Science and Public Policy **39** (2012) pp. 258–270
Advance Access published on 17 February 2012
doi:10.1093/scipol/scs006

Head in the clouds and feet on the ground: Research priority setting in China

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Few countries have increased their expenditure on R&D as rapidly as has China in recent years. However, so far, little academic attention has been paid to how decisions are taken and priorities set in Chinese research policy. This paper analyzes priority-setting in China's recent research policy. We find that China's research policy is driven by a variety of different, and sometimes conflicting, objectives, leading to a multitude of often overlapping initiatives. Secondly, mission- and excellence-driven research dominates over institution- and capacity-building and diffusion objectives. Thirdly, the process of setting research priorities is characterized by a combination of central goal articulation—top-down decision-making—and decentralization, deliberation and stakeholder consultation—bottom-up mechanisms. Aside from contributing to the understanding of China's research and innovation policy and system, this paper provides insights into policy change in China more generally and also into the processes which shape priority-setting in transition economies.

Keywords: China, science policy, research, innovation.

1. Introduction and problem definition

In recent years, there has been a rapidly growing interest in the development of science, technology and innovation (STI) in the People's Republic of China. So far, scholarly interest has focused on the overall evolution and design of China's science and technology (S&T) system (Ke 2004; Gu and Lundvall 2006; Mu and Qu 2008; Simon and Goldman 1989; Saich 1989; Suttmeier 1980; Wan 2008; Wang 1993), selected sectors and actors (Jakobson 2007; Zhang et al. 2009) or assessment of the state of its STI capabilities (D'Costa and Parayil 2009; Hu and Mathews 2008; Jakobson 2007; Lv 2007; OECD 2008; Zhou and Leydesdorff 2006). Surprisingly little attention has been paid, however, to how decisions are taken and priorities set in Chinese S&T policy (see, however, the primarily quantitative policy analysis in Liu et al. (2011)). We aim to remedy this by studying the processes and interests shaping the priorities in China's R&D programs and policies.

The choice of China may be motivated by its sheer importance in the world scientific system, where it is quickly moving from laggard to leader. The question remains how that transformation is related to policy practice, that is, how deeply the quantitative transformation of resource inputs has affected the design of the policy process. We argue that such a transformation of policy models is also underway, blending the traditional focus on large-scale missions with a pluralist funding of individual projects and scientific institutions, without strings attached to policy-oriented programs. Pluralism and elitism thus exist side by side. In this sense, the outline of a Chinese research policy model is therefore indicative of a more general policy change in China.

The emergence of a new priority-setting model has been driven by growing internal criticism of what are described as cumbersome and opaque allocation models. In an article in *People's Daily* in August 2010, prominent academics complained that the current S&T system is overfunded but institutionally weak (Zhao *et al.* 2010).

Similarly, in an editorial in *Science*, Shi and Rao (2010) argue that bureaucrats misuse or abuse the terms 'national needs' and 'expert opinions' to justify allocating research funding on grounds other than scientific excellence. As a result, they argue, the system for allocating funding is susceptible to various forms of rent-seeking and even corruption in lieu of transparent decision-making mechanisms. They claim that the current research system 'wastes resources, corrupts the spirit and stymies innovation' (Shi and Rao 2010). Such criticisms highlight a fundamental debate in Chinese science policy-making as to how research funding should be allocated and how research priorities should be set. That is, whether the massive spikes in public resources should be transmitted to universities and research councils, or whether they should be distributed through large-scale national programs, and which of these models may be best suited to fulfill the goal of making China a global scientific superpower (see also Hao 2008).

Critics of Chinese science policy-making portray it as strong on formulating high-level objectives but weak on building long-term capacity from below, where weak and impoverished universities co-exist with large scientific accomplishments such as the atomic bomb, hydrogen bombs, rocket missiles, and satellites (referred to as 'two bombs and one satellite'). Another ingredient in such accounts is that policy-making is shaped by highly politicized processes which relegate the scientific community and industry to secondary positions, even if individual scientists can become very powerful in certain fields of expertise (cf. Greenhalgh 2008). Thus, China can be clearly categorized as a top-down and centralized planning system, which focuses on large-scale accomplishments and numerical accomplishments, with a preference for grandiose plans.

Such stylized accounts fail, we will argue, to capture the dynamics of Chinese science policy-making, which are characterized by quickly, if somewhat unevenly, developing elements of both political planning and institutional empowerment, often under the political banner of 'controlled modernization'. This indicates that China is not moving towards a substitution of centralized research governance with a fully fledged pluralist system without strong coordinating mechanisms à la Russia after the Soviet period (Graham and Dezhina 2008). Neither is it opting for the type of soft, pluralist coordination that is emerging in many Western countries (cf. Braun 2008 on Europe; Block and Keller 2011 on the USA). Instead, China seems to be forging its own way with an evolving mixture of planning, decentralization and deliberation.

1.1 Trends in setting priorities

Explicit models for science policy priority-setting developed late and with great tensions. In his classic paper Weinberg (1963) formulated what later became a dominant mechanism for priority-setting in science policy in Western countries: the peer review system. With the tougher fiscal climate of the 1960s and 1970s and the rise of several political challenges, a new steering model emerged where political priorities invaded the decision-making process more explicitly (Elzinga 1985). Science policy-making has since been enmeshed with policies in other areas, reducing the professional autonomy of the scientific community in setting priorities (Ziman 1994). In the last decades, the rise of new public management within state administration has also had a major impact on science policy-making, where resources are increasingly tied to performance, goal attainment, and public accountability, and where public academic and government research institutions are expected to draw upon private resources (OECD 2003).

In most 'mature' research systems in Western societies, several models for priority-setting exist side by side: floor funding to universities, support streams for basic research via research councils, mission-oriented agencies, and strategic funds of various types constitute different policy layers, sometimes, but not always, under the coordinating umbrella of public research planning (Ruivo 1994). Today's mechanism for priority-setting in these countries is therefore a hybrid, sometimes drawing upon scientific expertise not only in low-level decision-making but also in the framing of societal challenges underlying science policy priorities (Pielke 2007), while at the same time devising and implementing mechanisms by which science can be put to productive use and where broader societal considerations inform priority-setting (Laredo and Mustar 2001; Braun 2008).

