Science in Political Context:

The Evolution of Taiwan's Science Policy

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Abstract

This thesis aims to explore the evolution of Taiwan's science policy through two mutually interactive perspectives: the development of scientific authority in society and the change of social accountability of science. Taiwan's ongoing democratisation provides a valuable platform for observing the intriguing relations between science and politics in a developing society.

Drawing notions from science studies and the policy issue approach, the analysis starts by examining five major policy communities: the general public, the scientific community, industry, the science administration and the legislature. The study reveals that under democratisation pluralistic participation has given rise to diverse policy issues and reshaped the relations between science and society. Policy issues have been constructed through continuous interactions between the politicisation of science and the scientification of politics. On the one hand, the role of scientific verification and scientific authority has considerably increased in public policy. On the other hand, diversified issues and concerns have changed the underlying justifications of science policy and thus imposed new social accountability upon science.

With the power restructuring of policy actors, Taiwan's science policy over the last decade has managed to consolidate scientific authority in the public sphere and to extend the social accountability of science. As to the 'policy for science' domain, government measures have explicitly addressed research excellence, funding reform and co-ordination capacity in order to justify public investment in science and safeguard the credibility of scientific production. With respect to 'policy through science', publicly funded research and relevant policy measures have been directed to encourage private research, enhance national security and expand the public good in the face of social and political demands.

A case study of Taiwan's space policy verifies my argument in detail. The case study reveals that despite security being a primary rationality for Taiwan's satellite programme, other issues raised by different policy actors have forced the science administration to respond, and hence have compromised policy coherence. While achievements are visible, the programme suffers from perfunctory legitimating process and inferior scientific credibility.

This study finds that Taiwan's science policy entails certain defects because of the fragile installation of 'knowledge power' across society, which has now become an obstacle to further promoting the social accountability of science and protecting scientific development. It is suggested that Taiwan's scientific development has come to a turning point where cultivating pluralistic settings for scientific production and deliberation is as important as building centralised control. Given Taiwan's current power structure around science policymaking, a scientific advisory body set up in the legislature is advocated as a possible means to penetrate the sanctuary of governmental scientific judgements, encourage civilian scientists and citizens to participate in policy, and nourish a healthier environment for the public understanding of science and for scientific debates in society.

Declaration and Copyright

Declaration

No portion of the work referred to in the thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

Copyright Announcement

To the memory of my mother

Chen Kuei Tz

who taught me to look on the bright side of life

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List of Abbreviations

AIDC	Aero Industry Development Centre (Aerospace Industrial Development Corporation after 1996)
ARTDG	Applied Research Technology Development Group
BSRBM	Battlefield Short Range Ballistic Missile
CEPD	Council for Economic Planning and Development
CSIST	Chung-Shan Institute of Science and Technology
COSMIC	Constellation Observing System for Meteorology, Ionosphere and Climate
DGBAS	Directorate General of Budget, Accounting and Statistics
DOH	Department of Health, Taiwan
DPP	Democratic Progressive Party
DSS	Dornier Satellitensysteme GmbH
EC	European Community
ECP	Experimental Communication Payload (ROCSAT-1)
ERSO	Electronic Research Service Organisation
FY	Fiscal Year
GEO	Geo-stationary Earth Orbit
GPS	Global Positioning System
HSIP	Hsinchu Science-based Industry Park
IDF	Indigenous Defence Fighter
III	Institute for Information Industry
IPEI	Ionosphere Plasma and Electrodynamics Instrument (ROCSAT-1)
ITRI	Industrial Technology Research Institute
KMT	Kuo-ming Tang

LEO	Low Earth Orbit
MND	Ministry of National Defence, Taiwan
MOEA	Ministry of Economic Affairs, Taiwan
MOTC	Ministry of Transportation and Communications, Taiwan
MRBM	Medium Range Ballistic Missile
NSC	National Science Council, Taiwan
NSPO	National Space Programme Office
OCI	Ocean Colour Imager (ROCSAT-1)
PRC	People's Republic of China
R&D	Research and Development
ROC	Taiwan, Republic of China
RSI	Remote Sensing Instrument (ROCSAT-2)
SAR	Synthetic Aperture Radar
S&T	Science and Technology
SLV	Space Launch Vehicle
SMEs	Small and Medium-sized Enterprises
SSC	Superconducting Super Collider
STAG	Science and Technology Advisory Group
TMD	Theatre Missile Defence
TRW	Thompson Ramo Wooldridge Inc.
TT&C	Telemetry, Telecommand and Tracking Centre
UCAR	University Corporation for Atmospheric Research

CHAPTER I

Themes and Analytic Structure

A. Introduction

The thesis argues that the growth of scientific authority in society and the expansion of the social accountability of science have together combined to shape the evolution of Taiwan's science policy during the 1990s, when extensive changes of power structure took place in and among different policy communities and redefined the relationship between science and society during a process of democratisation.

Science, more than ever, is regarded as a tool for solving various problems of mankind, rather than just a knowledge system conceived from nature. Christopher Freeman, one of the pioneers in the economics of technological change, writes: "technological capacity is the main source of the competitive strength of firms and nations" (Freeman, 1987, p. 1). Indeed, science and technology (S&T) policy has undoubtedly become a crucial policy area since World War II. This climate has led most nations around the world, whether developed or developing, to embark upon promoting science, technology and innovation. With substantial funds and resources, governments everywhere are committed to establishing excellent scientific foundations in order to reap S&T benefits. Taiwan, once reliant on agricultural exports for survival, now impresses the world by its information technology products. During the last decade, the government's commitment to promoting S&T has increased. Bright prospects are reflected through a range of political slogans such as 'constructing a science and technology island', 'building a technologically advanced nation', 'forming an Asian-Pacific research foundation', 'realising a green silicon island' and so on. At first sight, the intention behind Taiwan's S&T effort is clear and simple. Situated in a catch-up position in the global knowledge-based economy, deepening the S&T base is the best choice for its development, and in fact there is no obvious alternative. It has become a general belief that public investment in science and technology will benefit industrial upgrading, and eventually national development, in a linear process from science to industry and from science to political gains. The idea that the deepening of the science base is needed when facing limits of technological exploitation is commonly found in developing countries, and the concept of a linear relationship is widely rooted in the hearts of the architects of national development and the general public alike. For example, facing intensive globalisation, Li Kwoh-ting who has been dubbed the country's 'father of technological development', once argued: "... ROC [Taiwan, Republic of China] industries must upgrade their production structure and become more technology intensive. With this in mind, the ROC government has promoted a phase-by-phase acceleration of science and technology development..." (Li, 1992, p. 21).

This general perception could provide a powerful interpretation of Taiwan's development in the context of the arguments of scholars who find that a 'governed market' strategy (Wade, 1990, p. 26) or the state's 'embedded autonomy' (Evans, 1992, pp. 162-64) explain why certain Eastern Asia countries kept beating the odds in the last two decades by exploiting S&T to boost their economy.

Although the general perception based on the concept of a linear relationship from state-led technology development to economic growth is not in itself mistaken, it fails to reveal certain dimensions of Taiwan's S&T so far. For example, it is hard to explain, given the government's constant commitment to promoting high-tech industry, why the link between academic research and industrial R&D has long been criticised for its poor functioning and inefficiency. On the other hand, how can we explain Taiwan's adoption of large-scale scientific projects in the last decade with no evidence of immediate returns, such as the satellite programme and high-energy particle physics? Does this mean a pure science enterprise has been launched in the island? Apparently, the interfaces between science, industrial technology and economic growth are much more complicated than a simple linear model suggests. The characteristics of scientific production and science policy deserve to be placed at the centre in order to arrive at a full understanding of Taiwan's S&T development, rather than science being understood as either an inert instrument or a subsidiary object.

Furthermore, since the end of the 1970s the Taiwanese government had proclaimed 'enhancing the quality of life' as one of objectives of national S&T policy, but not until the 1990s were conspicuous measures taken to support scientific projects with social concerns, such as large-scale ecological research or hazard mitigation. How can we explain this change? What kind of implication can be drawn out from the differentiation between creating a good quality of life through industrial upgrading and prompting the public good from environmental research? Does the transformation result from the changing perceptions of policymakers? Then, who made their perspectives change, and how? The idea of a linear movement from science to political ends is inadequate to interpret the dynamic behind the transformation of Taiwan's science policy. The social aspect of scientific development and the relationship between science and society need to be taken into account. One might untangle the above questions to some degree by stressing the impacts of global trends in science policy or the windfall of technology build-up. But the timing raises another issue. Why do the reform of public funding, the exploitation of dual-use technology and humanities-science integration arise in the 1990s while such issues were institutionalised in the Western countries and even appeared in the discourse of Taiwan's politicians decades ago? Numerous studies of science and technology have shown that the linear vision of a relationship between science and productvity does not fully account for dynamic and heterogeneous elements in the process of knowledge production and the complicated interfaces between science and politics.[1]

The thesis thus aims to probe the evolution of science policy in Taiwan during the last decade by placing the emphasis on social and political aspects of policy change. The study will focus on two dimensions of science policy: the politics of the science production system and science's external relations with society. The study could be viewed simultaneously as a sociological, political and historical study of national science development, and as a policy analysis of the scientific establishment. The identification of successes and failures in agenda setting and the synthesis of policy trends will lead to policy implications for future practice and planning. Sociological and political scrutiny helps to provide a dynamic interpretation of policy evolution and changes in policy communities. This thesis is an attempt to analyse science policy from the perspective of the politics and sociology of science.

B. Scope and Definition

National Level Analysis

Placing the focus on science policy as a whole, with its numerous measures and sub-

[1] See, for example, Nelson, 1993; Sarewitz, 1996; Jasanoff and Wynne 1998; Guston, 2000.

areas, the study has to be interdisciplinary in nature and inevitably kept at national level observation in order to cover a vast terrain and reveal policy trends. The national level analysis is a meso-level study in which observed issues and actions are related to national science policy, rather than to a specific sub-policy. As Wayne Parsons notes, a meso-level analysis does not present a logical sequence which culminates in a decision, but defines problems and agenda continuity or discontinuity (1995, p. 85). In order to concentrate on national level objects, constraints and impacts derived from macro-level structure, especially socio-economic globalisation, can only be treated as background or structural parameters. But external constraints are by no means negligible and in fact reappear in the course of analysis. In addition, the case study of Taiwan's space policy is included in order to compensate for the limitations of a purely meso-level analysis.

The Boundary of Science Policy

An immediate obstacle to the analysis of science policy at a meso-level is that the policy boundary of science is difficult to define. A wide range of policy measures have significant impacts on S&T development, including education, training, investment, trade, intellectual property, regulation, planning, and so on. At the same time, many of the policies undertaken to enhance national S&T have significant distribution consequences. As a result, it is also difficult to draw a sharp line between science policy and other policy areas such as economy, industry, education, defence, health, agriculture, environment and public welfare. Harvey Brooks usefully distinguishes the above terrain into 'policy for science' and 'science in policy'. The latter refers to matters which "are basically political or administrative but are significantly dependent upon technical factors"; the former is concerned with policies for "the management and support of the national scientific enterprise" and "the selection and evaluation of substantive scientific programmes" (Brooks, 1964, p. 76). Based on the above classification, I go further to endorse Jean-Jacques Salomon's more precise definition, that is, science policy is "the collective measures taken by a government in order, on one hand, to encourage the development of scientific and technical research, and on the other, to exploit the results of this research." The two aspects, 'policy for science' and 'policy though science', are complementary (Salomon, 1977, pp. 45-46).

The Boundary between Science and Technology

On the above definition, however, science policy still embraces a vast area. I restrict my concern mainly to academic research or basic science in contrast to industrially or economically oriented science policy and focus attention on the heart of contemporary debates on science, but without excluding applied research or technology areas. The term 'science policy' as used here particularly refers to academic research or basic science. Empirically, science policy refers to Taiwanese national policy concerned with the role, functions, activities and measures of the National Science Council (NSC). The NSC founded in 1967 is Taiwan's cabinet-level administration in charge of academic research promotion, co-ordination of national scientific projects, and management of the science-based park. The main concern of this thesis focuses on NSC's measures in relation to scientific research and project co-ordination, but excludes its jurisdiction on management of the science-based park.

Despite the limiting of scope for analytic purposes, it is noteworthy that the distinction between science and technology, or academic research and strategic research has become increasing blurred and unhelpful (Webster, 1991, pp. 3-4; Rip, 1992). The blurring results not only from the modern design of research processes, the division of labour among scientists, and the inseparability and inter-penetration between them, but also from the process of scientific socialisation (Ziman, 1994, pp. 23-41; 76-92). This phenomenon is crucial to contemporary society and to my argument as well. Therefore, throughout I use 'science and technology' or 'S&T' as a general term in a way that makes no precise distinction between science and technology. Readers must not confuse the meaning of 'science policy' as the object of study here with the content of 'S&T policy' which refers to broader policy measures and relevant implications. In other words, whereas my discussion in the domain of 'policy though science' inevitably extends to the technology aspect or even to various broad applications, observation is centred on and restricted to basic science or academic research.

C. Theories and Themes

Probing science policy from political and social aspects is not new in the scholarship heritage of policy analysis and science studies, but it is a novel approach in the context of Taiwan.

Local Literature Review

Thus far, few of the academic studies in Taiwan dedicated to industry and technology policy address science policy. Lin Chung-shan in his MA dissertation *Science Policy in A Developing Country: The Case of Republic of China* could be seen as the pioneer attempt to analyse Taiwan's science policy. He applied system theory and the policy process model from David Easton and Charles O. Jones to probe science policy from the perspective of administration and policy process (Lin, 1982). In 1994, Wang

Chung-hsing's dissertation *The Role and Function of the NSC in National S&T Development Policy* highlighted the administrative operation of the NSC from an institutional perspective (Wang, 1994). Both of them concentrated on formal organisations of science policy and their argument mainly focused on the justification and effectiveness of the policy process. Although their accounts have shed light on Taiwan's science policymaking, the development of science and its relationship with political power did not receive a proper treatment. They thus failed to offer a convincing interpretation of how science policy has evolved.

A new generation of young scholars however emerged in the end of the 1980s, mainly based in the History Department of Tsing Hau University, and started to look into the history of science. For example, in his essay *A Historical Study of Taiwan's Science and Technology Policy (1949-1983)* Lin Chung-hsi showed that Taiwan's science policy had been shaped by and served to sustain the authoritarian regime and the ideology of the political elites (1989). Professor Fu Daiwei in his book *The Space of Knowledge and Power* provided an incisive account of the new wave of knowledge power manoeuvring among the scientific community at the dawn of democratisation (1990a). Other studies regarding contemporary Taiwan's scientific development have flourished in the last decade, covering such topics as the scientific community (Chiang, 1990), hepatitis B control (Lin, 1994), nuclear energy debate (Hu, 1995) and reproductive technology (Chang, 1999). A common characteristic of these studies is the employment of concepts and tools from the sociology, history and philosophy of science of Western scholarship, from such authors as Thomas Kuhn, Paul Feyerabend, Imre Lakatos, Michel Foucault, Robert K. Merton, Brian Wynne, and so on. But in line with the current tendency of science and technology studies, most works tend to be confined to micro-level case study. While their interpretations profoundly enrich the understanding of Taiwan's science development, they are limited by their relatively narrow focus.

In addition, considerable commentary from within the scientific community has appeared in the last decade. Although small in volume, material expressing the scientists' viewpoints regarding policy provides a useful guide to issues and ideas in current Taiwan's science policy.

Overall, as Lin Chung-hsi has pointed out, studies of science in Taiwan are still in a nascent stage (1995, pp. 182-84), let alone the sociological study of science policy. It is therefore appropriate to enrich my argument by drawing notions from contemporary science studies, without losing sight of Taiwan's social context.

The Social System of Science

Undoubtedly, the emergence of the 'sociology of science' in the 1930s pioneered by Merton significantly advanced the understanding of the contemporary social structure of science.[2] In his view, the institutionalised norms and ethos of science are the institutional characteristics demarcating science from non-science.

Merton identifies a set of institutional imperatives of science, including universalism, communalism, disinterestedness and organised scepticism (Merton, 1942, pp. 270-78). The norms of science, its institutionalised ethos and the doctrine of scientific autonomy secure both the rationality and the progress of science. In the system, originality and priority disputes are essential impetuses for scientific enterprise.

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[2] Here, the term 'sociology of science' refers exclusively to the Mertonian view and its supporters. I use 'science studies' to loosely encompass the entire range of works in historical, sociological, political, or cultural studies of science, which may include the 'sociology of science', 'social studies of science' and others. The 'social studies of science' refers to one strain of science studies that revolves around the epistemologically relativistic critique of science.

Merton comments:

> Like other social institutions, the institution of science has its characteristic values, norms and organisation. Among these, the emphasis on the value of originality has a self-evident rationale, for it is originality that does much to advance science. Like other institutions also, science has its system of allocating rewards for performance of roles. These rewards are largely honorific, since even today, when science is largely professionalised, the pursuit of science is culturally defined as being primarily a disinterested search for truth and only secondarily a means of earning a livelihood (1957, p. 323).

Although having been largely modified or criticised, Merton's pioneer claims significantly indicate the communal process of scientific activities and the social institutions of scientific practices. If the history of science is punctuated by the 'priority of discovery', the fundamental social system of science is academic communication (Merton, 1957, pp. 286-87; Ziman, 1984, p. 58). For this function, the social institutions of science contain a series of self-regulation mechanisms including publication, recognition, accreditation, and reward though papers, journals, books, peer review, citation, conferences and scientific associations (Hagstrom, 1965, pp. 99-100, 108-11; Ziman, 1984, pp. 58-69). Scientific autonomy, which refers to individual and institute freedom of research and social distance for scientific production as a whole, is maintained by the social system of science and is necessary for cultivating scientific authority, producing certified knowledge and commanding power in the public sphere. From a historical perspective, the formation of scientific autonomy is a social process of legitimisation. Thus, Joseph Ben-David indicates that 'decentralised systems' or democratic societies have been more effective for the institutionalisation of science apart from social values and interests (1971, pp. 169-71). Michael Polanyi's concept of 'the republic of science' emphasises the importance of a liberal societal environment for securing scientific enterprise (1962). Once insitutionalised, scientific values, norms, and authority in turn make science a persistent feature in culture and society and provide a locus for the operation of scientific communication and rewards.

Then, the problem is who is to control the social system of science. Institutionally, this is resolved and maintained by a stratified system, specialisation and elitism (Cole and Cole, 1973, pp. 37-89). However, in the stratification system, not only fraud, deviate behaviours and malpractice, (Zuckerman, 1977; 1984; Chubin and Hackett, 1990, pp. 125-63), but also what looks like structural biases and inequality exist, such as the 'Matthew effect',[3] group culture and geographic dominance (Merton, 1968; Zuckerman, 1970). For Merton, hierarchy and stratification in science are functionally necessary and efficient, and he believes that "sooner or later, competing claims to validity are settled by universalistic criteria" (Merton, 1942, p. 271, n. 6). Incentives, punishments, and social contracts in science are highlighted as means to remedy defects and strengthen the social system of science from which certified knowledge is secured (Zuckerman, 1977, p. 113; 1984, pp. 12-13). The underlying axiom of the high level rationality of science, as Barry Barnes pointed out, is to accept that "science has been allowed to define what we hold to be true about the world" (1974, p. 5).

The concept that science, as a certified knowledge of the true, is conducted thought a unique social system, as we shall see shortly, has confronted challenges both from the cognitive and external dimensions. However, the notion of the social institutions of science is far from redundant and in fact is still held by the majority of

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[3] As expressed in the *Gospel according to St Matthew*, the Matthew effect refers to the phenomenon by which the rich grow richer, and the poor grow poorer found in the

scientists and the general public. Observation of the social institutions of science still provides significant insights into scientific practice, not because it provides a complete and satisfactory interpretation, but because the special status of scientific values and the form of self-regulation mechanisms have been internalised in our culture and belief.[4] It is therefore crucial for this research, examining science from a policy perspective, to understand what the social institutions of science mean to the scientific community and other policy actors in a given society. Especially in a developing country where even scientific autonomy and authority are at a formative stage, the self-ensuring and self-controlling mechanisms of science are fragile and have to rely on governance imposed from outside. In this sense, actions taken to address the social institutions of science and their limitations essentially imply a change in science policy. This is the first theme of the thesis.

Science and Politics

According to the discussion so far, science is supposed to produce fact and truth. Hence, 'speaking truth to power' was once proposed to define the boundary between science and politics by Don K Price. He divided the spectrum from truth to power into four estates, in which the political estate pursues action and power, while the scientific estate is concerned solely with knowledge and truth; within them administrators rely less on knowledge and are closer to ultimate power, while the professions have a commitment of service to the public but maintain self-government to certain degree (1965, pp. 126-44). The failure of scientists to maintain distance from the political

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reward system of science (Merton, 1968).

[4] Chubin and Hackett, 1990, p. 5; Cole, 1992, pp. x-xi; Gieryn, 1995, p. 405; Jasanoff, 1998, p. 7; Weingart, 1999, p. 158.

estate offers grounds for assaults on their credibility.

Nowadays, however, the relations between science and politics are far more intimate and complicated. Michael Gibbons' famous 'Model 2' argues that new knowledge production has become application-oriented, transdisciplinary, heterogeneously organised, socially accountable and quality controlled (Gibbons, pp. 1-16). Under the prevailing tendency no one asks whether the state should intervene in scientific research but only how it should intervene. Immense governmental support for science and scientific research designed for solving a wide range of social problems has made scientific authority and autonomy more ambiguous. With the expanding governmental role in support and regulation, science is subject to political constraints. John Street, for example, draws out three dimensions of the state-technology relationship – the state as regulator, as customer and as underwriter, and claims that a separation between politics and technology is impossible (1992, pp. 46-49, 178). Sanford A Lakoff from another perspective points out that scientists and technologists become involved in policy in three roles: as advocates of support, as advisors and as adversaries (1977, pp. 374-79).

Consequently, the boundary between science and politics has become vague and debatable. The biases in the stratification of science and the intrusion of external roles, commitments, and values into the scientific evaluation system appear far more serious than the Mertonian view. Elite scientists involved in policy tend to be manipulated by political elites and alienated from the scientific community; scientific advice may involve scientists' own preferences or serve politicians' goals; in fact, there exists a conflict between scientific standards and political ends (Blume, 1974, pp. 211-12; Lakoff, 1977, pp. 372-73; Ezrahi, 1977). That is why Stuart S. Blume warns that at the highest levels scientific elites tend to be politicised and only scientific dissension can inhibit emergence of this 'pathological situation' (Blume, 1974, pp. 14). Problems may also arise from the limited political skills of scientific advisors, or from officials' neglect of knowledge seeking (Gummett, 1980, pp. 111-17, 232-33; Ashby, 1983).

Tensions between science and politics go further with the increasing weight of scientific knowledge in various political expectations and social demands. David Collingridge and Colin Reeve find that there is a difficulty in conducting rational policymaking when expertise is introduced into the policy arena (1986, pp. 145-58). Can science fulfil social demands? The hybrid character existing between science and politics generates what Alvin Weinberg calls a 'republic of trans-science' and supports the view of Peter Weingart who argues that the 'scientification of politics' goes hand-in-hand with the 'politicisation of science' (Weinberg, 1972; Weingart, 1982, p. 73). The fundamental dilemma here is that on one hand science and scientific applications have increasingly affected society as a whole and thus involved a variety of values, while on the other hand, unresolved problems in public policy at large extensively rely on science and scientific advice for seeking a resolution (Weingart, 1999, pp. 157-59). The role of science in society has already gone beyond the provision of knowledge and the delivery of economic productivity.

Seeing this, David H. Guston and Kenneth Keniston divided the tensions between science and democracy into three aspects: populist tension between professionalism and various expectations, plutocratic tension between economic domination and common welfare and exclusionary tension between elitism and public participation (1994, pp. 24-28). Indeed, the relationship between science and politics has become a crucial and vexing problem in contemporary society. To resolve the tension between science and politics, from a different perspective, Jurgen Habermas and Sheila Jasanoff come to similar viewpoint to advocate reciprocal communication between scientists and politicians or continuous negotiation among agencies, scientific advisors, adversarial views and public opinion (Habermas, 1971, pp. 66-67; Jasanoff, 1990, pp. 249-50). Guston has advocated a principal-agent concept to describe the linkages and relationship between science and politics, and more recently has promoted collaboration, monitoring and incentives as a means to replace the traditional laissez-faire perspective, self-regulatory norms and the linear model from input to output (1994; 1996; 2001).

Can these approaches resolve the tensions between science and politics, and secure scientific integrity and the social accountability of science? The effectiveness of these efforts still needs to be seen. What can certainly be said is that the relationship between science and politics is as hotly debated today as it ever was.

With these considerations in mind, then, we may ask how policy actors see and seek to shape the relationship between science and society in Taiwan. How does science policymaking accommodate scientific authority together with the social accountability of science? These problems lead me to formulate my second thematic enquiry.

Science and Power

So far the discussion has not called into question the validity of scientific knowledge as whole, although deviations from the norms of science and external power manipulation have been discussed. But, in the last two decades scholars from the 'social studies of science' perspective have come up with a very different view of science, although they similarly see 'social' and 'cultural' factors as essential components in the construction of scientific knowledge. They argue that the crystallisation of scientific claims, production and paradigms is constructed, interpreted, negotiated and deployed by contingent culture factors and actor interests found in everyday life, rather than through unique norms of science (Barnes, 1974, pp. 84-98; Mulkay, 1976; Collins, 1985, pp. 51-78). Taking on this view, the norms of science are, at most, formal or surface rules that are subject to actors' reinterpretations. Furthermore, they question the supposed essential qualities of science and advocate a causal, impartial, symmetrical and reflective explanation of science knowledge in pursuing their programmatic interest – to present an alternative interpretation of states or beliefs of science.[5] This approach thus claims that scientific statements are not so much descriptions of natural phenomena as notions fabricated by scientists situated in and affected by numerous social influences (Knorr-Cetina and Mulkay, 1983, pp. 5-6, 118-19, 125-26). This view fundamentally diminishes the foundation of scientific authority, because it rejects any privilege which scientists can claim to hold. The most important insight of the social studies of science approach is that scientific claims are to a large extent socially constructed.

