of the NPC. Budget reform initiated in 1999 changed the basis of budget making from categories of functions (such as capital construction, government administration and national defense) to government departments (bumen yusuan). The reforms also required the budget to be submitted to the legislature earlier so as to allow enough time for review.
It is clear that the NPC exerts a relatively feeble influence compared with its legislative counterparts in typical western countries. The NPC does not have authority to amend budget proposals but must choose either to approve or disapprove. In practice the budget proposal from MoF will therefore always be passed as a package.\(^28\) Moreover, several ministries other than the MoF also have authority to allocate certain types of funds. For example, MoST has authority to allocate some public R&D funds without effective oversight from the NPC or the MoF, a practice which weakens national political accountability for the use of budgetary funds.

The principal R&D funding modes also have shifted significantly during past three decades. In the early 1980s, public sector R&D activities were subject to central planning, and were supported through block grants, with the amount of money hinging on the size of the personnel roster of the institute. Since 1985, the central government established a number of national S&T programs and foundations that were to be allocated project funding on a competitive basis. This gradually became the major channel for support of public R&D activities. In 2002, the project-oriented system (\textit{ketizhi}) was formally brought into the management of national S&T programs, displacing the traditional institute-oriented system. A survey conducted by Ministry of Finance showed that in 2006, the share of public research funding allocated through competitive mechanisms accounted for almost 80\% of the total funds.\(^29\)

In recent years, the public R&D funding system has increasingly been criticized for putting too much emphasis on competitive mechanisms. At the same time, the practice of block funding was reduced to the point where it cannot support the operation of the institutes. Researchers who are supposed to undertake R&D tasks assigned by the state have to spend much of their time seeking additional project funding, a situation which works against the successful implementation of top-down planning initiatives. In recent years, several national programs have been developed to increase the proportion of non-competitive funding, such as the \textit{Fundamental Research Funds for the Central Public-interest Research Institutes} (2006) and the \textit{Fundamental Research Funds for the Central Universities}. However, the problem persists. In addition, researchers complain that there are too many restrictions put upon the use of public research funds. For example, in most national R&D projects, the proportion of grants that can be used for salary support has been quite limited (until recently, often no more than 10\%), typically not enough to pay for graduate students and postdoctoral researchers. As a result, the actual cost of projects cannot be fully covered by the grants if the regulations are strictly followed. Not surprisingly, this contributes to a hypercompetitive research environment characterized by a bottom-up grant seeking entrepreneurship which departs from the tenets of coherent national planning and invites misconduct. As one Chinese administrator put it, there is considerably more effective top-down direction and control in research programs administered by US federal agencies than there is in the ambitiously planned China.\(^30\)

\textit{Research Evaluation.}


\(^29\) Interview, 2011-08-09.

\(^30\) Personal communication.
Since the 1980s, but especially after the early 1990s, China has been paying much more attention to formal processes of research evaluation. The interest in evaluation was stimulated, in part, by observing trends in the OECD countries, where evaluation was becoming more formalized and systematized as part of the various "new public management" trends in member countries. But, in addition, changes in the Chinese research system - especially the movement towards competitive grant making and the introduction of national programs - also stimulated thinking about evaluation as an instrument of management and control.

Formal evaluation activities began in CAS as early as 1982, expanded with the establishment of NSFC in 1985, and took on additional importance with the birth of analytical work in scientometrics (which permitted improved benchmarking) in the late 1980s. In 1997, MoST established the National Center for Science and Technology Evaluation which has done a number of important studies, including a review of the 863 program and, more recently, provided support for the international evaluation team reviewing 25 years of NSFC activities. The work of evaluation involves reviews of both programs and projects, as well as the performance of institutions and individual researchers, and has become a major factor - and source of contestation - in shaping the implementation of science and technology policies. Bureaucratic interests in identifying quantifiable indicators of performance, leading to a heavy emphasis on published papers and patents granted as success indicators (rather than qualitative assessments requiring professional judgments), is increasingly seen as a source of many of the pathologies now affecting the research system. But evaluation also plays a key role in the widespread practice of international benchmarking which has become a signature feature of Chinese approaches to governance.