1.2 Analytical assumptions

On the basis of this discussion, we argue that research priority-setting may take the following (not mutually exclusive) directions: diffusion-oriented, mission-oriented, excellence-oriented, and oriented toward capability building. Ergas (1987) identifies two principal orientations of countries' technology policy: diffusion- and mission-orientation. While Ergas' categorization is useful, it needs to be complemented with two more dimensions. The first is excellence, in order to capture programs and policies which are primarily aimed at research quality (cf. Cantner and Pyke 2000). The second is related to institution- and capacity-building and governance of the S&T system, and in particular floor funding of academic institutions. Ergas' work and other attempts to classify technology policy (Cantner and Pyke 2000; Foray 2000) have generally focused on economically advanced countries and thus presuppose relatively well-developed and mature S&T institutions, basic capacities and governance mechanisms. However, emerging S&T systems, such as China's, combine rapid advances in S&T resources with significant

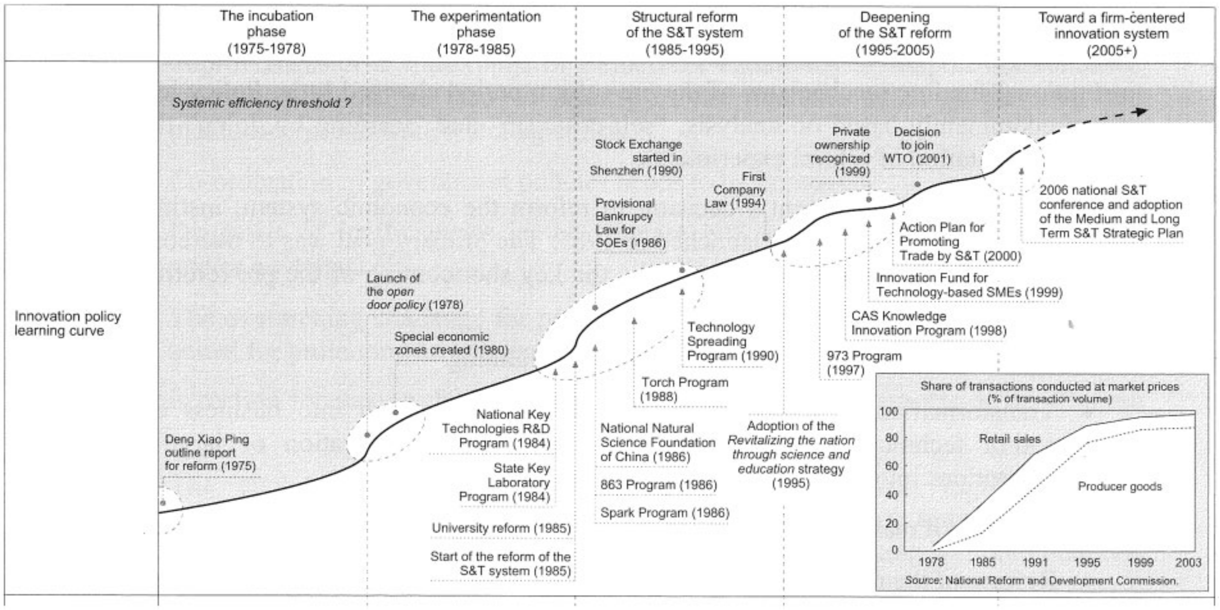


Figure 1. Phases in Chinese S&T policy making.
Source: OECD (2008: 72).

systemic immaturities regarding for example funding allocation mechanisms, and infrastructures for research. These systemic weaknesses place different demands on policy-making and thus require an additional category. While diffusion relates more to commercialization issues, institution- and capacity-building and governance refer to efforts aimed at creating basic foundations for research and innovation.

Thus, we address the following questions in this paper:

- How are research priorities set in China?
- What are its defining characteristics and practices: for which purposes is funding allocated, and which mechanisms are deployed?
- What is the distribution between support of diffusion, mission-orientation, excellence and capacity-building?
- Which interests do the funding model and the mixture of allocation streams reflect?
- How is the funding model related to current trends of 'coordinated decentralization' in science policy?

2. China's S&T system and policy: An overview

2.1 A short history

While China has a long history of scientific and technological discovery, in modern times it has lagged behind Western countries in S&T (Ke 2004). Beginning with the founding of People's Republic of China in 1949, a Socialist centralized S&T system was built in the 1950s by adding the Soviet model of centralized planning onto the S&T system that had emerged in the Republic of China (e.g. Wang 1993; Simon and Goldman 1989). Five S&T 'forces' or actors were identified: the Chinese Academy of Sciences (CAS), the public research institutes affiliated to the ministries, the public research institutes affiliated to the provincial governments, the universities and the national defense research institutes. These actors operated on the basis of a clear division of labor with little interaction between them. During the 'pre-reform period', the development of the S&T forces was frequently interrupted by political movements, especially during the Cultural Revolution (1966–76).

Overall, the pre-reform S&T system in China was characterized by a disconnection between research and commercialization on the one hand, and between research and education on the other hand, and by priority-setting clearly geared towards national defense-related projects in strategically targeted areas, like the hydrogen bomb, and the man-made satellite (Suttmeier 1989).

After the end of the Cultural Revolution, the direction of China's development policy, and with it its S&T policy, changed radically (Gu and Lundvall 2006; Simon and Goldman 1989), and can be summarized in four major phases since 1978: experimentation, structural reforms, deepening and the firm-centered phase (OECD 2008) (see Fig. 1).