Often, studies of this strain are characterised by their epistemological relativism, micro-orientation and use of a deconstructive approach. As a result, such studies tend to offer thick description on 'winners' and 'losers' among scientific claims and artefacts, but encounter ambivalence when they seek to provide a means or a critique to intervene in tensions between science and society in the real world, a weakness which is inherent in their relativistic approach.[6] In practice, the social institutions of science and the self-government mechanisms of science are, at least formally, enduring

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[5] See Bloor, 1991, pp. 5-23. For comparative interpretations of this school see Webster 1991, ch. 3; Callon, 1995; Restivo, 1995. For its limitations see Lynch 1993, pp. 74-82 and Gieryn, 1982 from different perspectives.

[6] Its epistemological principle is exemplified in the claims of Karin D. Knorr-Cetina and Michael Mulkay: "Epistemic relativism asserts that knowledge is rooted in a particular time and culture" (1983, p. 5).

in society, as is the underlying notion of norms. Therefore, with regard to theoretical potency, Rob Hagendijk asks, "if every thing is constructed, what makes some constructions more tenable then others?" (1990, p. 50) To enhance the practical implications of this approach, certain scholars have started to call for "putting science back into society," or offering a critical analysis of social factors which affect the formation of scientific claims, or even taking part in scientific controversy, planning and assessment without losing impartiality and symmetry.[7] As Jasanoff points out, work to present an alternative view of science is political in depth, for it reshapes "the way we come to grips with the enduring problems of truth, power, agency, legitimacy, individual rights and social responsibility" (1996, p 397).By endorsing these notions, this thesis retains the social constructive view of science and looks into actor interaction processes beneath scientific claims and formal institutions of science, although it does not set out from a micro-political perspective.

Insight into the knowledge-power relations, I find, is a key contribution of the social studies of science approach to uncovering the interaction between science and its external social factors. Michel Callon advocates an actor-network theory to show how scientists present their expertise as a useful means to solve problems, and then use power derived from their expert knowledge and strengthen the authority of their patrons through a process of enrolment or translation.[8] Using the ethnographic approach, Bruno Latour similarly shows how the construction of facts and machines is a collective process involving persuasion, rhetoric and the marshalling of resources;

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[7] See Chubin and Restivo, 1983; Cozzens and Gieryn, 1990; Webster, 1991, pp. 31-32; Cole, 1992, pp. 2-3; Rip et al., 1995, pp. 1-8; Jasanoff, 1996.

[8] See Callon, 1986a, pp. 196-233. It is worth noting that the actor-network is essentially heterogeneous, including unpredictable elements from human, nature and society (Callon, 1986b, pp. 33-34; 1987, p. 97).

knowledge claims are constructed as facts through their originators establishing alliances and networks of association with significant outsiders who will lend their authority to what is being said, without at the same trying to change what is being said (1987, pp. 103-76). Enrolment, interacting among scientists, patrons and nature, creates a network in which trade-offs occur between science and power. Those observations are crucial in that scientific verification and scientific statements are formulated through power manipulation both from insiders' knowledge power and outsiders' authority (mandate). The analysis of knowledge-power relations thus reveals a contingent interaction between science and society. These approaches start from the social construction view of scientific knowledge and claims, and bring out an explanation of why disputes between science and its surrounding social context occur and then come to closure.

Taking on this notion then, it is not surprising to recognise that not only elitism and nepotism, but also individual interests and other aberrations, are the components of the social system of science that binds the scientific community. Therefore, "its stratification as well may be aberrant," "its rational decision-making authority diminished," "and its omniscient certainty about future outcomes severely impaired." (Chubin and Restivo, 1983, p. 58) Even further, these limitations and biases have led to academic pork barrel and political earmarking (Savage, 1999, pp. 12-18).

Placing knowledge power manipulation in a broader social context, David Dickson finds that science may tend to build a network with powerful institutions, such as industry and the military, rather than address the democratic control of science (1988, pp. 308-9). Dorothy Nelkin argues:

> Power may hinge on the ability to manipulate knowledge to challenge the evidence presented to support particular polices.

> But as technical expertise becomes a resource, exploited by all parties to justify their moral and political claims, it becomes difficult to distinguish scientific facts from political values (1992, p. xix).

Such observations not only question the rationale of the linear model from science to politics, but also uncover the centrality of scientific controversy, an arena in which science and politics collide into each other. That is why scientific autonomy may not be seen as a guarantee of scientific integrity and authority but proves "convenient for agency officials and other politicians seeking safe havens in turbulent political environments."[9] Seeing power operation as a crucial dimension in the process of the social construction of science, science policymaking naturally become an arena in which power derived from the inside and outside knowledge production system is exerted to shape national science development. From this point of view, science policy is a result of social practice. Stability and change in science policy are based on a given power structure and interactions among policy actors and communities, rather than on rational problem-solving and planning.

This is not to say that knowledge-power relations can explain everything about scientific knowledge and the justification of science policy. The social studies of science approach cannot completely deny that certain knowledge conceived as 'fact' still is one of crucial criteria for evaluating scientific claims and reaching consensus (Cole, 1992). Susan E. Cozzens and Thomas F. Gieryn point out that sometimes science gains support without offering a specific rationality and immediate interests for a trade-off (1990, pp. 171-73). Indeed, there are even aesthetic and metaphysical dimensions of the good in scientific research (Frodeman and Mitcham, 2000). Thus,

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[9] Cozzens and Woodhouse, 1995, p. 541; see also Cozzens, 1990; Tuner, 1990.

the old demarcation between science and politics has been thrown into doubt but a new model for settling the obscure boundary has not yet been firmly constituted (Jasanoff and Wynne, 1998, pp. 7-9; Cozzens and Woodhouse, 1995, pp. 540-45). Consequently, the effectiveness of the self-regulation and self-controlling institutions has not been totally deconstructed, but recognised as socially constructed.

In the light of this discussion, the two key themes – the social institutions of science and the accountability of science – can be expressed as follows:

1. The social institutions of science, including its norms, communication systems and reward mechanisms, are the basis of scientific authority and enterprise, which are socially constructed.
2. The imposition of accountability on science redefines the role of science in society and challenges the social institutions of science. In the process of redefinition, manipulation through the exercise of power is inevitable.

With reference to these two themes this thesis shows how science policy in Taiwan addresses the issues of scientific authority on one hand and the social accountability of science on the other. The social construction perspective offers an instructive approach, which led my research not to confine investigation to the institutional aspect but also to observe changing power relations in and among policy communities.

D. Approach

Having clarified the main themes of the thesis, one methodological problem remains to be solved. It is always difficult for power analysis as well as policy studies to bridge the gap from power to policy, and from policy actors to policy change. Particularly in this research, meso-level analysis restricts the tools available to identify appropriate empirical evidence to pinpoint policy trends. It is therefore necessary to draw some notions from the field of policy analysis to supplement the analytical framework set out here.

In the last two decades, the focus on 'agenda setting' or 'policy issues' in the political system has come again to the fore in the field of policy studies, partially because of new forms of policy debates and controversies (Parsons, 1995, p. 168). For example, Peter M Haas recognises the need to stress 'epistemic communities' in international policy analysis (1992, pp. 1-16). Similarly, Giandomenico Majone argues in *Evidence, Argument and Persuasion in the Policy Process* that "in a system of government by discussion, analysis – even professional analysis – has less to do with formal techniques of problem solving than with the process of argument" (1989, p. 7). Focus on the process of argument, then, is particularly useful in analysing such topics as professional debates and issue contests that are essential in the process of decision-making, and therefore is compatible with the task here in analysing science policy.

Among others, Kingdom has developed a well-known approach to the study of policy agendas that separates policy issues into 'problem', 'policy', and 'political' streams, and analyses the conditions under which all three streams come in to phase behind an idea. Once what he calls a 'policy window' has been created, a new public problem or a new policy idea is pushed through the window and then forms a policy agenda (1995, pp. 165-95). By focusing on policy windows, analysts can recognise why some ideas succeed but others do not, and what cause policies to change. The agenda setting approach provides a way of linking political events with policy issues, and of showing how floating policy issues of concern to various actors lead to policy changes. Like the notion of the 'garbage can model' (Cohen, et al., 1971), Kingdom emphasises the complexity and feasibility of the policy process, suggesting that over-restricted causal concepts may fail to identify policy learning, contingency and policy process in the real world. The contingent elements of the policy process are somehow in accordance with the multiple factors of scientific knowledge construction as mentioned. Thus focusing on the power dimension in science policymaking does not make it necessary to exclude other flexible factors in agenda setting in science policy or in the formulation of scientific knowledge.

Again, however, care must be taken not to press the approach too far. In a sense, the strength of Kingdom's view causes its own weakness. Criticism usually points out that he overstates contingency and inconsistency as an impetus to 'open' the policy window, because historical, structural and institutional influences on agenda setting cannot be ignored (Jasanoff and Wynne, 1998, p. 10). It is also worth recalling here that there always exist biases, constraints and suppressions in policymaking processes as some influential studies in policy analysis have shown (Bachrach and Baratz, 1963; Lukes, 1974). Furthermore, as part of globalisation, policy changes in a developing country are vulnerable to the prevailing ideology and economic structure (Cammack, 1997, pp. 256-59). A supplementary view can be found in Majone (1989, p. 95):

> The entire machinery of government, ... is a vast collection of constraints that define the roles of different policy actors and limit the range of strategies open to them. In the very short run, politicians, bureaucrats, interest groups, and private citizens must act within the rules defined by the existing institutional framework. In the longer run, however, the rules of the policy game can and do change.

Based on a sort of evolution viewpoint, Majone suggests "the cultural milieu is not viewed simply as a constraint but as a target for persuasion, propaganda, and political action," following the recognition that "institutional arrangements not only determine who decides, but also influence what is decided" (Majone, 1989, p. 102, 104). Combining issues and power as an analytical tool is not novel. Charles E. Lindblom and Edward J. Woodhouse states that "by using the term *political* more narrowly, however, it becomes possible to contrast reasoned persuasion with power" (1993, p. 7). Taking these views it is feasible to apply issue observation or agenda setting in a way to reflect, though not exclusively, the power struggle in a given social context, and vice versa.

As illustrated above, seeing power manipulation as a significant part of the formulation of scientific knowledge and the relationship between science and politics, the exercise of power must be central to my analysis in order to examine the evolution of science policy. In addition, there is a particular need to take power relations into account in that Taiwan's scientific establishment largely relies on government support. Moreover, Taiwan is a newly democratised state which lacks a pluralistic tradition for processing policy issues, so it is essential to locate policy issues and ideas with the rapidly changing power structure into account.

For analytical purposes here, I focus on policy communities as observed agents, but distinguish them from mainstream usage of policy networks or the policy community approach that provides a useful synthetic approach to link ideas, actors, institutions and power, but is prone to centre on micro-level studies and ignore network changes (Marsh and Rhodes, 1992, pp. 15, 22).

Drawing on notions of agenda setting and policy issues, this thesis seeks to trace the evolution of science policy by examining the changing policy issues and power relations in major policy communities, in the context of a process of democratisation that accelerated throughout the 1990s.

E. Structure of Thesis

Based on the above themes and approaches, Chapter Two describes the historical origins of science policy, the development of science administrative structures and the external political-economic environment. It shows that security and economic conditions and the perceptions of political elites provided both momentum and constraints to science policy up to the 1980s. The final part of the chapter depicts the immense political and economic changes that took place in the 1980s and after, heralding a crucial transition in the policy environment and in science policy.

In Chapter Three, the analysis is divided into three parts. Each part deals with a primary policy community situated outside the governmental apparatus: the general public, the scientific community and industry. It aims to show how under democratisation changing power relations affect the capacity of those policy actors to raise new science-related issues and to impose social accountability upon science policy. The chapter demonstrates a dynamic process of redefining the relations between science and society.

Chapter Four concentrates on the core policy communities of science policy, examining the science administration and the legislature. It shows how the restructuring of power relations and of policy justification have relatively enhanced the power of the science administration among other governmental departments, and reinforced the governance of scientific production. At the same time the legislature has become an effective issue carrier for conveying emerging social demands into policymaking and framing a set of new policy agendas in the science policy arena. Chapter Three and Four together represent a interaction between the scientification of politics and the politicisation of science as a result of changing power and issues of policy communities.

Chapter Five, based on changes in different policy communities, illustrates how science policy has evolved in Taiwan over the last decade. Along with the two themes of the research it shows Taiwan has stressed both scientific authority and the social accountability of science. With regard to 'policy for science', conspicuous trends are found in relation to addressing scientific excellence, reforming funding mechanisms and extending co-ordination capacity on governmental scientific reviews. With regard to 'science through policy', science policy is directed towards encouraging private research, bearing security responsibility and expanding the public good. Finally it found that a policy convergence is emerging to integrate scientific achievement and its social relevance.

In Chapter Six, a case study of Taiwan's space policy verifies my argument in detail. At a micro level, the case study reveals how media reports, scientific debates, scientific advice, industrial reaction, legislative scrutiny, agency management and politicians' considerations construct the development of space policy. It shows that despite the security issue being an initial impetus for Taiwan's satellite programme, other issues raised by different policy actors have forced the science administration to respond and compromise, with the result that policy coherence has been lost. While some achievements are visible, the programme has suffered from perfunctory legitimating process and low scientific credibility.

Chapter Seven concludes by arguing that although democratisation has pluralised policy participation and issues through the exercise of political actions, knowledge power is centralised in the hand of the science administration. The imbalance of scientific authority has become an obstacle to the further promotion of the social accountability of science policy and the preservation of scientific authority. This study suggests that Taiwan's scientific development has come to a turning point where cultivating pluralistic settings of scientific deliberation and assessment is as important as strengthening centralised managerial planning for science.

CHAPTER II

A Historical Review

Historical and structural constraints have largely influenced the formation of Taiwan's science policy. Its need to catch up in the global market, the authoritarian rule to which it was subjected for nearly forty years, and the constant security alerts arising from China's military threats, are all connected with the way science policy developed and the perceptions policymakers adopted. Before looking into the evolution of Taiwan's science policy over the last decade, there is a need to offer a brief account of the previous development of policy and its political-economic context.

A. The Initiation of the Scientific Establishment

Survival

The eight-year war against the Japanese invasion and the civil war between the Kuo-ming Tang (KMT) regime and the Communists immediately after World War II brought the Republic of China (ROC) into a desperate situation. After decades of intermittent warfare, the economy of the Mainland China was in disarray. Taiwan was soon dragged into the political and economic chaos after it was liberated from Japanese colonialism and returned to ROC sovereignty in 1945. Before the KMT regime made its temporary capital Taipei in December 1949, Taiwan had been suffering political repression and economic retrogression at the time of the civil war on the mainland.[10]

In such an extremely difficult situation, survival rather than development was all that state leaders could think of. Science was one of the last things on the policy agenda. Between 1949 and 1958 there was no scientific establishment, nor any central agency in charge of scientific affairs, not to mention any science policy (NSC, 1995c, sec. 1.1; Hsia, 1993, p. 10). The Academia Sinica was the only formal scientific institute apart from two universities, while resources, facilities and manpower were all severely lacking (Wu, 1986, p. 42).

The situation was gradually stabilised as the KMT regime successfully executed various reforms and economic measures, such as land reform and import-substitution industrialisation during the 1950s (Pang, 1992, pp. 160-2). What was equally important was the then international context: the cold war. The outbreak of the Korean War forced the US to change its policy towards the Taiwan issue. The US's previous hands-off policy was replaced by active intervention, placing the fate of Taiwan within the global anti-Communist crusade. Assisted by American military protection and financial aid, Taiwan achieved a degree of recovery by the end of the 1950s (Gold, 1986, p. 58).

Interestingly, despite such difficulties, an agenda focused on entry into atomic energy research originated at the same time. With the closer Taiwan-US relationship and the US's active promotion of the peaceful use of atomic power, the military's intention in the 1940s to engage in atomic research was revived (*China Times*, 4 September 1989, p. 4). To maintain planning capacity and talent, in 1955 the government set up the Atomic Energy Council and re-established Tsing Hua

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[10] See Gold, 1986, pp. 49-53. The defeat of the KMT regime in the civil war sent prices on the island up to the stratosphere with 3,500% inflation (Ho, 1978, p. 104).

University on Taiwan. The reopening of this university resulted directly from the installation of a US-made research atomic reactor (Lin, 1989, pp. 14-8). Bearing in mind the fact that there was no demand of any kind to develop atomic science at that time, the decision was mainly concerned with military purposes, brought forth by US control over atomic power in the context of cold war (Lin, 1989, pp. 19-22).

The Long-term Programme

Political and economic stabilisation opened up an opportunity to push science enterprise forward. Promoted by Hu Shih, then President of the Academia Sinica, the National Long-term Science Development Programme was approved in 1959. This was the first science plan devised by the government. It was based on the visions of Hu Shih and of Wu Ta-you, who was one of the figures involved in atomic energy research and later became president of the Academia Sinica (1983-94) (Wu, 1986, pp. 229-31). It mainly aimed to address the scientific infrastructure and brain drain problems. To these ends, the vital measures taken under the programme were:

- an appropriation to support scientific facilities, visiting lecturers, research grants, academic journals and accommodation for scholars;
- the allocation of 80 per cent of research grants for the fields of the natural sciences, basic science and basic engineering;
- the setting up of the National Long-term Science Development Council as an implementing organisation, consisting of twenty-six committee members who were also members of the Council of the Academia Sinica, and three representatives from the Ministry of Education (Wu, 1986, p. 22; Lin, 1989, pp. 48-51; Hsia, 1993, pp. 12-3).

The programme was explicitly characterised as an 'academically orientated approach', not only because of the urgency of building up a scientific base and domination of the Council by the Academia Sinica, but also because of the vision upon which the Long-term Programme was based. Wu Ta-you continuously pointed out that the most significant features of the predicaments in which Taiwan's science development found itself were the lack of scientific talent and the poor quality of scientific education. He once emphasised that it was right to include the principle of application in a given context or strategy, but it was wrong to set the principle as a policy direction for national science development (Wu, 1986, pp. 10-11). He applied the following logic to the issue of scientific application: economic power is an essential foundation for society and nation, and yet an economy is based on science; hence, the national objectives of science development ought to be academic autonomy and sufficient talent. Therefore, given Taiwan' weak scientific base, the government ought to focus resolutely on the cultivation of manpower (Wu, 1986, p. 44). This idea of the Long-term Programme was maintained for most of the next decade, creating the foundation of Taiwan's scientific development.

It is worth noting that, at first, the funding, later named the Science and Technology Development Fund, mostly came from US aid (about 90 per cent). After US aid was withdrawn in 1965, the fund was financed from the government budget, and there has been a standing fund for science since then. The fund started with an appropriation of NT$24 million (US$0.7 million), increased to NT$60 million (US$1.67 million) in 1967 (Wu, 1986, p. 22).[11]

Aside from economic stabilisation, US aid and the advocacy of Hu and Wu,

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[11] For the purpose of comparison, throughout the thesis, sums of local currency (New Taiwanese dollars) will be accompanied by an approximate US$ value based on published average exchange rate for the period concerned, except for a few cases where direct US$ values are given in the original source.

President Chiang Kai-shek's support for the Long-term Programme was attributed to the launch of the Soviet Union's Sputnik, the speed-up of Communist China's scientific investment and the fact that the US-based Chinese scientists, Lee Tseng D. and Yang Chen-ning, received the Nobel prize in 1957 (Lin, 1989, p. 56).

The Science Development Plan

In the 1960s, the relaxation of the cold war facilitated the general expansion of world trade. Japan's low-priced products became a great threat to American manufacturers. The US was forced to adjust its trade policy. Under US pressure, the Taiwanese government started to liberalise its economic and financial controls and commenced an export-expansion policy (Gold, 1986, p. 77). As the potential risks of opening the domestic market were clear, the negotiation skills and views of the technocrats became important. At a time when economic growth had become the substance of KMT legitimacy, economic and industrial planning was seen as the core feature of government performance. Later, some of those technocrats with experience in the Council of US Aid, the Council for International Economic Co-operation and Development, the Ministry of Finance and the Ministry of Economic Affairs (MOEA), such as Sun Yun-suan, Yu Kuo-hwa and Li Kwoh-ting, had a decisive influence on the fate of Taiwan's economic progress and S&T development. The increasing importance of economic affairs cast a shadow over the previous academic-oriented science policy. In 1972, Wu Ta-you deplored the fact that short-sighted, application-oriented ideas had taken over the minds of certain actors in the top policy circle (Wu, 1986, p. 76).

As to the political aspect, while China had made great breakthroughs in nuclear weapons during the period 1964 to 1967, Taiwan faced a leadership succession problem in the 1960s. In 1966, the National Security Council was set up as an advisory body for the President in the period of martial law. In the following year it established the Science Development Steering Committee on the order of Chiang Kai-shek. The Committee was made up of one chairman, two vice chairmen, six committeemen and six *ex offico* members, the heads of the Academia Sinica, the Atomic Energy Council, the Ministry of Education, the MOEA, the Ministry of National Defence (MND) and Ministry of Transportation and Communication (MOTC). The Committee literally took charge of the planning of national S&T policy and its budget, and the overseeing of all agency-sponsored projects (Wu, 1986, pp. 23, 80). In 1967 Chiang Kai-shek asked US-based physicist, Wu Ta-you, to head the Steering Committee, partially because of his early experience in the atomic energy research establishment. In the same year, the MND asked for Wu's comments on the 'Hsinchu Plan' for developing nuclear weapons (Lee, 1991b, pp. 375-6). Due to his negative attitude, Wu was excluded from any involvement with the plan thereafter. However, the plan was taken forward, and led to the birth of the military-run Chung-Shan Institute of Science and Technology (CSIST) in 1969. Under the CSIST, the Institute of Nuclear Energy Research was responsible for nuclear-related research.

Lead by Wu, the Science Development Steering Committee co-ordinated all agency S&T sub-policies and in 1968 elaborated the National Science Development Plan, which set out a framework for scientific development over three four-year periods. Within its academic orientation, the plan emphasised three policy directions:

- scientific education: to improve the science curriculum, staff and facilities;
- scientific research: to improve university facilities and research;
- co-ordination between science and national development: to develop technology for industry, agriculture, defence and communication (Wu, 1986, p. 45).

Following the suggestion of the Steering Committee, the National Long-term

Science Development Council was reorganised as the National Science Council (NSC) in 1967 and was made formally subordinate to the Executive Yuan two years later. This represented a change in organisational type, with the much more independent peer-run organisation of the Long-term Council being replaced by a bureaucratic form of science administration.

Authorised by Chiang Kai-shek, the Steering Committee was supposed to be the highest authority in the national S&T policy system. The fact was, however, that the National Science Development Plan was put together from various agency sub-plans, which were not properly integrated, and the Committee had no power and capacity to function synergically (Wu, 1986, p. 58). Observing this, Lin Chung-hsi concluded that the National Security Council, like other then non-statutory organisations, was designed to help Chiang Ching-kuo, the son of President Chiang Kai-shek, succeed him in power. In Lin's view, Chiang Kai-shek never intended to grant supreme and permanent authority to the Steering Committee (1989, pp. 90-1). Combining this interpretation with the emerging application-oriented strategy and military demands, Lin points out that at this very moment the 'Military-Applied-Technological Developmental Programme' began to assume greater importance than the 'Academic-Basic Developmental Programme' (1989, pp. 43-44).

Lin's interpretation correctly identifies the critical transformation of Taiwan's S&T policy over the next twenty years. However, it is worth noting that from the start military technology policy was insulated from the civil S&T system, both in terms of policy scrutiny and decision-making. In fiscal year (FY) 1969, the same amount was spent on civil science expenditure, about NT$600 million (US$16.7 million), as on nuclear energy science (Wu, 1986, p. 28). The latter appropriation had little relation with science or economic development. The private sector was not granted access to military technology until the 1990s.

Furthermore, although the Steering Committee did not function as expected, President Chiang's support and the committee's influence in forming the NSC as a ministry-level agency represented a step forward. After the NSC began to function, in 1968 President Chiang assigned NT$320 million (US$8.9 million) to the science development fund, a significant increase over the NT$60 million (US$1.7 million) of 1967 (Wu, 1986, pp. 22, 45). In addition, led by Wu, the organisation of the NSC strengthened administrative capacity and scientific authority in the central planning of science policy. Later, the NSC gradually developed into a science administration capable both of integrating policy deliberations through its committee board, made up of scientists and ministers, and executing funding evaluation through its academic departments. The main organisations of the NSC evolved into eight departments: the Natural Sciences, the Engineering and Applied Sciences, the Life Sciences, the Humanities and Social Sciences, Science Education, International Programmes, Central Processing, and Planning and Evaluation departments. The characteristic of the academic departments (the first six above) was that their heads came mostly from the academic community. Implementing funding on the base of peer review, the NSC maintained a direct link with the scientific community.

B. Science in A Changing Society

In the 1970s, Taiwan's stable development was challenged by new waves of economic and political threats. The 1973 and 1979 oil crises, the global economic depression, the security threat from China, and the diplomatic crisis arising out of Taiwan's precarious sovereignty put Taiwan in a difficult situation. The situation reached its worst point when Taiwan was expelled from the United Nations in 1971, and the United States opened diplomatic relations with mainland China and ended them with Taiwan in 1979. The plight became even desperate, following the fall in the number of accredited diplomatic representatives from 68 to 21 and in the membership of international government organisations from 39 to 10 (Kau, 1992, p. 237). Economic growth and export trade became crucial symbols and channels for Taiwan's existence and its link with the outside world. The failure to overcome the political and economic crisis not only meant the loss of its hegemony and legitimacy but also meant, to the general populace, the end of the pursuit of wealth and freedom (Gold, 1986, p. 97).