B. The Promise and Perils of Professional Governance

There is a long tradition in science which celebrates the self-governing nature of scientific activities. This tradition is related to ideals of professionalism, often seen as a “grand bargain” in which professionals gain sufficient autonomy to exercise complex judgments based on their expertise in return for a commitment to serving important public values rather than short term monetary interests. This ideal is premised on the idea that certain tasks require high levels of expert autonomy afforded by neither the commercial considerations of markets nor the political considerations of governments; markets and governments may intrude on the ability of experts to do neutral work. A classic formulation of professional governance in science was Michael Polanyi’s "Republic of Science" article offering a "political and economic theory" of how the community of scientists operates. Sociologists of science, such as Robert Merton and Warren Hagstrom, have also called attention to the importance of self-governing mechanisms within the

scientific community based upon shared norms, principles of exchange of ideas, and mechanisms of social control.33

Over time, however, science has had to accommodate itself to social pressures in ways that may compromise these conditions. As research became more expensive, government and/or industrial funding has become essential but, in turn, expected accountability from scientists that limited autonomy. In some cases, for instance involving national security or proprietary knowledge claims, open communication within the scientific community is constrained. In addition, a variety of social values are now imposed on the scientific community, thus forcing extra scientific considerations into decision-making and making the regulation of science a far more complex activity than that envisioned by the early defenders of self-governance.34

The role of technical professionals in the governance of Chinese science has changed dramatically from the Cultural Revolution years when scientists and engineers were routinely denounced as members of the "stinking ninth category." Technical professionals now enjoy status and privileges that are not available to the average Chinese. They are routinely consulted on important policy matters and, as we have seen, are involved in decision-making on research program design, project selection, and evaluation. As Cao Cong’s chapter indicates, efforts are being made in CAS to further strengthen professional values and professional governance mechanisms.

In many ways, though, Chinese scientists and engineers do not function as a professional community in the governance of the research system. In the first instance, there are significant political and institutional limitations on professional autonomy. The voluntary nature of professional association which is the default condition in most of the countries of the OECD world is precluded by the tenets of the Chinese Communist Party which require political control over associational life. Chinese professional societies, and their peak organization, the Chinese Association of Science and Technology (CAST) are understood as mass organizations under Party control. To be sure, during the post-Mao era, professional values and concerns have become far more central to the operation of these organizations, but they remain fundamentally different from Western professional societies, which ideally would distinguish between partisan considerations of the regime and a scientifically determined statement of the public good. Party control over universities also limit the development of high levels of autonomous faculty governance. As a result, in universities as in other science-oriented institutions, development of a strong professional identity, which could be the basis for enhanced professional regulation, has been attenuated. China thus misses out on an important redundant source of governance which could serve its concerns for evaluation, quality control, and scientific integrity.

As suggested above, the operation of the research funding system creates a dependency on the state which makes the rendering of independent professional judgments quite difficult. As critics such as Rao Yi and Shi Yigong have noted, there are powerful forces operating in the research system which put a premium on the cultivation of officials by researchers in ways that


both contribute to scientific misconduct and constrain autonomy.\textsuperscript{35} The absence of autonomous professional organizations further facilitates the development of this dependency, as does attitudes of \textit{xue er you ze shi}, i.e., the long tradition of linking academic accomplishment with service as an official.

The ways in which professional norms and values are limited by political and bureaucratic interests is illustrated in the implementation of peer review, and evaluation more generally, in approaches to the control of scientific misconduct, and in the ways in which scientists approach their fiduciary responsibilities \textit{vis a vis} complex technical issues affecting environmental protection, safety, and health. The introduction of peer review mechanisms in the 1980s, in conjunction with the introduction of competitive grants to replace block funding, was rightly seen as a step towards enhancing the role of professional values in the research system. Although there has been progress made in institutionalizing a peer review system with integrity, especially at NSFC, it is also the case that the system has been troubled by a shortage of qualified reviewers and inattention to the maintenance of confidentiality in reviews.\textsuperscript{36} As Zhi Qiang’s chapter notes, moreover, the relationships between scientists and bureaucrats in the administration of research programs has varied over time, but the role of the latter has certainly not diminished. This has given rise to widespread perceptions that the peer review process is often controlled by high status scientists who enjoy comfortable relationships with the program officials at funding agencies, and that funding decisions are complex functions of bureaucratic interests, scientific merit, and personal connections.\textsuperscript{37} The influence of bureaucratic values over professional values in the face of peer review problems is also evident in the operation of research evaluation activities which valorize quantitative measures of research output - publications, patents - over the more difficult qualitative assessments requiring peer review.\textsuperscript{38}

