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Occasional Paper

CHUNG-HUA INSTITUTION FOR ECONOMIC RESEARCH

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This paper is intended to provide economic information and stimulate further research. Any opinions expressed within are solely those of the authors and not those of the Chung-Hua Institution for Economic Research.

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Should Government Intervene in Civil Research and Development? -- The Case of Taiwan

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Jiann-Chyuan Wang*

Abstract

A decades-old debate has been raging on the relative virtues of a free market as opposed to government intervention in civil research and development activities. Government intervention in private sector R&D unavoidably causes administration costs and negative externalities, but this does not imply government intervention is unnecessary. We conclude that government involvement in civil research and development cannot be overlooked, because there are lessons from advanced countries which indicate it is necessary, and especially due to the dominant status of small and medium-sized enterprises in Taiwan's industrial structure. This conclusion further holds even when literature which is anti-government involvement is assessed.

However, if we take intervention costs into account, implementing policy measures respecting fundamental market principles is suggested. Furthermore, shifting government aid from particular industries toward functional activities, promoting communication among government authorities, industry, and academic groups, and allocating government aid to research activities with large spill-over effects are also major principles of government intervention that should be followed.

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I. Introduction

The trend of economic liberalization has attracted worldwide attention in recent years. Some "inappropriate" policy measures, (considered as such by the proponents of free markets), such as price controls, direct subsidies and intervention in civil research and development (hereafter referred to as R&D) have been heavily criticized.

The interventionists, however, respond that R&D often has an open and non-exclusive nature and the market mechanism alone is not effective to guide towards desirable action. In this regard, there exists "market failure," that is, the market mechanism fails to lead to the optimal level of R&D investment in a market economy. Government involvement in the private sector R&D, however, may bridge this gap between private and social return. Therefore, government can play an essential role in promoting R&D investment in the private sector, enhancing overall industrial competitiveness.

The argument against government intervention, on the other hand, centers around the assertion that market failure is a necessary, but not sufficient condition for government to intervene. The effect of government intervention may not be as beneficial as expected or even misdirected when there exists information asymmetry between government authorities and industry[1]. Under such circumstances, the direct administration cost of government intervention and resulting negative externalities such as resource misallocation due to false policy implementation, may offset the intervention benefit, leading to a fall in national welfare.

[1] The information asymmetry between government and industry exists because government authorities lack information about the needs of the industry. As a result, government is unable to finance industry projects properly.

The above arguments have their own respective theoretical backgrounds, and consequently this debate inevitably remains inconclusive.

This paper explains why government should intervene in civil R&D by analyzing literature critiques, lessons from advanced countries and the dominant status of small and medium-sized enterprises (SMEs) in Taiwan's industrial structure.

Furthermore, we make policy recommendations as to how government interventions may best induce and nurture industrial innovation.

Section II presents a brief overview of literature on the pros and cons of government involvement in private sector R&D. In section III, we explore the necessity of government assistance in civil R&D. In addition, we offer several suggestions for government intervention in section IV. Section V contains concluding remarks.

II. Literature review of pros and cons of government intervention in civil R&D.

There has been a long-existing debate on whether government should be aggressively involved in private sector R&D activities. Arrow (1962) indicates that R&D can produce productive knowledge and information which often has an open and non-exclusive nature. In other words, the inventors can not totally exclude others from free-riding on their research results, especially in basic and applied research where applications are diffuse and appropriating reward for innovative activity is almost ignored. In addition to the non-excludability problem, uncertainty associated with R&D projects discourages firms from investing in inventive and innovative activities[2]. Because of non-excludability and uncertainty, firms may allocate less to R&D than they otherwise might.

Due to the accelerating pace of technological change and broader range of technical capabilities firms must possess, scale barriers are a big concern for firms in high-technology areas. Galbraith (1969) argues that the growing scale of barriers of modern technology are such that governments increasingly have to intervene financially to help firms avoid technological and market risks; many justifications, civil or military, may be readily found for government assisting the R&D for an industry's technological development. Sun (1989) favors government's involvement in civil R&D by pointing out the problem of low private sector R&D investment willingness in Taiwan. He argues that Taiwan's capital market is in a beginning stage and royalties and patents are not well protected. The research input will be lower than the optimal level as a result of inappropriability and uncertainty. Based on these reasons, it is a must for the Taiwanese government to assist local industry to engage

[2] For more details on non-excludability and uncertainty of R&D see Hall (1986)

in more R&D investment. In addition to correcting the market imperfection problem, Ma and Wang (1990) support government intervention in civil R&D by providing evidence of dynamic comparative advantage for firms in high-technology areas.

