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Scientists' Impact on Decision-making

A Case Study of the China Hi-Tech Research and Development Program

Peng Ru

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ROUTLEDGE

Scientists' Impact on Decision-making

With the increasing influence of science and technology (S&T) on socioeconomic life and public affairs, there has been a growing demand for S&T expertise in today's public decision-making.

The National High Technology Research and Development Program (863 Program), involving hundreds of S&T experts, marked the beginning of a new journey for China's hi-tech development. This book discusses China's S&T decision-making mechanism, with the 863 Program as the central case and scientists' influence on public decision-making as the focus. More importantly, it extracts three key elements to analyze the determinative factors behind that influence – knowledge, value and institutions, and proposed a KIV framework of macro-analysis. The KIV, being the first framework to generalize factors that could affect scientists' influence on public decision-making, is of both theoretical significance and innovative value. In addition, by finding out those factors, this book attempts to create a decision-making environment conducive to scientists' contribution of their knowledge.

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Contents

Figures

Tables

Preface

The end of WWII in 1945 marked the beginning of a period of peace and development for human society. Since then, there has been a rapid and incessant succession of major inventions based on scientific principles, such as the computer and the chip, which are generally referred to as high technology. It has been found that such hi-tech innovations are quick to translate into mass-produced commodities with immediate benefit for society. This has changed our mode of production and our way of life, work and thinking. It has started a wave of new technological revolution around the world, and made innovation an impetus for social progress.

Under such circumstances, public decision-making in a country or a region not only requires knowledge in political, economic and social spheres, but also – and more and more strongly – scientific/technological expertise and wisdom. As a result, scientists, engineering technologists and technological management experts with an insight into the trend and pattern of technological development, the scientific spirit of being precise and realistic, farsightedness and macro-thinking capability, have been involved in policy-making processes in an extensive and profound way. As a crucial part of the nucleus of public decision-making, they have provided decision makers with advisory opinions and technological justifications. Good results have been achieved in many developed countries where scientists are invited to play a role in public decision-making.

Since the founding of the People's Republic of China (PRC) in 1949, scientists, technologists and experts in all fields have gained access to the making of major decisions with a bearing on social and economic development. For instance, they have played a prominent role in such crucial decisions as the "two bombs and one satellite" (the atom bomb, the hydrogen bomb, and the man-made satellite), the Three Gorges Dam, the Qinghai-Tibet Railway, and the South-to-North Water Diversion Project. Their advice and suggestions have significantly enhanced the scientificity of decision-making. Scientists and technologists play an even more outstanding role in decisions on science and technology policies. For instance, in as early as 1956, over 600 scientists, technologists and technological management experts participated in the drafting of the PRC's first plan on scientific and technological development (Long-Term Plan for Scientific and Technological Development 1956–1967). In 2003, when the state launched strategic research for a plan for mid- and long-term scientific and technological development and the drafting of the plan's outline, over 2,000 experts of natural science, social science and engineering as well as those from the business community took an active part in it by offering their advice and suggestions. In this way they have made a great contribution to the making of China's strategy for the new century – the building of an innovation-oriented country in which development is led by innovation.

The 863 Program, which is regarded as a pioneer of hi-tech development in China, offers a successful example of the crucial role played by technologists in our country's major strategic decisions. In March 1986, in view of the development of high tech around the world, four scientists (Wang Daheng, Wang Ganchang, Yang Jiachi and Chen Fangyun) wrote a letter to Deng Xiaoping calling for the launch of a Chinese program for hi-tech research and development. Upon receiving the letter, Deng wrote an instruction, "Make a decision on this without delay." In November 1986, the National High-tech R&D Program (i.e. the 863 Program), the making of which involved hundreds of experts, was ratified by the Communist Party of China (CPC) Central Committee and the State Council, which marked the beginning of a new journey for China's hi-tech development. The four scientists' outstanding contribution in decision-making consultation will go down in history forever.

Thanks to extensive practice in the past 25 years, the 863 Program has drawn worldwide attention to its achievements and accumulated a great deal of experience in how to organize and carry out major technological plans. To give full play to the role of scientists in decision-making, implementation and management have always been an important feature of the decision-making management mechanism of the Program. Carefully selected from around the country, the outstanding scientists, in the "863 spirit" of "justice, innovation, truth-seeking, cooperation and dedication", have played a vital role in decision-making consultation on the macro-management level (implementation strategy, field configuration and the allocation of resources) and the execution level (division of research projects, project management and final inspection). They have made a great contribution to the smooth implementation of the Program and the hi-tech boom in China by ensuring that planning and decision-making are scientific and democratic. From another perspective, the past 25 years' precious experience in organizing and carrying out major technological programs with Chinese characteristics is worth sorting out and summing up in a systematic way.

I am pleased to see that Dr. Peng Ru, in this book written under the guidance of his supervisor Prof. Su Jun, has conducted systematic empirical research and profound theoretical discussions on the major theoretical and realistic issue of scientists' participation in mechanism and system of the state's public decision-making and achieved valuable results.