The 1978 National Science Conference coincided with the launch of the economic reform and open-door policy and was an important watershed event for S&T in China. At the opening ceremony, then-Premier Deng Xiaoping declared that S&T were 'the productive force' rather than an ideological category, thus reinstating scientists and academics as 'respectable' members of society after they had been reviled and attacked during the Cultural Revolution and laying the foundation for a politically favorable environment for S&T. As China started the transition from a planned economy to a market economy, this entailed a reconstruction of the S&T institutes as well as the universities and, in particular, a modest connection between research and commercialization (for analyses of the transition see Feigenbaum 2003; Saich 1989; Suttmeier 1980).

The next phase, of structural reforms, began in the mid-1980s, when the China Communist Party Central Committee (CCPCC) issued policy documents outlining three major systems reforms: of the economic system in 1984, of the S&T system in 1985, and of the education system in 1985. The latter reforms focused primarily on the funding system, pushing scientists to seek funding from the market while launching the National Natural Science Foundation of China (NSFC) and national S&T programs for researchers to apply to on a competitive base. The 1985 reform has been described as:

> ...'highly systemic' in the sense that the focus was on re-shaping the division of labor and the interaction between producers and users of knowledge and innovation. (Gu and Lundvall 2006: 15)

The next phase, of deepening, occurred with the 14th Congress of the CCPCC (in 1992), which explicitly proposed to establish the Socialist market economy system. A decision on accelerating the progress of S&T was launched in 1995, proposing a national strategy entitled 'strategy of revitalizing the nation through science and education' (*kejiao xingguo*). The decision on 'acceleration of progress in S&T' marked a further step towards orienting S&T towards China's social and economic needs and towards linking STI efforts more closely with market forces and the private sector (US Embassy Beijing 1996). President Jiang Zemin also emphasized the importance of indigenous S&T capability. From the beginning of the reform period, S&T constituted one of the 'four modernizations' identified by Deng Xiaoping (and earlier by Zhou Enlai) as pillars of the reform, the other three being agriculture, industry and national defense. Throughout the era, Chinese leaders have pointed to science as a key to economic progress and competitiveness, most recently through the concept of 'scientific development' and the launching of the indigenous innovation strategy (e.g. Wen 2008).

2.2 Governance of the S&T system

An important element characterizing the governance of China's S&T system throughout the phases identified before is the strong involvement of China's top leaders in S&T decision-making. This is exemplified by the Leading Group on Science, Technology and Education of the State Council, created in 1998, and currently chaired by Prime Minister Wen Jiabao. The Ministry of S&T (MOST) plays a key role both through its responsibility for formulating S&T policy—for example in the Medium and Long-Term Plan and in the five-year plans for S&T development—and as a key dispenser of research funds (Springut et al. 2011). In formulating policy, MOST has a number of research institutes at its disposal, such as the Chinese Academy of S&T for Development (CASTED) but also the Institute for Policy Management at the CAS and academics at selected universities, such as Tsinghua. The Development Research Center under the State Council (DRC), a think tank, also contributes to setting overall policy directions through its analyses. The National Development Reform Commission (NDRC) and the Ministry of Finance influence S&T policy-making through their responsibilities for overall economic policy and the budget, respectively. Finally, provincial governments and S&T offices play an increasingly important role in setting priorities for industrial development, in funding research and in establishing research institutions (for an overview of key institutions and actors see also Kroll et al. (2010)).

Priority-setting in Chinese research policies and programs operates on different levels. The first level concerns ideology and overarching national strategy. The Chinese government's programmatic and overarching emphasis on a 'harmonious society' and, more recently, on 'indigenous innovation' as beacons of policy-making more generally, are examples of the first level of priority-setting, but also the fundamental policy stance on opening up China for trade and investment, for example through accession to the World Trade Organization and the policy of attracting foreign technology and investments. The second level concerns the formulation of medium- and long-term plans. The third level concerns the design of the national S&T programs, while the fourth stratum is at the level of research organizations (i.e. the CAS) and funding agencies (i.e. the NSFC).

At the meso-levels (level 3 and 4), priorities are set within the framework of long-term (and five-year) plans, and medium- and long-term plans for S&T (MLP). Thus China has continued on the Soviet model of using plans (*jihua*, or *guihua*) to drive the development of S&T, as well as economic and societal development.

The latest MLP was presented in February 2006 and lasts until 2020. It proposed guidelines which are expressed in 16 Chinese characters: indigenous innovation (*zizhu chuangxin*), leapfrogging in key areas (*zhongdian kuayue*), supporting economic and social development (*zhicheng fazhan*), leading the future (*yinling weilai*). Priorities expressed in the MLP include 'strategic priorities' (*zhanlue*

Table 1. China's R&D programs

Program	Starting year	Objective
6th Five-year Plan		
National Key Technologies R&D Program	1984	Foster key technologies to upgrade traditional industries and create new ones
State Key Laboratory Program	1984	Support selected laboratories in universities, public research institutes and firms
7th Five-year Plan		
Creation of NSFC, 1986		
National High-technology R&D Program (863 Program)	1986	Foster China's overall innovation capacity in high-tech sectors and enhance its international competitiveness
Spark Program	1986	Support technology transfer to rural areas and promote development of agriculture based on S&T achievements
State Key and New Product Program	1988	Support new high-tech products for key industries
9th Five-year Plan		
National Program on Key Basic Research Priorities (973 Program)	1997	Support basic research
Innovation Fund for Technology-based SMEs	1999	Support innovative activity by high-tech SMEs
Special Technology Development Project for Research Institutes	1999	Support central government-related technology development research institutes
Action Plan for Thriving Trade by Science and Technology	2000	Facilitate exports of high-tech products with high value-added and foster international competitiveness
10th Five-Year Plan		
Agriculture S&T Transfer Fund	2001	Foster development of S&T achievements in agriculture and diffusion of agricultural technologies
11th Five-Year Plan		
Mega-science Program	2006	Promote four top scientific areas
Mega-engineering Projects	2006	Promote technology and engineering projects with highly strategic national goals
Date of creation unknown		
International S&T Cooperation Plan	2001?	Use global S&T resources to develop critical technologies; provide a platform for international cooperation
State Engineering Technology Research Centers		Provide technologies and equipment to firms
Soft Science Research Program		Provide reliable scientific advice to national and local policy-makers