The proponents of free markets (Demsetz (1962), Stiglitz and Dasgupta (1980)), however, argue that inappropriate policy measures implemented by the government may result in misallocation of R&D resources because of information barriers. Furthermore, bureaucracy and low research efficiency lead to failure in many government-sponsored research projects. Since government failures exist almost everywhere, the ability of government to take any action in the economy which is not counterproductive is often skeptically viewed.

Moreover, Nelson and Eads (1971) have argued that government-financed projects with large commercial development potential come under pressure from interest groups. As a result, government may bear the risk of subsidizing second-best projects. Jewkes (1972) gives a similar argument. He worries that government financed projects often lead to an intervention-breeding system, as firms reap profits through lobbying and government subsidies, instead of through R&D investment.

Although in many Western countries, we can find evidence of government involvment in industrial activities, however, Pavitt and Worboys (1977) offer the example of Switzerland and the Netherlands to oppose Galbraith's scale indivisibility of modern technology, arguing that there is no strong evidence of increasing government involvement in financing industrial R&D. In their opinion, government intervention may hamper rather than facilitate the necessary adjustment of industry.

III. The desirability of government intervention in civil R&D

From the analysis of the relevant literature, we conclude that whether government should intervene in private sector R&D activities is still very controversial in general. Consequently, our focus in this section is to explore the appropriateness of government involvement in civil R&D in Taiwan. We propose to discuss the desirability of this involvemet from three different viewpoints. First, we offer several suggestions to correct the drawbacks which are often cited against government intervention. Second, we address the importance of government involvement in the private sector's R&D activities, and pay special attention to Taiwan's SMEs-dominant industrial structure. Third, the belief that the benefits of intervention outweigh the costs, and thus leading to government intervention in civil R&D in many advanced countries, is also considered.

1. Suggestions on drawbacks of government intervention in the relevant literature.

The reasons of opposing government intervention in civil R&D in various literature can be summarized as follows.

Firstly, market failure is a necessary, but not sufficient condition for government intervention. Government intervention is not capable of correcting the market failure phenomenon as long as there exists an information barrier. Secondly, the risk of failure in many government-led technology programs is very high. The reason for such failure stems from the frustration of dealing with bureaucracy and information asymmetry. Thirdly, the pressure of industrial lobbies may force the government to run the risk of financing second-best projects.

With regards to the first problem, there is no doubt that the information barrier between government and industry is a major cause of some inappropriate policy measures implemented by government. In recent years, however, we have seen much better communication among government officials, industry entrepreneurs and academic scholars. As a result, the information barrier has been reduced to a certain extent, and part of the bureaucracy defects have also been successfully solved. The joint development of the notebook sized computer (NBSC) is a good example of successful cooperation between government and private sector[3]. Because of the close communication between government research institute and private industry, the NBSC project has accomplished, with the technical assistance from ITRI, several expected goals such as keyboard design, technical standard establishment and prototype production in a three months span[4]. This project successfully pooled industrial resources and promoted R&D efficiency.

The position opposing government involvement in private sector R&D often rests on the argument of alleged information deficiency on the part of government. However, due to the accelerating pace of technological change, the cost of information-collecting has increased tremendously, firms may have less advantage in collecting some types of information than government. In terms of the trend of a particular technological development and where the market is, a particular firm or industry may have more information than the government does. Nevertheless, in terms of the macro-environment the government's information is likely superior to a local firm's. For instance, in areas such as the planning of technological resources, inter-industry interactions, international cooperation,

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[3] It is expected that the notebook sized computer might replace a large share of the lap-top computer market in the next few years. As a result, firms are anxious to get a piece of the big pie. However, small and medium-sized enterprises lack technical capability to engage in this field of R&D alone and they seek cooperative arrangements to serve to supplement their in-house research and development. Under this situation, the Taiwan Area Electrical Equipment Industrial Association initiated the NBSC development plan, which is mainly executed in the Industrial Technology Research Institute (ITRI) - one of the government-sponsored research institutes. NBSC attracted 46 firms to join the program.