The Triumph of the Orientation towards Applied Technology

Despite the awareness of the need to maintain economic growth, the task was formidable. Besides various drastic measures to cope with economic depression, Chiang Ching-kuo, who became Premier in 1972, promoted a series of fresh national construction projects, called the Ten National Construction Projects, including highways, airports, harbours, railways, electrification, steel mills, and shipyards. It was hoped that by doing so, it would be possible to rebuild the industrial infrastructure. The government moved actively to develop capital-intensive heavy industries, especially petrochemical industries. Facing increasing domestic labour costs, the emerging second oil crisis and increasing Asian competition, the commitment to labour-intensive heavy industries was due to change. In 1977, Chiang, reorganising the previous economic task force, formed the Council for Economic Planning and Development (CEPD) and launched the Six-year Economic Plan with a view to promoting technology-intensive, high value-added and energy-efficient industries (Gold, 1986, p. 102). At the onset of the 1980s, strategic industry planning was explicitly focused on electronics, information and machine products. During 1983-4, the government promoted trade liberalisation, offshore banking, venture-capital firms and stock markets in order to attract foreign investment.

At this critical time for national development, the considerations underlying science policy were bound to change. Chiang Ching-kuo criticised the previous academic-oriented scientific development and stated that the critical obstacle to science progress was the divide between science development and nation building (*NSC Monthly*, December 1973, p. 33). In 1972, the Science Development Steering Committee was reduced in size and Wu Ta-you was forced to leave the post of NSC chairman (Wu, 1986, p. 258). Basically, for the next twenty years, the applied technology orientation dominated Taiwan's S&T policy. Wu admitted later that from then on, the Steering Committee was left with nothing to do (Wu, 1986, p. 258).

Just at the same time, the most significant applied technology establishment was created, when the Industrial Technology Research Institute (ITRI) was founded in 1973 by the MOEA. As a non-profit R&D organisation it was designed to engage in applied research and technical services for industry. It has since grown to become a technical centre for industry and an important arm of the government's industrial policies.

The Science and Technology Development Plan

S&T policy planning was divided between the NSC and the MOEA after the reduction in size of the Steering Committee (Lin, 1982, pp. 127-8). To speed up technology exploitation, Premier Chiang Ching-kuo established the Applied Research Technology Development Group (ARTDG) under the Executive Yuan in 1976. The aims of the ARTDG were to promote applied technologies and to co-ordinate research supported by public funds (Lin, 1982, p. 121). To these ends, it received authority from its members, consisting of the Ministers of Economy, Education, Transportation, Defence, and Agriculture, the chairman of the NSC and the governor of Taiwan Province. On the basis of Chiang Ching-kuo's support, the ARTDG became the lead institute on S&T matters. Under the leadership of the then Minister without portfolio, Li Kwoh-ting, the applied technology orientation of S&T policy was further pushed forward. By that time, Li, a Cambridge-trained researcher in physics, had been General Secretary of the Council of US Aid, Vice Chairman of the Council for International Economic Co-operation and Development, and Minister of the Economy and Finance, all at the heart of government economic sectors. Li Kwoh-ting's perception of S&T was distinct from that of Wu Ta-you. For Li, S&T was equivalent to skill; the purpose of S&T policy was to attract and transfer advanced foreign technology in order to increase industrial development and economic growth in a very short time.[12] Arguably, his vision and leadership made possible Taiwan's industrial transition in the face of the crisis. From this point to view, the applied technology orientation of S&T policy was incorporated into a state-led strategy for industrial development rather than being devoted to the building of a foundation for S&T.

As a result, despite literally having the same function, the NSC was virtually made subordinate to the ARTDG. This was exemplified by ARTDG domination of central government planning. In 1978 the First National Science and Technology Conference was held. Just after the conference, Premier Chiang succeeded as President and Sun Yun-suan became Premier. In 1979, following the conclusion of the conference, the ARTDG announced the Science and Technology Development Plan. This had the following aims:

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[12] See Lin, 1989, pp. 103-8; Li's idea on science and technology can be found in Li, 1988, especially pp. 232-6.

- to aid economic construction: advance technology-intensive industry, promote agricultural modernisation and exploit natural resources;
- to enhance military industry: to develop new types of weapons and establish an autonomous military R&D system;
- to enhance public welfare: to encourage medical research, protect the ecology of the environment and improve levels of nutrition;
- to select energy, materials, information and automation as key technology areas (Executive Yuan, 1979, sec. 1).

This plan explicitly declared the triumph of the applied technology orientation in which S&T was seen as a tool serving economic growth and defence autonomy. However, the new agendas emerging in the programme, such as environmental concerns and nutrition, implied that the social concerns of science were beginning to be addressed.

It is noteworthy that, although the direction of science policy had been drastically changed, the form of decision-making still remained dominated by elites. At that time, the political elites, increasingly enrolled from among technocrats and economic professionals, had in fact increased their power over decision-making, partially due to their professional competence in responding to external changes. For example, Taiwan's semiconductor industry was mainly based on the vision and advocacy of Sun Yun-suan, then Minister of Economy, and Pan Wan-yuan at the Radio Corporation of America, US (Meaney, 1994, pp. 172-3; Lin, 1989, p. 116). The Science and Technology Development Plan likewise relied on the support of political elites, because each concrete proposal was predetermined by the public sector (Lin, 1989, pp. 120-4).

The characteristic of the state-led technology push strategy was particularly exemplified by another crucial technology establishment – the Hsinchu Science-based Industry Park (HSIP). The setting-up of HSIP in 1979 was again attributable to the vision and support of elites such as Chiang Ching-kuo, Sun Yun-suan and Li Kwoh-ting (Li, 2000; Shu, 2000). Interestingly, Shu Shian-shiou, as Chairman of NSC (1973-1981), was actively involved in the initiation of the HSIP and finally this entire industrial establishment was placed under the jurisdiction of the NSC.[13]

In 1979, the Executive Yuan set up the Science and Technology Advisory Group (STAG), chaired by Li Kwoh-ting. The STAG was a high-level scientific advisory body reporting to the Premier, which received advice from foreign advisors. In practice, the STAG fulfilled the following functions: to maintain industrial and academic links with the US after Taiwan-US diplomatic ties were terminated in 1979 and to conciliate Li Kwoh-ting, who had considerable influence over the S&T policy area and yet had no proper post in government as Shu Shian-shiou had refused to leave his post as chairman of the NSC (Lin, 1989, p. 122; *SciTech Reports,* October 1989, p. 17).

Following the Second National Science and Technology Conference, the revision of Science and Technology Development Plan was embarked on by the ARTDG and announced in 1982. The main points of the amended plan included:

- increasing overall R&D expenditure as a percentage of GDP from 0.6 to 1 per cent;
- placing more emphasis on basic science research;
- adding biotechnology, opto-electronics, food technology and hepatitis prevention to the key S&T areas initially identified;
- issuing the Program for Strengthening the Training and Recruiting of High-level

[13] Shu's main idea of orienting academic research towards applied science had a significant impact upon the academic atmosphere of the time, as funding was restricted to research that could benefit national development (*SciTech Reports*, October 1989, p. 17).

Technological Personnel (NSC, 1990, p. 47).

The Long-term Ten-year Plan

In 1984 Yu Kuo-hwa became Premier, after Sun Yun-suan suffered a stroke. Chen Liu-an, who was then Vice General Secretary of the KMT, was appointed NSC Chairman. In 1986, the Third National Science and Technology Conference was held and the Long-term Ten-year National Science and Technology Plan replaced the Science and Technology Development Plan. From Chen's appointment to the NSC's involvement in the Third Conference, everything signalled that the domination of Li Kwoh-ting was beginning to be resisted by a new power bloc (*SciTech Reports,* December 1989, p. 17). With this, S&T policymaking authority was gradually institutionalised and centred on the NSC.

Besides 'promoting economic development', 'enhancing the quality of life', and 'establishing an autonomous defence capability', the Long-term Ten-year Plan announced 'raising science and technology standards' as one of the national objectives, indicating that a vision of long-term science development seemed to be regaining its influence (Executive Yuan, 1986, sec. 1.2). The primary measures of the plan included:

- expanding the research and development (R&D) base: the number of researchers was expected to rise to 43,000 by 1995. The government would maintain a steady growth of the nation's S&T budget. It was anticipated that R&D would account for 2 per cent of GDP in 1995;
- enhancing R&D efficiency: a range of means would be adopted to reach this goal, such as strengthening management and assessment systems, mapping out a specific collaboration and co-operation system, selecting key R&D areas, accelerating resource flow between the public and private sectors, and improving administrative

assistance;

- inducing private R&D: instruments such as subsidies, tax deduction, procurement policy, information delivery and intellectual property protection would be used to encourage enterprises to undertake R&D;
- developing high-tech industry: expanding joint venture companies, exploiting HSIP developments and integrating technology resources between industry, academia and public sectors would provide a favourable environment for setting up high-tech industries;
- promoting international co-operation: this strategy mainly focused on the co-operative relationship with European and Asian countries on the issues of technology transfer, skill training and research co-operation;
- improving public understanding of S&T: measures for improving scientific education and relevant public activities were designed to increase citizens' scientific literacy in order to earn public support for the government's S&T policy (Executive Yuan, 1986, sec. 1.3).

In addition to the eight existing key areas of technology, disaster prevention, synchrotron radiation, marine science, and environmental science and technology were announced as key areas in the plan.

By the middle of the 1980s, the democratic and external environment had changed rapidly, and the S&T policy was about to face new challenges.

Security Constraints and Military Technology

The start of the Korean War had revived Taiwan-US relations and protected Taiwan from immediate threats from Chinese military invasion as exemplified by the bombardment of Quemoy, the attack on Ta Chen Island in 1954 and the heavy bombing of Quemoy and Matsu in 1958. After the 1958 talks between the US and the People's Republic of China (PRC), US intervention defused the Taiwan Strait crisis but also prevented the KMT from attacking the mainland. Although the situation in the Strait in the 1960s was calm, 'repossessing the mainland' and 'no compromise with the communists' formed basic orientations for Taiwan in responding to China's call for peaceful liberalisation.

At the end of the 1960s an ambivalent US attitude appeared in the context of deteriorating relations between China and the Soviet Union and the uncertain legacy of the Vietnam War. Those situations plus the advancement of China's development of the nuclear bomb, as mentioned above, drove Chiang Kai-shek to set up the Institute of Nuclear Energy Research in 1968, and the CSIST and the Aero Industry Development Centre (AIDC) in 1969. Since then, those institutes have gradually built up their capability, although their efforts have been described as a sort of technology laundering scheme (Huxley and Willett 1999, p. 49). Due to their extreme sensitivity, those military technology developments were conducted in secrecy and insulated from civilian evaluation, except by top national leaders.

On 28 February 1972 the U.S. and China issued the Shanghai Communiqué in which the PRC government was acknowledged as the sole legal government of China. Knowing the US stance might change further, Taiwan accelerated its accumulation of military-related technology. Taiwan's nuclear weapons research based on the Taiwan Research Reactor (heavy water), which was subjected to US inspection and fuel supply restrictions, was said to be gradually developed during the 1970s (Lin, 1989, pp. 20-21). In 1982, the Chief of the General Staff, Hau Pei-tsun, expressed his anger about the US's threat to suspend fuel supplies, and announced an intention to seek supplies from South Africa and to initiate high energy research (into hydrogen) in the military-run Chung Cheng Institute of Technology (Hau, 2000, pp. 60, 180-1, 205). As to missile development, by 1980, the CSIST had developed the battlefield short range ballistic missile (BSRBM) with a maximum range of about 139km (CSIST, 1999; *Jane's Defence Weekly*, 17 April 1996, p. 43). However, the further development of the Tien Ma medium range ballistic missile (MRBM) was delayed in 1982, due to US pressure (*Jane's Defence Weekly*, 10 March 1999, p. 4). In the less sensitive aviation area, the AIDC had built up its capability in assembly, engine production, part production and design by producing 58 Chiehshou propeller trainers, 18 UH-1-H helicopters, 52 T-CH-1 trainers, 200 F-5E fighters and 60 AT-3 ground attack trainers by 1980 (Ding, 1997, pp. 17-8). To maintain this level of military technology development, defence expenditure accounted for over 50 per cent of the government budget by FY 1987 (Lee, Wei-chin 2000, p. 56).

In due course the US and the PRC signed the Normalisation Communiqué in 1978 and the US formally switched its recognition from Taipei to Beijing in the following year. The Joint Communiqué of 17 August 1982 (Communiqué 817) was subsequently issued by the two countries. According to these communiqués, the US administration accepted that Taiwan would eventually be reunified with the mainland by peaceful means. Thereafter, the PRC adopted an 'open door' policy to the outside world, including Taiwan for the purpose of economic reform and adjusted its policy towards Taiwan by advocating 'one-country, two systems'. However, at the same time, China launched a series of diplomatic offensives designed to isolate Taiwan in the international community. Consequently, cross-strait relations became officially rigid but continued to improve through civilian contacts.

In Communiqué 817, the Reagan administration agreed that arm sales to Taiwan would not exceed, either in qualitative or in quantitative terms, the level of those supplied between 1978 and 1982, and they would gradually reduce, leading to a final resolution of the China-Taiwan relationship (Lee, Bernice 1999, p. 78). Interestingly, just a few months after the normalisation of US-China relations, the US Congress passed the Taiwan Relations Act, which highlighted the differences between the US administration and Congress on the issue of Taiwan (Hao, 1997). The Act virtually guaranteed that the US would provide Taiwan with such articles in such quantity as might be necessary for its defence. [14] The ambiguous situation constituted a framework for Taiwan-US military technology transfer in which US military sales to Taiwan declined overall by the late 1980s while technology transfer and commercial sales were maintained (Lee, Wei-chin 2000, pp. 57, 63-4).

Table 2. 1 Progress of Missile Production by CSIST

Year	Systems
1977	Successful testing of Hsiungfeng I anti-ship missile
1980	Service of Hsiungfeng I anti-ship missile
1986	Successful testing of Tienkung I ground-to-air missile and Hsiungfeng II anti-ship missile
1987	Successful testing of the short-range Tienchien I air-to-air missile
1989	Successful testing of Tienkung II ground-to-air missile
1990	Service of Hsiungfeng II anti-ship missile
1993	Service of Tienchien I missile and Tienkung I ground-to-air missile
	Successful testing of the medium-range Tienchien II air-to-air missile
1994	Service of Tienchien II missile (with IDF)

Source: CSIST, 1996, pp. 6-7.

[14] Article 559 of the US's Overseas Aid Act of 1999-2000 stated that, regarding arm sales to Taiwan, either in qualitative or in quantitative terms, the executive sectors had to consult with Congress's related committees before any decision was made (*Central Daily News*, 7 October 1999, p. 7).

In 1982, the Reagan administration's rejection of Taipei's request to purchase a more advanced FX fighter aircraft shocked Taiwan's elites and fuelled their commitment to develop indigenous high-tech weapon systems. Fearing that the first generation weapons could no longer sustain their technological lead over the Taiwan Strait, Taiwan's AIDC launched the production of Indigenous Defence Fighters (IDFs) with dual-use technology transfer and parts from the US. The first prototype was completed in 1988. Parallel with the IDF, a range of missile research was advanced. By the end of the 1980s, Taiwan had equipped itself with its own anti-ship, ground-to-air and air-to-air missile systems (see Table 2.1).

Due to the lack of a nuclear warhead, the development of an MRBM, satellite and launcher was slowed down (Hau, 2000, p. 53). However, nuclear weapons research continued. In 1988, a US satellite spotted a small nuclear test in southern Taiwan and later the 'Chang Hsien-yi events' occurred.[15] Chang, then Vice President of the Institute of Nuclear Energy Research, suspected of being a Central Intelligence Agency undercover agent, secretly fled to the US. As a result, the Taiwan Research Reactor was closed in 1988 (Hau, 2000, pp. 1269-71), and the Institute of Nuclear Energy Research was removed from the CSIST to the Atomic Energy Council. Although, since then, Taiwan has been regarded as a regime with the potential capability to develop nuclear weapons, the claim can only mean a counter against any weakening of US security commitments.

It is noteworthy that Taiwan's military technology establishment had largely been

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[15] In a meeting with the Chief of the General Staff, Hau Pei-tsun, on 20 January 1988, David Dean, then Director of the Taipei Office of the American Institute in Taiwan expressed a strong demand from the US for the demolition of any facility relating to nuclear warhead research and asked Taiwan to sign a categorical agreement within one week. On that occasion, Dean showed Hau a US reconnaissance satellite image indicating a small nuclear test in Jioupeng, southern Taiwan (Hau, 2000, p. 1270).

dominated by its unique security constraints. The planning and implementation of military technology build-ups had been insulated from science development or economic considerations. Although since 1979 an 'autonomous defence capability' has been set as the national objective of S&T policy, except for the Science and Technology Development Plan of 1979, no concrete measures and strategies for military technology can be found in the various government S&T plans, even during the 1990s. However, this should not be regarded as implying that military R&D has had no connection with the civilian scientific base. With the expansion of the CSIST, the MND established a collaboration network with and recruited personnel from the most prestigious universities. Besides the already mentioned nuclear expertise at Tsing Hua University, the MND played a decisive role in the initiation and continuous support of the following research at particular institutes: aerospace at Cheng Kung University, materials at Chung Hsin University, electronics and information at Chiao Tung University, and mechanics and applied dynamics at Taiwan University (Hau, 2000, pp. 297, 395, 442, 572-3; TRF, 1989, p. 170). According to the 1979 Science and Technology Development Plan, the National Defence Industrial Development Fund was set up to promote industrial and academic research into military R&D (Office of the President, 1979). In 1985 the National Defence Technology Co-ordination Group was organised by the MND and NSC to galvanise and support academics to engage in non-confidential military technology research. However, it needs to be emphasised that those efforts and connections were all based on military needs rather than any co-ordination mechanism with national science or economic development. In fact, the CSIST itself did not install a technology evaluation system until the 1980s (Hau, 2000, p. 722). My study here, which focuses on science policy, cannot also cover military technology, but it will continuously show the changing relationship between national science policy and military technology.

C. Towards the 1990s

In the 1990s, Taiwan again experienced dramatic changes in almost every dimension ranging from politics and society to the economy. Among other things, the process of democratisation transformed the way of people lived in Taiwan. This study is set against this background and considers its effects on the development of science policy. While some more detailed analysis will be given in the following chapters, this section outlines the basic structural factors that shaped Taiwan's science policy in the last decade.

Social Liberalisation: the Anti-DuPont Movement

Clearly, any observation of the changes in Taiwan must take the evolution of civil society into account. The growth of public power and the awakening of interest groups directly challenged existing rules and the policy ideas that had been followed so far. The most important change in science policy was that a set of emerging public values provided a justification for an alternative policy that challenged the basic rationality of the application-oriented direction of policy.

By the mid-1980s, a growing number of people in all parts of Taiwan were uneasy and sometimes angry about the effects of pollution on the land Portuguese sailors had named 'Ilha Formosa', the Beautiful Island. Environmental consciousness and related health concerns were fed in some cases by direct experience and everywhere by press reports in Taiwan and abroad of industrial pollution. In 1981, for example, the peasants of Huatan village in Changhua County brought a lawsuit against local brick manufacturers, whose emissions had damaged neighbouring rice paddies. This was the first collective anti-pollution suit presented to a court, and it resulted in compensation of NT$1.5 million (US$37,500) for damages (Reardom-Anderson, 1992, pp. 10-11). However, a much more large-scale event with extensive social impact did not occur until five years later. This was the anti-DuPont movement. It has been regarded as the beginning of Taiwan's organised environmental movement (Kuo, 1997, p. 69). This symbolic case demonstrated the extent to which the orientation of state-led economic and technology policy was threatened.

At the end of 1985, DuPont Taiwan Ltd., a wholly owned subsidiary of the American chemical giant, received permission from the government to build a titanium dioxide plant near the city of Lukang on the west coast of central Taiwan. For the next fifteen months, local activists mobilised the people of Lukang and the surrounding communities against the factory, which they feared would destroy their environment and, by extension, their way of life.

At first, the calculations of government officials were primarily economic. They were especially interested in the state of the art 'chlorine method', a patent of which was held by DuPont on the manufacture of titanium dioxide. Although the risk of provoking political instability was already sensed, one expectation was shared by government and corporate officials: "if you got the support of the central government, things would happen quickly and we could be fairly confident that we could build in a timely fashion" (Reardom-Anderson, 1992, p. 4). This unfortunately explained many of their later difficulties.

Facing local resistance, government officials advised DuPont to keep a low profile, not to engage the Lukang community in open debate and to follow Taipei's lead. The official solution was to invite influential figures from Laukang and

Changhua County to visit and report back on titanium dioxide plants in Edgemoor, Delaware, US (Reardom-Anderson, 1992, pp. 36-40). However, the robust local demonstration of opposition shocked the relevant authorities and went far beyond the expectations of the government, which up to this point had studiously ignored protests in Lukang. On 3 July 1986, Premier Yu Kuo-hwa announced his decision: the deal to build the factory in the Chang-pin Industrial Zone would proceed only after two conditions had been met. First DuPont must submit an environmental impact assessment; second, the relevant agencies had to give a full public account and the concerns of the local residents had to be resolved (*Central Daily News*, 4 July 1986). Losing full government support, DuPont withdrew its proposal in 1987.

In the aftermath of the event, Premier Yu reorganised the old Environmental Protection Bureau into the Environmental Protection Administration, which received increased funding, personnel and visibility. Annual public and private investment in pollution control more than doubled, from US$900 million in 1986 to $1.9 billion in 1989 (Reardom-Anderson, 1992, p. 88).

The Anti-DuPont movement marked a crucial turning point whereby the single-minded commitment to economic growth began to erode and technological advantage was no long the most important principle to be observed in developing industrial policy. Non-economic concerns had to be taken into account, not only because of their moral claim but because of their political influence. The single-minded concentration of S&T policy on applied science had been diluted.

Economic Challenges

Economically, Taiwan struggled with old problems, while new challenges continuously arose. The four most urgent predicaments that Taiwan's economy confronted in the

1990s will now be outlined.

Pressure for Fair Trade

While Taiwan was gradually incorporated into the international market, developed countries shifted their trade policy from 'free trade ' to 'fair trade', dealing a serious blow to Taiwan's export staples such as textile, footwear and televisions during the 1980s. Neo-protectionist non-tariff barriers eventually developed into the anti-dumping and anti-subsidy principles adopted by most advanced countries, and especially enforced by the US and the European Community (EC). From 1985, on the basis of the Trade and Tariff Act of 1984, the US Trade Representative imposed a series of Section 301 Investigations to deny newly industrial countries market access in order to fulfil the principle of 'fair trade' and safeguard its domestic products (Vakerics, et al., 1987, pp. 431-2).

Furthermore, export restraints became much more rigid when fair trade pressure was combined with the sensitive issue of intellectual property rights. The US exerted substantial pressure on Taiwan to enforce laws protecting intellectual property rights through bilateral negotiations and severe retroactive compensation. In addition, U.S. trade offensive initiatives included forcing the appreciation of the New Taiwan dollar by 40 per cent between 1986 and 1989, and opening Taiwan's market to more imports from the US (Bello and Rosenfeld, 1990, pp. 9-10).

Economic Dependence

Speaking of unbalanced trade between Taiwan and the US, another factor must not be missed. That is Taiwan's heavy import dependence on Japan. Taiwan was running multibillion-dollar trade deficits with Japan, while its exports relied heavily on the US market. For example, although the booming information industry, with an annual turnover of US$6.4 billion in 1991, made Taiwan the world's sixth largest manufacturer of information products, in the case of 75 per cent of key computer components such as CRTs, DRAMs and LCDs, it relied entirely on imports from Japan (Hsia, 1991, pp. 40-41). According to the statistics, the unbalanced foreign trade structure remained throughout the 1990s (Table 2.2).

Table 2. 2 Balance of Commodity Trade with Major Partners

US$ Billion

	1980	1983	1987	1991	1992	1993	1994	1995	1996	1997
U.S.	2.1	6.7	16	8.2	7.8	6.9	6.3	5.6	6.9	6.3
Japan	-3.2	-3.1	-4.8	-9.7	-12.9	-14.2	-14.7	-17.1	-13.8	-17.3
Hong Kong	1.3	1.3	3.4	12.4	15.4	18.5	21.3	26.1	26.8	26.7

Source: CEPD, 1998, p. 210.

Moreover, despite the hot and cold character of cross-strait relations, economic links between Taiwan and China have remarkably increased since Deng Xiaoping's 'open-door' policy of 1978. Lukewarm government support did not impede Taiwan's business community from seeking profits on the mainland and taking advantage of its low production cost through third party trade.[16] Table 2.2 shows the rapid increase of the cross-strait trade by way of Hong Kong. By the end of 1995, Taiwanese investment in China stood at an estimated US$30 billion – more than one third of Taiwan's total capital outflow. What is more, Taiwan's trade surplus with China, about US$16.3

[16] Taiwanese exports through Hong Kong to China increased 104-fold during the 1979-88 period at an average annual growth rate of 52%, to reach US$220 million in 1988, while Chinese-made products exported to Taiwan via Hong Kong increased at an average annual growth rate of 24% during the same period, to reach US$1.7 billion in 1988 (Chang and Chang, 1992, pp. 275-7).

billion, larger than its overall surplus of US$8.12 billion, indicated that a new economic dependence had already been created (Lee, Bernice, 1999, p. 25). The difference was that the new economic dependence on China was constructed on the extremely fragile special cross-strait relationship, which was defined at base by military rivalry. Thus, the economic dependence on the US, Japan and China seriously threatened the long-term stability of Taiwan's industry and trade.

