

Some Considerations on Deepening the Reform of China's S&T System

Fang Xin

Institute of Policy & Management

Chinese Academy of Sciences

ABSTRACT

In light of the worldwide S&T and economic development and the demands set on the S&T system by the national modernization drive in China, the author examines the government's authority and duties in the macro-management of the S&T system on the basis of a brief evaluation of China's S&T reform over the past decade or so.

Reform is a process of institutional changes, in which, at any stage, the characteristics of a given institutional arrangement must have its contextual logic and cognate inter-relations of mutual causality. Just as Douglass C. North points out: History is always important and its importance lies not only in the fact that we might take something valuable from the past, but that the present and future are to link the past via the continuity of a society's institutional system. The choice of today and tomorrow is determined by the past. So, when we come to consider the future steps of S&T reform in the new century, it is necessary for us, first of all, to review the past and analyze the new problems we have to face.

I. A brief review of the S&T system reform

After the founding of New China in 1949, the country introduced an S&T institutional system featuring centralized administration and unified planning. This system was compatible with the catch-up strategy for structural development that was not solely aligned to economic targets. In the conditions of international embargo and

extreme scarcity of domestic S&T resources, it was effective to mobilize and concentrate limited resources on the strategic targets. Under its guidance, China succeeded in building a comparatively complete organizational system and infrastructure facilities and nurturing a great number of outstanding personnel in a decade or so. And the scientific community solved many key S&T problems in the fields of socio-economic development and national defense, enabling China to rank itself in the advanced countries in some areas of natural science. After the conclusion of the third plenary session of the Party's 11th National Congress in 1978, the country's developmental strategy was gradually shifted to a new structural catch-up strategy with a strong economic orientation and hence the current reform drive began. Against this background, the hidden, inherent pitfalls deep-seated in the S&T system were brought to light. First, it was an isolating vertical system, in which research institutions at any level were only responsible to their immediate superiors, lacking various horizontal ties with its peers in other social sectors (such as education and business). Next, the system was detrimental to technology diffusion because it was devoid of concepts of intellectual property and effective mechanisms for carrying out compensated technology transfers. Third, excessive and direct national administrative interference in economic performance led to the strangling or holding back of initiatives and enthusiasm of the research bodies. Fourth, both the personnel composition at a research institute and its staff's knowledge structure became ossified as research bodies degenerated into isolated entities under such an over-rigid system, imposing restraints on the creativity and initiative of their research professionals. Evidently, such a system had to be restructured and upgraded.

The CPC Central Committee's Decision on the Institutional Reform of the S&T System issued in May 1985 marked a turning point in the process of institutional reform from a spontaneous phase to a stage of all-round implementation under a unified leadership. The "Decision" made it very clear that the ultimate objective of the S&T institutional reform is to apply S&T results to production rapidly and widely and to bring the role of S&T workers into full play so as to greatly liberate the S&T

productive force and promote S&T and social development in China.¹ Since then, in line with the readjustment of the goals and priorities of the reform, the State policies to promote the reform of the S&T system have so far covered the following three stages:

Stage I (1985-1992). The guideline for China's S&T development in this stage was to put in force the principle of "economic development must rely on science and technology, while science and technology must be geared to economic development." The S&T policies were directed to "revitalizing research institutes and their research staff." Various policy measures were adopted for promoting the restructuring of the government funding system, establishing technology market, readjusting organizational set-ups, reshuffling the personnel management system, constructing experimental zones for high-tech development, and encouraging the development of non-governmental S&T firms.

Stage II (1992-1998). Marked by Deng Xiaoping's speech delivered in his inspection tour to south China in 1992, the national economy entered a new phase of socialist market economy. In this stage, S&T reform was reoriented, and defined as economic development must rely on science and technology while science and technology must be geared to economic development, and researchers should strive to scale S&T heights. In line with the requirement of "stabilizing one end and setting the rest free," policy measures were introduced to promote the integrated S&T and economic development through personnel repositioning and structure adjustment.