[4] ITRI was established in 1973 as a non-profit research institution. The institution was initially funded by government. Besides government funding, the-institution also receives funds to carry out contract research for local enterprises. ITRI is responsible for developing many key technologies, transferring them to local industry, and facilitating Taiwan's technological development.

technological-niche product markets and the like, government input is valuable; especially for Taiwan's SMEs since their ability to collect information is rather weak.

Additionally, in a changing world, the desired institutional changes in markets do not occur automatically. The government can play an important role in correcting the market imperfection problem, especially at a time when the economy is going through a period of structural transformation; strategic planning by government may speed up the industrial upgrading. Mrinal (1990) indicates that when market signals alone are not effective guides for desirable action, then appropriate non-market institutions have to be implemented. Thus, the dichotomy of market and government is a false conception[5], and government involvement can not be overlooked.

With respect to the second problem, in order to facilitate technological development in the private sector, the government has sponsored many cooperative projects with local industry. Among them, Software Engineering Environment Development (SEED), the joint development of two-stroke engines, and NBSC are noted examples. The former two cooperative undertakings, however, have not performed as well as expected. The information asymmetry between government and industry, poor incentive scheme of research institutes, and far-fetched research goals set by government authorities are major causes of failure in these government-led technology projects. SEED and two-stroke engine projects, in general, are "research-oriented" cooperative endeavors. The main purpose of these two projects is to establish technical standards, and consequently, only a small portion of embodied technological results derived from them can be transferred to an individual firm. In the beginning, firms preserved their corporate image and a sense of responsibillity by sending experienced senior staff to join in the projects. As time went on, member support waned because they perceived these two projects as having only a slight chance to generate private benefits for them, and they began to lose interest in the projects.

As we know, SMEs constitute the largest portion of the Taiwanese economy, and

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[5] See Mrinal (1990)

with little research activities, industry has to heavily rely on government research institutions' equipment, research staff and technological bases in cooperative projects. The research staff which come from ITRI, usually receive little extra credit even when they come up with a new finding or idea. As well, they are not under the threat of job security if they do not make serious mistakes. This poor incentive arrangement discourages researchers from being dedicated to the cooperative projects, which, certainly, has a negative influence on research progress.

In addition, the information asymmetry is an crucial reason of failure in many government-funded technology programs. To avoid the risk of an information gap and to diversify decision-making, government has to establish a series of complicated and time-consuming monitor processes. This definitely affects research progress. The low research efficiency of the government research institution, therefore, discourages firms to take part in government-led cooperative research projects.

The NBSC, on the contrary, is a project falling in the middle ground between research-oriented and product development, which develops potentially marketable results. These results have a high probability to be commercialized. With the technical assistance from ITRI, firms are aggressively participating in this development plan.

As a result, the Taiwanese government has paid a great deal of attention to these problems. Sy Tu (1991) has designed an "x" indicator[6] (x = firm's cost sharing / government funding) to solve the information asymmetry problem. The government can use the x indicator as a measurement to monitor the efficiency of research projects. The larger the indicator, the higher the research project's attractiveness. The x indicator can also help government in allocating R&D resources, facilitating the decision-making process and

[6] The information asymmetry between government and industry exists because government authorities lack information about the needs of the industry, and as a result, government is unable to finance industry projects properly. As well, the pressure of industrial lobbies may force the government to finance the second-best projects. The idea of an x indicator is to give government authorities an objective standard to screen projects. The higher the indicator implies that firms have confidence on the cooperative undertakings, and are willing to shoulder a larger share of project cost. These cooperative projects thus should be proceeded with high priority. An x indicator can provide government authorities an open evaluation system and avoid the pressure from interest groups. For more details see Sy Tu, Ta-Hsien (1991)

avoiding information asymmetry. In addition, these cooperative ventures will be much more efficient under the supervision of local industry. NBSC, as indicated previously, is a fairly good example of efficient government-industry cooperation.