The problems of scientific misconduct in China are widespread and are inconsistent with both professional and bureaucratic principles.\textsuperscript{39} Not surprisingly, therefore, there have been efforts coming from both the state funding agencies and from CAST to promote ethical research conduct. Progress has been slow, however, in large part because the sanctions for misconduct are often quite mild, if they exist at all, and there is no robust professional governance to reinforce the laws regulations coming from the state pertaining to misconduct. As a result, the fight against

\begin{itemize}
    \item \textsuperscript{36} \textbf{Error! Main Document Only.} “International Evaluation of Funding and Management of the National Natural Science Foundation of China.” June 1, 2011.
    \item \textsuperscript{37} The S&T Progress Law (Article 57) calls for "Administration authorities for projects covered by the scientific and technological fund set up with government funds and projects covered by scientific and technological plans shall establish academic integrity files for the scientists and technicians involved in the project, which shall serve as the basis for appointing scientists and technicians to specialized technical posts or conferring on them academic titles, or for examination in granting their applications for scientific research and technological development projects."
    \item \textsuperscript{38} In an effort to promote sound peer-reviewed practices worldwide, the US National Science Foundation took the lead in sponsoring the first "Global Summit on Merit Review" in May 2012 at which the heads of the research councils of 50 countries met to discuss standards for good professional practice and released a set of six principles to guide professional merit review. These include expert assessment, transparency, impartiality, appropriateness, confidentiality, and integrity and ethical consideration. See, \url{http://www.nsf.gov/news/news_summ.jsp?org=NSF&cntn_id=124178&preview=false}.
    \item \textsuperscript{39} According to the S&T Progress Law (Article 44), "Scientific research and technological development institutions shall, in accordance with the provisions of their articles of association, conduct activities of scientific research and technological development; they shall not practice fraud in scientific and technological activities or participate in or support superstition."
\end{itemize}
misconduct often falls to individuals, such as Fang Shimin, to lead the campaign against misconduct using diverse tools of exposure and shaming, or the occasional leader of the research organization who is willing to use his/her authority to punish acts of plagiarism and fraud.\footnote{See for instance, David Cyranoski. "Research ethics: Zero tolerance." Nature, January 11, 2012. At http://www.nature.com/news/research-ethics-zero-tolerance-1.9756. Article 70 of the S and T Progress Law states that when a scientist commits an act of misconduct, "... the unit which he belongs to or the competent department of the unit shall order him to make rectification and shall, according to law, give sanctions to the leading person directly in charge and the other persons directly responsible; the government funds earmarked for scientific and technological progress he has obtained and his illegal gains, if any, shall be recovered by the relevant competent department; and if the circumstances are serious, said unit or department shall make known to the public the violations committed by the scientists or technician and shall, within a certain period of time, prohibit him from applying for any project covered by the national scientific and technological fund or by the national scientific and technological plans."}