Regional Competition

In addition, Taiwan's economic competitiveness continued to be challenged by new regional competitors. After 1986, currency appreciation and rising labour costs forced the newly industrial Asian countries, such as Taiwan, Korea, Hong Kong and Singapore, to expand their foreign direct investment and technology transfer to other neighbouring Asian countries, such as the members of the Association of Southeast Asian Nations. At the same time, major Asia-Pacific direct investment and technology suppliers such as Japan and the US were also increasingly pouring investment into these emerging industrialised countries (Tho and Urata, 1995, pp. 302-8). Consequently, the regional division of labour previously centred on and led by Japan broke down. With the technological advancement of those new competitors, the relationship between Taiwanese firms and other Asian countries, including Japan, became a mixture of the complementary and competitive, which has continuously made the issue of technological upgrading one of Taiwan's top policy priorities.

Domestic Disadvantages

The pressure of international competition, currency appreciation, the rise of labour costs and the upsurge in land prices threatened the base of Taiwan's export-oriented economy. Those difficulties, in combination with rigid and immature financial systems, triggered rampant money speculation and spiralling property prices during the period 1986-1992 and led to stock market slumps and rising numbers of bad loans thereafter.

Related predicaments also obstructed domestic investment and accelerated industrial relocation off the island. These included labour shortages, rising wages, environmental protests, the unavailability of the land, and the generally lukewarm investment in R&D mainly caused by the skewed industrial structure, dominated by large numbers of small and medium-sized enterprises (SMEs). As a result, the fear of 'industrial hollowing-out', referring to the preference of manufacturers to invest or relocate abroad, especially in mainland China, constantly cast a shadow over Taiwan's economic and industrial development.

As it appeared, all the above challenges strongly pointed in one direction – only an accelerating and deepening technological upgrading could maintain Taiwan's prosperity and economic stability. Yet, at this time, OEMs (original equipment manufactures) and ODMs (original design manufactures) were not good enough to cope with the challenges ahead.

Cross-strait Relations and National Identity

The question of the security of the Taiwan Strait is complex and ambiguous, because it is not only related to the interaction between the ROC and the PRC but was also subject to the White House's interests and interpretation of its relationship with the two countries. As already mentioned, the relative stabilisation of cross-strait relations resulted from the normalisation of US-China relations and the rapidly growing cross-strait business, even though China repeatedly vowed to take the island by force.

By the end of the 1980s, with the development of democratisation, the sub-ethnic conflicts between indigenous Taiwanese and mainlanders on the island stirred a new wave of impacts on the cross-strait relationship. Taiwan's people no longer wished to endure the international isolation implicit in being confined by Beijing's 'one country, two system' and KMT's 'no negotiation, no contact and no compromise', which implied a zero-sum game that played into the hands of Beijing's efforts to isolate Taiwan (Kau, 1992, pp. 239-41). Taiwan's officially defined cross-strait relations appeared more and more unreasonable as economic interactions and civilian contacts increased.[17] Once President Lee Teng-hui consolidated his position, he began to carry out a pragmatic diplomacy. It was announced that the state of civil war with China would end in 1991 under the 'one China, two political entities' concept. The new conceptual framework confirmed the coexistence of Taiwan and China on the one hand, and Taiwan's aggressive intention to extend the diplomatic front on the other. Taiwan took an active part in international government and non-government organisations in a bid to penetrate its China-imposed isolation.

The adjustment of cross-strait relations, however, ran parallel with the demand for outright Taiwanese independence provoked by the Democratic Progressive Party (DPP), the first and largest opposition party. This demand, inspired by Taiwanese sub-ethnic sentiment, was opposed not only to China's hostile isolation but also to the KMT's basic line on national identity: the one China principle. This tendency made China very suspicious throughout the 1990s.

To advocate either independence or international recognition, Taiwan had to play a dangerous game with China. As David Shambaugh notes: "when Taipei was

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[17] In 1987, visits by Taiwanese with close relatives on the mainland were permitted via third countries, mainly Hong Kong and Macao.

successful in enhancing its international status, its security was endangered" (1996, p. 1287). Indeed, President Lee sometimes engaged in the extremely dangerous game of playing down China's military threats in order to gain public support for his policy of semi-independence.

This, along with the impact of the democratic climate on the authoritarian system, was a main factor in severe cuts in military investment at the beginning of the 1990s. This tendency would not change until China's missile threats in 1995 and 1996.

In order to solve the practical problems in the regulation of trade and interactions across the Strait, the two sides began a series of negotiations dubbed the 'Koo-Wang talks' in 1993 and 1994. However, since they were confined to sovereignty issues, the progress of the talks was limited. The tension finally turned into military crisis after Lee's US visit. In 1995 and 1996, China launched the most serious military manoeuvres since the 1950s and conducted two missile tests at sea near Taiwan.

Although the conflicts did not fundamentally alter cross-strait relations, the two sides seemed to learn some lessons from the crisis. For the Taiwanese people and policymakers, with the triumph of Lee Teng-hui's victory in Taiwan's first direct popular president election seen as a reward for the defeat of China's military threats, the prices of offending China was acknowledged. Specific concerns arose about military technology development and procurement. But in contrast to the past, security concerns were not based on the prior political ideology of anti-communism, but were entwined with Taiwan people's national identity – a choice to be Taiwanese or Chinese.

Democratisation

Perhaps the most drastic change in Taiwan in the last decade of the twentieth century was democratisation. By the end of the 1980s mounting political demands and social movements, accompanied by rapid economic development, forced the KMT regime to begin a process of democratisation in Taiwan. Table 2.3 notes the significant events in the process. The political transformation led to such a major power reconstruction that the balance between different government sectors and between the state and society shifted considerably.

Table 2. 3 Taiwan's Democratic Transformation

Date	Major Events and Process
1946	Promulgation of the ROC Constitution
1948	Promulgation of the Temporary Constitutional Provision for the Period of National Mobilisation for the Suppression of the Communist Rebellion
1951	County magistrate and city council elections
1967	Supplementary election for the National Assembly and the Legislative Yuan
1977	Anti-KMT Chung Li Incident
1979	Dissident ally – Tangwai (outside-the-party) – established
1979	Anti-KMT Kaohsiung Incident
1982	Tangwai Campaign Assistance Association founded
1983	Quasi-opposition organisation – Tangwai Public Policy Study Association
1986	Opposition party – the Democratic Progressive Party created
1987	Martial Law lifted
1988	Ban on press and party lifted; Assembly and Parade Law passed
1989	Civil Organisations Law passed
1991	Comprehensive National Assembly election; Statute for the Punishment of Insurrection repealed; Temporary Constitutional Provision repealed
1992	Comprehensive Legislative Yuan election; Criminal Code, Article 100, revised
1993	Military de-politicised
1996	Direct popular election of president
2000	First DPP (non-KMT) president, Chen Shui-bian, elected

Soon after the adoption of the Constitutional Law of the Republic of China in 1946, democratic progress had been interrupted by the Chinese civil war, which led to the promulgation of the Temporary Constitutional Provisions. After moving to Taiwan, the KMT regime controlled society under its authoritarian rule, but initiated local government elections in 1951 to differentiate its ideological base from that of the Communists. According to the Temporary Constitutional Provisions, the members of the three national representative bodies – the Legislative Yuan, the National Assembly and the Control Yuan elected, all in 1947 on mainland China – were not subject to elections to renew their mandates until a return to the mainland became possible. To solve the problem of ageing representatives and the KMT's legitimacy in Taiwan, supplementary elections to fill vacancies had been held since 1969. However, dissatisfaction with the limited political reform accompanied with the sub-ethnic conflicts between Taiwanese and mainlanders eventually triggered the first popular anti-government violence in 1977 and bloody riots in 1979. These costly conflicts forced the KMT and the opposition to adopt a rather more moderate strategy, in order to earn support in elections. In the 1980s, the opposition shifted its strategy from attempted rebellion to reform within the regime. In the meantime, from above, the party/state leaders started to promote the relaxation of authoritarianism. It is generally agreed that President Chiang Ching-kuo gave the initial impetus to Taiwan's democratic transition in the later stages of his life (Clough, 1996, p. 1067; Tien, 1997, pp. 124-25). Since 1986, the interaction between the KMT leaders' commitment to liberalisation and the vigorous force of the opposition ally – the Tangwai (outside-the-party) and later the DPP – have accelerated a series of significant acts promoting democratic transition, such as lifting the ban on political parties, the media and social organisations, restoring constitutional law, and holding elections for legislators and the President (see Table 2.3).

The subsequent process of democratisation in Taiwan therefore fits Samuel P. Huntington's category of 'transformation', in which "those in power in the authoritarian regime take the lead and play the decisive role in ending that regime and changing it into a democratic system" (1991, p. 124). Yet, one of the characteristics of 'transformation' is that the former monopolistic party gives up its monopoly of power but not the opportunity to compete for power by authoritarian means (Huntington, 1991, p. 120). As Huntington notes, democratic transformation is a complex political process involving a variety of groups struggling for power, with the three crucial interactions being between government and opposition, reformers and standpatters in the governing coalition, and moderates and extremists in the opposition (1991, p. 123). Indeed, the process of Taiwan's democratisation was full of such power and ideological struggles.

Under democracy, Taiwan's political competition inevitably provoked many more actors to engage in policy debates and led to greater policymaking transparency. The extent to which Taiwan's democratisation affected the power structure of policy communities and the formulation of science policy are further discussed in the next two chapters.

D. Conclusion

This chapter has shown that Taiwan's S&T policy evolution has been intimately related with its political, economic and security constraints. Science policy was adapted due to the elites' perceptions and the changing socio-economic conditions. The initial academic-oriented approach was replaced by an applied orientation of S&T policy in the 1970s. Beneath the process throughout lurked national security concerns that took an arcane and insulated form to build up military research capacity. By the 1990s Taiwan's political, social and economic environments had experienced a large transformation and were facing new challenges. How science policy evolved in the face of those challenges is the basic focus of this research.

CHAPTER III

Actors and Issues: The Societal Aspect

In this research, democratisation, a fundamental political change, is regarded as a leading force affecting the overall policy environment in general and science policy in particular. Such a presupposition seems simple and logical, but a number of steps need to be taken to analyse its implications. First, we need to establish what stage Taiwan's democratisation has reached. Secondly, we need to observe the changes in science policy actors and their networks that have been triggered by the democratised society. Thirdly, it is crucial to identify the policy issues that arose with shifts of power position in and among different policy communities if we are to understand the evolution of policy. This chapter and the next focus on the main policy communities inside and outside government in order to demonstrate the impact of democratisation. Each policy community and its concerns are examined in order to draw out fundamental trends in the science policy domain.

Before looking into the changes in core policymakers, this chapter scrutinises three policy communities outside the state: the general public, the scientific community and industry. They are latecomers but increasingly important actors in relation to science policy. Relevant demands and ideas generated from these new social forces are presumed to redefine the underlying values and justification of science policy. The fading of the old patriarchal domination is unveiling a new era of science policy formulation that is generating different policy ideas, directions, conflicts and problems.

A. Forming Civil Society

An essential impetus to Taiwan's democratisation is the formation of civil society.[18] While the social pressure comes from political opposition movements, issues arising through the awakening of public awareness go far beyond political boundaries (Tien, 1997, p. 142).

Research conducted in the early 1990s indicated that people in Taiwan were dissatisfied with the government's performance with regard to such matters as the environment, work, education, traffic, bureaucratic corruption, medical care, unfair taxation, social order, the judicial system, and wealth distribution (Chu, 1995, p. 35; Hsiao, 1992, p. 57). Among other issues, environmental degradation has been one of the most sensitive problems in society, partly because of the government's notorious neglect of the side effects of a one-sided development strategy (Edmonds, 1996, p. 1245-49). Environmental protest movements played a crucial role in Taiwan's democratisation process, as revealed by the anti-DuPont movement discussed in the previous chapter.

Increasing social diversification is the most salient characteristic in Taiwan's changing society. The number of registered civil associations expanded from 10,625 in 1987 to 23,682 in 1999 (Peng, 1993, p. 149; Ministry of the Interior, 2000). Social diversification expands popular demands in relation to a variety of public issues.

Emboldened citizens in many social sectors, sensing the denial of their grievances or the neglect of their concerns by the government, no longer hesitated to take collective action to deal with problems the government seemed incapable of resolving. From 1983 to 1988, the number of reported protest incidents rose from 175 to 1,172

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[18] For a short discussion of the applicability of the Western concept of civil society to

(Chu, 1992, p. 102). Referring to research on eighteen social movements in the 1980s, Hsiao Hsin-huang observed that they constantly sought to redefine state-society relations (1992, pp. 69-71). Previous party/state corporatist controls could not safeguard the state's hegemony nor effectively respond to public pressures.[19] With the ending of martial law in 1987 and the subsequent lifting of bans on the media, associations, parades and parties, Taiwan's public realm has flourished.

The media, a vital vehicle in the formation of civil society, boomed after the lifting of martial law. In 1988, the total number of newspapers in Taiwan was frozen at 31, either owned by or associated with the KMT. As of April 1991, after deregulation, 210 newspapers were registered with the Government Information Office while the number of registered magazines reached 4,138 in December 1990 (Rampal, 1994, p. 644). Despite the fact that two leading newspapers, the *China Times* and the *United Daily News*, still dominate circulation, issues have been brought to the public eye from different political positions and social aspects. Competition between the two leading papers was a crucial instrument in pushing forward the overall trend towards press freedom.[20]

Furthermore, a process of legalisation and licensing of underground radio and cable television broadcasting also took place during 1994-5, after protracted negotiations and numerous confrontations between the owners and the Government

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Chinese society see Gold, 1997, pp. 172-4.

[19] For a detailed account of KMT state corporatism see Gold, 1986, pp. 59-69; Tien 1989, pp. 42-63; Peng 1993, pp. 149-56.

[20] See Kuo, 1993, pp. 110-1. Thanks to KMT intra-party conflicts, the contest between KMT 's two loyal backers, the *China Times* and the *United Daily News*, taking sides with KMT mainstream or non-mainstream factions, enlarged the role of the media in steering public opinion in the 1990s. For further discussion of the development and limitations of the media in the Taiwanese democratisation process, see Chen, Sheue-yuan 1998.

Information Office. Apart from political issues, aboriginal culture, grassroots movements and environmentalist viewpoints have appeared on radio and television.

In sum, the development of civil society is dramatic and interest groups are likely to have many more channels through which to express their opinions and pursue policy influence. As Thomas Gold notes, "civil society wields much authority, and politicians in the KMT as well as other opposition parties attempt to co-opt or latch on to movements and ideas generated within it" (Gold, 1996, p. 1112).

In this inaugural phase, however, Taiwan's civil society is not mature. It is still vulnerable to the domination of the state apparatus and other new challenges.

B. Public Concerns as Legitimacy

The growth of civil society is not necessarily paralleled with well-established public participation in the science policy domain. It is generally true that public participation in S&T policymaking, which has always been difficult, is now becoming even more so. The reason for this are principally that S&T development is intimately connected with the international division of labour, the industrial structure, market competition, professional manpower management and scientific uncertainty, issues on which it is difficult for interest groups, even groups from industry, to make judgements (Hilpert, 1991, pp. 3-40). However, despite being inconsistent and fluid, value-based public opinion is changing the way in which S & T policy is defined and justified.

Issue-oriented Social Mobilisation

In the past, for the general public to question science policy was rare. According to Lin Chung-shan's study, no popular initiatives were raised in the legislature during the period 1950-1970 (1982, p. 112). Even to date, unlike in developed western countries, Taiwan does not conduct regular large-scale official surveys in order to understand public opinion towards science and science policy, indicating that the general perception and level of public understanding of science are not yet seen as a crucial factors in assessing policy.[21] Similarly, considering the absence of an explicit 'attentive public' around science and science policy, whether pro-scientific or anti-scientific, Taiwan's general citizen is unable to wield a direct, effective, and powerful influence on policy.[22] Therefore, public apathy towards science is evident.

However, it is also unthinkable that vigorous social movements can keep away from science-related issues when science applications are so widespread in public lives. With democratisation, a range of highly controversial events such as environmental protection protests and anti-nuclear movements have mobilised social forces through scientific controversies and evoked public reflections upon science. The analysis of topics from media polls might help to support the above inference, presuming that the media, if they do not lead public opinion, at least respond to its main concerns. According to a series of surveys conducted by the *United Daily News* in the period 1986-1997, despite the fact that there were few opinion polls directly relating to science and science policy, science-related issues with direct negative impact on people's lives attracted public concerns (Table 3.1). Disputes about nuclear power

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[21] The NSC did plan a large-scale survey in 1990, but the results cannot be accessed from its archive (*NSC Monthly*, May 1990, pp. 616-8). In view of the dissemination of science through the Internet, recent research has called for a large-scale survey in order to reveal the extent of the scientific and medical literacy of the general public. See Hsieh, 1997.

[22] An attentive public, a concept first advanced by Gabriel Almond, is a classical requirement for recognising public opinion towards a given policy. Characteristics of an attentive public may preliminarily be identified by the organisations to which they belong and the specialised journals to which they subscribe. See Almond, 1950 and Miller, et al., 1980, Prewitt, 1982.

were the most persistent and salient. In other words, the development of general public concerns towards science-related policy was a supplementary product of the growth of concerns about daily lives. These developments led public scientific concerns towards an issues-based orientation, with strong non-technological values.

Table 3. 1 Media Polls on Scientific Topics (*United Daily News,* 1986-1997)

Year	Direct scientific topics	Science-related topics	Total polls
1986-7	--	Fifth Naphtha Cracker Astrology	13
1988	--	Nuclear Power Food Security	82
1989	--	--	125
1990	Space Policy	Fifth Naphtha Cracker	148
1991	Computer Applications	Nuclear Power (2)	132
1992	--	Nuclear Power (2)	119
1993	--	Nuclear Power	65
1994	Computer Applications	Nuclear Power	75
1995	--	Nuclear Power Dengue Virus AIDS	79
1996	--	Nuclear Power (3)	94
1997	--	Nuclear Power (2) Separate Provision between Clinic and Pharmacy	93
Total	3	20	1,025

Source: Academia Sinica, 2001.

The Expression of Social Forces

There is no simple answer to the question of the extent to which such an issue-based public opinion exercises influence over policy. However, lay public scientific concerns are, in fact, involved in the marshalling of social power during Taiwan's process of democratisation. Taiwan's prolonged debate about the fourth nuclear power plant is a testimony to social forces that policymakers will not risk ignoring in future. To a certain degree, Taiwan's anti-nuclear movements have considerably altered the character of both general public and governmental responses to science-related issues and controversies.

The commercial operation of nuclear power in Taiwan started in 1978. So far, three power plants have been put into operation, and at times have generated as much as one third of the island's electricity. In 1998, nuclear power accounted for nearly 20 per cent of the installed capacity of all power generation. While previous nuclear power plants had experienced less opposition, the dispute over the fourth nuclear power plant, which was approved as early as 1980, has lasted for over twenty years.

In 1983, 46.2 per cent of respondents from the general public did not know of the existence of any nuclear power plant, and 97 out of 100 people had insufficient knowledge about nuclear energy (Hsiao, 1987). Expert opinion was therefore an important source for the judgements of the general public (Hu, 1995, p. 48). During the period 1984-1985, a strong anti-nuclear movement arose. Falling electricity demand, a tight budget, constant anti-nuclear suspicions and security problems all led the Executive Yuan to postpone construction of the fourth plant in 1985. By that time, environmental movements had gradually won acceptance from the public. However, grassroots movements and sporadic specialist criticism of nuclear power were still incapable of impacting on the debate from scientific perspective. The birth of the Taiwan Environment Protection Union in 1987, combining grassroots forces and anti-nuclear specialists, created a platform for the expression of views against the scientific claims of the government and nuclear experts (Hu, 1995, p. 59). Since then, continuous and systematic scientific debates, along with other criticisms on economic, efficiency, security, disposal, and moral grounds have strengthened anti-nuclear claims, as illustrated in anti-nuclear propaganda, an example of which is *Ten Questions against Nuclear Power Plants* (TEPU, 1998).

Reinforced by the political opposition, anti-nuclear concerns permeated upwards from grassroots protests, to local-central government conflicts, and central policy debates. More and more, nuclear engineering experts felt obliged to clarify nuclear power issues and the government faced difficulty in initiating the further establishment of nuclear facilities. To regain commitment to the fourth plant, the Taiwan Power Company even spent NT$1.2 million (US$46,000) in 1989 on persuading experts to justify the plant publicly (Hu, 1995, pp. 64-6). To some extent, this also increased public understanding of nuclear power.

The agenda for constructing the plant was then revived after 1990 due to the urgent demands of electricity supply. The feasibility assessment and environmental impact assessment proposed by the Taiwan Power Company were approved by the State-owned Business Council of the MOEA and the Atomic Energy Council of the Executive Yuan by the end of 1991, on the premise that the plant had to proceed and had been placed in the Six-Year National Construction Plan. The renewal of permission for the construction of the plant was eventually approved in the Legislative Yuan in June 1992. To suppress contention, officials claimed that the decisions concerning the construction of nuclear power plants ought to be left to expert assessment (Lin, Chung-hsi, 1991). However, facing increasing opposition, the plant's assessment and review authorities, both the State-owned Business Council and the Atomic Energy Council, repeated that their remit was limited to the technical level (*Central News Agency*, 8 May; 24 September 1991). Embarrassingly, many disputes also arose in the assessment process. For example, in the fourth environmental assessment meeting, civilian scientists openly claimed that improper methods had been employed in assessing the maritime ecology around the plants, data on which was used as an environmental impact indicator to support the construction of the plant (*Central*

News Agency, 8 July 1991). Arguments also arose in the second feasibility assessment meeting when government-sponsored research done by the Chung-Hua Institution for Economic Research pointed out the disadvantages of nuclear power in comparison with other energy sources (*Central News Agency*, 8 July 1991). Consequently, formal scientific investigations were unable to resolve the contention.

Since 1992, nearly every year the plant's continuing construction has come under threat from legislators' boycotts and under tremendous pressure from anti-nuclear movements, whose actions have included lobbies, demonstrations, sit-ins, hunger strikes, signature campaigns, physical conflicts, impeachment and prosecution. In July 1994, a budget package totalling NT$1,125 billion (US$43 billion) for the main part of the eight-year construction programme was approved amid physical confrontations inside and outside the Legislative Yuan (Chang, 1998). In May 1996, a bill to close all nuclear power plants was passed by opposition legislators and not reversed until October 1996 when reconsideration was approved (*Central Daily News*, 11 May 2000, p. 3). In November 1997 the Legislative Yuan once again attempted to freeze the total budget for the fourth nuclear power plant. In 1999 the construction permits for the main structure were issued and up to May 2000 the construction process was 30 per cent complete (*Central Daily News*, 11 May 2000, p. 3).

In the course of the conflict, both sides regarded the general public as a target to be educated, mobilised, and enlisted for support. Four informal local plebiscites showed that citizens' antagonism had grown considerably. In Taipei city's plebiscite of 1996, 51. 5 per cent of voters were against the construction on the basis of a 58.7 per cent turnout (GCAU, 2000). This of course could not be entirely related to any increase in citizens' understanding of the nature of nuclear power, but it revealed the increasing strength of the anti-nuclear movements. The claims of scientific authority formulated by the government and nuclear experts around nuclear energy were challenged by various social concerns, ranging from security problems to waste disposal. These longstanding conflicts finally led the government to adjust its energy policy and to announce in 1998 that no more nuclear power plants (the fifth plant) would be constructed (*Independence Morning Post*, 28 May 1998, p. 4). The development of the anti-nuclear movement exemplified not only the fading of the doctrine of economy-first in national policy priority but also the transition of public perceptions of science: a scientific claim is not respected as absolute.

It is hard to identify the threshold at which public concerns will turn into direct impact on policy. However, in a society which has a relatively flourishing media, a social issue can suddenly have influence.[23] For example, in recent years the media has introduced gene-related issues to Taiwan's people. At first, news coverage upon gene-related issues mostly referred to current events abroad, such as scientific progress, biological diversity and the security controversy.[24] As to indigenous concerns, news reports kept a stance in line with official considerations.[25] The regulation of genetically modified food was connected with the question of whether relevant regulations would affect the Taiwan's application to join the World Trade Organisation (*China Times*, 20, September 1999, p. 6; *United Daily News*, 30 January 2000, pp. 1, 11). With respect to biological diversity, issues around Taiwan's sovereign rights over biological information and resources were mostly related to economic interests rather than to the

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[23] Although media reports on scientific events could be false and misleading, the media's information dissemination function is unquestionable (Hsieh, 1997).

[24] *United Daily News*, 20 February 1999, p. 5; 19 September 1999, p. 11; 18 January 2000, p. 11; *China Times*, 20 May 1999, p. 10; 19 July, p. 10; 15 January 2000, p. 5; 15 May 2000, p. 10; *Economic Daily News*, 1 February 2000, p. 9.

[25] Fang Chien-san's finding in his study of the scientific news reports on the Superconducting Super Collider case is similar (Fang, 1995).

purpose of preservation of the biosphere (*United Daily News*, 1 March 1999, p. 8). Alongside intense international deliberation in 2000, the media started to cover the government's tardy response, but gained little attention from the government (*United Daily News,* 30 February 2000, p. 8; 26 May 2000, p. 5). In October, the Environmental Quality Protection Foundation declared that 17 out of 36 food samples contained genetically modified ingredients (Liou, 2000; *Central Daily News*, 16 October 2000, p. 4). Through the media and the Internet, genetic regulation swiftly became a hot subject of public concern. The government was forced to enact relatively strict regulations in the following year, adopting the principle of compulsory labelling on genetically modified foods (DOH, 2001). Scientific knowledge may be arcane, but once it was mixed with social values, social mobilisation could quickly command sufficient influence to sway policy.

However, the fact that science-related issues stem from general public interest has its own side effect: over-politicisation. The growth of social forces raising a variety of issues is paralleled by the development of democratisation, where the political opposition is normally involved. Thus political conflicts always dilute the scientific verification function, adding confusion to already complicated scientific controversy. An event discussed below represents a typical scenario of this type.