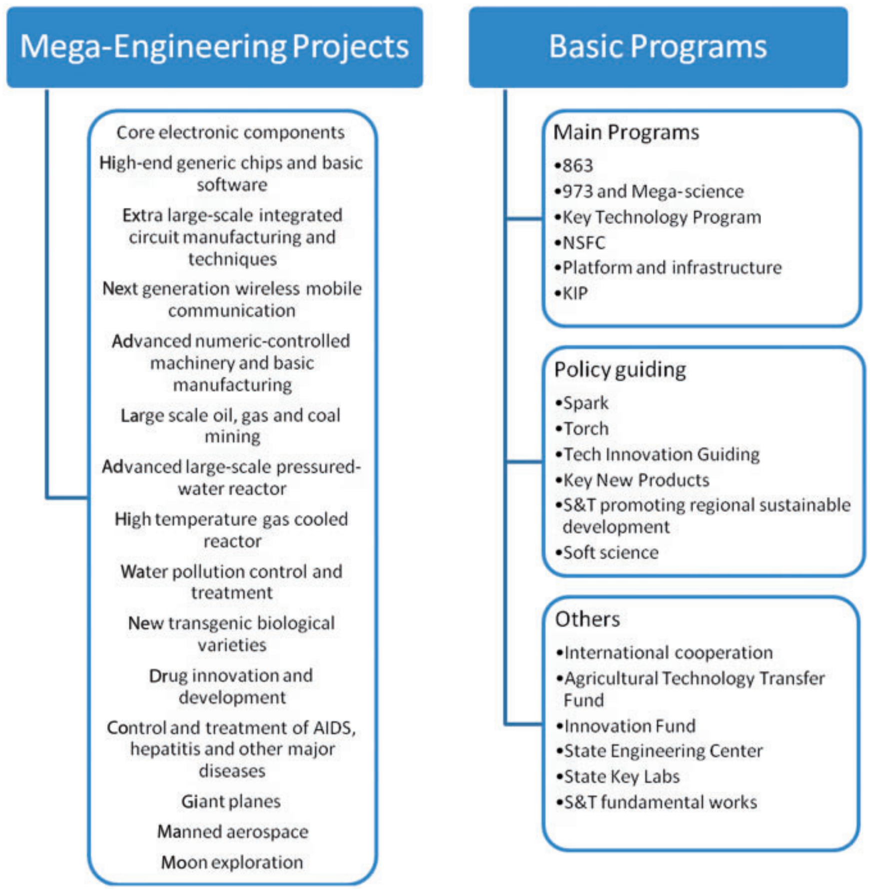
Source: OECD (2008) and MOST website (see Note 2).

zhongdian), 'key fields' and 'priority themes' (*zhongdian lingyu jiqi youxian zhuti*), 'mega-engineering projects' (*zhongda zhuanxiang*), 'frontier technologies', and 'basic research' (Cao et al. 2006; Schwaag Serger and Breidne 2007). So-called mega-engineering and mega-science projects are aimed at 'leapfrogging' in key areas, while key technology programs play the role of supporting economic development, oriented to priority fields and themes identified in the MLP.

In addition to the plans, research policy is structured and implemented by national S&T programs. China has launched various national S&T programs (*jihua*).[1] The most salient programs in recent history are the National Key Technologies R&D Program established in 1984, the State High-tech R&D Program (also known as the 863 Program), initiated in 1986 and the State Basic R&D Program (also known as the 973 Program), established in 1997. The 863 Program serves the goal of 'leading to the future' by supporting the development of frontier technologies. The 973 Program serves the same goal but focuses on strengthening basic research that addresses national strategic goals or needs.[2] In addition, there are programs which focus on strengthening agricultural and rural development research, on promoting the development of high-tech small and medium-sized enterprises (SMEs), on creating or supporting research institutes and labs, on increasing international cooperation etc. (see Table 1). The medium- and long-term plans and national S&T programs are not independent of each other. Rather they are connected, with the former guiding and providing an overarching framework for the latter (in their five-year plans).

The MOST recently proposed that the structure of national S&T programs be changed from the '3 + 2' (three core programs: National Key Technologies R&D Program, the 863 Program and the 973 Program; and two group programs: Construction of S&T Infrastructures and Construction of the S&T Industrialization Environment)[3] to 'basic + mega', reflecting the greater emphasis placed on basic research and infrastructure, but also on the allocation of resources into mission-driven activities (see Table 2).[4]

Table 2. Structure of national S&T programs



3. Setting priorities: Objectives and processes

3.1 Excellence, outcomes and goals: Classifying policy objectives

In this section, we attempt to disentangle the abundance of plans, programs and projects by examining which goals are pursued through the various priorities identified in the latest and largest plans and programs. Key data for expenditure by Central Government on the main S&T programs is shown in Table 3.

Fig. 2 classifies China's main S&T programs, based on data on national S&T programs provided in the *China Statistical Yearbook on Science and Technology* (2009). It can be argued that by definition, all programs will ultimately strengthen capacities and institutions. However, we argue that in the short- and medium-term, programs where academic excellence and 'missions' are clearly declared goals and where research and resources are concentrated in a few geographic or thematic centers of excellence can be juxtaposed with programs aimed at raising the general level of S&T throughout the country. We also distinguish between programs which focus on academic excellence as opposed to a mission. The majority of NSFC programs are obvious examples of programs targeting primarily academic excellence whereas the Mega-engineering Projects (for which, unfortunately there is a lack of data), the 863 Program and the Key Technologies Program, clearly identify specific 'missions' or targets which are to be funded or achieved. It should be noted that the negative values for the categories 'diffusion' and 'institution- and capacity-building' do not reflect a value judgment in the sense that these two categories might be inferior to the other two categories, 'excellence' and 'mission'. Rather they should be seen merely as a graphic tool enabling us to locate the programs visually in a four-axis diagram. While the four positions are not mutually exclusive, they illustrate the multifaceted nature of priority-setting: for instance, some emphasize concentration under the banner of excellence, while others focus on capacity-building.