China faces an increasing number of important public policy issues involving complex technical considerations - environmental degradation, food and drug safety, nuclear power, etc. These call for responsible professional judgments from the technical community. When we look at these cases, however, we again see tensions and conflicts between bureaucratic and professional values. Consider the case of tobacco research, for instance. When Xie Jianping, deputy director of the Zhengzhou Tobacco Research Institute was elected to the Chinese Academy of Engineering in December, 2011, the act could readily be interpreted as a manifestation of bureaucratic values - a reward for a scientist who had faithfully served an Institute belonging to the China National Tobacco Corporation, a state entity that earned $79 billion in revenue in 2010. Subsequently the tobacco industry nominated a project entitled, "Formulation and Application of a Theoretical System for Chinese Cigarettes," for a 2012 National Science and Technology Progress Award offered by MoST. Again, we see the close relationship between science and economic interests of the state. In both cases, however, other parts of the technical community reacted strongly in criticizing these actions, as inconsistent with sound principles of national public health, out of a sense of professional fiduciary responsibility.\footnote{See, "Tobacco Scientist's Election Tars Academy's Image." Science. Vol. 335 (13 January, 2012). p.153; "A New Uproar over Chinese Tobacco Research." Science. Vol. 336 (20 April, 2012). p. 280.}

The case of genetically modified crops is also telling. Research on genetic modification has been part of national research planning for a number of years and enjoys the endorsement of much of the technical community. On the other hand, there are also a significant number of scientists who have urged caution in the actual use of genetically modified seeds, especially with regard to rice. Until recently, the momentum has tended to be with the bureaucratic-professional alliance of proponents of GM crops. In the last several years, however, deliberations over the issue have been influenced by the actions of Greenpeace and other activist groups, including the new left group, Utopia. This has led to a draft proposal from the State Council in early 2012 that would lead to legislation to restrict "research, field trials, production, sale, import and export of genetically engineered grain seeds."\footnote{See, Monica Tan. "China Shuts Down GE Rice?" At, http://www.monica-tan.com/2012/02/china-shuts-down-ge-rice/; see also, "Activists Go on Warpath Against Transgenic Crops - and Scientists." Science. Vol. 331 (25 February, 2011). pp. 1000-1001.}

The rise of these complex issues of science, technology and society, requiring sound "regulatory science," are not surprising given the trajectory of China's scientific and
technological development and, not surprisingly, create new challenges for bureaucratic-professional approaches to governance. The emergence of NGOs and activist groups, reminiscent of similar developments of other societies facing new types of technological risks, suggests that further modifications of the bureaucratic-professional model - allowing for greater inclusiveness - may also require a place on the reform agenda.43

C. The Market-Oriented Approach.

If energy in the bureaucratic-professional model tends to be top-down, the opposite, in principle, is true in a market-centered vision. Research and innovation activities are assumed to grow out of the identification of commercial opportunities in the marketplace. These are then matched with pools of technical knowledge, when available, and/or lead to R&D activities targeted on new products and processes which can lead to success in the market. Further, the products of science and technology circulate according to market rules. Scientists are employed predominantly in non-state organizations. Competition is seen as core to scientific development, even for public goods. In other words, in a market-oriented system incentivized actors located in the economic realm, rather than the state bureaucratic actors, take the lead in identifying whether, what, and how technology development and innovation should proceed. Such a system naturally orients S & T endeavors toward research achievements that can be monetized in the short- or long-run. The approach also tends to assumes that scientific success cannot necessarily be identified ex ante by state actors; in other words, the government will not be in the business of “picking winners.”44 Instead, market forces are expected to drive technological choices in a politically neutral regulatory environment. The role of the state is limited to supporting the rule of law, including a well functioning regime for the protection of intellectual property, maintaining the integrity of the financial system, and ensuring competition..

In fits and starts since the onset of economic reforms begun in the 1980s, the Chinese government has endeavored to devise a national innovation system suitable for a market economy. Previous discussion in this chapter has made clear the attraction of the PRC government to norms of competition. Market-oriented reform efforts also have been driven by the specific problem of overcoming the separation between research and production, a distinctive legacy of the Soviet approach to designing a national innovation system. As Chinese exposure to the capitalist world deepened, beginning in the 1980s, its leaders began to more fully understand that the innovativeness of capitalist economies was related to the critical role that industrial corporations played in the national innovation system (in ways that are quite foreign to the Soviet model), and the fact that private corporations in fact sponsored a large share of the R&D in capitalist countries in their own corporate laboratories or in cooperative relations with universities or government research institutes. Reformers seeking to move beyond technological “catch-up” to create a science-driven society in which China contributes to and benefits from advances at the frontiers of scientific and technological knowledge and practice, expect to draw heavily on Chinese firm behavior.