At the end of 1994 the leading global chemical company, Bayer, planned to build a Toluene Di-Isocyanate (TDI) factory in Taichung County, in the middle of the island. This investment received a warm welcome from central government and industry, and gained great privileges, such as a special zone in Taichung Harbour, a reduced land rent for 100 years, and incentive measures treating TDI production as a 'key technology industry' (*Commercial Times*, 22 December 1997, p. 3). Although this case reflected the top-down decision-making model dominated by economic considerations, the investment was claimed to involve the acquisition of a high-tech manufacturing process and a set of high quality management procedures in industrial security and environmental protection. In the meantime, because the Environmental Impact Assessment Law was enacted in 1994, this investment was subjected to an environmental assessment. However, the neglect by technocrats and by Bayer of the local fear of toxic leakage, as happened in the case of a similar factory in Bhopal, India, which killed 2,500 people and injured more than 200,000, caused constant protests from local residents. This grievance was fuelled by the involvement of local politicians and media exposure.

While the investment was approved by the first and second environmental assessments, former Legislator Liau Yung-lai organised the Anti-Bayer Operation Union in November 1996 due to the potential for lethal toxic leaks. Regardless of whether Liau was truly concerned about this matter, he was chosen by the DPP to run for mayor of Taichung County and he needed such an issue to mobilise his constituency. Liau argued that the decision about final approval of the construction of the factory and the issuing of a construction permit, which was under county jurisdiction, should be handed over to the local residents to decide by plebiscite. After Liau was elected, the credibility of the scientific assessment and the political commitment completely disappeared. On 18 March 1998, Bayer announced that the investment was no longer attractive, due to the failure to secure sufficient guarantees, and would be moved to Texas (*Economic Daily News*, 19 March 1988, p. 3).

It is worth noting that during the above process three experts representing anti-Bayer groups were actually invited to the second round of the environmental impact assessment, which was then approved without objection (*China Times*, 26 February 1998, p. 1). Some previous anti-Bayer academics and local representatives changed their minds and expressed optimistic viewpoints after visiting the Bayer headquarters in Germany (*China Times*, 13 February 1998, p. 2). To secure their position, the opponents of the project used false information to attack Bayer's security record in public debate (*China Times*, 26 February 1998, p. 1). In a situation of over-politicisation, scientific verification appeared to be endangered.

One outcome of over-politicisation is that issues that have become the subject of debate have remained unresolved or even become more engulfed by controversy. In the aforementioned nuclear power conflict, intense anti-nuclear pressures drove the state-owned Taiwan Power Company and the Atomic Energy Council to adopt a defensive attitude and accept a serious delay to their schedule. Those factors finally caused arbitrary administrative behaviour in environmental assessment, budgeting and the protection of pre-historical anthropological relics on the construction site and led to 'corrective measures' issued by the Control Yuan in 1995 and 1999 (Control, Yuan, 1995; 1999a; 199b; *Central News Agency*, 15 September 1995; 5 November 1999).

In Taiwan, while public understanding of science is still immature, the politicisation of science helps the general public to turn their attention to the role of science in society – the 'scientification of politics'. Yet, over-politicisation also casts a shadow over scientific credibility and authority in the perception of the general public.

Attitudes, Issues and Legitimacy

Does issue-based public pressure undermine public allegiance towards science? Does increasing scientific controversy indicate that the lay public does care about the implication of science in modern society? According to Hsieh Ying-chuen's study, most people in science-related sectors, journalists, and students in high school and university tend to hold positive attitudes towards science as a institution (1997).

Scientific controversy does not necessary lead to public anti-science sentiment.

Furthermore, scientific verification seems to be increasingly connected with autonomous social actions. One piece of research found that although only 6 per cent of Taiwan's environmental groups conducted their own scientific investigations in 1993, a total of 65 per cent of the groups involved themselves in academic research or contracted out targeted research to outside consultants (Kuo, 1997, pp. 81-82). This indicates that, despite limited resources and funds, professional verifications and claims have generally become a crucial element in their arguments. This tendency has been institutionalised further. For example, after continuous advocacy by interest groups, the latest revision of the Air Pollution Control Act of 1999 entitles private persons or interest groups to bring a lawsuit in the Administrative Court against an agency responsible for neglecting regulatory enforcement, and to request a verdict ordering the agency to enforce relevant laws (Office of the President, 1999d, art. 74). The initiation of such actions involves not only legal expertise but also technological competence. Soon after the promulgation of the new law, the Environmental Quality Protection Foundation drew on its professional capability to gather individual grievances and file eleven pollution cases against various local authorities, marking the first use by citizens of legal procedures to challenge government's inadequate regulatory behaviour (EQPF, 1999). Thus, while the 'politicisation of science' has infused science policy justification with various social values, the 'scientification of politics' in the social movements is also strengthening. A survey from 2000 provides a snapshot of such a public attitude towards science. A Gallop poll revealed that although 67 per cent of respondents were concerned about safety problems and 74 per cent demanded labelling, 65 per cent still accepted that genetically modified foods will be a future trend (Chiou, 2000; *Central Daily News*, 18 October 2000, p. 4).

Overall, several tendencies are visible. Firstly, economic benefit alone can no longer justify science policy. The previous application-oriented science policy needs to be modified, as shown in the above cases. Secondly, the increasing public concerns over science raise policy issues regarding the social and local relevance of scientific research. These issues swiftly influence the perception of legislators and scientists in deliberating the role of science in society. I will return to these issues bellow. Thirdly, a new set of science-related social values, including moral, ethical, legal, health and ecological concerns, are being brought to bear upon science. This is evident in the 1992 Amendment to the Constitution, where it states that "environmental and ecological protection shall be given equal consideration with economic and technological development" (Office of the President, 1992, art. 18; 2000c, art. 10). This tendency has been conspicuously paralleled by the rapid development of regulatory government mechanisms in relation to science-related public affairs. By examining public policy overall, Table 3.2 demonstrates that in the 1990s alone, a set of intensively enforced measures were adopted to respond to the social values mentioned here. From environment to ecology, from human rights to animal rights, from medical ethics to genetic experiments, social concerns have been taken into account in a wide range of policy initiations. What is more, scientific verification systems and citizen participation have been introduced into the regulatory policy areas with a view to resolving value-laden scientific controversies (Table 3.2). The trend may not be attributable entirely to bottom-up demands, but it does show that various issues actively promoted by interest groups are reflected in policy measures.

Table 3. 2 Taiwan's Science-related Regulations in the 1990s

Year	Law	Object under Regulation	Connected Issues
1992	Artificial Disaster and Dispute Resolution Law	Artificial disaster and disputes	Environment Scientific verification Citizen participation (through panel resolution)
1992	Addition Articles and Amendment of Constitution	Compatibility of science development with environmental and ecological conservation	Environment Ecology Accountability of science
1994	Environmental Impact Assessment Law	Planning permission and government policy	Environment Scientific verification (through panel review)
1995	Regulation relating to Wild Life Protection Advisory Committee	Wild life and relevant research	Ecology, Animal rights Ethics of science Scientific verification Citizen participation (through panel review)
1997	Environmental Chemicals Control Law	Antiseptics, germicides, pesticides, anti-pollution chemicals, and relevant experiment and research (including genetic engineering)	Environment Ecology Ethics of science Scientific verification
1998	Animal Protection Law	Animal experiments.	Animal rights Ethics of science Scientific verification (through panel review)
1999	Health Food Control Law	Scientific prerequisites for health foods	Health Scientific verification
2000	Regulation for the Operation of Field Trials of Genetically Modified Plants	Genetically Modified Plants	Ecology Health Scientific verification (through panel review)
2000	Medical Harm Relief Law	Victims of medical harm	Health Human rights
2001	Regulation for the Medical Ethics Committee	Medical ethics	Ethics of science Citizen participation (through panel review)

Source: Office of the President, 1992; 1999e; 1999f; 2000a; 2000b; 2000c; 2000d; 2001; HOD, 2001b; Council of Agriculture, 1995; 2000b.

Owing to the trend towards issues-based mobilisation, science-related social values may appear to be varied and fluid.[26] At a meso-level, however, a direct consequence of social demands is visible in the changed environment surrounding S&T policy considerations. In particular, situated in an environment of political transformation, the bottom-up demands explicitly constitute a crucial dimension affecting policy justification. Public demands thus impose a new social accountability upon science policy, a new science-society relationship, which marks a sharp differentiation from previous policy legitimisation, which was defined by patriarchal wisdom and the rhetoric of the elites.

Finally, it needs to be pointed out that despite the increasing importance of the social accountability of science, government acknowledgement of public capacity to raise issues relating to scientific verification and judgement over controversies is still limited in Taiwan. In the case of genetically modified foods mentioned above, the Department of Health (DOH) denied that the labelling regulation introduced resulted directly from escalating public concern, stating that since 1998 a sponsored Study on Management Systems for Biotechnological Foods had been carried out by a government-supported laboratory – the Food Industry Research and Development Institute (Lu, 2001). However, commercial interests and the high costs of food regulation led the government to delay for two years before taking regulatory action (Chou, 1999; Chen, Shih-jung 2000, p. 11; *Central Daily News*, 22 September 2000, p. 4). The DOH finally issued a progressive measure, by which foods containing generally modified soya and maize were first targeted for labelling, but there was no

[26] The specific content of relevant social values and the policy impact of different issues might be revealed only by a micro-examination of the nature of the issues, the characters of the advocates, the effect of media channels and the concerns of those affected.

information as to why looser or stricter measures were not taken.[27] It was presumed that the agency and government scientists had adopted the best choice from different measures implemented in the West and Japan after a thorough and objective scientific review (DOH, 2001a; *China Times*, 24 October 2000, p. 24; Lu, 2001). A secret policy review of this kind fails to create a healthy basis for nourishing public understanding and participation, and this in turn encourages interest groups to adopt direct political action and sensationalistic mobilisation to press their demands. At the same time, appeals to the 'public good' can be used as a means of covering up other interests at stake. If appeals to the public good and commitments to the social accountability of science are not accompanied by knowledge rooted in the public domain and across society, but remain subject to secrecy and the exercise of unaccountable political influence, science-related public concerns cannot be free from the distortions of power.

C. Autonomy of The Scientific Community

So far, we have shown that the involvement of scientists and experts is important to the awakening of public concerns about scientific affairs. Unlike in the case of the general public, the actions of the scientific community, which is a subject and beneficiary of whatever science policy delivers, have a direct and explicit influence on that policy. In other words, changes in their power position and their role in society challenge old policy configurations, particularly for arrangements concerning scientific autonomy, authority and accountability. This has involved a process of redefining the relations and boundaries between science and society.

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[27] For example, why is it reasonable in the regulation on the labelling of foods containing genetically modified soya and maize to set a 5% *de minimis* threshold for the contamination of non-genetically modified produce, while in the UK that is

General Structure

In Taiwan, the scientific population is mainly concentrated in three areas: industry, the universities and scientific institutes. Taking 1998 as an example, over 62 per cent of scientific researchers worked in industry, and 15.4 per cent in universities and 22.6 per cent in research institutes (see Table 3.3).

Table 3. 3 Scientific Researchers by Sector, 1998

Sector	Universities			Research Institutes			Industry			Total
	Public	Private	Sub Total	Public	Private	Sub Total	Public	Private	Sub Total	
Number	8,261	3,564	11,825	8,186	9,157	17,343	2,489	45,133	47,622	76,790
%	10.8	4.6	15.4	10.7	11.9	22.6	3.2	58.8	62	100

Note: For total full time equivalence figures see Table 5.1.
Source: revised from NSC 1999a, pp. 28-9, 63, 71.

The policy impact of these sectors does not, however, match their size. Although the situation is changing, the policy influence wielded by industry-based scientists is weak. The scale of industrial R&D is rather small and fragmented within the state-led industrial structure. Not until 1993 did the R&D expenditure of the private sector consistently surpass that of the government (NSC, 1999a, pp. 22-3). The current growth of funds directed by private firms into R&D is increasing industrial managers' and stockholders' influence over policy agendas, to which I will return later, but it is not yet the case for scientists and engineers in private sectors. Neither large private laboratories nor notable private in-house research centres have developed a relatively independent status. They simply have no institutional position to 'translate' their

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established at 1%?

expertise into power. In my analysis, their policy influence, if any, is considered as part of that of a much broader policy community – the entrepreneurs.

On the other hand, on many occasions, especially in the area of applied technology, members of many non-profit research institutes appear active in Taiwan's industry policy. However, this impression needs to be clarified. With the exception of the Academia Sinica, which has always been considered an academic unit, the most significant research institutes, whether private (non-profit) or public, have been set up to carry out strategic government R&D or to bridge technological gaps in industrial production. Such prominent organisations include the Industrial Technology Research Institute (ITRI), the Institute for Information Industry (III), the Development Centre for Biotechnology, the National Health Research Institute, and so on. In 1998, government funds accounted for 85 per cent of the total funding of research institutes, and even private institutes relied on public funds for 73.7 per cent of their total expenditure (NSC, 1999a, p. 22). As a result, with government financial support and mission orientation, scientists and engineers in those research institutes have interests that are consistent with those of their sponsors. Because of this, the structure of dependence on government patronage has not been dramatically altered by political changes so far. The role of the research institutes is confined to implementing official R&D at a technical level, and they will not gain authority in the policy domain till they achieve greater autonomy. Even when their opinions do become the primary element in policy initiation and implementation, their policy advocacy is deeply embedded in a decision-making process which makes no distinction between their professional and administrative positions. In fact, even in 1999, most occupants of management posts of those institutes, especially the semi-public non-profit institutes, were retired politicians without any technological background (*Legislative Gazette*, 88 (25), pp. 305-6). For these reasons, the institute-based experts can be regarded as government scientists and as part of the science administration establishment.

Finally, staff and researchers in higher education institutes and the Academia Sinica are normally perceived as the scientific community, mainly because academic scholars enjoy relative autonomy in their work. The best way to view the role of academic scientists is to place them under a broad concept – intellectuals. Basically, intellectuals in traditional Chinese society are seen as symbolic of knowledge, wisdom, reputation and power. Academic scholars play not only an internal role of teaching and research, but also a social role of inspiring the public and solving social problems. Ironically, while this traditional role as intellectuals offers academics a sense of social responsibility which enables them to take action to improve society, it also makes it difficult for academics to resist the temptation of power, as shown below. By using their own words as much as possible, the following discussion presents the changes in and limitations of the scientific community from two perspectives – scientific autonomy and authority respectively.

Constraints on the Scientific Community

Despite having social responsibility as intellectuals, Taiwan's academic scholars as a scientific community appeared rather constrained before 1980. Here, historical factors were significant. Under Japanese colonialism, Taiwanese professionals were forced to concentrate on practical disciplines, such as medicine, mining, mechanical engineering and so on. Weak manpower in basic sciences was evident in the membership structure of the Taiwan Provincial Science Promotion Association, the first independent cross-disciplinary Taiwanese scientists' organisation (Chiang, 1990, p. 42). This shortage in the basic science population did not change until the 1980s, when a large number of overseas students and scholars returned. Thus, in general, the number of academics who could be identified as scientists was relatively small, which worked against the establishment of a knowledge-pursuing ethos (Lin, Jiun-yi 1991, pp. 26-7).

Secondly, the scientific community became even weaker in the face of political suppression under the authoritarian regime. Teachers were reduced to being a primary foundation for the solidity of the authoritarian regime (Peng, 1993, p. 91). The political suppression of academics and their associations recurred under authoritarian rule.[28] Before deregulation, the government imposed the restriction that only one academic association could be set up for a single discipline or purpose (Lin, Jiun-yi 1991, p, 28). This allowed government-supported associations or the participation of government scientists to dilute the presumably unwelcome progress of scientific autonomy. For example, the Taiwan Medical Association, the oldest and most prominent professional medical association in Taiwan, was asked to rename itself and reorganise on several occasions.[29] Authoritarian top-down penetration and manipulation to prevent challenges from intellectuals made it difficult for the scientific community to cultivate bottom-up organisations and inspire scientific research informed by local concerns (Fu, 1991, pp. 406-7). For instance, during the period 1955-1973, the Chinese Association for the Advancement of Natural Science, an early government-supported organisation composed mostly of scientists and government technocrats from the mainland, framed its role in terms of pure knowledge dissemination and the upholding of policy, and

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[28] Those events have largely been exposed in the last decade. Investigations are being undertaken to give victims justice and compensation.

[29] See Lin, Jiun-yi 1991, pp. 28-29 and Su, 1989, p. 8. The historical conflicts divide the current Taiwan medical community into two major blocks: one led by Taiwan University Hospital represents Taiwanese medical professionals and the other led by the National Defence Medical Centre represents mainlanders (Chang, 1999, pp. 18-21).

rarely addressed local scientific issues and social responsibility (Chiang, 1990, pp. 45-48). As a result, it is not surprising to see that, even today, on many academic society boards, large numbers of members are government agents, technocrats and politicians.[30]

Thirdly, the intimate relationship between the scientific and political spheres is also related to the prevalence of 'credential worship' in Chinese society, rooted in a traditional belief that excellent intellectuals have more capability to pursue wealth and power. This belief was intensified after the emergence of the technocracy in the 1980s. Since then, academic experts have become the major human resources of political elites. In the last cabinet of the long-standing KMT regime, there were 18 members out of 42 had held academic or research posts in their earlier careers (Table 3.4). This high interchangeability of personnel between the academic and political spheres tempts scholars to yield to the temptations of political power (Lee, 1991b, pp. 378-9; *SciTech Reports*, July 1992, p. 33) and indirectly impairs the independence of the scientific community (*SciTech Reports*, July 1989, p. 4). While an individual scientist may become a member of the political elite, the community as a whole generally lacks the strength of self-regulation to counter political hegemony.

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[30] See *SciTech Reports*, 1990, p. 19. Taking the Aeronautical and Astronautical Society of the Republic of China (AASRC) as an example, in 2000, a total of 47 board members, including executives, supervisors, and advisors, included 15 members who were government scientists, agents and managers of state-owned companies (AASRC, 30 (2), p. 5).

Table 3. 4 Ministers with Academic Backgrounds (January 2000)

Post	Professional	Post	Professional
Vice Premier	Chemistry (PhD)	Chairman of the Research, Development and Evaluation Council	Management & Business (PhD)
Minister without portfolio	Economics (PhD)	Chairman of the NSC	Chemistry (PhD)
Minister without portfolio	Electronic Engineering (PhD)	Chairperson of the Council of Labour Affairs	Sociology (PhD)
Minister without portfolio	Agriculture (PhD)	Chairman of the Overseas Chinese Affairs Commission	Law (PhD)
Minister of Education	Education (PhD)	Director General of the Directorate General of Budget, Accounting and Statistics (DGBAS)	Statistics (PhD)
Minister of Economy	Marketing (PhD)	Chairman of the Mongolian & Tibetan Affairs Commission	Management & Business (PhD)
Minister of Foreign Affairs	Law (BA)	Chairman of the Mainland Affairs Council	Politics (PhD)
Minister of Finance	Economics (PhD)	Chairman of the Atomic Energy Council	Dynamics (PhD)
Minister of Health	Medicine (BA)	Chairman of the Council for Cultural Affairs	Domestic Sciences (BA)

Given the above limitations, the social environment for the institutional autonomy of academic scientists was infertile. While numbers of scientific associations gradually increased and ranged between 200 and 350 in the early 1990s, depending on how the boundary was set, the functions of most scientific associations were limited, beyond holding an annual conference. Furthermore, the high dependency on foreign knowledge always placed limits on the influence of the local scientist community. Financial shortages caused difficulties to the extent that most academic societies lacked permanent offices and staff, not to mention the capacity to undertake professional verification, participate in policymaking, and promote research (Peng, 1991; Liu, 2000). In the field of chemical engineering, professional associations were described as follows: "in the past, certain association exercises relied on the patronage of state-owned enterprise bosses, now those exercises are mainly social meetings" (Lin, Ho 1991, p. 392). It was generally agreed that scientific associations were ineffective in their function as political actors offering policy advice (*SciTech Reports*, November 1991, p. 6)

Only in technological disciplines did academic associations have more financial independence (Chen, 1992). Being involved in national development, engineering societies also had a chance to influence public policy. For example, the launching of Taiwan's semiconductor industry together with its core organ for industrial upgrading – the ITRI – was tied to a network of local Chinese Institutes of Engineers and overseas Chinese engineers (Hong, 1995, pp. 20-1; Meaney, 1994, pp. 174-5). However, due to the nature of the discipline, their functions were merely to provide consultation at a technical level rather than to act as gate-keepers or as a source of policy advice based on considerations of social accountability and meta-science (Peng, 1991, p. 17; Lin, 1998).

Up to the 1990, Academia Sinica was the only link with relevant international scientific bodies in many fields, for example, the International Council for Science. Ironically, the domination of the Academia Sinica also impaired the international recognition and status of certain local scientific associations.[31]

Fu Daiwei, one of Taiwan's pioneers in the philosophy and sociology of science, offered the following sketch of Taiwan's scientific community:

> Facing the state apparatus, the patronising hegemony, scientists are ideologically compliant, they are incapable in political

[31] *SciTech Reports*, July 1989, p. 4; August 1991, pp. 15-16. Before the 1990s, there were only two scientific journals, published by local scientific associations – the Physical Society of the ROC and Chinese Chemical Society, which were regularly listed in the Science Citation Index (*NSC Monthly*, April, 1988, pp. 558-68; *SciTech Reports*, July 1988, p, 7; April 1989, p. 20).

advocacy, and their cultural perspective is constrained or entirely jejune (other than fighting for resources, producing a track record, and battling for important posts of technocrats). The scientific community is thus insulated from other various sub-cultures of civil society (1991, p. 406).

Action as Autonomy

The impact of social liberalisation and political democratisation upon the scientific community has been immense but, on the other hand, it has not happened overnight.

Academic activism was driven at first by social and political reforms. The previously mentioned Taiwan Environment Protection Union has reflected the active involvement of scientists. Others like the Cheng She (Illumination Society), the Taiwan Association of University Professors, the Alliance of Medical Professionals in Taiwan, organised by single or cross-disciplinary professors and experts, have been striving to promote social welfare and political reform (Lin, Yu-ti 1993b; MPAT, 1998; Chiu, 1999). Founded by professors and experts, their opinions and ideas deploy the knowledge necessary to guide social movements and influence policy. The following statement from Lin Yu-ti, a member of the Taiwan Association of University Professors, is a typical example: "[our] members' opposition depends on 'knowledge' and 'deep concern' for their own locality, therefore differing from 'blind opposition'" (Lin, Yu-ti 1993a, p. 4).

Such academic activism naturally evokes the scientific community's active participation in public affairs, whether based on cognitive obligations or individual interests. Press conferences, public hearings, social movements, think tanks, all sorts of new types of channels were open for academic scientists to express their professional opinions (Fu, 1990a, pp. 6-7). Particularly after the lifting of martial law, the appearance of numerous academic specialists in the public policy arena were described as the overuse of expertise (*SciTech Reports*, January 1988, p. 6). In some extreme cases, scientists took part in elections to the legislature, the National Assembly and local government.[32] An open media, social movements and political opposition gave rise to scientists' influence on society and politics.

In the bigger picture, three characteristics mark the differences from previous relations between science and politics. Firstly, the locale of the expression of expertise has expanded from behind the doors of government offices to the public arena, creating a new knowledge/power complex and a new figure – the civil expert (Fu, 1990a, p. 10). A parallel phenomenon to this is that the pluralistic environment, where more room is left for a range of experts to address policy problems, threatens or challenges the authority of elite and government scientists. Thirdly, as a result, the scientific community itself has become a target of various interest manipulations and power penetrations. Several large civil academic foundations established at the start of democratisation reflect this complex network (Fu, 1990a, p. 5). Consequently, scientists in various positions, whether as advocators, advisors, or adversaries, have considerably increased their authority.

These circumstances made scientists ambivalent about how the boundary between science and politics should be defined. On the one hand, they felt a responsibility to become involved in social affairs. According to Fu Hsiu-ya's investigation in 1995, all but one of 109 life science researchers in the Academia Sinica agreed that scientists should take part in the popularisation of science, and 54.6 per cent had been involved in such activities on a regular basis in order to promote public understanding (70.1 per

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[32] For example, in the 1989 legislative election, two candidates, Professor Lin Juin-yi and Hsieh Shiue-shian, came directly from the universities with a science background

cent) or to influence legislation (44.3 per cent) (1997, p. 109). Thus, in the controversy over space policy, the unwillingness of certain scientists to question the satellite programme was criticised by the scientific community itself (*SciTech Reports*, December 1989, pp. 18; April 1990, p. 5; May 1990, pp. 22-3). Scientists called for contributions to industrial technology, the taking of social responsibility and the search for a local scientific paradigm.[33]

On the other hand, the movement of scientists between academia and politics in the name of social responsibility has likewise led to disputes. When Lin Juin-yi, Professor of Biology at Tunghai University, ran for election to the legislature and later for Mayor of Taichung City, an appeal was made to him to return to the university in order to protect the integrity of science (*SciTech Reports*, December 1993, p. 30). Similarly, when Lee Cheng-yuan, a prominent academician in the area of toxicology, devoted himself to social welfare and political reform, his move was seen as an abuse of his expert knowledge (*SciTech Reports*, October 1991, pp. 22-3).

These contradictory examples reflect the deep anxiety of the scientific community. Can the scientific community sustain this expanding authority without losing autonomy? To address this question, the development of the scientific community in various loci and dimensions will now be outlined.

The Rising Role of Academia Sinica

The changing role of the Academia Sinica explicitly displays the dynamic process whereby scientific authority expands and is accommodated in society.

(*SciTech Reports*, November 1989, pp. 16-17).

[33] See *SciTech Reports*, November 1989, p. 21; December 1989, p. 18; April 1990, p. 7; May 1991, pp. 16-22; September 1991, p. 14; December 1993, pp. 12, 28-29; February 2001, pp. 16-7; Yang, 1994; Liu, 1999a; b.