To correct incentive scheme defects, the research institution may encourage its research team to work on a specific project which has spin-off benefits. The institution sets a timetable for this team to start a spin-off company. Moreover, the new positions and stock shares of the research team in the spin-off company are arranged according to their contribution in the project.

The positive correlation between individual effort in cooperative projects and returns of the spin-off company will promote the institution's research efficiency, and thus induce more firms to take part in government-funded projects.

In Taiwan, far-fetched research goals are also one of the major causes of failure in many government-led cooperative projects. The government authorities usually set research goals which are too high and too broad to entail much private benefit for member firms to make a strong commitment to the projects. To be productive, research goals must be rearranged to fit in with Taiwan's current environment and firms' needs. In other words, to be successful, a cooperative research venture must not only pursue the joint interests of the participating firms as a whole, but also the private interests of each individual participator. Fundamental knowledge and ideas developed by "research-oriented" cooperative programs are rarely utilized by industry with little R&D resources. Consequently, firms are reluctant to join in government-sponsored cooperative projects. Nevertheless, a pure "product-oriented" cooperative project will create "niche collusion" among members, resulting in the collapse of cooperative organizations. As a result, a compromise between "product-oriented" and "research-oriented" activities which allow research goals to fall in the middle ground between research-oriented and product development is advisable to match Taiwan's current needs. In recent years, the Taiwanese government has worked very hard to adjust research goals and it has showed signs of improvement.

As to the pressure of industrial lobbies which, some critics assert, may force the government to finance the second-best projects, the opinion of this paper is: if the government can screen projects by an open evaluation system, the pressure from interest groups will be lowered to a certain degree. As mentioned above, the x indicator will assist in the allocation of government R&D resources and avoid picking the second-best projects to subsidize.

2. Taiwan's SMEs-dominant industrial structure

We now turn to Taiwan's special industrial structure which is dominated by the small and medium-sized enterprises (SMEs). SMEs have very limited resources to conduct R&D investment, particularly since the minimum scale of efficiency in high technology industries has increased rapidly and entry barriers exist. Because of the limitation of SMEs in R&D capabilities, the overall R&D efforts of Taiwan's industrial sector are not very encouraging. The slow structural transformation is the result of the sluggish R&D investment. In terms of statistics, Taiwan's research intensity (R&D expenditure as a percentage of GNP) in 1988 was only 1.22%, which is low in comparsion with 2.65% for the U.S. and 2.57% for Japan, and even lower than 1.90% for Taiwan's major competitive country - South Korea (see table 1).

Table 1: Comparisons of R&D Expenditures in Major Countries

item / country, FY		R&D expenditures (million U.S.$)	R&D expenditures as percent of GNP
R.O.C.	1988	1,566	1.22%
Japan	1987	73,006	2.57%
U.S.A.	1987	118,782*	2.65%*
West Germany	1987	35,953	2.81%
France	1987	22,509*	2.29%*
Netherlands	1985	3,164	2.11%
U.K.	1986	12,943	2.29%
Sweden	1986	4,847	2.93%
Korea	1988	3,431	1.90%

*: represents estimated value.
Source: Indicators of Science and Technology, Republic of China (1990)

Under present market conditions, large capital requirements to undertake risky new projects have made firms more cautious to conduct R&D investment. On the other hand, the chances of acquiring key technologies from technology-leading countries are very slim these days. Accordingly, it is very difficult for a firm to single-handedly achieve economies

of scale and compete with foreign giants in R&D. The situation is ominous especially when Taiwan is compared to South Korea which is dominated by a fewer number of very large companies such as Goldstar, Samsung and Hyundai. Playing catch-up cooperative research, most firms believe, can serve as a way to keep up with foreign powerful rivals.

A pooling of R&D resources and scientific talents to promote R&D efficiency is an important way for Taiwan to deal with rapid changes in the complexity of technology and to enhance industrial competitiveness. Nevertheless, a "free ride" attitude and management frustration discourages firms from engaging in R&D cooperation. These difficulties definitely need the government's assistance to be overcome.

The fact that Taiwan has to upgrade its production technology in order to remain competitive in the global market, implies that the changes necessary to overcome the difficulties of structural transformation are many, not easy, and rather long-term in process. Government should thus prepare to adopt a strategic, long-term approach to innovation policy.