44 Great skepticism also has been expressed in the US over picking technology winners, as exemplified by the problematic loan guarantees by the Obama administration to solar panel maker Solyndra.
This re-orientation is reflected in critical planning documents - the 15 Year Medium-to-Long Term Plan for Science and Technology (2006-2010), and the 11th (2006-10) and 12th (2011-15) S&T five year plans – which all stress the importance of firms as key actors in S & T development. The value of private firms (as opposed to state-owned enterprises) appears to be increasingly recognized as perhaps more responsive to market demand and more capable of successful innovation for both domestic and international markets. Recognizing the potential for contributions by private firms, from 2002 to 2007 central government funding for private firms grew faster than for other institutions (SOEs, universities, and government-led research institutes), although the absolute amounts remained small. Private firms have been given a key role in some government-led consortia.45

The development of a market-oriented model in China, therefore, has involved complex, multifaceted initiatives to stimulate transfers of technology to enterprises from research centers in universities and government research institutes, and has sought the transformation of firms into innovation-seeking entities having the desires and capabilities to manage research and innovation activities. A variety of policies to implement the 1985 Central Committee decision to reform China’s S & T system provided incentives for the spin-off of new technology firms from universities and research centers. Some of the most prominent of these firms have their roots in the high-tech zone of Beijing’s Zhongguancun Science Park.46

Just as significant is the effort to provide a broader policy and institutional ecosystem that can enable market driven innovation. It is this need for the state to provide a “proper” environment for the non-state sector’s ability to foster innovation that most clearly has demonstrated, internationally, the hybridization of governance models. China’s reform trajectory is no different, as it has embarked on numerous efforts to create a governance infrastructure that will support the market, and presumably could permit a partial withdrawal of the state. Examples of such efforts include the building of an intellectual property regime and competition policy, efforts to develop a venture financing system, preferential tax and government procurement policies, as well as R&D subsidies from the government.47

Despite the general assumption that markets may be more successful at inducing technological innovation, extensive reliance on the guidance of markets has three widely recognized pathologies. As in other countries, Chinese authorities recognize these problems of market-oriented models, and have tried to fine-tune policy to anticipate or react to them. First, firms in market systems have a tendency to underinvest in R&D (especially basic research). This is particularly evident in developing countries such as China, where firms operating in market conditions have advanced their technological capacities by acquiring foreign technology rather than investing in their own R&D. As a result, the state maintains an active role as a key driver even as it encourages greater reliance on market forces.

A second challenge for market-oriented systems arises from the generation of negative externalities from market transactions: tendencies toward monopoly, failure to provide public goods, and the production of “public bads” such as environmental degradation and unsafe products and working conditions. The need to compensate for these failures has meant that

46 On these incentives stemming from the 1985 policy shift, see Liu, Simon, et all (2011).
47 Many of these efforts are described in OECD. 2008. Reviews of Innovation Policy for China. (Paris: OECD Publishing)
market-oriented models legitimate a continuing role for the state, including in regulation – again, producing a hybrid system of governance. In other words, market-oriented models have increasingly become paired with models of government regulation intended to make markets work better. Economic regulation exists to promote fairness in the market. While economic regulation is most often associated with anti-monopoly (pro-competition) policy, in the case of S & T development in China perhaps the clearest indication has been the development of laws to promote and protect (private) intellectual property. A second form of regulation – social regulation - is designed to protect the public against externalities produced by scientific innovation undertaken for private gain, externalities such as pollution, fraudulent goods (such as pharmaceuticals), or possibly dangerous activities (as is often claimed for genetic alterations made in biotechnology).

As a result, market-oriented reforms have helped induce the turn toward foreign regulatory models, especially those that originated in the US but have now spread through much of the world. The hallmark of the model is the establishment of regulators, who balance the promotion of the good that can come from private actors and protect against the bad. Ideally these regulators are “independent,” meaning they maintain organizational autonomy from both political (and politicized) actors who might act arbitrarily, and from private actors who might try to “capture” regulators. The PRC government began in 1998, and accelerated after 2003, the effort to create regulatory bodies that, to some degree, were to follow this model. “Social regulators” to protect consumer interests against externalities that are related to scientific endeavor include the State Environmental Protection Agency and the State Food and Drug Administration. But as seen in the field of telecommunications, the “independent regulator” – in this case, the MIIT – can also be the chief bureaucratic sponsor of the development of the industry.