The phrase of "stabilizing one end" has two implications: First, it means the government would firmly support research in basic science, high-technology and major R&D endeavors critical to economic development, social progress and national security. In this way, China's overall S&T strength, R&D level and sustained development momentum would be upgraded by nurturing its edge-cutting research realms and achieving key research breakthroughs. Hence, a contingent of S&T workers small in size but highly competent was kept up for playing a constructive role at the disciplinary frontiers of contemporary science. Its second meaning refers to the classification and categorized deployment of research bodies, optimizing the structure and layout of basic

¹ The Guide to China's S&T policy (the White Paper on S&T No.1), the State Science and Technology Commission, Beijing S&T Literature Press, 1986

research institutions and providing an organizational framework and modernized model for the research units to be “stabilized.”

The expression of “setting the rest free” is meant to give free rein to R&D units having direct bearings on economic growth and social progress, to relax various mandatory restraints on their activities to promote the commercialization and industrialization of S&T results so that their operation would be market-oriented and contribute to the economic growth and social progress. In May 1995, “A Resolution on Accelerating S&T Advancement” was jointly issued by the CPC Central Committee and the State Council. It confirms the two developmental strategies, i.e. revitalizing the country through science and education as well as sustainable development, as the cardinal guideline for national development at the turn of the century. This was a key strategic re-alignment for China’s S&T development and even for the whole nation’s revival. Because this strategy has been put in actual practice since 1998, we designate the period from 1992 to 1998 to be an integral and independent stage in consideration of the continuity of the national policies.

The stage III (1998-). An essential readjustment has been seen in China’s S&T developmental strategies and institutional reform of the current S&T system. “Revitalizing the country through science and education” becomes a part of the national development strategy and the former Premier Zhu Rongji claimed at his cabinet’s first press conference: “To achieve a national revival by means provided by science and education is the primary task to be completed by this session of Chinese government.”² The S&T policy in this stage has been directed to further developing the national innovation system and accelerating the industrialization of S&T results. Policy measures are adopted to promote institutional transformation of the R&D bodies, upgrade the innovation capacities of enterprises and reform the rewarding system.

After an 18-year-long reform drive, and in particular since 1998, China’s institutional environment sees a noticeable improvement in the aspect of S&T development. This could be found in the following facts: national R&D input is going up dramatically; the mainstay of innovation is experiencing a structural reconstruction

² From the former Premier Zhu Rongji’s speech at the first press conference of his administration, March 1998

in a bid to adapt itself to the market economy; a national innovation system complying with the opening-up situation and market economy is taking its initial shape; with a remarkable uplift in S&T strength, a host of major research results start mushrooming and hence, Chinese S&T cause makes its way into the one of the best period for development since the founding of the people's republic in 1949.

In spite of these advances, however, S&T system reform in China lags behind that of economic system. There still exist some deep-seated problems that are in discord with the socialist market economy and hinder the development of S&T productive forces. In response to the new historical era to build China into a moderately well-off society, efforts are called to speed up the tempo of the on-going process of socialist modernization through posing and meeting a lot of essential and urgent demands to science and technology. In such a circumstance of burgeoning development, some new issues make their debut and wait for their final settlement. The latter find their expressions in the following aspects:

(1) An evident lag in the national system of S&T macro-management

China's S&T management system still retains traces left by the over-rigid system of a planned economy.

Giving priority to governmental support rather than market deployment. Consequently, departmentalism and self-isolation are rampant as the relationships among the government, market and enterprises have not been clearly sorted out. The distribution of S&T resources is made by following the past malpractice to dispense everything "in a unified and well-proportionate way under a mandatory plan." There is no a clear borderline between the State financing for public projects with the market deployment of the resources. Hence, many key national S&T programs have degenerated into administrative plans for allocating government resources.