Table 3. Allocations for S&T by Central Government in main S&T programs (in million RMB)

Item	2001	2002	2003	2004	2005	2006	2007	2008
NSFC	1598	1968	2049	2250	2701	3620	4331	5358
National Basic Research Program (973 Program)	589	686	800	897	983	1354	1648	1900
National High-tech R&D Program (863 Program)*			2974	3768	4025	3795	4440	5592
Key Technology R&D Program	1053	1338	1345	1614	1624	3000	5441	5066
National Science and Technology Infrastructure Program			100	593	573	754	686	24
S&T Basic Work	200	200	200			103	178	150
Special Technology Development Project for Research Institutions	158	214	193	183	186	200	250	250
Innovation Fund for Small Technology-based Firms	783	540	664	827	988	843	1256	1462
Spark Program	100	100	100	105	117	102	150	200
Torch Program	70	70	70	70	70	108	139	152
Agricultural S&T Transfer Fund	400	200	200	250	300	300	300	300
National Engineering Research Centers	50	50	50	86	60	84	86	
State Key Labs	130	130	130	130	134	216	1600	1605

Source: All data for programs, except data for 863 Program, are from National Bureau of Statistics, MOST (2009) (see Note 2) and China Statistical Yearbook on Science and Technology (2009).

*Data for 863 Program are from MOST (2009) (see Note 2), China Science and Technology Indicators (2008) and from <http://www.sts.org.cn> accessed 20 May 2011.

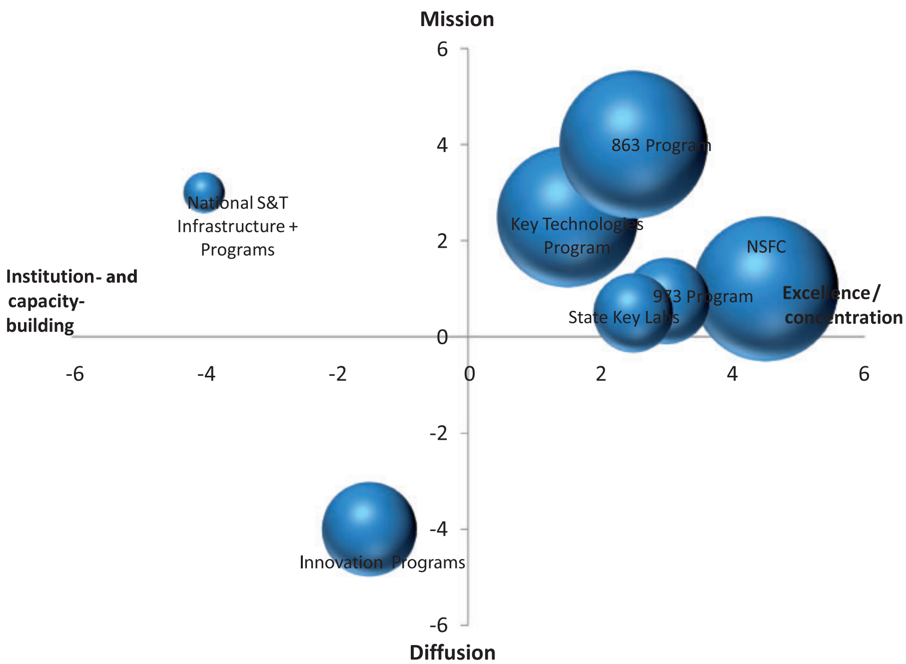


Figure 2. Weighting of funding in Chinese science policy.
Source: 2009 China Statistical Yearbook on Science and Technology Data from 2008.
Note: In order to simplify, some programs have been grouped into one 'bubble'. Thus, the 'Innofund + programs' includes Innofund, Spark, Torch, Agricultural S&T Transfer Fund, National Engineering Research Centers (data from 2007) and the New National Products Program. The 'National S&T Infrastructure + Programs' include the National S&T Infrastructure Program, the S&T Basic Work Program, the Special Technology Development Project for Research Institutions and the NSFC Fund for Less Developed Regions. The Mega-engineering Projects is missing due to lack of data.

By classifying national S&T programs into these categories, we reveal a strong emphasis of China's S&T programs on mission and academic excellence, as opposed to diffusion and building institutions and capacity. Secondly, there appears to be an overlap of programs with similar goals, both regarding thematic missions or technologies and the aim to strengthen. The concentration of resources in mission- and excellence-focused programs reflects a long-lasting orientation in Chinese research and innovation policy, tending towards tangible projects and activities rather than investments in infrastructure and diffusion.

One principal program, the Mega-engineering Projects is missing due to lack of data. However, though we do not know their exact size, we know they have a clear mission focus and as such should be located quite close to the 863 Program and the Key Technologies Program, further confirming that government S&T funding is strongly concentrated on mission-based research.

3.2 Mission

Traditionally, the S&T programs of the People's Republic of China have had a clear, and sometimes overwhelming, mission orientation, often identifying specific areas where radical innovations are sought. The 16 Mega-engineering Projects identified in the last MLP are clearly mission-oriented, selected to address major economic and societal needs, promote strategic industries, acquire proprietary core intellectual property rights, improve China's indigenous innovation capability, and improve industrial competitiveness and upgrade in general. While the mission orientation has remained prominent throughout the history of the People's Republic of China, there has been a trend towards increasing diversification of research priorities by including diffusion- but also excellence-oriented measures.