While both political interference and regulatory “capture” are difficult to avoid even when institutions are well-entrenched, the context of China’s party-state bureaucracy and the role of the party have meant that political independence – and, indeed, effectiveness - has met enormous challenges. Indeed, despite the PRC’s explicit adoption of aspects of the “regulatory state” model, the aspirations inherent in this model are undermined by the strength of the bureaucratic-professional model and by legitimate party interventions. One of the most serious pathologies of the new social regulators is that they do not have sufficient authority to operate effectively. For example, the SFDA has had insufficient authority, backed by legal tools, to effectively guarantee safe practices in the pharmaceuticals industry, and well-documented health scandals have ensued. Many economic regulators, such as MIIT for telecom, have been created from old government ministries that also spawned the behemoth SOEs they are charged to regulate. In short, while new regulators have been created, older bureaucratic bodies have not adequately had their sails trimmed and remain as powerful, if not more so, than the official new regulators. Another challenge for regulatory development is that political intervention cannot

truly be removed from the system. Indeed, contrary to the Western ideal of the regulatory state, the party does interfere in regulatory matters, and has the legitimacy to do so.

A third widely recognized drawback of the market-oriented model relates directly to the difficulty of constructing an independent regulatory system, but focuses on the notion of regulatory capture. A hallmark of modern capitalist economies is of course the large conglomerate firm. Corporations undeniably play a huge role in setting both market conditions and public policy. Despite the promotion of anti-trust and competition policies, it remains extremely difficult to regulate large corporations, on which economies are so dependent.

Corporations are deeply entrenched in the life of research universities (such as the Novartis Institute located at the periphery of the MIT campus, or Chevron’s University Partnership Program to fund faculty, labs and students for work on energy issues) and their ability to lobby the US government is extensive. Similarly, in China, large SOEs that exist in sectors such as oil and telecommunications have extensive capacity to lobby the government and influence policy. We can only expect the government relations capacities of these large firms to grow even more formidable in the coming decades. If the PRC government’s regulatory capacities do not expand in kind, we are likely to see very deep challenges for the regulatory system in S&T.

Overall, the operation of the market-oriented model in China remains quite puzzling insofar as it remains unclear how successful the push for commercialization has been. On the one hand, recent national policy has consistently emphasized the importance of the enterprise sector becoming the center of the national innovation system. And, indeed, in looking at national R&D accounts, we now see the enterprise sector as a leader of both funding and performing R&D. Key firms, such as Huawei, spend generously on R&D at levels comparable to leading high-tech firms internationally, and have developed into important, technologically progressive companies in their industries largely in response to market forces. And yet other statistics indicate that, overall, Chinese firms do not spend much on R&D as a percentage of sales, and often prefer to meet their technological needs by acquiring, through various means, foreign technology.

Generalizing about a market-oriented model in China is therefore difficult. Market forces now play a very significant role in the operation of Chinese industrial enterprises, and in some cases, become a major driver of innovation. We see these classical “animal spirits” at work in the firms that constituted the “Shanzhai” culture of south China, we see them at work in some of the more innovative companies in the SOE sector, and we see them at work in the more knowledge intensive enterprises in high-technology zones and in the startups being formed by Chinese scientists and engineers returning from abroad. Yet the further development of a market-oriented regulatory regime will be constrained by the facts that so much of the nation’s science and engineering talent, and so much of the institutional infrastructure for research, remains in the universities and the Chinese Academy of Sciences. While increasingly affected by market forces, these institutions are nevertheless largely subject to bureaucratic-professional processes. There

53 See Ministry of Science and Technology, Science and Technology Statistics, Data Book, 2011. P. 8. To understand fully the operation of market-oriented incentives in support of science and technology, one also has to understand the regulatory environment for international technology transfers, a subject beyond the scope of this chapter.
is, in addition, a certain irony in the fact that many of the successes that have been realized in building a market-oriented model, have come as a result of the powerful pressures and incentives offered by the state.