Laying stress to micro-management rather than strategic plan. Many S&T development plans become a mere formality while S&T management departments at various levels are still focusing on the management of individual projects, taking too much into their hands. However, their consideration on strategic deployment scheme is short of the fundamental and forward-looking S&T layout concerning the country's long-term or medium socio-economic development and national security.

Over-emphasizing individual reform measures while lacking a comprehensive consideration of the entire design. In the past practice, our reform drive featured micro-management steps and single reform projects but in want of overall blueprints and accessory measures. Some reform arrangements (such as the budgetary reduction for science operation) were over-simplified with a flavor of “shock therapy.” In this way, we did not succeed in stabilizing those that should have been stabilized, let alone making it effectively strengthened. At the same time, we failed to relax control to those that should have freedom so as to enable them to merge with enterprises and combine with social elements, losing chances for their sound development.

One-sided emphasis on the financial input in R&D projects while overlooking the development of R&D capacities. The chronic inadequacy of S&T input, over-rigid system for the deployment of R&D resources in addition to the fact that the lion’s share of the national S&T investments was gulped down by concrete research projects, all of these leads to a poor state of the national S&T infrastructure and S&T institutions are mostly unable to carry out the build-up and reconstruction of their innovation capacities as a precondition for a sound and long-term development. In such a situation, it is impossible for them to independently build up high-ranking research bases, a competent contingent and profound academic stockpile.

(2) New problems facing the integration of S&T endeavors with economic operation

Progress has been scored in the integration of S&T endeavors with the economic performance through the current reform drive. Channels have been set up for translating S&T research featuring rapid effects in a short run into practical applications. However, along with the rapid social and economic development, the integration is facing new and deep-seated problems.

The relationship between our S&T development and economic growth has been shifted from inadequate demand into inadequate supply. For a long time in the past, the integration between S&T and economy used to be puzzled by the inadequate demand from the domestic socio-economic development. With the burgeoning development of the national economy as a result of its opening-up to the outside world, Chinese firms have seen a rapid upgrade in their technical capacities.

However, their S&T innovation level remains to be raised. There are relatively few research breakthroughs in theoretical studies or at disciplinary frontiers. There is not much technological innovation capable of giving birth to new growth points for industries. What is worse, the original storage of R&D results achieved by Chinese scientists has been gradually delivered to industrial practice in recent years, the current situation of the integration is shifting from the deficiency in effective demands to the insufficiency of effective technical supply. A big-margin increase of China's capacities in independent innovation and assimilation of the imported know-how should be the major orientation for furthering the reform drive.

It is urgent to energetically promote the R&D activities for social welfare, for solving common technical problems. The market-oriented institutional reform is merely effective in solving the problem of integration between S&T progress and economic performance in the social sections where market mechanism is highly effective. It is unable to provide a solution to the supply of public technologies in the case of market failure or poor influence exerted by the market. So, effective enhancement has not been attained in this respect, resulting in insufficient display of the critical role of science and technology in promoting the overall socio-economic development.

Effective integration is still unavailable among innovation resources while a real value chain of innovation is out of sight. In recent years, Chinese enterprises saw a boom in updating their technological capabilities. But their innovation dynamics is still meager in the current context of globalization, in which the elements of knowledge-based expertise are in rapid circulation over the world. This may be seen in the comparatively poor state of our technological development capacity and the disengagement of our technical renovation and introduction with technical innovation. In the same time, our R&D institutions are still accustomed to keeping all of their R&D results in their units' possession and satisfied with the self-assimilation and self-circulation of the R&D results achieved by them. A nationwide mechanism aiming to socialization and scope development through conscientious integration with social elements now falls short of taking its shape.

(3) It is urgent to strengthen the national capacity of S&T innovation

In the past practice of the S&T institutional reform, insufficient emphasis was placed on the build-up of national innovation capacity, which was unable to sustain a fast-speed and steady development of our national economy.