Starting from the determinative factors and formative mechanism for scientists' influence on science and technology decision-making in China, the author has developed a theoretical model (based on theories about policy science, technology and society, and the application of knowledge) to explain the influence of the actors in such decision-making processes and put forward a number of scientific propositions. This indicates his originality in the grasping of theoretical cutting edge and the observation of practical issues. With the 863 Program as the central case, he has conducted many in-depth interviews with dozens of people with personal experience of decision-making management in the Program and collected a great deal of precious historical data. His vivid description of the development of the Program's decision-making management mechanism has provided important reference for the study of the evolution of decision-making in China's technological programs.

I was greatly honored to have participated in the feasibility study of the 863 Program, and I still vividly remember how excited it made me feel. I had never expected that I would serve the Program another unforgettable six years for its early implementation management. Since then, I have always been involved in the Program in terms of management consultation and strategic studies. I am very glad to see the publication of this academic work that discusses China's S&T (science and technology) decision-making mechanism from the perspective of the 863 Program. I fervently hope that its readers would probe into the scientific, democratic and procedural aspects of decision-making management for the Program from the perspective of development and innovation. In this era of global innovation, fast changes are taking place in hi-tech competition. To keep abreast of the times, any nation must reform its management of hi-tech decision-making. A good decision should be technically feasible, economically reasonable, legally permissible, executively controllable and politically acceptable to all parties involved, with achievable results and a sensible balance between overall benefits and general costs. This calls for scientific decision-making through incessant incorporation of scientific knowledge and opinions and the active application of scientific methods and procedures, and democratic decision-making through listening to opinions of the people and the parties concerned in order to know what they think and pool their wisdom.

Hail to the experts and scholars who have turned the achievements and experience of the 863 Program to good account for society!

Ma Junru
Member of the Expert Consultant
Team of the 863 Program
Former Director General of the
State Administration of
Foreign Experts Affairs

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1 Introduction

1.1 Background

1.1.1 Scientists' policy participation: practical significance and theoretical value

Since the end of WWII, with the increasing influence of science and technology (S&T) on socioeconomic life and the increase of S&T factors in public affairs, there has been a growing demand for expertise in today's public decision-making. Since the expertise involved in such decision-making is way beyond the knowledge of decision makers, scientists have gained wide and profound access into policy processes owing to their superiority in knowledge. They have become important actors in public decision-making processes, which have consequently been more and more strongly characterized by being as scientific they are political (Golden, 1991).

Owing to the long-term practice of planned economy after the founding of the PRC, the government became the matter-of-course leader of public decision-making. Under such circumstances, if the government failed to pay effective heed to professional opinions from the academia when making decisions, it was likely to make misjudgments on scientific issues, which might lead to terribly wrong decisions. Since the advent of the reform and opening up, the Communist Party of China (CPC) and the Chinese government have come to a deep understanding of the necessity of science and democracy in decision-making. As a result, they have listed it as a major task in political reform[1] and reiterated many times the need to create a democratic and scientific decision-making system.[2] In practice, the government has placed more and more stress on the important role of experts and expertise in the making of policies and intensified interaction and cooperation with the S&T community. The remarkable increase of scientists' participation in and influence on public decision-making has made the government's decision-making much more scientific. A typical example is the letter written by Wang Daheng and three other scientists to Deng Xiaoping in 1986, which led to the creation of the 863 Program and marked the beginning of China's new journey of high technology. However, under the influence of our lasting cultural and political tradition, the progress toward scientific and democratic public decision-making has been slow. The government still has absolute control over decisions involving a great deal of expertise and public interests, with little participation by experts and the public. This has incurred questions and criticism from the scientific community and the public. Some scholars have called for giving top priority to more scientific and democratic decision-making in the current effort to promote political reform and accelerate the building of socialist democracy (Chen Zhenming *et al.*, 2007). In this sense, to discuss how to improve the public decision-making process in China and make it more scientific and democratic so that the policy outcomes are more compatible with the interests of the state, society and the public is of profound practical significance and a subject deserving painstaking research by theorists.

During a public decision-making process, the more influential participants will make the policy outcome more in line with their own interests and values so as to obtain maximum benefit. Naturally, who can exert more influence on others and thereby dominate the decision-making process, which factors determine the participants' influence, and what causes the wax and wane of influence among different participants are considerations with heavy political weight in policy games. Scientific answers to these questions are of great theoretical value because they would help us grasp the essence of the decision-making process and gain an insight into the interactive game between the participants and the consensus-reaching mechanism. It is out of such considerations that we have chosen to examine public policy processes in China from the perspective of the participants' influence on decision-making.