3. The lessons of advanced countries

During the last few decades, it is increasingly recognized that an explicit technology policy for stimulating industrial innovation is an essential and integral part of any government's overall industrial strategy. Galbraith (1969) has argued that "the growing barrier of modern technology forces governments to intervene in civil R&D to share technological risks." His proposal for government involvement has already been acted upon in Western Europe in the aircraft and computer industries.

The U.S. industry has been enjoying some comparative advantage in some high-tech areas because of the U.S. government's promotion through their military and space programs. General Motors and Boeing have obtained a substantial share of government subsidies

through contract research and is a good example of government intervention. Japan has been famous for promoting close ties between MITI (Ministry of International Trade and Industry) and industry, and a large proportion of research funding of private enterprises comes from MITI. MITI's aggressive involvement in VLSI (Very Large Scale Integrated Circuits) projects has been regarded as one of the crucial reasons behind Japanese firms' comparative advantage in high-technology areas. Under such circumstances, the U.S. government has been forced to modify its anti-trust law, allowing more innovational cooperation in order not to lose its technology-leading position to Japan. Therefore, in terms of the lessons from advanced countries, government intervention in civil R&D may induce and nurture desirable industrial innovation. However, opposite opinions express concern about subsidizing the second-best projects. The opinion of this paper is that if the government authorities can screen projects by an open evaluation system, the pressure from industrial lobbies can be avoided. Furthermore, if government employs policy tools which respect fundamental market principles (for instance, information networks, advisory and consultancy services provision in Table 2), then its intervention will not cause too much distortion to the market mechanism. The voices which oppose government intervention would thus be silenced as long as the benefit of intervention exceeds the cost of intervention.

In summary, government intervention in private sector R&D unavoidably causes administration costs and negative externalities, but this does not imply government intervention is unnecessary. We conclude that government involvement in civil research and development cannot be overlooked, because there are lessons from advanced countries which indicate it is necessary, and especially due to the dominant status of small and medium-sized enterprises in Taiwan's industrial structure. This conclusion further holds even when literature which is anti-government involvement is assessed.

Table 2: Classification of government policy tools

Policy tool	Examples
1. Public enterprise	Innovation by publicly owned industries, setting up of new industries, pioneering use of new techniques by public corporations, participation in private enterprise
2. Scientific and technical	Research laboratories, support for research associations, learned societies, research grants
3. Education	General education, universities, technical education, apprenticeship schemes, continuing and further education, retraining
4. Information	Information networks and centres, libraries, advisory and consultancy services, databases, liaison services
5. Financial	Grants, loans, subsidies, financial sharing arrangemet, provision of equipment, buildings or services, loan guarantees, export credits, etc.
6. Taxation	Company, personal, indirect and payroll taxation, tax allowances
7. Legal and regulatory	Patents, environmental and health regulations, inspectorates, monopoly regulations
8. Political	Planning, regional policies, honours or awards for innovation, encouragement of mergers or joint consortia, public consultation
9. Procurement	Central or local government purchases and contracts, public corporations, R&D contracts, prototype purchases
10. Public services	Purchases, maintenance, supervision and innovation in health service, public building, construction, transport, telecommunications
11. Commercial	Trade agreements, tariffs, currency regulations
12. Overseas agent	Defence sales organizations

Source: Rothwell & Zegveld (1981)

IV. Suggestions

As mentioned earlier, government intervention may be necessary to correct market failures and enhance industrial competitiveness. Government involvement in civil R&D is not unwarranted. However, in recent years, there exists a trend which appears to be away from government intervention. In the early years of Taiwan's economic development, the government acted aggressively in helping local industry deal with market imperfections and a fragile industrial structure. Today, on the other hand, government should gradually adjust its role and shift more of its responsibilities to the private sector. Government aid to private R&D focusing on a more general, "climatic" promotion of innovation will be better suited for Taiwan's current environment.

The role of government today is going through a dynamic adjustment process, therefore, there are several principles of government intervention which should be followed.