S&T input is on the low side and its structure is irrational. Although national S&T budget saw a remarkable increase in recent years, the actual amount is low in comparison with large developing countries, developed countries which share the same stage of national development with China or in comparison with demands for the whole country's booming development. If viewed from sources of the S&T input, investors from other social sectors do not have a full play of their investing potentialities; viewed from its composition, the eye-catching issue is the excessively low proportion granted to basic research and the fundamental studies on common-use technological development as the current share of basic research in the whole R&D input is consistently lower than 6% (while the same figure in the international community is 12% in average and more than 15% in the US, Japan and Germany). Evidently, this situation is incompatible with our country's goals to beef up our capacities of original innovation, increase our own independent patented rights and raise the national competitiveness.

S&T talented personnel are unable to meet the development demands in terms of quality and quantity, Although the contingent of S&T workers is massive, there is a pressing problems about upbringing and employment of the research professionals. Competition-oriented mechanism is unavailable for a sound development of talented people. There is a generation gap for senior researchers. A market for S&T talents is not seen well developed. It is still hard to fully display the real value of talented people and bring their potential to full play.

Another urgent task for us is to raise the innovation level. In spite of the fact that a great number of key R&D results have been achieved, we still have a long way to go if compared with the advanced international level. Now, the R&D papers to the credit of Chinese scientists see a steady and sustained increase. But the proportion of the theses published in the internationally prestigious journals is not high and their citation rates should be further updated. The number of recipients of high-ranking

prizes from the three State-issued national S&T awards has seen a drop. A big-margin increase now appears in the numbers of patent application and authorized licenses. But the percentage of invention applications is low. Especially in such fields as information science, biology and medicine, Chinese scientists have few patents of their own on key technological issues. This indicates there are more following-up and imitation but less trail-blazing feats in our research work. At present, insufficient originality in S&T innovation of some key research realms becomes the main stumbling block to China's R&D progress and economic development.

Our S&T infrastructure has to be further bolstered in a big way. On one hand, a great number of fundamental installations are to be renewed or rebuilt; on the other hand, the utilization rate of our R&D equipment is low as it is now plagued by departmentalism, repetitive introduction and monopoly of their owners. Literature, databanks and key research facilities are not fully shared by other researchers out of their owner's units and inaccessible to the public of the whole society. We need to build up more trans-departmental technology platforms for common use, which are open to the rank and file and in a unified and systematic layout.

The current S&T institutional reform aims to marry S&T progress to national economic performance, and focuses on the restructuring of R&D institutions and in particular on the major research bodies directly affiliated to ministries of the State Council. Although the drive has so far achieved remarkable results, snags in the heart of the system were exposed as the reform was incessantly deepened. In the past, the Chinese S&T community always blamed external restraints as the root cause for reform difficulties. The decline in R&D strength, for example, was attributed to insufficient financial input; the poor integration between research and economic growth was imputed to the shortage of effective demands from enterprises; and the researchers' lack of enthusiasm for their professional work was blamed on the lagging development of the reform drive's accessory measures. Yet, when the country yearned for science and technology to create new demands for economic growth in the wake of high-speed economic development, the problem turned itself into the dilemma that domestic R&D resources failed to provide strong support in spite of the increased S&T input from both the government and enterprises. The inadequate academic build-up, less powerful

innovative impulse and the clogged channels of propagation were the main hindrances to furthering the reform drive.