The Academia Sinica, as a public research institute, has a relatively privileged position enjoying government largesse. Constitutionally, it comprises various research institutes and national academicians and is the highest academic institute, being directly under the Office of the President. Partially because it was largely devoted to basic research, the Academia Sinica as a whole remained remote from society in the past. Even though academicians enjoyed influence on policy as a result of their international reputation, policy advice was conveyed to policymakers in a covert way. In recent years, the influence of overseas-based academicians has been further undermined by scepticism about their ability to make judgements on domestic problems (Lee, 1991a; *SciTech Reports*, April 1998, p. 2; May 1999, p. 11).

On the other hand, researchers in the various institutes (over 3000 in 1997) and local-based academicians are attracting attention in many public policy discourses. This has been specially so since Lee Yuan-tseh (known as Yuan Lee), a 1986 Nobel laureate in chemistry, accepted President Lee Teng-hui's invitation to take the post of president of the Academia Sinica. In a speech to his fellows researchers soon after starting the job, Lee made the following statement:

> We are capable of offering objectively analysed data and views as a reference for government policymaking...This is the best way to forge the authority of Academia Sinica. We can no longer quibble in an ivory tower. It is our obligation to step into society. However … the Academia Sinica should stay away from the decision-making circle of government, otherwise we will witness an unfortunate scene where the academic is contaminated by political intervention (Lee, 1994, pp. 13-14).

Many efforts have thus been made to enhance the scientific authority and policy competence of the Academia Sinica. To address local issues, its mission-oriented projects are focused on such topics as South Asian studies, Taiwan studies, Sinology, social problems and cross-strait issues (*SciTech Reports*, August 1996, p. 6; *Legislative Gazette,* 84 (46), pp. 191-2; 87 (40), p. 274). To exploit its research capacity, the links between basic research and applied products and between academia and industry are emphasised.[34] Life sciences and information technology are particularly set as priority areas. Furthermore, Lee's active efforts in the recruitment of world-class scientists to lead in-house research have considerably enhanced the institute's authority and competence in many fields (Swinbanks and Cyranoski 2000, pp. 419, 422). With those changes, the influence of the Academia Sinica has increased. With regard to science policy, reforms advocated by Lee and his colleagues are reflected in appeals such as those to loosen government funding restrictions on scientific research (*Central News Agency*, 21 August 1994), to increase flexibility regarding the acquisition of patents by inventors in government-sponsored research (*Central News Agency*, 11 November 1995), to establish an independent S&T department (*Central News Agency*, 16 September 1996), and to extend the function of the Academia Sinica so that it offers doctoral education (*Central News Agency*, 2 July 1994; *Central Daily News*, 28 February 2000, p. 4).

Consequently, issues have been raised concerning the role of the Academia Sinica in the national science policymaking process. For a time, an informal meeting was held every three months between Lee, the NSC chairman, and the Minister of Education to exchange opinions regarding research and education (*Central News Agency*, 25

[34] In a speech to the legislature, Lee Yuan-tseh illustrated three areas of research that will directly benefit local academic-industrial collaboration: blood products, agriculture biotechnology and information science applications (*Legislative Gazette*, 86 (18), pp. 376-8).

February 1994). Furthermore, Lee and his colleagues advocated establishing a clear role for the Academia Sinica in national science policymaking, as constituted by the Fundamental Science and Technology Act.[35] Such a gesture directly challenged the national framework of science policymaking.

What is more, the stand of the Academia Sinica in relation to policy engagement no longer solely depends on the support of politicians, but is based on an appeal to the general public. It is enthusiastic and close to decision-making in many policy areas, but also intends to maintain its distance from policymaking circles themselves. This sort of stand is crucial in fostering the neutrality of the nascent authority and autonomy of science. Unfortunately, its enthusiasm and efforts easily turn to frustration and disappointment in the face of bureaucratic obstacles. Conspicuous cases are those of education reform and 921-earthquake relief action.[36] On the former, Lee Yuan-tseh criticised the ignorance of the Minister of Education and President Lee Teng-hui when they did not accept the proposals of the Education Reform Advisory Committee, led by Lee and fellow members of Academia Sinica (*Legislative Gazette,* 86 (18), p. 384; *China Times*, 10 February 1997). In the case of the 921-earthquake relief and reconstruction, Lee was appointed Vice Chairman of the government's 921-earthquake Relief Civilian Donation Fund Management Committee, but was also in charge of civil groups, becoming Convenor of the National Alliance for Post-earthquake Reconstruction and Chairman of the Post-quake Reconstruction Advisory Association. As a result, the situation sometimes turned awkward when the government had to respond to Lee's criticisms concerning its lax actions in addressing the problems of

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[35] See *Central News Agency* 2 July 1994; *Legislative Gazette*, 84 (46), p. 191; *SciTech Reports*, April 1998, pp. 2-3.

[36] So called because the earthquake happened on 21 September 1999.

homelessness among affected households (*Taipei Times*, 1 December, 1999, no. 13147; *SciTech Reports*, October 1999, p. 29). At same time, his prominent social involvement was also considered to cross the boundary between expertise and politics (*SciTech Reports*, January 1999, pp. 6-7) and he had to reconfirm his dedication to both science and society (*United Daily News*, 4 July 1990, p. 6). It seems that the more scientists participate in public affairs the greater is the extrinsic power needed to safeguard its authority and to overcome resistance to it. On 13 March 2000, just one week before the tenth Taiwanese Presidential Election, Lee announced that he was backing the opposition DPP's presidential candidate, Chen Shui-bian. To some observers, Lee's support, based on his scientific achievement and upright image, was seen as a turning point in the campaign for Chen's victory (*Commercial Weekly ePaper*, 23 May 2000, Cyranoski, 2000; *Central Daily News*, 14 April, 2000, p. 5). His 'king maker' move and then his intention to take the premiership naturally provoked immense disputes, particularly in the scientific community (*Central Daily News*, 14 April 2000, p. 5; *Taipei Times*, 14 March, no. 27743, 27748). Despite his respected patriotic motivation, ironically, his moves are contrary to his previous warning about the autonomy of scientists.

The fact that the Academia Sinica has reconstructed its social authority not only gives it a leading role in scientific research and science policy but also gives it greater weight in addressing public affairs. However, the transition process has also opened the way to political power, which in turn has called scientists' autonomy and objectivity into question.

The Campus Freedom Movement

The fragility of scientific autonomy and the re-politicisation of science are not entirely the result of external political intervention, but in part of the weak inner norms of the scientific community. The evolution of Taiwan's campus freedom movement shows how the rising power of the scientific community exposed its own limitations.

Demands for freedom in universities, which harbour most of the population of academic scientists, emerged at the start of the political democratisation process. In 1994, the promulgation of the amended University Law was a crucial step in the de-politicisation of universities, granting them autonomy over finance, personnel and the curriculum (Tsai, 1996; Law 1998; Mok, 2000, pp. 644-45). The campus freedom movement reflected one dimension of the revival of social power and the rise of scientific authority and autonomy.

In particular, in personnel affairs, the candidates for university president and dean are now subject to a two-stage election: in the first stage staff elect three candidates, and in the second the Election Committee organised by the Ministry of Education appoints one of those candidates as president. While before 1994 staff recruitment and promotion were controlled by appointed university administrative leaders, they are now decided by faculty committees based on the criteria of academic merit and individual commitment (Office of the President, 1994, chaps. 3-4). The self-accreditation system is another crucial measure by which universities can exercise their power of self-government to consider staff's research qualifications and publications in matters of recruitment and promotion. By 1996-7, fifteen universities had been granted such a power (Law, 1998). The campus freedom movement has therefore cut off the cosy ties between academia and politics which were maintained through administrative personnel appointments.

However, given the weak self-regulation of the scientific community, the campus freedom movement has been involved in unprecedented contention and scandal. When

Taiwan University held an election to choose its candidates for president in 1993, as a trial, the election from the start was full of disputes about the fairness of delegation, sub-ethnic conspiracies and shady election processes (Chu, 1993). In the same year, the election of the Dean of the Medical School of Taiwan University involved even more serious internal strife. Verbal attacks, friction between groups, poison-pen letters and procedural flaws during and after the election revealed the still fragile state of scientific autonomy and self-regulation (*SciTech Reports,* December 1993, pp. 16-26; February 1994, pp. 10-18). Thereafter, similar scenarios and scandals continued to occur when campus elections were held. In 2000, the most striking case was found in the election of presidential candidates for Chung Hsin University. Vicious disputes led to the exposure of the fact that Peng Tzuo-kuie, one of the elected candidates and a former Minister of Agriculture, had committed plagiarism. He was later appointed by the Ministry of Education to be president.[37] Seeing so many scandals in the selection of university presidents, it is fair to assume the continued existence of unhealthy cronyism at the top of the education system. Those scandals eventually forced the Ministry of Education to ban campus-wide elections for the leadership of universities and worked on revising the University Law (*SciTech Reports*, June, 1996, p. 39; September 2000, p. 32). At present, the pace of the extension of academic freedom against external suppression is not matched by the progress of internal self-regulation among the scientific community.

With the progress of the campus freedom movement, market-oriented university

[37] Peng was accused of committing plagiarism in his one book and one article. Even though it knew about this scientific malpractice beforehand, the Election Committee of the Ministry of Education still gave the post of president to Peng who only scored second highest vote in a campus-wide staff election (Su, 2001). Later, the allegation was confirmed by the Academic Review Committee of the Ministry of Education and the Academic Ethics Review Committee of the NSC. Peng then resigned just three

management brought another fundamental challenge to the scientific community, which I will discuss further below.

Scientific Integrity and Funds

The above discussion leaves us with no difficulty in understanding why the funding mechanism has remained a crucial issue in the scientific community. In the face of their changing role in society, scientists also raise questions about funding mechanisms – one of the crucial pillars of the social institutions of science. Issues around academic funding reflect the transition process as the scientific community struggles to establish its integrity, credibility and autonomy. As mentioned in Chapter One, the nature of scientific self-regulation is far from satisfactory, but problems in Taiwan's funding system are much more fundamental.

Research funds administered by the NSC to support academic research can be traced back to 1959, when the National Long-term Science Development Council was set up with research grants to support scientific research, a fund later called the Science and Technology Development Fund. The research grants initially ran as a reward mechanism for university researchers on poor and rigid pay scales and to help retain top scientists attracted back from overseas (Liu, 2000, p. 22). By the end of the 1980s, NSC funding had changed from being financial aid for low-income researchers to a dual system, composing of 'Research Grants' and 'Project Assistance'. Research Grants were given to researchers who achieved excellent performance and were ranked as Outstanding (top 5%), Excellent (5-15%) and Ordinary Awards (top 50%). The unique characteristic of the funding scheme has been that money is given to recipients

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months after assuming the post.

as bonuses based on the merits of publications.[38] The latter, Project Assistance, was similar to the project fund for subsidising research proposals chosen on a competitive basis. It was introduced in 1983. Since then it can be said that a modern style of funding has existed on the island. NSC funding has not only represented material support but has also given an honorific identity to academic scientists.

In the past, the most blatant stain on the evaluation of funding might be political intervention. Among the most absurd cases exposed have been essays praising political elites or reproaching the political opposition (Fu, 1990a, p. 77; *Legislative Gazette*, 79 (103), pp. 34-35). Although bias of this kind, mostly found in the social sciences, was supposed to be eliminated with the ebb of authoritarian rule, the funding evaluation mechanism remained problematic in both structural and procedural terms.

At the end of the 1980s, criticism from reform-minded scientists became strong. Aside from technical measures, two principal interrelated issues were raised: the lax funding criteria of the two schemes needed fundamental reform in order to enhance funding effectiveness; and funding evaluation needed to adopt open and fair measures to reinforce the ethos of objective scientific enquiry (*SciTech Reports*, February 1990, pp. 6-7; September 1990, p. 1; Fu, 1990b, p. 11). The dilemma here was that both issues threatened the existing interest structure of the scientific community and questioned the integrity of peer review.

As to funding schemes, one problem was that although the Project Assistance

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[38] It is hard to call this scheme "research funding" or "awards" in the general meaning of the terms. Judging from its flat reward distribution, covering 1/3 of researchers in each field with a current success rate at over 50% and a higher one in earlier times, it is more like a "bonus" for scientific performance (*Nature*, 11 September 1997, pp. 113-17). Around 1990, an Ordinary Award recipient was awarded NT$120,000 a year, and the winner of an Excellent Award received NT$150,000. An Outstanding Award winner could receive NT$600,000 in two years (Cheng, 1988, p. 51; *SciTech Reports*, March 1990, pp. 18-19).

scheme was given most emphasis,[39] lax criteria allowed regular applicants to obtain both Research Grants and Project Assistance at the same time for a single proposal (*SciTech Reports*, February 1990, p. 6). The fundamental problem was whether researchers should have the bonus-like largesse of the Research Grants, simply for doing their jobs. As shown in later developments, because abolishing or reducing the awards directly affected researchers' interests, official resolution of the issues could only go part way. The reality is that because of its fairly flat grant distribution, which still covers around one third of active researchers and 80-100 per cent of staff in some prestigious departments, few researchers can ignore the incentives and pressures of the awards. As a result, this scheme has been encouraging scientists towards volume production on an annual basis. An obvious side effect of this is to drive academic scientists to ignore teaching and rush into trivial works with an eye to a high rate of publication (Chen 1990; *SciTech Reports*, May 1995, p. 18; Liu, 2000, p. 22). Therefore, the award scheme has lost its function of encouraging novel and breakthrough research and acts as bonus-like incentive to produce work of indifferent quality.

The above problem was exacerbated by another burning issue – the weak credibility of peer review. Due to the rather small population in a given area where reviewers were often either collaborators or competitors, the negative effects of group culture were heightened. The process of peer review was kept away from outsiders in the name of confidentiality. Up to the beginning of the 1990s, the names of neither

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[39] Under the "Project Assistance" scheme, funded projects rose dramatically. In just three years, from FY 1985 to FY 1989, the number of funded projects increased from 1967 to 4260; in FY 1991, funds for project support reached NT$2.8 billion (US$108 million), about 46% of the total "Science and Technology Development Fund" (*SciTech Reports*, August 1990, p. 31). In FY 1990 the approval rate for Project Assistance rose to 88%, much higher than the Research Grant approval rate of 68%

panel nor review committee members were publicised, not to mention the resolution of conflicts of interest, nor was it considered necessary to issue review commentaries (Fu 1990a, pp. 66-67; Fu, 1990b, p. 12). These factors together with the lack of a referee system meant that the whole peer review process was carried out behind closed doors. Criticism from the scientific community continuously pointed out that NSC funding could become a trade-off between government scientists and academic leaders; the review process could be distorted by a handful of elites who might be incapable of making professional judgements; and the granting of awards would tend to exclude young scholars, researchers at private universities, and novel or peripheral studies.[40]

Mounting pressure and scepticism forced the NSC to convene a committee to consider reform in May 1989 (*SciTech Reports*, September 1990, p. 1; *NSC Monthly*, December 1995, p. 1114). Up to this point, the scientific community did show its rising autonomy and ethos of self-regulation to a certain degree. However, these characteristics were still fragile and ambivalent. According to a survey by Cheng Eyu-wen, a journalist, in 1988, only 38 per cent of respondents (professors and associate professors) in seven universities considered the research evaluation a fair system, while 75 per cent saw the awards as helpful for research (Cheng, 1988, p. 63). Furthermore, to question peer review was so sensitive that 37.1 per cent of respondents answered 'no comment' on the fairness of peer review in Cheng's survey (Cheng, 1988, p. 61).

Consequently, the NSC proposed an incremental reform by applying distinct criteria to separate the two different schemes, so that funds would directly encourage

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(*SciTech Reports*, September 1990, p. 4).

[40] See Cheng, 1988, pp. 51-58; Fu, 1990a, p. 66; Fu, 1990b, p. 12; Chen, 1990; *SciTech Reports*, December 1993, p. 29.

research rather than constitute personal rewards, but strikingly the peer review problems were deliberately left aside (NSC, 1992, pp. 467-72; *SciTech Reports*, September 1990, pp. 1, 4-5; Fu, 1990b). The NSC's hesitation indicated resistance from a scientific community that wished it to deal with the problems of the effectiveness of funding but not to adjust the peer review process, or affect their incomes.[41] Consensus on funding reform was only reached four years later, in 1994, when an open and rigorous process of peer review was put in practice. Interestingly, even in the reform of 1994 Research Grants, now called 'Research Awards', were retained. An earlier survey carried out in January 1990 by the Science Monthly, a civilian scientific organisation, had shown that 75.6 per cent of the researchers investigated might support abolishing the flat awards but still wished funded projects to have a personal reward attached to them (*SciTech Reports*, 1993, p. 8). Some scientists worried that the Research Awards scheme had enhanced Taiwan's research standards in the past and that abolishing it would severely affect the morale of the scientific community (*SciTech Reports,* August 1993, pp. 4-5, 14). Despite a campaign against the Awards scheme by 200 professors of Tsing Hua University during 1992 (Liu, 2000, p. 23), the reform agenda was put to one side. The scientific community has raised critical issues about improving the national funding and awarding system, but the reform agenda has been hampered by its own equivocation.

The difficulty in improving scientific assessment is partially a cultural problem. In Chinese society, avoiding people losing 'face' and spoiling 'kuan hsi' (relationships) is an ingrained obstacle to establishing a fair funding mechanism (*Nature*, 11 November 1997, p. 113). To avoid the problem, merit criteria and outsider (overseas)

[41] See *SciTech Reports*, September 1990, pp. 1, 4-5. Even taking the incremental approach, the funding reform of 1994 did cause a decline in Research Awards

review are gradually being introduced by Taiwanese returnees from overseas.[42] On the grounds of simplicity and credibility, the NSC particularly favours the publication indicators of international journals, such as the Science Citation Index. Since 1993, applicants for both Research Awards and Project Assistance have been asked to submit their last five years' publications with information about citations and the impact factors of journals (*SciTech Reports*, October 1993, p. 22; *NSC Monthly*, October 1993, p. 1150). The fashion of applying merit review has been quickly transmitted from funding evaluation to evaluations in university recruitment, researcher promotion and institutional standards (*Nature*, 238, pp. 113-15; Liu, 2000, p. 22; Tseng, 2000a. p. 6). With the promotion of merit reviews, a fever of building up a voluminous personal track record soon pervaded Taiwan's scientific community.[43]

Although emphasising publication and bibliometrics does not necessarily lead to undesirable results, scientists now raise two issues: scientific integrity and social accountability. Due to the weak self-regulation of the scientific community, the fashion of building up track records has increased the threat to scientific integrity. So far, there have been several cases where winners of the Outstanding Awards and candidates for university presidents have been found committing plagiarism; criticism has even come from US universities and internationally prestigious journals condemning plagiarism and multiple submissions by Taiwanese scholars and prominent Taiwanese journal

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recipients to 3436 in 1995, from 4552 in 1993 (see Table 5.5 below).

[42] For example, Wu Cheng-wen, former director of the Institute of Biomedical Science at the Academia Sinica (see Kinoshta, 1993, pp. 348-49).

[43] For example, the funding process in the Life Sciences Department of the NSC has developed a sophisticated "Research Performance Indicator" by setting different weights for different categories of candidates' papers (original article, short communication, case report, review, dissertation, patent, book and so on), the impact factor of journals (international SCI, domestic SCI, non SCI, etc.) and the author order of published papers (first, second, third author, etc.) (NSC, 1999c).

editors themselves.[44] Certain scientists have accused the Research Awards system and bibliometrics of being a source of scientific malpractice (Liu, 1999a; 2000; Chen, Kuo-cheng 2000; Tseng, 1999a, p. 310; 2000b, p. 10).

On the other hand, while the fever to pursue publication has speeded up the increase of publications in high-ranking journals, their relative citation impacts have remained curiously low at 0.35, even lower than for the Philippines (0.58) and Thailand (0.52) (*Nature*, 238, p. 113; Tseng, 1999a, p. 308; 1999b, p. 10). More surprisingly, the works of recipients of Outstanding Awards and domestic candidates for academicians also have a low citation impact score (*SciTech Reports*, August 1999, p. 3; Liu, 2000, p. 23). The fashion of merit review does not fundamentally improve research results and scientific self-regulation, but gives rise to disputes regarding the effectiveness of public funding. Moreover, over-emphasis on merit review further consolidates elitism in funding evaluation. Concerns have arisen about the relative neglect of local demands and indigenous scientific interests, and the increasing disparity of funding between hot and peripheral topics, elite and ordinary scientists, senior and young researchers, public institutes and private universities, the north and south, urban and rural zones, and so on. Such issues deviate from the paradigm of the pursuit of excellence, and link with the democratic principle to reinforce the grievances of those who fail to meet the requirements of research evaluation. Despite being dwarfed by the paramount concern for scientific excellence, those issues, grounded on localism and egalitarianism and frequently raised in the legislature, wield an indubitable policy influence.[45]

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[44] See Liu, 1999a; 1999b; *SciTech Reports*, May 1999, p. 12; August 1999, p. 3; October 1999, pp. 10-11, Tseng, 1999a, p. 310; 1999b, p. 10.

[45] See *Legislative Gazette*, 87 (7), pp. 68-69 and Chapter Four, B, below.

Apparently, egalitarianism and elitism will continue to be in conflict with each other and impose their principles upon funding policies, with scientific autonomy and integrity at the centre of the conflict.

Independent Scientific Organisation

Given the stifling atmosphere in the scientific associations, as mentioned, the transition that has taken place in Science Monthly, the only cross-disciplinary scientific group which so far has shown an ability to establish its autonomy against government, offers another indicator of the development of scientific autonomy and authority.

Science Monthly was first organised as a publication promoting science, then developed into a scientific organisation. Its origin can be traced back to the 1960s, when a campus movement at Taiwan University developed into a movement to promote scientific knowledge (*SciTech Reports*, January 1989, p. 4; Chiang, 1990, pp. 55-60). Chiang Jen-shian has pointed out that the pioneers of Scientific Monthly, such as Lin Shiau-hsin, had a strong consciousness of embodying scientific enlightenment, a sentiment mingling patriotism with scientific positivism (1990, p. 65). The concept was then taken overseas when Lin pursued further study in the US. Led by Lin Shiau-shin and inspired by his enthusiasm, 1,000 overseas Taiwanese students consented to support a scientific magazine in Taiwan with an eye to popularising scientific knowledge to the public, especially to high school students. As a result, the magazine *Science Monthly* was first published in January 1970 with a rather large circulation of over 18,000 copies at that time (Chiang, 1990, p. 66; *SciTech Reports*, January 1989, p. 5). With the members and participators returning to Taiwan, their honourable 'returnee' status transformed them into respectable 'scientists' and 'professionals', which enhanced the authority of Science Monthly as a scientific organisation. The content and style of *Science Monthly* continued to reflect its original goal – to diffuse scientific knowledge. Besides the publication itself and other activities of scientific promotion, however, Science Monthly, as an organisation, also involved itself in the policy domain, in contrast to previous cross-disciplinary civil scientific organisations and professional associations. However, under authoritarian rule, the activities of Science Monthly were cautiously presented as patriotism and scientific objectivity. This approach meant that the organisation placed limitations on its activities (Chiang, 1990, p. 78). In the name of scientific objectivity, Science Monthly managed to use seminars to pursue its relatively independent role of raising indigenous policy issues such as scientific education, science policy, defence technology, scientific communication and the reflection of humanity on science during the 1970s and 1980s. In 1979, in the face of the lack of an active governmental response to the conclusions of the First National Science and Technology Conference, Science Monthly collected policy suggestions that were submitted to the then President Chiang Ching-kuo. The results led to the removal of the NSC chairman and the reorganisation of the NSC and CSIST (Chiang, 1990, p. 90).

In January 1982, a sister publication, *SciTech Reports*, was launched. In contrast to *Science Monthly*, this was free to subscribers and aimed to offer more professional information in relation to local scientific developments, professional conferences and relevant official news in various fields. In its original four to eight page edition, the key parts were editorial columns in which cynical anecdotes described irrational bureaucratic scientific arrangements, hypocritical academic behaviour, unhealthy science education and policies and newly emerging scientific controversies. The style of the articles was rare under authoritarian rule and popular in scientific circles (*SciTech Reports*, November 1992, p. 8). For instance, the eminent national S&T

planner Li Kwoh-ting encouraged the publication by sending an expression of support to the editors (*SciTech Reports*, November 1988, p. 2). A editor of *SciTech Reports,* Hsieh Ying-chuen, stated that the initiation of *SciTech Reports* in the early 1980s displayed those pioneers' wisdom in establishing a truly professional scientific magazine (*SciTech Reports*, January 1988, p. 4). Although Science Monthly had paved the way for the probing of meta-science problems and engagement with local issues of scientific autonomy, the opinions of Science Monthly generally had no explicit policy influence, except in the case of the aforementioned events of 1979. In the long run, however, those pioneers hoped to forge Science Monthly into an organisation like the American Association for the Advancement of Science in order to perpetuate its role in Taiwan's scientific community (*SciTech Reports*, January 1989, p. 5; June 1992, pp. 10-12; April 1993, p. 29).

In 1989, with a view to responding to vigorous social liberalisation and the challenge of competition, the Science Monthly group adjusted itself in several ways. Firstly, it converted itself into an organisation with around 140 card-carrying members at the end of the 1980s (*SciTech Reports*, January 1989, p. 11).[46] Second, *SciTech Reports* was increased in size to thirty-two, or even forty pages, adding information on new academic research directions, policy-related commentary, personnel information and cutting-edge world S&T developments. Since then, it has charged its subscribers (*SciTech Reports*, January 1989, p. 1). Third, *SciTech Reports* started to make open criticism of scientific policy, ranging from key national technology programmes to research fund distribution. Fourth, the group took part in direct action and campaigns to support or oppose policy-related issues, such as calling for the US government to

[46] This figure expanded to 386 in 1993; most of them were university staff, with a few coming from secondary and primary schools, and industry (*SciTech Reports*, January

grant firm protection to China's astrophysicist Fang Li-zhi and protesting about the NSC's reduction of funding for life sciences (*SciTech Reports*, June 1989, p. 6; August 1989, pp. 8-9). All those efforts transformed Science Monthly from a publication and academic club into a cross-disciplinary scientific group, and gradually enlarged its visibility and influence.