Since the making of policies in different fields and at various levels tends to show different features, it is very difficult to create a unified model for the general policy-making process in China. The present study is focused on the sphere of technological policies. In Western countries, there has been a transition from elite to community as the leading makers of such policies, and the trend of participation by interest groups and the public is becoming more and more apparent. In China, however, participation in S&T decision-making by businesses and the public remains scant, and the elite (including the political elite and the intellectual elite) is still dominant (Li Xia and Runchuan, 2001; Li Xia 2007; Chen Ling, 2005), with officials and scientists occupying most of the policy arena. In view of this situation, we have ignored participants like businesses and the public, and have only considered the two major actors (officials and scientists) and discussed their interactive game and influence in decision-making. Since the influence of one usually increases in proportion to the decrease of the other's, to understand the issues related to the influence of one side is tantamount to outlining the decision-making pattern of both sides. Therefore, we have further narrowed down our study to concentrate on scientists' influence on decision-making.

At present, research into scientists' policy participation is mainly conducted from three theoretical perspectives – policy science; science, technology and society (STS); and the knowledge utilization theory. Policy science is interested in how expert politics and democracy operate, STS stresses the social construction of scientific knowledge and scientists' activities on the border between science and policies, and the knowledge utilization theory focuses on the effects of the use of knowledge in policy processes and the influencing factors. Scientists' influence on decision-making is a subject of common interest for all the three perspectives, and scholars have contributed a lot in this respect. However, in the existing studies, the examination of scientists' role in and influence on policy-making is largely limited to partial discussions on micro-levels, and a macro-framework of analysis has yet to be established. It is therefore our intention to bridge this theoretical gap by creating a framework for overall analysis based on systematic examination and differentiated integration of the determinants of scientists' influence.

1.1.2 Scientists' participation in S&T decision-making in China

CPC organizations play a core role in public decision-making in China's political decision-making system. People's congresses at all levels and their standing committees are the top decision makers in a legal sense in their respective regions. They are the top authority, nationally or locally, exercise legislative power and supervise policy implementation by the government. The State Council is the top administrative body of China. The heads of the State Council and local governments have the final decision-making power and take responsibility for their decisions. Multiparty cooperation and political consultation under the leadership of the CPC are basic political systems of China, and democratic parties influence the CPC's decision-making through participation in the deliberation and administration of state affairs and democratic oversight. The Chinese People's Political Consultative Conference (CPPCC), an important body for promoting multiparty cooperation and political consultation, influences and participates in the decision-making of people's congresses and governments in the form of organization. Such a decision-making system forms the cornerstone of China's decision-making model.

It is generally believed in academia that China's political decision-making mechanism is a typical one of elite decision-making (Lampton, 1992) and a main characteristic is that, in the political process led by political elites, a decision is made mainly based on the top leadership's consideration of the reality and a top-down approach, while it is very hard for bottom-up policy initiatives to automatically include policy needs in the political process. Economic and social development has brought about a more diverse composition of elites. Intellectual, social, economic and other elites have more opportunities to directly participate in the political decision-making process, and the number of elites who can influence decision-making is also growing. The decision-making interactions between different elite groups are increasing and more political decisions have been made as a result of such interactions. Although political elites on the top level remain the final decision makers, their freedom to choose policies is being reduced (Wei Shuyan, 2006).

In terms of S&T policies, the top administrative body for decision-making is the State Council under which there is a National Leading Group for S&T and Education, a core decision-making and coordination organization in the field of

S&T. The Leading Group is responsible for strengthening overarching guidance on S&T and education work and coordination of major S&T matters and promoting the reform of S&T and education systems. The head of the Leading Group is Premier of the State Council, deputy head is the Vice Premier or State Councilor in charge of S&T and education work, and its members include leaders of relevant ministries such as the Ministry of Science and Technology (MOST) and Ministry of Education (MOE). As part of the State Council for the overall coordination of S&T affairs in China, MOST is mainly responsible for mapping out the macro strategies for S&T development as well as the guidelines, policies and regulations on giving play to the role of S&T in driving economic and social development, studying major issues concerning the role of S&T in driving economic and social development, planning for S&T development and identifying priority areas, facilitating the building of a national S&T innovation system, etc. Other organizations that play an important role in S&T decision-making and management include institutions of higher learning led by MOE, research institutions led by the Chinese Academy of Sciences (CAS), Chinese Academy of Engineering (CAE) and Chinese Academy of Social Sciences (CASS), and science foundations represented by National Natural Science Foundation of China (NSFC). In addition, economic authorities such as National Development and Reform Commission (NDRC) and Ministry of Finance (MOF), specialized ministries such as Ministry of Industry and Information Technology (MIIT) and Ministry of Agriculture (MOA) are also important stakeholders in the S&T decision-making system. China's current S&T decision-making and management system is shown in Figure 1.1.

Scientists as intellectual elites are the core participants of China's political decision-making process. Their role in S&T decision-making is even more significant.