The reasons for this situation are multifarious. First, the current reform drive sets as its goals the integration of S&T development and economic growth, and the acceleration of technology transfer, but it neglects the necessary premise that the S&T system must ensure a fully-fledged S&T development. Although such a deviated understanding has been recognized and somewhat corrected since the 1990s, the adopted remedial measures were not so effective and forceful. The result is that the objectives of the reform are partially realized at the expense of some parts of the premise. Secondly, in any society, its economic system is the primary groundwork and other systems are derived from it. Before the peripheral setting sees a full upgrade, the S&T system is forced to shift its directions and the input of its financial sources is cut short. This move cannot end the chronic malady of disengagement between the research and economic growth. Instead, it will cause the loss of existing resources of the research institutions, leading to an imbalance in the national layout of overall S&T strengths, and a breakdown in the deployment of R&D resources so that the long-term development of China's science and technology will be impaired. Thirdly, the current reform of the national S&T macro-management system lags behind and the S&T management efficiency is very low. For instance, a "junction" organ in charge of trans-departmental coordination and inter-regional linkage has to be established in the national administration because various governmental sectors have their own distinctively different routine work to do due to preset labor divisions. To date, however, the problem has not been solved satisfactorily. So, S&T plans plotted by various governmental departments cannot be compatible with one another and hence, the R&D resources are not deployed nationwide in a concerted way. What is worse, our country is at the transitional stage of transforming its economic performance from a planned system to a market-oriented one and therefore the interactive mechanism between the government and markets for promoting innovation endeavors is still unavailable. The government's absence, dislocation and over-reaction in administrative affairs occur frequently. So, we must urgently carry out an institutional reform of the national S&T macro-management.

II. In order to meet the demands of our time, the existing macro-management system must be restructured

The rapid development of contemporary science and technology, and in particular, the rise of information technology and biotechnology, greatly expands humanity's innovation capacity. The new technologies have exerted a deep influence on various aspects of social life such as industrial performance, public health, national security, and environmental protection. In addition, they are changing and will continue to reinvent diverse social organizations, rules and management approaches, posing an unprecedented challenge to all countries and the system of international politics. Furthermore, they put forward brand-new research topics in managing these newly emerging techniques themselves. The technologies that are promoting the on-going industrial revolution are both systematic and complicated in nature. Their implementation needs collective action, socialized infrastructure and specific expertise. Information technology and biotechnology do not possess similar characteristics. Their control and employment are more in the hands of individual users. Because of this unique distinction, it is more possible for them to be abused than traditional technology invented by man. Also, it is more complicated to manage those technologies under the control of individual users. The key is the extent to which such a dispersed distributive system is to be managed and how to manage it.

The emergence of a knowledge-based economy and economic globalization pose new demands for S&T development: science and technology become an engine of economic growth and S&T progress is urgently needed to create new demands and new growth points; the comparative advantages formed by tangible factors are weakened while knowledge and the capacity to use it become crucial factors in the nurture of competitiveness; and, China's accession to the WTO means that the market will have more say in the deployment of resources, domestic enterprises have access to advanced technology developed by the outside world and the government's interference in economic and S&T operations must be changed.

Against this background, a worldwide trend of governance transformation emerges as various countries are striving to build governments with wider representative scope, quicker response and a stronger sense of responsibility, i.e. **a government with enhanced predictability and acting as a helmsman instead of an ordinary rower; its function is to orient the country to anticipated targets instead of the partition of the budgets. They should adhere to the principle that clients are first served before all other factors and service is to be the top priority. Its administrative power is to be authorized or decentralized rationally to all frontline units and both competitive mechanisms and entrepreneurship are to be introduced.**

China's modernization program makes further demands on S&T development: making substantial contributions to industrial restructuring and the raising of innovation capabilities in high-tech industries, full S&T support for maintaining a sustainable development of the whole society, national defense and national development of advanced culture. Last but not least, it is set to play a crucial role in promoting the medium and long-term socio-economic progress and sustained and steady S&T development.

All of the new demands require a further deepening of the restructuring of the current S&T system.