The role and function of Science Monthly was decisively enhanced by the controversy over the satellite programme, which emerged in the last quarter of 1989 and will be addressed in detail in Chapter Six. In this case, core figures in Science Monthly took the lead in the opposition bloc to question the priorities and decision-making processes of the programme, initiating huge scientific policy debates and establishing its unique status in the civil scientific community. In December 1989, President Lee Teng-hui's personal congratulatory letter on the twentieth anniversary of Science Monthly and his meeting with core figures of the group in May 1990 highlighted the increasing influence of the organisation (*SciTech Reports*, December 1989, p. 11). The various ways in which it had an impact on policy will now be described.

Firstly, as a civil organisation, Science Monthly states its role to be to monitor and where necessary oppose current science policy and its administration. In this sense, government domination of decision-making and information has been challenged by the organisation. Any negligence could lead to extra costs to remedy it. The NSC experienced this kind of lesson as a result of its early reckless announcement of the satellite programme in the early 1990s, which almost jeopardised the programme and threatened to lose the NSC chairman his position.[47]

1993, p. 11).

[47] See Chapter Six below.

Second, recognising the increasing influence of Science Monthly, NSC administrators have constantly offered responses or explanations in *SciTech Reports* on policy-related issues, for instance, on how biomedical funding was being implemented, why the Research Performance Index was adopted as a measure for assessing scholars' performance, how to assess national agriculture biotechnology projects, and so on (*SciTech Reports*, October 1995, pp. 7-8; December 1995, pp. 4-5; July 1999, pp. 8-11). Government science ministers such as Hsia Han-min, Kuo Nan-hung and Liu Chao-shiuan have been invited by Science Monthly to defend their policy ideas on a wide range of subjects (*SciTech Reports*, April 1992, p. 1; Kuo, 1996; Liu, 1997). *SciTech Reports* and seminars held by Science Monthly have become a non-official forum for policy debates.

Third, in a few cases, specific policy inputs have been channelled by policy-related research and public discussion promoted by Science Monthly. For example, a survey examining the NSC's research awards and funding method was produced by a core figure in Science Monthly, Professor Chen-kung Chou, and sponsored by the NSC in 1990 (*SciTech Reports*, August 1992, p. 1). When the NSC Chairman, Kuo Nan-hung, attempted to reverse the previous resolution about whether to join the Superconducting Super Collider (SSC) projects, he held a public hearing co-organised with Science Monthly, representatives of which raised searching questions about the policy change (*SciTech Reports*, April 1993, pp. 5-21).

Fourth, the Science Monthly group has been able to use its organised autonomy and collective actions to monitor thorny policy issues that have always involved political concerns and academic ambivalence. This has prevented the triumph of short-sighted solutions and safeguarded the autonomy of the scientific community. For instance, from its early suggestions to recent criticism, *SciTech Reports* has continuously expressed its anxiety about the awards and funding reforms.[48]

Fifth, as a civil association, it has been able to raise peripheral science-related issues quickly and easily, reflect emerging concerns regarding the research environment and policy changes, and invoke responses, such as humane reflections on science (*SciTech Reports*, April 1989, p. 10) and on gender issues in science (*SciTech Reports*, October 1992, p. 1).

The unique influence of Science Monthly, however, has had its limitations. While it has so far maintained a relative autonomy, the effectiveness of its policy impact seems to be waning after earlier single-issue campaigns (*SciTech Reports*, March 1993, p. 14). The scientific establishment, planning, rules and regulations have become so complicated that Science Monthly with its limited manpower and funds cannot afford to raise in-depth enquiries or give advice by presenting tangible evidence or research. In particular, the booming media and the increasing maturity of the domestic scientific community have squeezed the circulation and influence of *SciTech Reports* (*SciTech Reports*, January 2000, p. 3). To deal with those challenges, the Science Monthly group is currently returning to its original goal of expanding science popularisation, while the promotion of a significant involvement in scientific policy and policy-related research appears to be a luxury it cannot afford. The prospect of reaching a similar status to the American Association for the Advancement of Science is unlikely to be accomplished in the near future.

Overall, the increase of 'knowledge power' has enhanced scientific autonomy and authority in society, but it also induces ambivalence and conflicts. Facing a rapid

[48] In particular, Liu Kwang-ting, Professor of Chemistry at Taiwan University and a core figure of the group, waged a campaign for over ten years to abolish the existing Research Awards scheme, which was being taken undue advantage of, with an eye to safeguarding scientist integrity and research quality (Liu, 1999a; 1999b; 2000; 2000

social and political transition, the scientific community has moved to engage a wide range of social affairs, and also pays attention to the social accountability of science and locally orientated research. The scientific community has reshaped its own role and functions, and scientific verification and credibility have been applied to various social affairs and policies. To justify their positions, they have also pursued policy issues relating to the internal and external codes of the scientific community. At this very point, they encounter their own limitations. In Taiwan, the autonomy of science still needs to be nourished. A paradox here is that increasing academic participation in political and social debates actually exerts pressure on the still fragile base of scientific autonomy. The increasing scientification of politics has inevitably given impetus to the politicisation of science.

D. The Demands of Private Industry

The rise of the private sector's political influence has produced a set of rather different issues in relation to science policy. The entrepreneur is one of the newly emerging powerful actors in Taiwan's S&T policymaking. Given Taiwan's industrial structure, characterised by a large number of SMEs and a prominent role for state-led industry, in the past entrepreneurial interests were identified, interpreted and harnessed by the state. The emergence of private enterprises' autonomous influence has been a feature of the last two decades.

The Political Influence of Private Entrepreneurs

After the move to Taiwan, the government retained control over the huge state-owned

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interview).

enterprises and financial mechanisms. These state-owned enterprises plus central economic planning gave the state strong leverage for transmitting policies to the private sector and forming a top-down party-state corporatism (Gold, 1986, p. 127).

During the 1980s, however, the capacity of the state to steer the economy was markedly eroded. Facing mounting international pressure from economic liberalisation and a deteriorating domestic investment environment caused by social movements and political turbulence, the KMT regime opened formal channels for the involvement of entrepreneurs in policy in order to consolidate its political legitimacy. In 1985 Taiwan's entrepreneurs were allowed to participate directly in central economic policy, and their policy involvement, which in the past had been maintained by an extremely small number having informal relationships with officials, began to be institutionalised (Wang, 1996, pp. 72, 108). With the government's adoption of liberalisation and globalisation, the private sector gradually moved away from its dependence on the state. The government-business relationship evolved from the previous clientelism to a reciprocal dependent partnership.

With the expansion of electoral politics and parliamentary power, business interests gained new opportunities to pursue the accumulation of influence, as entrepreneurs bargained over their preferences during the setting of new economic and financial regulations, and used their political ties and economic prerogatives in seeking public contracts, capital, information and policy support (Chu, 1994, pp. 125-26). In response to their powerful patrons, the lawmakers' general critique of S&T policy became more and more pragmatic and paid greater attention to the cost-effectiveness of public investment (Ker, 2000, interview; Su, 2000, interview; Hau, 2000, interview).

Furthermore, while political elites, whether in office or opposition, echoed the demands of society to consolidate their political power during political conflicts, they were also compelled to ask for the support of the business community and local factions. As a result, rent seeking, which had existed for a long time in local politics, was transmitted into the central policy arena (Tien & Chu 1996, p. 1149). As to S&T policymaking, the increasing influence of private industrialists meant that the administration now had to take into account possible private sector reactions and prepare itself for compromise.

For example, opinions regarding direct government technological engagement and the role of the ITRI and its subsidiary the Electronic Research Service Organisation (ERSO) were never consensual (Meaney, 1994, 178). In the past conflicts of interest between those public sponsored research institutes and private firms had been mitigated by powerful agencies such as the MOEA and the CEPD. Now, with the growing political influence of private industry, the state-led strategy of technology push and the synergy between government and industry are facing challenges.

When the project of developing a 16-Mbyte DRAM (dynamic random access memory) and a 4-Mbyte SRAM (static random access memory) chip made with 0.5 μm CMOS (complementary metallic oxide semiconductor) technology on 8-inch wafers, commissioned by the MOEA, was successfully completed by the ERSO and its Submicron Laboratory in mid-1993, the debates arose again over whether the ITRI/ERSO should take up volume production as it had done before in the previous state-led model. Morris Chang, Chairman of ITRI, and Shih Ching-tai, Vice Director of the ERSO, insisted that the ITRI/ERSO remained in the project to take up volume production and argued at the same time that R&D was crucial to fulfil the state-led strategy and to meet the long-term interests of Taiwan's semiconductor industry. On the basis of previous experience this proposal, representing the specialist viewpoint of the government-supported institutes which dominated the Supervisory Committee of

Submicron Technology Development Project, would have been adopted by the MOEA. However, private firms such as United Micro-Electronics, TI-Acer and Micronix strongly argued that the project and laboratory should play a purely R&D role rather than being involved in business operations, since this would cause a duplication of national resource investment and damage private business interests through unfair competition (Liao, 1994, pp. 143-50). The mounting pressure from private firms, together with considerations of encouraging private R&D activities and reducing the government's financial burden, eventually forced the MOEA to commercialise sub-micron technology by inviting private firms to form a consortium – the Vanguard International Semiconductor Corporation. Similar conflicts between public and private sectors were also witnessed in many giant foreign technology transfers, such as the proposal for a joint venture between local companies and McDonnell Douglas Corporation, domestic firms and British Aerospace in the aerospace industry (Liao, 1994, pp. 143-50; Chan, 1996, pp. 79-80).

The rise of private sector influence is by no means synonymous with a demand for government withdrawal from its role in technology upgrading. Rather, in the current government-industry partnership, the private sector still depends heavily on the public provision of technological assistance. Yet the growth of private R&D capacity and the diversification of industrial interests make it difficult for government to exercise control. Put simply, private entrepreneurs require government assistance but can resist government manipulation.

Problems in the State-led Strategy

The progress of democratisation and the growth of private sector influence called the application-orientated S&T policy and state-led industrial development strategy into question on account of a much more fundamental principle: that of justice. It was understandable that in order to remedy private industry's lack of technology capacity the government, besides various incentives for private investment in R&D, was directly involved in running research institutes like the ITRI. The crucial functions of such research institutes were to mediate between industry and bureaucracy, monitoring the products and production processes of international competitors, studying near-market technologies, organising technology transfers and co-ordinating new projects in alliance with local firms. The key feature of this model is that a balance has to be maintained between market rules and state interventions. However, the exact measures necessary to hold this balance are complicated and uncertain. Once the power structure between government and industry has shifted, the balance immediately faces challenges, not to mention the cost-effectiveness of the strategy.[49] Pressure came particularly from the legislature, which questioned whether spinning off assets and talents (or leaking patents) from government-supported research institutes to private corporate was not basically unjust (*Legislative Gazette*, 85 (56), pp. 203-6, 222, 225).

Despite the fact that the government introduced market mechanisms and value-added technology, the underlying logic of its technology-push strategy was for it to engage in selection at various levels. The problem is that the technology and the sectors selected are not necessarily those which are characterised by better research capacity and productivity (Cheng, 1997; *Legislative Gazette*, 88 (14), pp. 262-63). Moreover, the state-led industrial strategy had the effect of supplanting those 'sunset' or heavy industries, which provoked opposition, although the causes of deteriorating

[49] One of the intrinsic tensions in the state-led strategy is the difficulty of deciding the ambition with which those research institutes should develop, in terms of the scale and depth of the range of technology they address. Critics pointed out that government block sponsorship could be distorted by continued support for the

traditional industry could be attributed to other market and non-market factors (*Economic Daily News,* 24 May 1998, p. 3; Wang, Chien-chiuan 2000). Thus, each phase of selection has meant resource redistribution and power restructuring in different industrial sectors, which causes grievances on the part of those sunset sectors and less well-subsidised industries, especially SMEs. The triumph of the information industry, backed by a range of tax incentives, public subsidy and technological assistance has gradually given rise to issues of the justice of tax policy and the effectiveness of resource distribution (*China Times*, 14 December 1998, p. 3; Tseng, 2000b, p. 5). A good example of such an argument was visible in the debates about the continuation of the Statute for Upgrading Industries in 1997. The Statute was considered as Taiwan's key measure to induce private R&D investment and promote high-tech industry during the 1990s. While it was agreed that the Statute should continue (Office of the President, 1999c), conflicts occurred between the MOEA and the Ministry of Finance. Finance Minister Chiou Cheng-hsiung argued that the part of tax deduction could reduce annual government revenue by around NT$30-50 billion (US$1-1.5 billion) and cause serious unfairness in taxation on general taxpayers, especially on some traditional industries and SMEs that were not able to apply for the scheme (*China Times*, 8 January 1998, p. 6).

Those grievances were eventually reflected in the legislative boycott of MOEA's subsidiary fund, through which the ITRI suffered a NT$2 billion (US$75 million) budget loss in FY 1994 (Liao, 1994, p. 157). Certain private entrepreneurs started to question the rationality of the existing innovation system and demanded 'direct' governmental assistance. A conspicuous governmental response came in 1997 when the MOEA's Technology Development Programme, which had been the major

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overheads of those constantly expanding institutes (Wu, 1992, p. 14).

financial resource for the MOEA-sponsored research institutes, was opened up to private industry and private-public joint research (MOEA, 1998, pp. 39-40). Private firms, with their growing capacity and autonomous interest in R&D, now appear as competitors of those research institutes.

Even in the terrain of military research and production, private industry has shown increasing interest in seeking business niches and technological transfers. According to Yang Ming-jen's research from 470 firms, 87.2 per cent of them expressed their willingness to participate in technology transfer from the CSIST, although scepticism and difficulties remained (1993, pp. 90-93). They asked to enhance the commercialisation of military technology and pressed to ease restrictions on the transfer process. Private industry and business have expanded their channels of access to the state's resources as much as they can and such a tendency is likely to be further extended.

The Relationship between Academia and Industry

Another deficit of the state-led strategy of technology development is the failure to streamline and co-ordinate the vertical link between academia and industry. Whereas in 1998, gross R&D expenditure increased to 1.98 per cent of GDP, higher education accounted for just 6.7 per cent of the gross expenditure on R&D, significantly less than the average figures of most advanced countries, such as 18.8 per cent in the UK and 28.8 per cent in the Netherlands (Tseng, 1999b, p. 10). This means that academic capacity has been ignored and has not been well exploited. The officially long-upheld slogan about the 'synergy of agency-academia-industry' was apparently limited to a few selective technologies. Structurally, the government has not made sufficiently serious efforts to break down the barrier to collaboration between academia and industry. Although the gap between academia and industry could well be ascribed to the industrial structure of large SMEs and their weak science base, over-emphasising near-market technology production by a national innovation system itself tends to hinder active interaction between academia and industry.

As a result, even at the beginning of the 1990s, industry was still not enthusiastic about joining in S&T policy discussions (*SciTech Reports*, May 1999, p. 9). Although some activities involving academic-industry co-operation were undertaken in the field of engineering, it was revealed that those activities created small benefits for industry, and even eroded scientists' integrity because participating academic scientists simply took such co-operation as an opportunity to earn extra bonuses (*SciTech Reports*, October 1991, pp. 16-18). With the growing self-governance of the scientific community, considerable suspicion was cast on such co-operation.

During the drafting of the Six-year National Development Plan, the first mass national economic construction plan in the 1990s, the then Premier, Hau Pei-tsun, gave instructions that solving the Taiwan-Japan trade deficit should be one of key themes in the Six-year Plan. As a result, the Key Components and Machinery Development Programme was added to the plan without the specific agendas discussed in the Fourth National Science and Technology Conference (*NSC Monthly*, October 1992, p. 1319.) Despite appearing arbitrary, his instruction was correct in pointing out the most fundamental problems of Taiwanese industrial upgrading, and the programme received a warm welcome from industry. At the same time, as already mentioned, the scientific community was beginning to reflect upon its role in society. Academic-industrial co-operation naturally became a hot topic of discussion.

Against this background, the NSC launched the Academic-Industrial Co-operative Research Projects, which, at least in their initial stage, were warmly received.

However, NSC Chairman Kuo Nan-hung's announcement that half of NSC research grant funding, about US$200 million, would be transferred to academic-industry research led to strong opposition from academic scientists (Johnstone, 1993, p. 358; *SciTech Reports*, February 1994, pp. 5-9; Kuo, 1996). This was because the policy initiative was based on resource reallocation rather than the provision of additional funds. In the face of several stringent measures derived from the administrative reallocation of funding, a signature campaign was conducted by researchers of the Academia Sinica in 1994 to protest at the NSC's neglect of basic science (*SciTech Reports*, February 1994, p. 1, 19). The backlash reduced NSC's academic-industrial joint projects to just 6 per cent of its research funds, at around NT$0.4-0.6 billion (US$18 million) (*SciTech Reports*, February 1994, pp. 21-22). In September 1995, again, over 300 scientists in the field of basic medicine, roughly two thirds of the field at that time, initiated a signature campaign directly appealing to then Premier Lien Chan, who announced that Taiwan's 'national competitiveness' would be raised to within the top fifth in the world before 2000. Scientists primarily argued that NSC funding as a main resource for basic science had been seriously distorted by the Academic-industrial Co-operative Research Projects, which had diverted considerable funds intended for basic research and blunted young investigators' passion for research (*SciTech Reports*, October 1995, pp. 1, 4-6). However, facing even more severe pressures from the legislature and industry, the NSC reaffirmed its commitment to both applied and basic research (*SciTech Reports*, June 1994, pp. 1, 5). In the face of the growing political influence of industry, which was seen as an encroachment on scientific autonomy, the anxiety of the scientific community could be sensed in the theme of the third Civil S&T Forum held by Science Monthly: the Predicament and Challenge of Basic Science, (*SciTech Reports*. April 1995, p. 23). In this forum, Professor Wang Kang-pei and others noted that Taiwan's scientific development had reached a 'steady state' in which further scientific development, which would need tremendous resource allocation, was dependent on social consensus rather than scientific capacity (*SciTech Reports*. April 1995, p. 18). Tensions between academia and industry still remain.

Furthermore, one consequence of the campus freedom movement has added another factor to the relationship between academia and industry. With academic deregulation and decentralisation, the number of universities jumped sharply to 135 in 2000 from 41 in 1989 (Mok, 2000, p. 646; Yung, 2000). Although the proliferation of higher education institutes is caused by various social and economic factors, such as the impact of globalisation, the campus freedom movement, social anxiety about education reform and the financial burdens on government (Mok, 2000), pressure from elected lawmakers in the face of local demands for manpower training and opportunities for private profits from educational investment are also crucial.[50] Riding on the tide, the Ministry of Education has encouraged the tendency even further. Since 1996, a new policy has been adopted to finance only 80 per cent of each public university's expenditure and to direct each one to seek its own income (Mok, 2000, p. 648). At the same time, newly established universities and private universities have also demanded public subsidy. As a result, the pressure of declining public subsidy of the universities caused by expanding numbers of institutes, declining student enrolment, and the ideology of privatisation, has been so intense that even some traditional universities have had to cease further staff recruitment (*SciTech Reports*,

[50] With the rigorous competition in higher education, issues of legislators' interest conflicts in earmarking for specific private universities have emerged recently. For example, an excessive fund allocation for seven private universities during FY 1998-2001 was suspected to be a result of legislative earmarking (*United Evening News*, 7

March 1997, p. 40). In 1999, the Ministry of Education came up with the idea of a government-owned, privately-run university, in other words, a higher education system aiming at autonomy and market-orientation (*Central Daily News*, 5 January 2000, p. 4, Mok, 2000, pp. 649-59). This impetus has reshaped the relationship between the academic and private sectors, since scientific research to meet social and industrial demand is now not just a matter of fulfilling a responsibility but a means of survival. A range of fund-raising approaches have been introduced, from traditional money-raising through alumni associations to a new type of strategic alliance exploiting research competence and results. Academia and university have been forced to adjust their perceptions and culture to face the challenge. For example, in 1997, Taiwan University urged the MOEA to allow it to set up its own foundation in order to solve its financial problems (*SciTech Reports*, July 1997, p. 36). The recent initiation of the MOEA's Technology Development Programme for universities to undertake innovative technology research was a sign of the rapid adjustment of the scientific community. Will this then imply that scientific research will be subordinated to commercialisation? So far, according to Liu Kwang-ting, professor of Chemistry at Taiwan University, the shortage of funds has hit student tuition fees, but not research (Liu, 2000, interview). On the other hand, Chou Chen-kung, professor of the Taipei Veterans General Hospital, asserts that his genetic research team will benefit from private networks (Chou, 2000, interview). However, in the light of entrepreneurs' faltering approach to investment in science and notorious private capital speculation, concerns are emerging regarding academic commercialisation (*Central Daily News*, 10 April 2000, p. 7). As the tip of an iceberg, the recent allegations of severe financial problems, vicious stockholders' disputes, presidential corruption, subsidy misappropriation and interest collusion (with

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top officials, gang members, lawmakers, and bankers) at the private Jinwen Institute of Technology, have revealed the serious downside to university privatisation (*Central Daily News*, 8 April 2001, p. 3; 10 April 2001, p. 3; 11 April 2001, pp. 1, 3; 15 May 2001, p. 4). Earlier worries about the erosion of the scientific ethos by application orientation and commercialisation were not unfounded.

E. Conclusion

In this chapter, the analysis has shown that while these three policy communities – the general public, the scientific community, and industry – have moved to new power positions along with democratisation, they have also challenged the internal order and external relations of science. On the one hand, the role of science has been given diversified social accountabilities, responding to not just state-defined applied research but also to environmental, health, and ethical demands, and private interests. The criteria for research funding refer to local problems and social concerns. On the other hand, public participation in scientific assessment has emerged and a bidding process has been introduced in allocating funding for technology research, with an eye to cost-effectiveness, while the integrity of peer review has been placed under question and required reform by the scientific community itself.

These developments add new issues and contents to the justification of science policy, giving impetus to change the power of the science administration and its relations with other departments and with the legislature, which represents different interests and concerns of science. The policy-related issues raised by these social transformations, along with the implications of the changes in the area of government, will be discussed at the end of Chapter Four.

CHAPTER IV

Actors and Issues: The Governmental Aspect

As social actors have changed, necessary adjustments have been made to central S&T policymaking. With the changes in power structure between the state and civil society and the proliferation of the social demands of science, the science administration is bound to adjust itself to meet the different policy environment. At the same time elected officials, being a central arena of political democratisation, are expected to play a crucial part in the ongoing interaction between science and society. This chapter aims to shed light on transformations in central policy circles, and the effects of those transformations on science policy. In the final section, a conclusion sums up the observations made in this and previous chapter.

A. Administration and Scientific Authority

Given the restructuring of political power, the increasing institutionalisation of the science administration in the 1980s continued in the 1990s and resulted in a strengthened, relatively independent, and centralised science administration – the NSC. The agency has changed from its previous subordinate status and consolidated its power in line with the expanding application of scientific authority in society and the diversification of policy justification. At this point, the power of the NSC consists of a compound of scientific and administrative authority. This is a subtle but crucial development and needs to be taken into account. This section thus takes an institutional viewpoint to probe the changes in science administration when it faces rapid social and political transformations. To start with, it is necessary to outline major changes that have taken place in the power constellation of the executive sectors along with democratisation.

The Decline of the Executive Power

One of the crucial aspects of democratisation has been the relative decline of executive power over policymaking. As Edwin A. Winckler rightly points out, leadership, as both personal power and an institutionalised role, was one of the critical components of KMT regimes at least until the death of Chiang Ching-kuo (1992, pp. 230-31). Soon after his death in 1988, intra-party feuding occurred between President Lee Teng-hui and Premier Lee Huan (1989-1990) from 1988 to 1990, and between President Lee and Premier Hau Pei-tsun from 1992 to 1993 (Wu, 1998, p. 111). The resulting factions that eventually led to the breakaway of the New Party from the KMT accelerated the process of democratisation and undermined the cohesive loyalty to the state leaders inside and outside the party.

The above intra-party conflicts represented a power contest between a reform-minded mainstream and party conservatives and more importantly a fundamental ideological shift. To consolidate his power, President Lee Teng-hui built up a consensus about the 'new Taiwanese' and a new nation in order to expel mainlanders from the core policy circle and squeeze the space available for opposition radicals (Wang, 1996, pp. 85-91). Appealing to a large sub-ethnic group, the Taiwanese, gave rise to policy localisation and a hostility to unification with the mainland, which consolidated Lee's hegemony, conciliated social demands and undermined the old power bloc of the economic bureaucrats and the armed forces. Through these successive conflicts, however, the previous charisma of national leaders was diminished.

Executive officials can no longer take the approval of bills and policies for granted. The KMT mainstream elites and the executive as a whole now need to build their political support from outside the party, that is, to appeal to urban and rural constituencies, to rely on local factions and entrepreneurs, and to tolerate corruption and the underworld (Gold, 1997, p. 171). As a result, the capacity of the executive to make policy without political and social alliances is declining and officials have to develop various new tactics to achieve their targets, such as coalition-building, compromise, and bargaining. President Lee's decision to call a non-statutory National Affairs Conference in 1990 and National Development Conference in 1996 to resolve constitutional issues illustrates the declining power of the incumbent KMT and the executive, and the need to broaden inclusion and participation in policymaking (Yang, 1998, pp. 3, 27-35).

In addition, as Winckler has argued, developments in the security apparatus, the ministry and the police, were key indicators of Taiwan's democratic transition (1992, pp. 235-36). After Chiang Kai-shek's death, the military influence on central policies sharply declined, especially in the area of economic planning (Wade, 1990, pp. 246-48). With the abolition of the Temporary Provision and the Statute for the Punishment of Insurrection in 1991, and the revision of Criminal Code Article 100 in 1992,[51] the symbolic and substantive political influence of the military-security apparatus and the significance of KMT-military-security ties weakened steadily. This process accelerated further following the decline of KMT control over the government and society, and the

[51] The Statute granted the security-military sectors power to crack down on any suspicion of insurrection by stating that persons who prepared or conspired to

KMT's commitment to democracy and localisation. Given the call for 'nationalisation' and 'neutralisation' the Legislative Yuan has shown a constant anxiety to supervise the National Security Council, the National Security Bureau, and the armed forces.