Firstly, involvement should not cause too much distortion in fundamental market principles. As we know, government intervention will produce direct administration cost and indirect social costs. The administration cost is expected to be low if policy measures respect fundamental market principles. For instance, information and infrastructure provisions will not cause a large conflict with the market mechanism. On the other hand, direct subsidies or direct controls can seriously distort the market mechanism and result in tremendous administration cost. In this regard, policy measures with low administration cost should be implemented with a high priority. In addition, although social cost is very hard to quantify and determine, government should however try to evaluate and ensure the benefits of intervention exceed the cost of intervention, and lead to a higher social welfare.

Secondly, the focus to government aid should shift from particular industries toward functional activities. In a medium to long-term horizon, it is very hard to distinguish between infant or strategic industries. Hence, the government's direct assistance to

particular industries should be eliminated.

In addition, Streit (1987)[7] states that there are two defects for financial assistance to particular industries: "First, this type of assistance needs more bureaucratic procedure than general subsidies for R&D activities. Second, it may provide a comparatively large monopoly-rent due to an information asymmetry between politican and bureaucrat."

The replacement of the "Statute for Industrial Upgrading" with the "Statute for Encouragement of Investment" is an encouraging effort by the R.O.C. government. The Statute for Industrial Upgrading provides incentives to companies which engage in R&D, environmental protection, enhancement of productivity, personnel training, and establishment of international brands, illustrating the new trend of functional activities assistance. As Saunders (1987)[8] points out, picking possible "winners" and "losers" carries all the risks of commitment to an always unexpected future. Furthermore, the major trend now predicted in demand and technology are so commonly known that each government authority is likely to pick much the same list of winners, and of losers; consumer-electronics, nuclear energy, aerospace, robotics, biotechnologies, information and telecommunication are featured in every programme of priorities. International overcapacity in these activities is not unforeseen. Therefore, the ten so-called "promising industries[9]" which have been identified by the Council for Economic Planning and Development in the Six-Year Development Plan is a step backward in the level and direction of intervention.

Thirdly, close communication among government, industry and academic groups is necessary. Through effective communication among these stated groups, the information asymmetry problem can be successfully reduced. If the information barrier is solved, the government decision-making process will be facilitated and intervention efficiency would be

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[7] See Saunders, C.T. (1981) ed. "Industrial Policies and Structural Change", Chapter 7.

[8] See Saunders, C.T. (1987), P.2.

[9] The ten promising industries are: telecommunications; information; consumer-electronics; semi-conductors; precision machinery & automation; aerospace; advanced materials; specialty chemicals and pharmaceutical products; medical & healthcare; and pollution control.

further improved.

Fourthly, protecting royalties and patents is very important. Since the open and non-exclusive nature of research may threaten the optimal level of R&D investment, an assurance for appropriating rewards from innovation activity is necessary. Consequently, the protection of royalties and patents have to be enforced, and product piracy deserves punishment, otherwise the incentive for innovation will be seriously damaged.

Fifthly, government aid should focus on research projects with large spill-over effects. The process of R&D can be roughly classified into three stages: basic research; applied research; and product development, even though these distinctions are often rather vague to discern. As the above definition indicates, the applications from basic and applied research are diffuse and have a major impact on society. On the other hand, the product development stage conducts research basically for appropriating benefits for particular firms. As such, the higher the spill-over effects of a research project, the higher priority it should be given for government subsidy. The subsidies, however, should stop at the end of pre-competitive process.

V. Concluding Remarks

For several decades, a debate has raged on the relative virtues of government intervention as opposed to a free market in civil R&D activities. Since each side has its own theoretical background, the debate inevitably remains inconclusive. In the case of Taiwan, the low research intensity of the industrial sector in comparison with advanced countries has indicated that market failure and a fragile industrial structure has imposed a serious obstacle to Taiwan's technological upgrading.

The required institutional changes in markets does not always take place automatically. The government can thus play an essential role in promoting and supporting the right kind of market institution, especially when Taiwan has proceeded to restructure its economy going from labor-intensive to capital-and knowledge-intensive business. The strategic planning by government can in this way accelerate industrial upgrading.

However, government intervention in private sector R&D may cause direct administration costs and negative externalities. Hence, employing policy measures which respect fundamental market mechanisms, focusing on functional activities support in substitution for assistance to particular industries, protecting royalties and patents, and promoting communication among government authorities, industry and academic groups are in urgent need.

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