Since the founding of the People's Republic of China (PRC), scientists and experts have taken part in the making of decisions on science and technology policies in various ways. They have played a prominent role in many important S&T decision-making processes. For instance, in January 1955, Mao Zedong personally chaired a meeting to listen to scientists' opinions on the decision to launch the great project of developing the A-bomb, the H-bomb and artificial satellites (Lu Yongxiang, 2003); in 1956, over 600 scientists, technologists and technological management experts participated in the drafting of the PRC's first plan on S&T development (Long-Term Plan for Scientific and Technological Development 1956–1967); in 1986, Wang Daheng and three other scientists wrote a letter to Deng Xiaoping calling for developing hi-tech research in China, which led to the 863 Program. With the development of the Chinese economy and the furthering of the efforts towards more scientific and democratic decision-making, a large number of experts have become involved in the making of decisions on social and economic development, which has greatly enhanced the scientific level of decision-making. For instance, many scientists have contributed important advice and suggestions to the feasibility study and the selection of designs for major national projects such as the Three Gorges Dam, the Qinghai-Tibet Railway and the South-to-North Water Diversion Project.

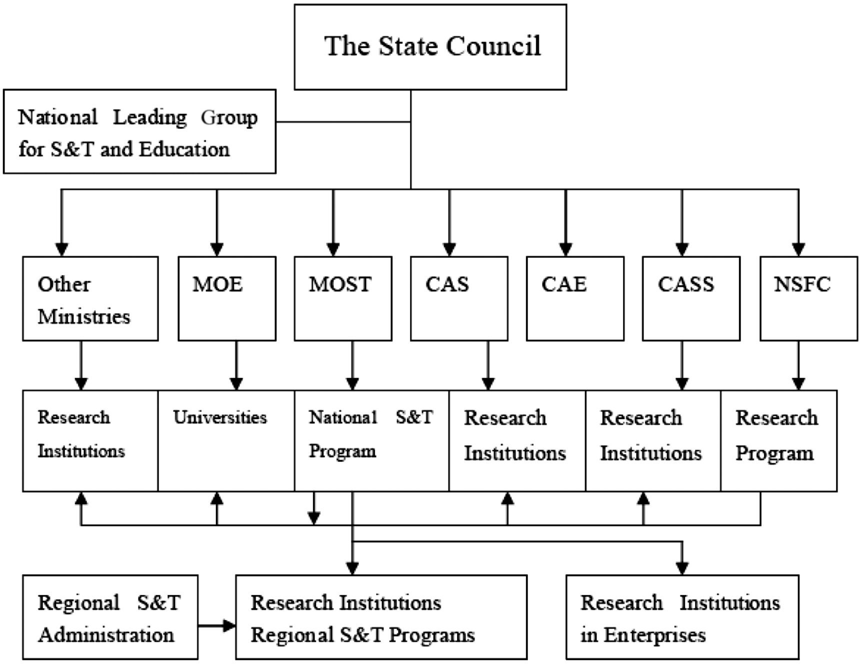

Figure 1.1 China's S&T Decision-Making and Management System

In recent years, the Chinese government has made a clear demand for experts' participation in S&T decision-making. In November 2001, MOST issued the Opinions on Improving Consultation with Academicians in order to make such consultation more regular and better regulated. According to the decision that "the State Planning Committee (SPC) and the authorities concerned would make specific measures to incorporate consultation with academicians into the decision-making on scientific and technological issues related to major national projects" by the State Science, Technology and Education Leading Group at its eighth session, the SPC issued the Opinions on Incorporating Consultation with Academicians into the S&T Decision-Making in Major National Projects in support of such consultation conducted by state authorities concerned. Scientists have generally played a vital role at every step of S&T decision-making and management. They have participated in every step of planning, pre-initiation evaluation and award giving in national S&T programs like the 863 and the 973. Their advice and comments have become the most crucial part of decision-making and management. At present, there are over 6,000 experts supporting the national 973 Program, nearly 20,000 experts working for the 863 Program, and over 30,000 experts at the State Scientific and Technological Award Office (Xu Guanhua, 2007). In 2003, when the state launched strategic research for a plan for mid- and long-term S&T development and the drafting of the plan's outline, over 2,000 experts of natural science, social science and engineering as well as those from the business community took an active part in it by offering their advice and suggestions. This became a successful example of experts' advisory role in major state strategic decision-making.

In April 2007, Minister of Science and Technology Xu Guanhua published an article in *Science and Technology Daily*, in which he fully acknowledged scientists' and experts' tremendous contribution in S&T decision-making, consultation and management in China. He also noted that S&T decision-making and management must comply with the objective law of S&T activities:

1 In basic research and exploratory research into cutting-edge technology, we should keep encouraging original innovation and free exploration and give full play to scientists' leading role in decision-making and management;
2 In market-oriented innovation in applied technology, we should insist on taking the market and application as guidance and give full play to the initiative of scientists, engineers and technicians as well as experts' advisory role in decision-making;
3 For major S&T programs and projects reflecting the state's objectives and strategic will, we should make use of the government's leading role in decision-making on the basis of heeding advice from experts in various areas (Xu Guanhua, 2007).

This is a summary of the Chinese government's experience in letting experts participate in S&T decision-making management over the years.