III. A discussion of some problems in macroscopic reform of the S&T system

Viewed from the experience of China's reform and requirements suggested by the contemporary world to science and technology, the tasks, characteristics and priorities for the reform drive in the next stage will be different from the previous ones. The tasks set for the previous stage were bold and resolute steps, breakthroughs at key points and energetic stress on market orientation, while at present the main tasks lie in the building of a new economic system, the founding and perfection of a national innovation system. What we need now is all-round advancement and overall coordination. We should stress the rationality of the approaches and routes we have chosen and the flexibility of implementation schemes designed by us. In the past, the reform measures we adopted

concentrated on regulating the mechanism of micro-management, highlighting policy guidance; at present, the drive has to push into the realms of macro-management, culminating in the formulation of basic rules and practical regulations. Evidently, the above tasks are both heavy and snag-ridden and need us to advance them by carrying out an additional reform drive of restructuring all accessories concerned and addressing multifarious involvement.

The deepening of the current reform drive is expected to achieve the following targets: the financial resources of a research institute and researcher must be guaranteed (including tangible and intangible personal properties, and the latter refers to the preference of a scientific discovery, patent rights of technological invention, and the reimbursement rights from commercialization of the R&D results), the relationship between administrative organs and the market or research bodies must be straightened out; the inauguration of a certain discipline's or research domain's new mechanism for automatic self-regulation or renewal, the nurture of a social environment conducive to innovation and sound development of S&T endeavors and the cultivation of capacities for sustainable innovation. The principal target is to promote high-speed and sustained development of all S&T undertakings, so as to push forward the national program of modernization. In order to advance the institutional reform of the macro-management system, some problems need penetrating exploration.

1. The government's powers and duties in S&T development

What we will discuss first are the limits of its authority when the government comes to manage S&T undertakings as this is immediately related to the origin of the governmental authority. In some countries, the legislature confers on the government administrative power through legislative authorization and any government's administrative behavior beyond the scope of the authorization constitutes a legal violation. This is the so-called administrative principle in which "a government behaves according to law and any administrative operation beyond the authorized power is invalid." Theoretically, the governments in these countries are limited entities in authorization. The same scenario is not true in our country. Although, our country's government nominally has its administrative powers granted by the people via the Constitution and laws formulated by the National People's Congress, the long-standing

concept of “State first” prevails in our political life. In the aspect of legal cases, the government’s authority stipulated by the legislature is presented in general terms. It seems that “rule of law” means the government can do anything not clearly prohibited by law. As a result, the government practically has limitless authority in governing the country. According to provisions in related statutes, for example, the government has the power to “exercise the leadership of and administer our country’s S&T endeavors”. In line with this provision, the government has an all-embracing power to manage various S&T activities. If we want to theoretically examine the transition of the government’s function, we have to consider a series of issues such as “State first” or “people first”, and a government’s limitless liability or limited liability. The reform steps concerning them will result from the continuation of the current political reform drive.

The next question is what authority the government has in its management of S&T undertakings. This is directly related to the duties and roles of the government and to the distinctive characteristics of S&T activities. In S&T development, the government plays a dual role: a macroscopic administrator and a provider of public goods. In response, it has two powers in macro-administration and the ownership of public goods.

The third question is the definition of the powers and duties of a government and the market, which actually is a game process. As a matter of fact, public goods and private goods are not an issue of one or the other as they constitute a continuous spectrum in which regional marketplaces and public economies may take various forms of their combination. So, they are able to provide ample room for accommodating multifarious institutional arrangements. In defining the powers of a government and market, we must take the following factors into account:

i). Whether the private sector has sufficient capabilities or motivation to take part in S&T activities? ii). Does an institutional space have to be available in favor of a robust growth of private organizations; iii). Are related rules established to adapt themselves to the game, i.e. whether there are proper mechanisms or not in charge of treating the conflicts or supervising their performance? iv). We should take the cost of the reform steps into our consideration. This includes the actual value of the cost and its partitioning scheme. If we consider neither of these factors nor the reliance on the

covered routes, we would resort to simply copying what has been done in foreign countries. In a worse case, we could even regard the reform drive's process as its goal and we could hardly avoid making a detour to prevent the government from landing in the quagmire of absence, dislocation or over-reaction in its management of administrative affairs. In this way, it is impossible for us to achieve an ideal performance from the reform drive.