Another strongly mission-oriented program is the Key Technologies Program. Created in the 10th Five-year Plan, its major goal is to address pressing S&T issues for national economic and social development.[5]

Finally, the 863 Program has strong mission elements. By strengthening innovation capacity in selected fields it aims to improve the international competitiveness of major industries. It is very specific, listing for example the development of a high-speed train as one of its objectives.

3.3 Excellence or concentration

Several of China's plans and programs are clearly driven by and selected according to criteria of academic excellence, and by the desire to concentrate resources in centers or nodes of excellence. Perhaps the most obvious example is the NSFC, founded in 1986, which was strongly inspired by the US National Science Foundation. The NSFC was a product of the official reform of the S&T system which started in 1985. It is a public institution directly under the State Council and its financial resources come mainly from allocations by the Central Government, although the NSFC accepts donations from domestic and foreign individuals or other organizations. The NSFC's budget has increased spectacularly by about 20% per annum since its founding. In recent years, we have seen an increasing orientation by the NSFC towards funding economic and socially relevant research, though the criteria of excellence remain.

The majority of MOST's funds are allocated for strategic projects, where funding is on a much larger scale than for the vast majority of NSFC projects. The funding of the 973 Program by S&T fields is shown in Table 4. The most salient example is the 973 Projects where the average funding for one project is 30 million RMB, about 100 times larger than for a project within the NSFC's General Program.

The 973 Program also has clear academic excellence criteria. However, the selection of areas is guided by their ability to meet national strategic needs (in agriculture, energy, information, resources and environment, population and health, materials etc.). The objectives are to produce groundbreaking research that addresses important scientific issues concerning national economic and social development.

Strong research excellence criteria can also be found in the basic research part of the MLP, and in the mega-science projects which were launched as a new national S&T program after the MLP. The basic research policy in the MLP is expressed in four categories, and four priority areas, thus representing an ambition to square 'national needs' with 'science dynamics'. Hence,

Table 4. Allocation for S&T by Central Government in S&T programs by fields: the Case 973 Program (in million RMB)

Item	*2001*	*2002*	*2003*	*2004*	*2005*	*2006*	*2007*	*2008*
Total	589	686	800	897	983	1354	1648	1900
Agriculture science	100	86	84	105	109	111	145	170
Energy science	77	68	90	84	95	90	156	168
Information science	79	81	105	85	114	80	159	153
Environment science	138	108	150	105	146	125	153	182
Human and health science	89	114	131	167	209	150	194	261
Materials science	88	99	111	106	119	117	162	189
Synthesis science	18	130	110	230	191	170	161	175
Forefront of major science						136	161	207
National Special Science Research Program						375	353	396
Others			9	15				

Source: All data are from National Bureau of Statistics, MOST (see Note 2) and China Statistical Yearbook on Science and Technology (2009).

the ideal of planning also shapes and influences programs for excellence.

Finally, the State Key Laboratory Program seeks to concentrate resources in a few centers of excellence, with 96% of the 220 State Key Laboratories based at the roughly 100 universities identified through the 211 Program, and more than half of these are located at universities in Beijing or Shanghai (*People's Daily*, 'Over 10 billion Yuan to be invested in "211 Project"', 26 March 2008).[6]

3.4 Diffusion

The 'Torch' and 'Spark' Programs are clear-cut examples of diffusion-oriented measures, aiming at promoting the development of high-tech industry and the use of S&T in rural economic development, respectively. The MLP also contains clear elements of diffusion-orientation, such as a tax rebate for firms' R&D expenditures, as well as the identification of public procurement to promote enterprises' innovation capability. The Innovation Fund for SMEs, which provides loans to high-tech SMEs, is another diffusion measure, as are the Agricultural S&T Transfer Fund and the New National Products Program.

Overall, it could be argued that S&T spending by China's government spending has been focused more on generating knowledge than on utilizing it. This is not an uncommon phenomenon when compared with many other countries. However, the imbalance acquires greater significance when a country has insufficiently developed capital markets compared with countries where there are mature markets and channels for innovation funding. While there is an abundance of capital in China today, the funding system for commercialization of new firms, products and services suffers from several institutional shortcomings and weaknesses, both with regard to bank lending and venture capital funding (Fuller 2009; White et al. 2005). As a result, there is a severe shortage of innovation funding, particularly for private firms and for SMEs (*The Economist* 2009; 2011), further accentuating the bias against diffusion in the S&T programs.

3.5 Institution- and capacity-building

Several programs aim at building and strengthening China's emerging institutions and capacities. Within the S&T programs, the most obvious are the National S&T Infrastructure Fund and the NSFC Fund for less developed regions. Other programs with institution- and capacity-building features are the S&T Basic Program and the Special Technology Development Project for Research Institutions. However, total funding for these programs is small compared with programs such as the 863 Program, the Key Technologies Programs, and the NSFC Programs. While the latter three can be argued to result in institution- and capacity-building, their short-term and official focus is on specific goals, like 'leap-frogging' technological development and concentrating research resources in a few selected sectors.

Perhaps the most important investments in institution- and capacity-building are made in the field of education. Perhaps most importantly, programs such as the 211 Program and particularly the 985 Programs provide funding to a few 'elite' universities, while government funding of education, both as a percentage of gross domestic product and compared with education funding in other countries, is low. The 211 Program aims to create a critical mass of world-class universities in China. As mentioned, only around 100 universities are funded within the 211 Program, amounting to 6% of the total number of universities in 2008 (*People's Daily*, 'Over 10 billion Yuan to be invested in "211 Project"' 26 March 2008).[7]

Similarly, the purpose of the 985 Program, established in 1998, is to strengthen China's higher education system by funding around 40 universities out of a total of around 2,000 regular institutions of higher education in China (Marginson 2006). A further indication of the 'bipolar' nature of China's university system is that the top nine universities, or less than 0.5% of the total number of universities, account for around a quarter of all Chinese scientific publications and citations (Springut et al. 2011).