1.1.3 Scientists' participation in S&T decision-making in Western countries

Scientists' role as important participants in public policy decision-making started during the late period of WWII, when natural scientists, mainly physicists, played a vital role in war decisions (the development and use of the atomic bomb). After WWII, in Western countries, notably the United States, a great number of natural and social scientists were involved in government decision-making processes as individuals or groups (advisory committees). As important participants in the making of public policies, they made scientific recommendations on S&T development and public policy to politicians and technocrats, including the highest decision makers. Here we will make a brief review of such participation after WWII, with the United States as an example.

In 1957, both the government and the public of the United States were shocked by the launch of the Russian satellite Sputnik. In response, besides a dramatic increase of S&T investment, President Eisenhower appointed MIT President James Killian as America's first official and full-time Science Advisor to the President. At the same time, he established the President's Science Advisory

Committee (PSAC), made up of twenty-odd eminent scientists, which was headed by the Science Advisor to the President. The creation of the PSAC symbolized scientists becoming one of the central participants in America's public policy decision-making. Through independent technical and policy research, scientists assisted the president in the coordination and overall management of federal S&T policies and related public policies as the president's right-hand men in public decision-making. Since then, expert advisory committees led by scientists have mushroomed in the sphere of public policy.

At the turn from the 1960s to the 1970s, the science and education community's opposition to the Vietnam War and the decline in federal S&T funds led to growing tension between this community and the government. This posed a severe challenge to the presidential S&T policy system, which consisted of the Science Advisor to the President, the PSAC, the Federal Council for Science and Technology (FCST) and the Office of Science and Technology(OST).[3] After his reelection in 1973, President Nixon relegated the Science Advisor to a domestic policy assistant not accountable to the president. He dismissed the PSAC and abolished the OST, and expelled dissident scientists from the White House. Meanwhile, due to malpractices in expert consultation, the public's questioning of the expert advisory committees of the government and the legislature reached a peak. As a result, scientists' participation in public decision-making sunk to low ebb.

In the late 1970s, worsening social problems in health care, environment and oil security led to the need for more complicated control – how to protect the public from the social risks and environmental damage from technological progress while letting them enjoy its benefits became an important issue. The government faced more specialized challenges in its decision-making and became increasingly reliant on expertise and scientists. More and more scientists re-participated in the making of decisions on military, environmental and health policies other than S&T policies. On the one hand, the United States introduced the Federal Advisory Committee Act (FACA) and authorized the Federal Administrative Management Bureau to coordinate FACA affairs in order to regulate scientists' participation in government consultation and public decision-making by legal means. On the other hand, it reestablished the OST[4] and the FCST[5] to guarantee scientists' policy participation through institutional development.

In the 1980s, the call to reestablish the PSAC grew stronger among scientists.[6] When President George H. W. Bush was in office, the President's Council of Advisors on Science and Technology (PCAST) was established and various technology advisory agencies thrived. According to statistics, by the end of 1991, there were more than 1,000 advisory committees in 57 departments of the federal government, and more than half of them were related to the S&T development (Smith, 1992). In the 1990s, the United States attached great importance to the significance of technological progress to social development and America's competitiveness. President Clinton updated FCCSET to the cabinet-level National Science and Technology Council (NSTC) headed by himself and staffed by the Secretaries to show the importance attached to S&T by the government. More and more scientists came out of their labs and to work in government decision-making departments at their invitation, closely providing intellectual support to public decision-making (Chubin, 2000). Scientists' relationship with the government in public decision-making entered a period of relative stability. In this way, scientists' potential for decision-making consultation was fully realized.

In the 21st century, the 9/11 attacks led the Bush administration to give top priority to counterterrorism among all kinds of policy. It dramatically increased investment in antiterrorist research and tried to revive America's defense industry. However, in dealing with its relationship with scientists, the Bush administration selected science advisors by partisan criteria and suppressed federal scientists' opinions on global warming, medicine and other issues that were not in line with those of the White House. This plunged the relationship between scientists and the government to a new low and incurred extensive criticism from the American science and technology community represented by the Union of Concerned Scientists (UCS) (UCS, 2004; Wang Zuoyue, 2007; Lambright, 2008).

1.2 The questions

From the perspective of policy science and STS studies, the relationship between experts and policy makers in policy processes represents the interrelationship between and coexistence of knowledge and power (Smith, 1992; Hisschemoller, 2001; Wiltshire, 2001). The implied assumptions here are that natural scientists and experts are vehicles of knowledge, that policy makers like political authorities and administrative officials are vehicles of power, and that the policy game between them reflects the struggle and coordination between knowledge and power. However, the reality is not so simple. In an actual S&T decision-making process, experts are not the only vehicles of knowledge; policy makers also possess a great deal of knowledge and information required for decision-making and are capable of accurate judgment on related issues, therefore encroaching upon scientists' domain to some degree. For their part, policy makers cannot completely dominate the decision-making process with their institutional power. In many cases, experts can play a key role in decision-making on the strength of their superiority in knowledge, and their influence would go far beyond the official authority they are endowed with by the rules. This suggests that we should not see the policy game between scientists and officials simply as confrontation and coordination between knowledge and power, but as a process in which the decision-making actors use knowledge and institutional power to contend for influence on decision-making. In this sense, to understand the S&T decision-making mechanism and process, we must grasp the key issue of the influence of the actors.