2. The government's macro-management of S&T activities

The institutional reform of macro-management and change in governmental functions has a group of multi-layered and complicated tasks to perform. The core task is to do a good job of the relationship between the government and market. The government itself is the promoter of the current reform drive and is duty-bound to solve new problems arising with the reform drive. At the same time, it has to carry out effective steps for self-renovation. In the reform of its self-management, the key lies in separating government functions from the management of enterprises and institutions, and straightening out authorities and powers in financial affairs in various governmental organs at different levels and regulating governmental behavior. We should also raise public service quality and efficiency and public servants' proficiency in handling public affairs. In the field of micro-management, the key lies in the establishment of basic rules and regulations, while both service and supervision are to be enhanced.

In S&T management, the government, acting as a macro-administrator, should strengthen its following administrative functions:

1). Maintaining the normal order of S&T activities via legislative means.

Although China has enacted the Law on S&T Progress, the Law Concerning S&T Transfer, the Patent Law and other legal provisions and statutes on S&T activities, the relevant system of legal legislation is neither sufficient nor perfect. For example, in light of foreign practice, a law in regard of the organization of a research entity should be formulated, clearly defining the legal forms, and related institutional norms for various R&D bodies so as to give explicit stipulations on an R&D body's establishment, alteration, expiration as well as its rights and duties. In this way, its legitimate rights might not be so easily violated. Another example is the enactment of a law concerning

S&T workers in a bid to effectively protect their legitimate rights and benefits and at the same time, their behavior should be standardized. The third example is the legislative procedure of an S&T plan. In the West, the latter is always adopted as a bill put in discussion and finally ratified by the parliament and put into effect by an executive organ. In our country, the S&T plans always make their debut in the form of government-issued decrees and are mostly executed by the governmental department in charge of them. Different approaches lead to different consequences. S&T plans put into force in a Western country are noted for their strong regularity and stability while our country's decision-making process for enacting S&T plans features high speed and caprice, tending to contain too many policy-oriented provisions and lacking concrete articles to rest or affix the responsibility on the personnel for dereliction of the duty. So, inconsistency is prone in the course of their execution and therefore, it is difficult for us to investigate or bring anybody to account when an S&T plan fails to be implemented properly and smoothly. Hence, in our country, any S&T measures higher than a decreed ceiling of the given financial input must be enacted by legislative authorization, definitely making clear their expected targets, content, methods for implementation, organs in charge of its execution and the latter's legal responsibilities. The government must draft and approve an S&T plan while withdrawing from the plan's management.

2). Various economic means are to be employed to guide S&T development and deployment of social resources.

The guidance may be direct or indirect. The direct means are mainly in the form of the governmental input, while indirect means include medium or long-term development schemes, loans, taxation, mandatory prices. The objective is to build a social system for deployment of S&T resources, in which the financial input in key R&D realms is to be ensured and a responsive socialized and marketable mechanism of S&T input in the overwhelming majority of R&D domains is to be introduced through the government's efforts to strengthen the research of strategies for both national development and disciplinary progress and the perfection of a public information platform capable of promoting S&T development and integration of S&T advancement with economic growth. To funnel financial resources via all possible means, we must step up, at the same time, the management of resources and raise their utilization

efficiency. At present, we have to step up the institutional reform of the national budget and financial management. In line with the concrete targets set for different types of S&T undertakings and fund circulation patterns, various methods for funding management of the national budget and both the input and output principles or financial allocations are to be formulated.

3). A variety of innovation-promoting measures are to be adopted.