**Concluding Thoughts**

The discussion above illustrates that the PRC – like other countries – mixes elements of our three different governance approaches into a hybrid system. But, as noted at the outset, the fundamental questions deal with proportions: how the elements of the models get mixed and what results are realized. It is hard to escape the notion that in China, more than in other countries that spend vast quantities on S & T, bureaucratic governance is dominant in the mix, or to mix metaphors, all roads lead back to the state. Thus, in spite of consistent calls to make enterprises the center of the national innovation system and promote market oriented innovation mechanisms, these tasks are seen as responsibilities of the state, discharged with a variety of promotional policies targeted at market players who often appear reluctant or incapable of taking on the challenges of innovation on their own. Thus, the latest reform document noted above, calls attention to the importance of R&D tax credits for enterprises, accelerated depreciation of equipment, state certification of high-technology achievements, R&D subsidies, etc. While such policy inducements, to be sure, are not unheard of in other countries, the inherent weaknesses for innovation of so much of the enterprise sector and the strong incentives for enhancing bureaucratic power within the state makes the strengthening of market-oriented mechanisms difficult. In short, there is much appreciation of letting the “market play a leading role,” but only in the context of government “macro control.” There is no doubt that the “macro control” show signs of becoming far more sophisticated and nuanced than it had been in the past, as seen for instance in the strengthening of programs for small and medium-size enterprises and the promotion of “collaborative innovation” (xielong chuangxin) through inter-sectoral strategic alliances, or networks, among firms, universities, and government research institutes. But the state is a long way from “retreating.”

As a developing country moving to modernize its stock and utilization of technology, it is not surprising that the state continues to play a central role. But, since at least the mid-1980s, as we have seen, Chinese leaders have understood that there are inherent limits to the effectiveness of the state, acting alone, in promoting modern science and technology. They have therefore sought to strengthen the role of professionalism in the bureaucratic professional approach, and to introduce robust market measures to further drive innovation. As we have seen, however, the ways in which the elements of these different models interact often produce perverse outcomes. While market forces clearly play a much more central role in the national innovation system, the very nature of the state has precluded the establishment of the neutral regulatory arrangements, noted above, which typically are required for a well functioning market-driven system of innovation. Similarly, the enhancement of professional governance mechanisms needed for an increasingly complex economy is also attenuated by the state and its political formula. The governance hybrid, therefore, appears increasingly incoherent in the ways in which different governing assumptions interact.

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Thus, the regulatory environment affecting such activities as grant making, personnel policies, and budgeting are seen as constraining the development of creative research and new innovations, and has led to an environment conducive to corruption and scientific misconduct. As a result, and despite previous reforms, the reform of the science and technology system is again on the agenda of national politics. Among all the items on the S & T reform agenda, the proximate question of greatest immediate importance remains the connection – or lack thereof - between science and technology and the economy (keji jingji liang zhang pi) which involves the ongoing efforts to build a market-oriented model while finding the proper role for the state.

These are bureaucratically and politically complex questions, but they are also questions of considerable importance for the success of China's science and technology aspirations. Further complicating this reform agenda is the more fundamental question of the constitutional status of many of the important institutions performing research and to China's current struggles with attempting to define the role of government in the research system. Most pressing, perhaps, is the reform of the shiye danwei system and the effort, essentially, to feed them into either the bureaucratic-professional system or the market-oriented system.

As the Chinese government has shown beyond the shadow of a doubt, it is willing to carry out round after round of reform on these and other issues. A new round of reform now seems imminent, and is likely to lead to a readjustment of the mix of all three elements. It is likely that the efforts will focus on strengthening a market orientation while also paying greater deference to the norms of professionalism. Accomplishing these goals while also protecting the state’s interests in research and innovation seems a bit like “squearing a circle.” Yet, China’s innovation aspirations are unlikely to be realized without readjustments in the ways the demands of the three approaches are accommodated.