What, then, are the determinative factors for a decision-making actor's influence in S&T decision-making? What interrelationship exists between these factors? How do they act upon the decision-making actors' influence and shape their game behavior? How is the evolution of S&T decision-making actors' influence and the decision-making mechanism related to the changes of these factors?

These are the practical and theoretical questions to be answered in the present study.

This study will answer these questions with the 863 Program as the central case.

1.3 The purpose and significance of this study

1.3.1 The purpose

This study attempts to make an in-depth analysis of S&T decision-making actors' game behavior and the determinative factors for their influence, with focus on scientists' influence on decision-making, in order to deepen our theoretical understanding of the S&T decision-making process and make beneficial policy recommendations.

The purpose of social science research includes exploration, description and explanation (Babbie, 2000). The purpose of this study is mainly reflected on the two levels of description and explanation.

1 The descriptive level

The interaction and game between the policy participants, mainly scientists and officials, during decision-making processes in the 863 Program will be systematically described, with emphasis on the change of the planning and decision-making management mechanism and the evolution of scientists' influence on planning and decision-making.

2 The explanatory level

1. Various determinative factors of scientists' influence on decision-making proposed by theorists will be analyzed; a conceptual framework with relevant hypotheses for overall macroscopic analysis of scientists' influence on S&T decision-making will be created.
2. After it is validated by case studies, the framework will be used to explain the causes of the evolution of scientists' influence and the decision-making management mechanism in the 863 Program.

It should be noted in particular that the central objective of this study is to explain *what* the determinative factors in scientists' influence on decision-making are on the level of "instrumental reason". In fact, there is no linear relationship between the influence of scientists and government officials on important S&T decision-making and the correctness of decisions: the rise of scientists' influence on decision-making does not necessarily make it more scientific; similarly, the rise of government officials' role does not necessarily make it less scientific or more in line with national interests. So how should we define the roles of scientists and other actors in a good S&T decision-making mechanism? We need to elevate our understanding to the level of "instrumental reason" and discuss how the S&T decision-making mechanism should be like, or the optimization of scientists' participation in it. This will be discussed in the last part of this book, though it would not be part of our main objective for the sake of the economy of key points.

1.3.2 Significance

1 Practical significance

At present, how to further the interaction between science and politics and make full use of the S&T community's role in public decision-making have become important issues in China's effort to build an innovation-oriented nation (Xu Guanhua, 2007; Hu Jintao, 2008). It is of great practical significance to accurately define the roles of scientists and other actors in S&T decision-making and build an S&T decision-making mechanism that can give full and appropriate play to scientists' role and raise the efficiency of decision-making. To this end, we must first of all find out the determinative factors for scientists' influence, based on which we would be able to identify the crux of the problem with experts' participation in the S&T decision-making mechanism. This is exactly the main objective of this study, which attempts to find out the central determinative factors for scientists' influence on S&T decision-making and the interrelationship between these factors and such influence, so as to provide a basic starting point and a substantial hinge for improving the S&T decision-making mechanism and creating a decision-making environment conducive to scientists' contribution of their knowledge.

2 Theoretical significance

Theorists have long been interested in scientists' policy participation, and scholars have done a lot of valuable research into scientists' influence on public decision-making. However, no one has generalized the many factors that could affect such influence or define any direct or indirect factors. Besides, the existing research is mainly limited to the discussion of scientists' influence on decision-making on the partial and microscopic level, and a macro-framework for theoretical analysis has yet to be formed. This is a regrettable deficiency that impedes a deep and accurate understanding of scientists' policy participation. As an experiment in this respect, this study attempts to make a systematic review of the relevant research, differentiate and integrate the determinative factors for scientists' influence, and extract from those the three key elements of knowledge, values and institutions. These would form the basis for a framework of macro-analysis, which can reveal the mechanism by which diverse and complex internal and external factors affect such influence. This would not only help us to deeply understand the historical changes in scientists' influence on decision-making, but also to make an accurate analysis of the behavior of scientists and other participants in S&T decision-making and the mechanism of their influence. The framework, therefore, is of both theoretical significance and innovative value.

1.4 Defining key concepts

1.4.1 Scientists and officials

1 Scientists

According to the *Webster's Dictionary* (2005),[7] a scientist is "a person having expert knowledge of one or more sciences, especially a natural or physical science". In this study, scientists refer to specialists with expertise and skills in natural science or engineering, who hold no official post in any government organization. This definition excludes the technocrats with specialized knowledge and skills who have received systematic training in science but who also hold official government posts.