The Knowledge Innovation Program (KIP) launched in 1998 by the CAS is expected to result in a select group of research institutes which strengthen China's S&T system by conducting world-class research, transferring research results to industry, providing S&T policy advice, and linking China into the international S&T community. Recently, however, the KIP has increasingly linked research at its institutes to mission objectives, again reinforcing the focus on missions rather than institutional development (Suttmeier et al. 2006).

Overall, institution- and capacity-building have received much less attention and focus than mission or excellence as priorities which shape policy. This finding matches the conclusions drawn by Gu and Lundvall (2006) who argue that the investments in S&T have not been sufficiently supported by institutional development. In particular, they point to the need to strengthen 'learning-based economic development' and 'interactive learning'.

4. Priority setting: Process characteristics

We now identify some key elements of processes characterizing research priority-setting and program design in China. We focus primarily on the so-called meta-level, using examples from some of China's most important programs and plans.

4.1 Setting the agenda

Chinese S&T policy-making can be divided into components which are part of the regular planning process, and programs and measures that are implemented outside the planning cycle. The five-year plans are the most obvious and structured tool of China's economic planning process in the sense that that it is clear to everyone when the next plan is due and thus, when the preparations and priority-setting processes are to take place. The medium- and long-term plans are not as strictly regulated as the five-year plans since their time span has varied over the range 8–15 years. The national S&T programs, such as the 863 Program, the 973 Program or the KIP, are created outside the temporal planning cycle in response to problems or challenges considered to require policy intervention.

Several national S&T programs and initiatives have been created following public appeals or statements made by well-known scientists. However, rather than being spontaneous initiatives taking the government by surprise, these appeals tend to address widely known issues or problems in China's S&T system. In some cases they may even be encouraged by the government, letting experts point to problem areas which the government already has identified and intends to tackle. As an example, the 863 Program was preceded by a letter written by four Chinese scientists (Daheng Wang, Ganchang Wang G., Jiachi Yang G,. and Fangyun Chen) to national leaders, calling for the acceleration of China's high-tech development. They stressed the need to meet the challenges of the global technology revolution and competition and pointed to the US Strategic Defense Initiatives as well as Europe's EUREKA Program. In March 1986, Deng Xiaoping personally approved the drafting of a National High-tech R&D Program, the 863 Program. From April through September of 1986, the State Council mobilized hundreds of experts to draft an Outline for Development of High Technology which was issued on 18 November by the CCPCC and the State Council.

The creation of the 973 Program, intended to strengthen basic research, is widely considered to have been the response by then-Premier Li Peng to concerns voiced by scientists at the Political Consultation Conference (*zhengxie*) in March 1997 that basic research was being neglected in S&T funding. The Political Consultation Conference is a political body in the Chinese political system. Its members are well-known scientists, intellectuals, and businessmen, belonging to various political parties. They usually take the opportunities provided by the conferences to provide policy suggestions to the government.

For the above-listed S&T programs, which are implemented outside the five-year or medium- and long-term planning cycle, the original impetus can be argued to have come from scientists, and thus from outside the government. However, the appeals or demands for policy action did not take the government by surprise and were not in conflict with the government's policy goals.

4.2 Identifying priorities: The role of experts, public consultation and debate

Once the decision is taken that something should be done, priority-setting processes tend to be based on heavy involvement by scientific experts. Thus, in the making of the latest Medium and Long-Term Plan, an 'expert consultation group for the overall strategy for the Medium- and Long-Term Plan' consisting of around 20 senior scientists was created in 2003 to provide input to the 'leading group' which was made up of the Prime Minister and top officials from 23 ministries and ministry-level organizations (Liu 2009; Schwaag Serger and Breidne 2007). These two groups were responsible for identifying key S&T issues relevant for the next medium- and long-term plan. In June 2003, 20 key S&T issues were identified and studies were commissioned. The process surrounding the strategic studies was open (except for the national defense issue). More than two thousand scientists, engineers, policy experts, corporate executives, officials from universities, ministries, and corporations participated in the strategic studies. Workshops were organized to exchange progress reports on research. In addition to the domestic process, workshops were held with international experts at the Multi-S&T Minister Forum in Shenzhen in October 2003, and an 'International Forum for MLP making' was organized in November 2003 in Beijing. In April 2004, the interim strategic research reports were sent to CAS, CAE, and the Chinese Academy of Social Sciences for consultation. The final results were then presented to Premier Wen Jiabao.

A senior policy researcher observed that the main actors involved in S&T policy-making were government ministries and scientists. Although industrial actors, especially large firms, were sometimes asked to provide input, such suggestions were not paid enough attention.[8]

In order to increase transparency, compared with the planning processes for earlier plans, the government created a website for public participation and consultation, encouraging citizens and organizations to make suggestions and comments.[9] However, neither the drafting of the strategic research reports nor the drafting of the medium- and long-term plan, which lasted approximately one year, were open to the public.

The planning process was surrounded by relatively public and heated debates concerning the fundamental choice of development strategy to be pursued in the plan (see also Gu and Lundvall 2006). The MOST propagated the idea that China should pursue the idea of 'indigenous innovation' or 'homegrown innovation' and strive to reduce China's dependence on foreign technology

(Mei and Luo 2005). In contrast, some economists, such as Justin Yifu Lin, argued that the country should continue to rely on China's comparative advantages (Lin et al. 2003). A related debate centered on the impact of foreign direct investment, which had been strongly encouraged by Chinese official policy, on China's technological upgrading, with MOST expressing skepticism (Mei and Luo 2005). During 2005, officials involved in the drafting sought input from foreign experts and diplomats on how they viewed the term 'indigenous innovation' (*zizhu chuangxin*).

Overall, the processes surrounding priority-setting in China's national S&T programs are characterized by formal and elaborate processes with an emphasis on input by scientific experts, particularly when it comes to the selection of thematic areas, but also formal processes for input by other stakeholders and, increasingly, public consultation.