In this regard, our governments at various administrative levels have so far initially enacted a complete set of policies, of which some are effective, some practically become dead ducks and some come down to be out-moded. Hence, it is urgently necessary for us to introduce their revision or adjustment in line with the changed environment both at home and abroad so as to meet renewed demands posed by the national development so that they may be further perfected. Their objects should be shifted from diverse geographic regions to different economic sectors. Based on different developmental stages of various industries, the revised policies should be designed in consideration of the cost and expected benefits derived from their implementation, subject to schemes of timely readjustment, and real incentives, while highlighting the principle of “top priority to be placed on talent attraction”. The means for putting them into practice should contain a tactical shift from the preferential treatment in both government planning priorities and tax exemption as the main tool for the integration of multiple means to be adopted, such as an enhanced application of governmental purchase, mandatory enactment of technical specifications and other administrative steps introduced by the authorities for enforcement of the policies. Another point worthy of our special attention is to coordinate the related policies drafted by different departments or by diverse regional authorities so that they may become mutually supplementary or compatible with one another instead of being contradictory or offsetting each other.

4). The all-round upgrade of the nation’s scientific quality and cultural aptitude so as to create an agreeable social environment for a sound S&T development throughout the country.

3. Developing a multi-layered contingent of S&T workers in rational labor divisions and a national network of diversified R&D bodies.

Acting as a provider of public goods, the government has both direct and indirect approaches for furnishing them. It goes without saying that there exist a variety of combinations between the two. Direct supply means the establishment of R&D institutions by the government in a bid to produce public goods to meet national demands. Indirect supply refers to the government-hosted purchases of various R&D results from all kinds of research bodies and supplying them to society, while the purchases are usually through the form of research projects that are contracted to research bodies. The funding direction of research projects and appraisal of the R&D results are used to regulate the R&D undertakings. The direct supply's strong points lie in the government's willpower to be directly carried through, R&D strengths may be rapidly mustered and resolutely concentrated to meet the national demands without snags and a relatively stable contingent of research professionals is nurtured and brought up. Therefore, both the continuity and benefits of R&D endeavors might be guaranteed. But the problem with the approach is that both institutions and their staff tend to indulge in inaction. The indirect supply is noted for its high efficiency and its weak point is its vulnerability to short-term acts. In some cases when the external market is not sufficiently developed, it is impossible to find anybody to take up a research task even if it is necessary. As for which approach is to be taken by a given R&D result, this is determined by the properties of either the R&D result itself or the research work.

From the above analysis, we might see, irrelevant to which type of the supply, the prerequisite is the availability of a contingent of S&T professionals with a multi-layered structure and rational division of labor and it is the existence of a variety of R&D institutions with diverse functions. These institutions include government-run research institutes, unprofitable R&D bodies, research establishments attached to collegiate communities or enterprises as well as various go-between agencies. Different institutions vary in their operational functions and the government's obligatory duties to them are different. To run the State-owned research institutions is one of the duties incumbent on the government. But the duty is a limited liability and it must comply

with certain principles: the first is the principle of obligation, i.e. the founding of these research bodies is a necessity in the government's binding duties; the second is the principle of economics, which means the founding and operation of these research bodies are within the reach of the government's financial resources; and the third is the principle of surplus, referring to the research bodies which are socially indispensable, but unaffordable or impractical for other social entities to found or run. As for other types of research institutions, the government's duties are to create a favorable environment and give support in diverse forms.

Under the long-time yoke of the planned economy, governments at different levels ran almost all research institutions in China. The on-going reform is to introduce a transitional process shifting them from the centralist pattern into a new pattern of diversity. The key to its success is to find an approach that could achieve maximum benefits at minimum cost. In my opinion, the first task is to make an overall organizational reshuffle of the existing S&T institutions in light of national goals and interests. The second is a full estimate of various possible social costs in the on-going reform drive and in particular, those costs to be burdened by the government. The third is the institutional innovation to be stressed in the drive: macroscopically, we have to create a favorable legal and institutional setting for the survival and development of various R&D bodies; microscopically, the institutional restructuring of various research bodies should adopt different schemes in their institutional design while an institutional pattern to be introduced to a given research institute should be independently decided in line with the institute's actualities.

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