2 Officials

In this study, officials fall into two categories – political authorities and common administrative officials. Political authorities are power elites with special political status, such as the high-level leaders of the ruling party and high officials at or above the ministerial level.

In S&T decision-making, their main task is to examine and approve S&T strategies and major policies and make decisions on important matters related to the S&T development.[8] Common administrative officials refer to officials at or above the intermediary level in government administrative departments. Their main tasks are to implement the strategies, guidelines and resolutions on major issues made by political authorities; plan and promote the introduction and execution of S&T policies, laws and regulations; and lead common activities of S&T management.

"Scientists" in this study refer to both individual scientists and scientists as a group. This is because individual scientists' policy behavior is the reflection of the group's characteristics on specific issues, and such characteristics are shaped by the behavior of many individuals. These two aspects are inextricably linked. Similarly, the concept of "officials" also has the twofold meaning of individuals and group.

1.4.2 Knowledge, value and institution

1 Knowledge

According to *Ci Hai* (the largest Chinese dictionary), knowledge means the results or crystallization of human cognition.[9] The *Webster's Dictionary* defines knowledge as "the understanding of the facts and states of things obtained through practice, study, association or investigation, the sum of humankind's understanding of truths and principles". In a broad sense, knowledge includes cognition of both objective facts and subjective matters (such as value and culture). In this study, knowledge refers to only cognition of objective facts.

2 Value

Value is a concept that is very difficult to define. According to the definition given in *American Heritage Dictionary* (2004),[10] value is "a principle, standard, or quality considered worthwhile or desirable", which suggests that it is a subjective assessment of things. In this study, value refers to cognition and assessment of culture, ethics, morality and interests, etc.

3 Institution

"Institution" is a general concept. According to *Ci Hai*, an institution is a procedure for doing things or a code of conduct that all members are required to follow. In the opinion of Douglas North, a leading figure of the neo-institutional economic school, an institution is "a series of formulated rules, law-abiding procedures and moral and ethical norms on behavior" (North, 1994); it is "a set of human-designed constraints on interactions between people" (North, 1990). In a broad sense, institutions include both formal constraints that are consciously designed or prescribed (e.g. political rules, economic rules and contracts) and informal constraints (e.g. social norms, conventions and morality) (Masahiko Aoki, 2001). This study adopts the concept of institution in the narrow sense, i.e. organizational structures, laws, regulations and policies, and decision-making rules that regulate people's behavior and the relationship between them.[11]

1.4.3 S&T decision-making

In this study, S&T decision-making means the proposing and setting of agendas on issues related to the S&T development and the making of judgments and decisions during the formulation, selection and implementation of action plans by participants in S&T policies.

S&T decision-making goes on throughout the process and levels of science and technology policies. In terms of policy processes, judgments and decisions on various issues are necessary for setting agendas, designing policies and plans (e.g. the selection of priorities and management models), implementing policies and evaluating the effects. On the decision-making level, decision-making behavior is omnipresent in the selection of strategic orientation; the making of plans; the issuance of plans as well as policies, laws and regulations; and the management and evaluation of specific projects. Thus S&T decision-making is reflected not only in the introduction of policies, but also in their implementation.

1.4.4 Influence

It is generally believed that it was Robert Dahl, a representative of behaviorism and pluralism and an eminent American political scientist, who was among the first to introduce the concept of "influence" into political science, define it and discuss it in a systematic way. According to Dahl, in the operation of politics, influence is often linked with such concepts as power, authority, control and imposition. At first, he simply defined influence as "A has an effect on B so that A changes B's action or tendency in some way" (Dahl, 1987). In recent years, he has elaborated on this definition – influence is such a relationship between human actors that the need, wish, tendency or intention of one or more actors has an effect on the action or action tendency of one or more actors so that their direction of action is in line with (not opposite to) the need, tendency or intention of the source of influence (Dahl and Stinebrickner, 2003). In this study, influence is defined as an ability or power that can impose compulsory forces or have effects on other people's actions, behavior and opinions so as to change them.

How, then, shall we define scientists' influence on S&T decision-making?

When examining American scientists' participation in public policies, American scholar Dean Schooler Jr. summarized scientists' influence in policy processes as "scientists' presence in and effect on policy processes that lead to the emergence of (new) policies or changes in the existing ones" (Schooler, 1971). Based on this theoretical contribution and the discussions in the previous part, this study defines scientists' influence on S&T decision-making as "scientists' ability to change the opinions and actions of other S&T decision-making participants through their behavior and consequently alter the results of decision-making".