Although the drafting of the medium- and long-term plan included structures for stakeholder involvement and transparency, overall, priority-setting in China's research policy tends to be characterized by a top-down selection of both thematic areas and fundamental development strategies. Scientific experts play an important role in anchoring important policies and in providing expertise on thematic choices, but they do so in a highly orchestrated and centrally controlled way.

5. Conclusions

Dingtian lidi, a Chinese idiom, is a 'slogan' metaphor among Chinese science policy-makers, meaning 'go forward with your head in the clouds and the feet on the ground'. The most common interpretation is that 'head in the clouds' (*dingtian*) means that Chinese research should be oriented to, and catch up with, the world frontiers. 'Feet on the ground' (*lidi*) means that Chinese S&T should be targeted at China's strategic economic, social and national defense needs.

The massive infusion of resources in recent years has been driven by a combination of motives: cultivating universities with global recognition, empowering individual researchers, increasing the visibility of Chinese research and enabling technological leapfrogging, strengthening linkages between academic environments and industry, supporting high value-added industry, and strengthening China's international prestige. Furthermore, the increasing research investments are expected to provide the foundation for future economic growth, to enable the restructuring of industry from low-tech to high-tech, allowing China to move up the value chain, and to solve many of China's daunting challenges, by providing technical solutions for overcoming problems such as scarcity of resources, provision of energy, and environmental degradation.

From a historical perspective, we have identified waves of modernization strategies, drawing S&T ever closer into the political core. The 1978 Science Conference functioned as a starting-point for a renovation of the S&T system by acknowledging S&T as a productive force. This paved the way for the 1985, 1995 and 2005 decisions and plans to strengthen the S&T infrastructure, linking investments in S&T to broader societal goals which gave science policy a widened political mandate. More recently, a 'post-catching up' strategy has emerged, integrating S&T with a new evolutionary path for China, as a leader in innovation, but also a society balancing economic growth with social stability and ecological balance. With every wave, we find a broader and more encompassing portfolio of priorities, as well as broader consultation and mobilization of interests behind different goals. In general, China is moving in the direction of pluralist priority-setting, but even bottom-up consultation processes bear traces of central control.

The overarching goals remain under strong central political control (notwithstanding factional debates among the policy elites). However, within this framework of overarching goals we find a blend of steering instruments, institutions and goals that can be derived from the broader goals and which reflects a much broader constituency, often at the behest of central government support of basic research (Mega-science Projects, 973 Projects) with programs for industrial development (Mega-engineering Projects) and sectoral technology programs on a more modest scale (Key Technologies Programs, 863 Projects). These loosely coupled programs are then reintegrated under a centralized rhetoric, for instance on the virtues of combined quality and relevance—head in the clouds and feet on the ground again—but in reality we find a broad set of programs tailored to different groups and interests.

Two features of priority-setting stand out in the Chinese case. Planning in the straightforward sense is one defining element, a heritage from the post-World War II planning exercises. It is a complex structure in itself, with medium- and long-term plans serving as umbrellas for sub-level planning exercises (five-year plans). The sub-plans are more loosely organized and open to rank political debates: indeed one of the goals of the political elite has been to foster such open exchanges. Hence, we find a combination of top-level control and bottom-up deliberations.

In themselves, the MLPs represent an important articulation of science and innovation policy with the broader fields of policy: for instance 'harmonious society' and 'indigenous innovation', indicating the contributions and frameworks of STI governance with broader policy process. Hence, the plans function as a discursive framing of science and innovation policies into the broader project of societal modernization, while also indicating the decoupling of science from the planning exercises of the past.

The dialectical relationship between central goal articulation and decentralization deliberation will most likely continue, as the reforms of governance continue to stress the need for articulation of actors' interests, building new constituencies among academics, academic institutions and industry to tap into their interests, but also with attempts to realign these interests: i.e. loosening central control without abandoning it. How this balance, unstable as it is and perhaps must be, will play out in the future is a key issue for students of Chinese politics in the years to come. Several contradictions confront actors in the Chinese S&T system: the large number of programs and initiatives, leading to overlaps, the ambition to foster public debates and pluralist deliberation, but also a risk of an overly strong reliance on a few elite actors. The marginal role of industry, particularly privately owned enterprises, as a stakeholder is another weakness in the policy process. Although the balance has shifted somewhat from top-down to bottom-up steering, we still find a strong emphasis on grandiose projects, less on the processes and the governance of S&T and reforms of S&T institutions. While there may be arguments for pursuing 'mega-projects' in some contexts, overall the dominant legacy of centralized planning for grandiose projects still looms over science policy, and may continue to thwart the ambitions of Chinese scientists to develop a more genuinely pluralist system of resource allocation.

Acknowledgements

The authors would like to thank Richard P. Suttmeier and the two anonymous referees for their valuable comments.

Notes

1. For more information about programs, see OECD (2008: Chap. 11).
2. For more information on the 863 and 973 Programs, see <http://www.most.gov.cn/eng/programs1/200610/t20061009_36225.htm> and <http://www.most.gov.cn/eng/programs1/200610/t20061009_36223.htm> accessed 20 May 2011.
3. See OECD (2008: 459).
4. Some suggestions about the reform of the national S&T programs management (*guanyu guojia keji jihua guangli gaige de ruogan yijian*), <www.most.gov.cn/tztg/P020060127327421562622.doc> accessed 20 May 2011.
5. See <http://www.most.gov.cn/eng/programmes1/200610/t20061009_36224.htm> accessed 20 May 2011.
6. See <http://english.people.com.cn/90001/6381319.html> accessed 20 May 2011.
7. See <http://english.people.com.cn/90001/6381319.html> accessed 20 May 2011.
8. Wu Y. 'Three suggestions to improve China's S&T policy', *Guangming Daily*, 14 May 2007, <http://www.gmw.cn/01gmrb/2007-05/14/content_605455.htm> accessed 20 May 2011.
9. The website was <http://gh.most.gov.cn>. A key official and policy-maker of the MOST reported that more than 3,000 people had registered at the website and that hundreds of suggestions had been given by the public (Shi 2004)

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