Two points are worth noting here:

1 Decision makers in policy processes are generally understood to be politicians or administrative officials with institutional decision-making power; scientists are regarded as advisors without actual decision-making power rather than decision makers who make the final policy choices. However, in the real-world picture of S&T decision-making, at particular policy stages or in particular policy areas, scientists play a larger role than common advisors and possess actual decision-making power (for instance, in the 863 Program until 2001, scientists enjoyed considerable autonomy in the distribution of funds in technological areas). Therefore, in the definition above, we see scientists as "decision makers" in S&T decision-making processes instead of limiting their role to "advisors" offering information and advice in an attempt to influence government officials with decision-making power.
2 Because this study only considers two kinds of participants – scientists and officials, according to our definition of scientists' influence on decision-making, the rise of such influence (which is equal to "the rise of scientists' ability to alter officials' opinions and actions") will lead to the decline of officials' ability to alter scientists' opinions and actions (which is equal to "the decline of officials' influence on decision-making"). In other words, the rise

of one inevitably leads to the decline of the other. In this sense, by focusing on the examination of scientists' influence, we would grasp the fundamental parts and the essence of interactions in S&T decision-making and would be able to depict the whole picture of influence on decision-making.

1.5 Research method

In this book, qualitative case study will be the main research method, with literature survey and semi-structural in-depth interview as the main data-collecting method. Deep description with be the main narrative means, and congruence procedure will be the main approach to case study.

1.5.1 The selection of the qualitative research method

The selection of the research method depends on the purpose of research, the nature of the issues under study, and the availability of research data, etc. This study attempts to find out the determinative factors in scientists' influence on decision-making and the causes of its evolution through the depiction of a historical picture of scientists' participation in S&T decision-making in China. Due to the complexity of Chinese policy processes and the difficulty in obtaining relevant data, deep revelations of Chinese scientists' policy behavior are next to nothing in theoretical circles at home and abroad. According to Marshall and Rossman (2006), qualitative research is quite applicable to in-depth study of complicated matters and processes, unknown phenomena, and cases where experiment is impossible for practical reasons. In the opinion of Creswell (1998), "One of the important reasons for choosing qualitative research is that the research you are conducting is an exploration, not writing about some well-studied issue. The researcher must work hard to collect information so as to establish a clear image [for the subject] on the basis of that."

These suggest that the adoption of the qualitative method for this study is appropriate and scientific. Admittedly, though, in relevant studies, especially those of the knowledge utilization school, there are some significant results of quantitative research that have effectively measured the variables of policy influence from the knowledge of experts (Huberman, 1994; Landry *et al.*, 2003). However, for the present study, even if it is possible to build a reasonable system of variables and design an appropriate measuring scale, the difficulty in obtaining information about experts and contacting them would militate against scientific sampling and data collection. Therefore, a quantitative method is out of the question.

Qualitative study focuses on describing, expounding and exploring events, phenomena and issues with language. It can be generally divided into such categories as participatory observation, document symbol and narration analysis, case study, file analysis, content analysis, communication analysis, psychological analysis, questionnaire research, and interview research (Zhang Mengzhong, 2001).

The existing literature shows that case study is the method adopted in the vast majority of theoretical research into policy processes and scientists' policy participation. Through case studies of specific departments or policy events, such research can penetrate deeply into policy processes, examine in detail the interactions between scientists and other policy participants, and reveal the mechanism by which scientists exert their influence on policies. Since this study is also an in-depth examination of decision makers' behavior in policy processes, a clear and scientific understanding cannot be achieved without detailed and profound analysis of specific cases ("the dissection of sparrows", so to speak). The experience of our predecessors shows that case study is a powerful tool for achieving the purpose of this study. That is why we have selected case study based on interviews and policy text analysis as our principal research method.

1.5.2 Case study with congruence procedure as the major approach

There are three ways to test a theory through case study (Evera, 1997): controlled comparison, congruence procedure and process tracing. Controlled comparison tests a theory through observing and comparing cases. Congruence procedure can be divided into two types: 1) testing a theory through observing and comparing cases; 2) testing a theory through observation and comparison within a case. Process tracing tests a theory through observation within a case; it is a stronger method than controlled comparison and congruence procedure. In this study, congruence procedure is the major approach to case study.

Congruence procedure falls into two categories: 1) comparing the values of variables in different cases against the standard values,[12] which is most useful when the variables under study have extreme values; 2) multiple comparisons within a case. The research will observe pairs of independent variables and dependent variables under various circumstances, and then assess these values to see whether they vary together as predicted by the hypotheses that are being tested. If they do, the test is passed.[13] This congruence procedure is most applicable when the following two features exist: 1) a lot of observation of the values of independent variables and dependent variables is possible; 2) such values vary significantly with the change of time and space (or regions, institutions and groups, etc.) (Evera, 1997).

In this study, a large number of decision-making cases in the 863 Program have been obtained through in-depth interviews with dozens of participants in the Program and the differences between those cases are quite obvious. Hence the second type of congruence procedure is adopted for this study.

1.5.3 The selection of the cases and the sources

1 The selection of the case

The National High-tech R&D Program (the 863 Program) has been selected as the central case for this study out of two considerations: 1) The main decision makers on S&T plans being government officials and scientists, the policy game is relatively simple, which makes it easier for us to understand scientists' decision-making behavior. 2) In comparison with other S&T programs, scientists have played an important role as advisors and decision makers at