Under the new Organic Law of the National Security Council of 1993, the National Security Council's status was changed from a non-statutory advisory body to the President to a constitutionally mandated organisation overseen by the Legislative Yuan (Office of the President, 1993a, art. 8). According to the new arrangement, the budget of the National Security Bureau, the top security agency, is subjected to legislative scrutiny and its personnel are recruited by civil service examination (Office of the President, 1993b, art. 20, 21). As a result, all security-related agencies have adjusted their role and actions by law.

As to military influence, soon after Martial Law was lifted in 1987, the notorious Taiwan Garrison Command, a military apparatus involved in suppressing mavericks and censoring the mass media, was discharged and most staff transferred to serve in the coast guard, in the training of veterans, and in the reserve for district control if required. The military representation on the KMT's Central Committee and the Central Standing Committee had declined significantly by 1993. Only three of the 33 KMT Central Standing Committee members chosen in 1995 had a military background; this figure fell to two in 1999, when the Minister of National Defence ceased to be a member (*Central News Agency*, 23 August 1996; 29 August 1999). Since 1993, furthermore, military personnel on active duty have been forced to withdraw from all party political activities.

The military's traditional affinity with the KMT benefited Taiwan's democratisation by avoiding any military intervention and yet has provoked the

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commit an act of treason against the state should be punished.

opposition to continuously attack the military, leading to overall deterioration of the latter's reputation (Su, 1999; Hau, 2000, p. 1260). The decline of military influence in government and society has come to the point where the military are unable to resist a series of reductions regarding their budgets, personnel and benefits. For example, between 1968 and 1992, 1,660 colonels and generals were allowed to transfer to the civil service by passing specially designed examinations (Hsiao, 1994, p. 96), but this transfer channel has been severely restricted by legislators and the Control Yuan since 1992.[52] Furthermore, defence expenditure as a percentage of the national budget declined sharply from 57.2 in 1983 to 22.6 in 1994.[53] It is worth noting that such a large reduction was not just the result of a normalisation of military size and role but also of political myopia fuelled by KMT intra-party conflicts and the hostility of the DPP. Later, when independence sentiment became explicit and President Lee Teng-hui's 'special State-to-State' dictum was clearly expressed in relation to cross-strait relations, recognition of the need to maintain military strength to resist threats from China regained ground among politicians and the public.

Consequently, the executive as a whole has lost its previous capacity to dominate policy and the military-security apparatus has suffered a significant loss of access to policymaking circles. The relative decline in the power of the executive, together with the awakening of social forces and the increase in the legislative power have affected the central power structure in the area of science.

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[52] See *Central News Agency*, 27 August 1992; 1 January 1996. According to Article 23 of the amended 1996 Civil Service Examination Act, this transfer is only valid to the civil posts of the MND, the Veterans Affairs Commission and a few military-service-related public sector areas (Office of the President, 1996, art. 23).

[53] Shambaugh, 1996, pp. 1294-96; MND, 1996, pp. 80, 117-18. However, the amount rose again after 1996, due to the 1995 PRC missile exercises in the Taiwan Strait.

The Institutionalisation of Science Administration

The Rise of the NSC

As mentioned in Chapter Two, with the declining influence of the dominating patriarchal elites, S&T policymaking authority gradually descended to departmental level. In 1988, the appointment of Hsia Han-min as Chairman of the NSC (1988-1993) and Convenor of the STAG (1988-1990) at the same time formally ensured the NSC's core role in national S&T policy. Hsia, a former President of Cheng Kung University (1980-88), was not a central figure in the then KMT, although his considerable competence in education had been noticed and he had been Administrative Vice Minister of Education in 1979-1980 (Hsia, 1993, pp. 312-13). Due to the continuing restriction on information at that time, there is no credible explanation as to why Hsia was chosen to assume the post amid intense political turbulence. However, some signs suggested the appointment was a result of a compromise in a KMT intra-party conflict. Firstly, the intra-party conflict that emerged right after the death of Chiang Ching-kuo was so intense that, despite the need to conciliate the conservative bloc in the KMT, President Lee Teng-hui had to take a rather tough stand in the cabinet reshuffle in 1988 which resulted in the so called 'Lee Teng-hui cabinet'. Premier Yu Kuo-hwa barely secured his post (Hau, 2000, p. 1350). Therefore the appointment to head the NSC needed to be in accordance with the interests and tactics of President Lee. Hsia's educational background and his less close relation with the old power bloc was a distinct difference from his predecessors (*SciTech Reports*, October 1989, p. 17). Secondly, Hsia's appointment, heading the NSC and STAG simultaneously, broke the traditional separate arrangement, and therefore integrated the administrative organisation – the NSC – with the core machinery of the application-oriented strategy – the STAG, ending the long domination of Li Kwoh-ting who had controlled the STAG for almost ten years by that time (Wang, 1994, p. 60). This action signalled the end of the Li Kwoh-ting era. The STAG as a co-ordination mechanism to streamline industrial, economic and financial ministries and applied research institutes based on Li Kwoh-ting's personal influence was in decline. This arrangement also pleased Premier Yu who had a long history of countering the influence of Li Kwoth-ting (Lin, 1989, p. 105). The appointment thus brought about the institutionalisation of S&T policymaking while the economic technocrats' domination and the overlap between the executive and the KMT declined.

When Premier Yu Kuo-hwa was replaced in the next cabinet reshuffle in 1989 by Lee Huan, the then secretary general of the KMT, the fact that Hsia held on to both posts indicated that the relative autonomy of the NSC was further consolidated. The institutionalisation trend went further in 1989 when the ARTDG and its functions were co-opted by the NSC and STAG (NSC, 1990, p. 41). In a sense, the NSC had gained an opportunity to cast off its subservience to the giant Ministry of Economic Affairs and move away from its previous domination by application-oriented policy.

Furthermore, with the normalisation of constitutional rule, the power of the National Security Council as an advisory body to the President declined, as mentioned above.[54] As a result, the Science Development Steering Committee, a body subordinate to the National Security Council offering the president scientific advice which had been suppressed under the previous applied orientation strategy, was finally closed down (*SciTech Reports*, July 1991, p. 12; Wang, Chien-chuang 2000). Of course, this does not mean that the security apparatus has lost all its influence on science policy.

[54] In fact, according to Hau Pei-tsun's diary, discussion of national policy in the National Security Council meeting was avoided as much as possible at the time so as not to give the impression that martial law had been surreptitiously restored (Hau, 2000, p. 1277).

Evidence shows that the National Security Council and National Security Bureau keep monitoring certain science projects which have security implications. For example, the National Security Bureau gave its consent regarding the military implications of the satellite programme, adding support for the project from the top security authority (*China Times*, 27 January 1999, p. 3). However, its role in planning overall S&T policy has diminished.

In the year he took the post, Hsia announced the initiation of Taiwan's space programme. Amidst political conflict and strong resistance from the scientific community, Hsia's determination to carry on the programme reshaped the image and role of the NSC. The initial space programme, proposing a five-year fund of NT$10 billion (US$420 million), which was bigger than the NSC's annual budget and twice the NSC fund for academic research at that time, pushed the NSC beyond being a merely basic research funding council or a support agency for industrial upgrading.[55] To secure the original proposal, Hsia even urged the lawmakers to oppose Premier Hau's decision (*Legislative Gazette,* 80 (64), pp. 116-17). The controversy over space policy ironically highlighted the increasing administrative autonomy and scientific authority of the NSC.

The Nature of NSC Power

From the functional perspective, the power of the NSC is strengthening along with the progress of industrial upgrading, the increasing magnitude of scientific verification in public affairs, and the restructuring of political power brought by democratisation. Firstly, the rapid success of the Hsinchu Science-based Industry Park in the 1980s has

[55] In the executive budget bill for FY 1990, the NSC's total budget was NT$6.5 billion, and the NSC's Science and Technology Development Fund was just NT$5 billion

built up the NSC's reputation across the country. Secondly, with increasing governmental investment in S&T, governmental capacity to review various S&T initiatives in relation to agency-sponsored scientific projects has become more and more important. Besides those traditional ministries consuming a large portion of government S&T expenditure, the soaring S&T outlay of certain small departments in the middle of the 1980s means that the topics of agency-sponsored research have started to multiply, especially in policy areas like the environment, health and agriculture.[56] Furthermore, in 1992, under strong pressure from the DPP lawmakers, the government met the 15 per cent minimum budgeting requirement for education, science and cultural affairs, a target laid down in Article 164 of the Constitution but continuously ignored by the government in order to direct resources into economic development and the military establishment. The sudden budgetary reallocation to S&T activities resulted in a rise of overall government funds for S&T, but also caused problems in resource distribution and quality control including the perfunctory monitoring of research (*Commercial Times,* 26 September 1997). Only the NSC as a major funding sponsor for the scientific community can systematically identify scientists capable of discerning priorities, results and impacts. Thirdly, at the same time, the issues regarding scientific integrity, credibility, and justice outlined in Chapter Three have driven the NSC to strengthen its role in governing the scientific community, scientific activity and research excellence, to the extent that the NSC has even become directly involved in the publication of academic journals and the regulation of

(*SciTech Reports*, May 1990, p. 8).

[56] For example, in FY 1986, the annual rate of increase of the budget of the Department of Environment Protection was 68.2%, and the DOH 62.1%, with the Council of Agriculture highest at 89.8% (NSC, 1996b, pp. 172-73).

academic ethics.[57] The functions of the NSC in relation to science policy have thus been strengthened on the following two fronts, apart from it being made responsible for the management of the science-based industrial parks:

- Power to review and audit national S&T projects;
- Resources for funding and regulating scientific research.

As a result, when the NSC regulates scientific production on the one hand and organises peer review to oversee national projects on the other, the power to perform these tasks itself becomes part of the social system of science. In this sense, the NSC is not merely a funding agency but a mechanism involved in stratification, recognition, accreditation, reward and publicity. Consequently, the strengthening of NSC power and the rising authority of science in general have reinforced each other.

Table 4.1, taking FY 1999 as an example, illustrates the NSC's budgetary allocation and its association with functions. Among other things, it shows how important space policy is to NSC status, manifesting NSC power through its direct involvement in this S&T programme. In addition, the fact that the S&T Development Fund represented 58.7 per cent of the NSC's total budget and acted as a major source for funding basic science and academic research connects the NSC with nation-wide talent, enabling it to extend power over planning, reviewing and regulation.

To stress the NSC's strengthening autonomy in contrast to the past is not to say that the NSC or basic science dominated overall public policy or even national S&T policy. From the organisational point of view, the political power of the NSC is based

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[57] In 1991 the NSC started to plan a Taiwan-published academic journal with an international reputation. In 2000, the NSC-sponsored *Journal of Biomedical Science* scored an impact factor of 0.99 in the Science Citation Index (*SciTech Reports*, October 2000, p. 29); As to the problem of academic ethics, the NSC issued a Guideline for Academic Ethics Allegations Settlement in 1999 (*NSC Monthly*, January, 2000, pp. 77-78).

on the collective decisions of the NSC Board, which comprises various ministers and elite scientists, as shown in Figure 4.1 below. In the framework, each ministry has its own obligation to promote mission-orientated scientific research and its applications, whereas the NSC is responsible, in addition to academic funding, for orchestrating government S&T performance on the basis of the power it derives both from its scientific reviews and from various departmental mandates. This organisational arrangement may give it the flexibility necessary for the promotion of various scientific applications to respond to multiple social demands, provided the NSC's co-ordination functions well.

Table 4. 1 NSC Budget Allocation (1999)

Accounting Item	NT$ m	%
General overhead	270.6	1.4
Synchrotron Radiation Research	686.7	3.6
High-performance Computing	371.5	2.0
Space Technology Development	2,402.0	12.7
Animal Breeding and Research	163.8	0.9
S&T Information Centre	273.0	1.4
Precision Instrument Development Centre	225.4	1.2
S&T Development Fund	11,120.9	58.7
Non-profit Fund	6.0	--
General Construction	3.6	
First Reserve Fund	1.5	
Science-based Industrial Park Administration	3,423.3	18.1
Total	18,948.3	100

Source: DGBAS, 1999.

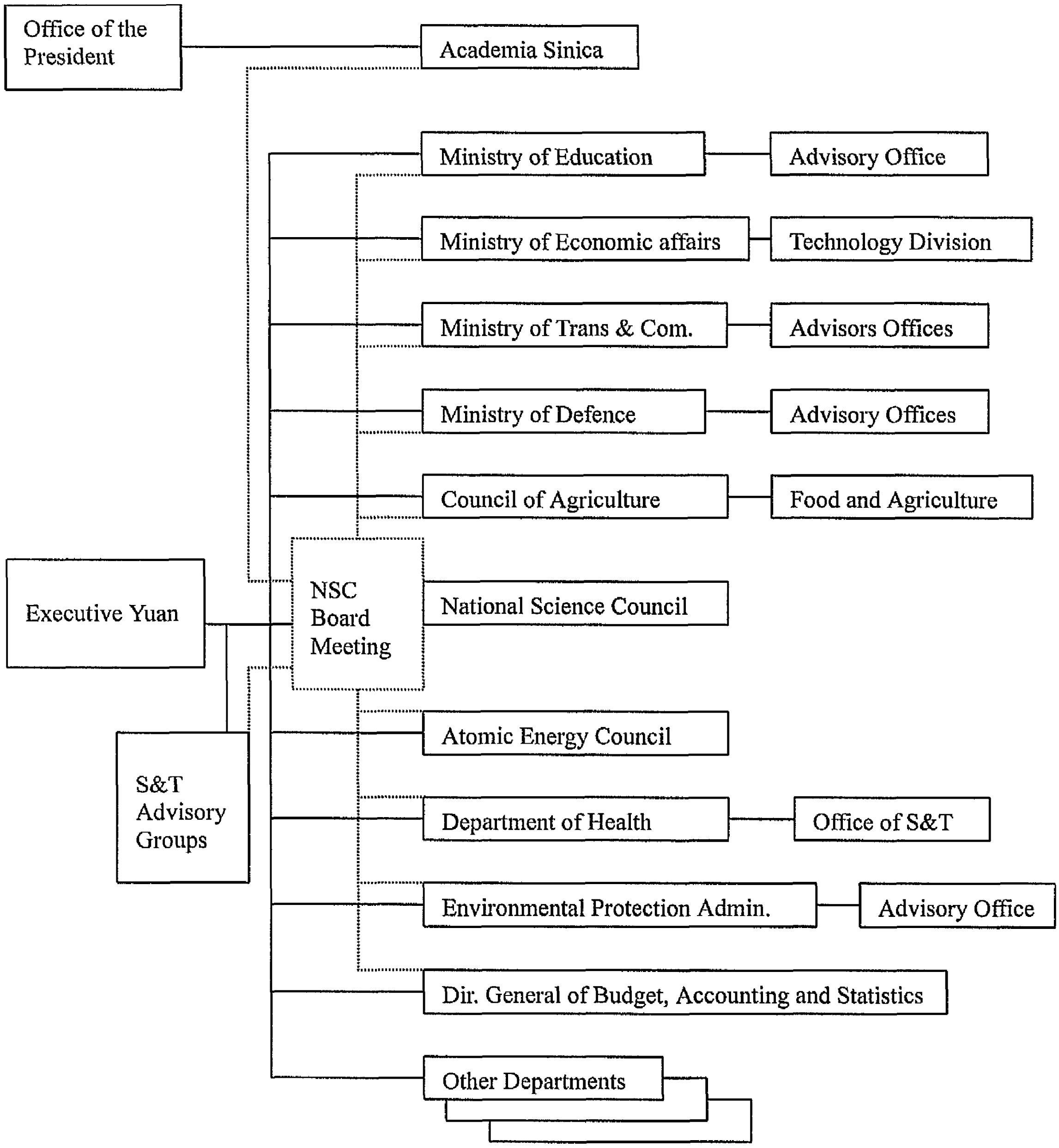
However, science itself is looked upon as only one of the many dimensions for policymakers to take into account. Even in FY 1999, government S&T expenditure was just 4.4 per cent of the total government budget, and the NSC's budget was only 1.4 per cent (DGBAS, 1999). It is not an easy task for the NSC to fulfil its co-ordination function, due to its mere departmental status and the premise that its power is based on collective decisions. The competence and power of the NSC are problematic even in the science policy arena. Table 4.2 illustrates that although increasing government resources have largely shifted to the NSC with a sharp decline in military technology investment, the NSC still confronts robust departments and institutes that are either beyond its control or are resource competitors. Among them are the strong Ministry of Economic Affairs equipped with crucial applied technology institutes, a huge military force which maintains a secretive and remote R&D body, the Academia Sinica with its world-level academics and independent budget, and the STAG, situated in the heart of the cabinet. Even if the NSC's co-ordination powers do function properly, criticism can be directed to its function in charge of both science production and evaluation. Hence, issues concerning the establishment of a more powerful independent scientific ministry or organisation keep attracting heated debates (for example, *SciTech Reports*, September 1996, pp. 10-12). Yet this is to a certain degree related with political power rather than the organisational issues.

Table 4. 2 Government S&T Expenditure by Department (1999)

Department	(NT$ m)	%	% (1984)
Ministry of Economic Affairs	19,063	36.8	17.7
National Science Council	16,093	31.1	19.0
Ministry of National Defence	7,002	13.5	45.1
Academia Sinica	3,881	7.5	5.5
Ministry of Trans. and Communications	433	0.8	0.1
Atomic Energy Council	571	1.1	9.9
Council of Agriculture	1,844	3.6	--
Ministry of Education	990	1.9	2.2
Department of Health	1,427	2.8	0.4
Environmental Protection Administration	51	0.1	--
Ministry of Interior	162	0.3	--
Council of Labour Affairs	128	0.2	--
Research, Development and Evaluation Council	151	0.3	--
Construction Commission	11	--	--
Total	51,807	100	100

Source: DGBAS, 1999.

Figure 4. 1 The System of Administration of Science



Source: NSC, 1997c, sec.2.3.

Power Consolidation and Expansion

The following section further depicts the dynamic changes of the NSC's role in its relation with the Academia Sinica, the MND and the STAG which represent other influential power and policy actors in the formulation of S&T policy. The changing power position of the MND and the STAG also illustrates the NSC's extended role in the two fundamental national objectives: security and economy.

The SSC Controversy

Taiwan's plan to participate in the US Superconducting Super Collider (SSC) project offers a dynamic account of the changing role of the NSC and its relationship with the Academia Sinica.

Around 1990, the debate about the construction of the SSC was at its peak in the US. The total cost of the project was estimated at up to US$8.3 billion. To reduce the financial burden, the Bush administration tried to seek international partners to share the construction costs. The proposed contribution from Taiwan was NT$1.2 billion (about US$60 million) for the central tracker of SSC's GEM detector, to be manufactured in Taiwan. In return, necessary technological assistance and transfer would be offered by the US counterpart, in what seemed a rather good deal for Taiwan (*Central News Agency*, 16 September 1992, Huang, 1993, pp. 12-14).

From the outset, the whole deal was backed by overseas academician Lee Tseng-dau, a 1957 Nobel Prize winner in physics. In December 1991, the NSC undertook a feasibility review of the proposal and soon decided not to join because of the limited contribution the project would make to Taiwan's scientific development (*SciTech Reports*, April 1993, p. 4). However, Wu Ta-you, then President of the Academia Sinica, insisted on continuing assessment. In July 1992, Wu and Lee pressed the government to take part in the project and Premier Hau gave his consent (*Central News Agency*, 18 September 1992).

In the meantime, five academicians, namely Lee Yuan-tseh, Teng Lee C., Wu

Chien-shiung, Luke C. Yuan and Samuel C. Ting (1976 Nobel Prize winner in physics), who were also members of the advisory committee of the Taiwan Synchrotron Accelerator, questioned the proposal's feasibility and legitimacy by sending letters to Wu and Premier Hau (*SciTech Reports*, September 1992, pp. 9-10). Key figures from Science Monthly also argued that there was no reason to join the project, given Taiwan's current scientific standards. They argued that the weakness of domestic research in high-energy physics might already mean that the investment in Taiwan's Synchrotron Accelerator, due to operate at the end of 1992, was wasted (*Central News Agency*, 16, 18 September 1992). In the face of fierce debates, the NSC position remained ambiguous. By the end of September 1992, the overwhelming support from political elites disposed Hsia to accept the SSC project (*Central News Agency*, 30 September 1992). However, based on the experience of the satellite project, the NSC maintained a cautious approach and held meetings with academics and related agencies to evaluate different viewpoints. To resolve the controversy and maintain the NSC's objective stance, the viewpoints of eleven overseas experts were introduced into the deliberations, and a Review Committee consisting of nineteen anonymous domestic experts was set up by the NSC to make a final decision. On 22 February 1993, based on the overseas experts' opinions, the Review Committee rejected the joint venture proposal for the SSC project by a majority of 12 to 4, and its report was then submitted to the Executive Yuan.

At exactly the same time, the general legislative elections and the contest between President Lee and Premier Hau led to a cabinet reshuffle, in which Hau was removed from the core political circle. Interestingly, with the cabinet reshuffle, Hsia Han-min and Kuo Nan-hung exchanged posts at the end of February 1993. Kuo had previously condemned the flaws in Hsia's decision-making procedure in relation to the satellite project (*SciTech Reports*, August 1990, pp. 1, 5). Surprisingly, soon after assuming the chairmanship of the NSC, Kuo declared that the SSC project should be re-examined on the grounds that more information needed to be presented. Despite the previous resolution made by the Review Committee, Kuo clarified this intention in a public hearing held jointly by the Science Monthly and the NSC, and recalled the previous Review Committee meeting (*SciTech Reports,* March 1993, p. 7; *Central New Agency*, 20 March 1993).

On 19 March 1993, Ting Shou-chung, a KMT legislator, severely attacked this proposal for its procedural flaws, uncertain effectiveness, high dependence and US intervention, a move which created intense public concern about this issue again (*SciTech Reports*, March 1993, pp. 23-27). The Ministry of Foreign Affairs soon denied having any connection with the renewed proposal (*Central New Agency*, 19 March 1993). After a further meeting of the Review Committee on 22 March, the NSC announced that the committee would defer the decision until June (*Central New Agency*, 22 March 1993). On the same day, academician Lee Yuan-tseh, a leading scientist in the opposition bloc of this dispute and later President of the Academia Sinica, disclosed that the US Department of Energy might have been involved in Taiwan's decision-making on the SSC project. On the next day, in the *China Times*, an individual claiming to speak for the Academia Sinica denied the above criticism and condemned the report as false (*China Times*, 23 March 1993). Knowing that the situation might get out of control, the NSC promptly declared that it would cease further involvement in the SSC issue by maintaining its previous resolution, and left the final policy decision to the Executive Yuan (*Central News Agency*, 24 March 1993). The Executive Yuan did not reverse the NSC judgement but kept the project under consideration. On the other side of the Pacific Ocean, the US Congress voted against the SSC project in October 1993, ending this highly controversial scientific project.

In the event, the critical role played by the NSC in policymaking was evident. Firstly, it showed that the institutional power of the NSC had pre-empted academicians' individual influence. Public and legislative pressures had diminished the legitimacy of elitism in science policymaking. Secondly, the NSC's espousal of the scientific advisory mechanism verified its dual authority commanding both administrative power and scientific authority, as already identified. Scientific advisory inspection and judgement offered the NSC a relative autonomy to counter the personal influence of political and scientific elites, and a scientific authority to cope with the pluralistic policy environment. Third, Kuo's policy reversal in a sense exemplified the autonomy of NSC power and yet disclosed a fundamental dilemma of the NSC which as an agency could not entirely exclude political power manoeuvring. The policy reversal revealed the operation of individual preferences and political intervention in decision-making. As a result, the strength of the NSC and the increasing reliance on institutionalised scientific judgement in the policy realm were mutually reinforced.

The controversy reveals that there was a tension between the NSC and the Academia Sinica. Thereafter, when the Academia Sinica led by Lee Yuan-tseh wielded policy influence by appealing for public support and professional authority as indicated in the last chapter, the NSC could no longer use an appeal to scientific authority to counter the growing organisational influence of the Academia Sinica. As seen in many NSC-funded projects and relevant policy deliberations which involve experts from the Academia Sinica, power sharing rather than exclusion characterises the current relationship between the NSC and the Academia Sinica. The Fundamental Science and Technology Act, mainly drafted by the NSC, explicitly states that advice from the Academia Sinica must be taken into account in national S&T policy planning

(Office of the President, 1999a, art. 10). The power sharing also responds to the Academia Sinica's complaints about its lack of material leverage to involve policy (*Legislative Gazette*, 83 (63), p. 357). But by apparently absorbing scientific authority from the Academia Sinica, its involvement in an advisory capacity consolidates the NSC's power.

Opening up Military Technology

In 1983, Hau Pei-tsun, then President of the CSIST and Chief of the General Staff, had recognised that "the firmest defensive technology is to root the military technology and industrial base in national technology and industry via full co-operation" (Hau, 2000, p. 265). However, conspicuous interaction between military and civil technology did not occur until the end of the 1980s. Despite sharply declining governmental support, decision-making regarding military technology research was almost closed off to outsiders. As a science administration, the NSC has no power to scrutinise military R&D and its policy, except applying a slogan, such as 'the promotion of autonomous military technology', to its plans. Efforts to exploit dual-use civil-military technology were limited.[58] Taking the IDF as example, although more than 100 local busineses were involved in component production, Steve Chan observed: "due to AIDC's insulation, there are few aviation engineers outside its guarded walls" (1996, p. 77).

With the decline of the military power, military R&D and the defence industry faced a legitimacy crisis and resource cuts. The crisis came to a peak when US

[58] Aside from political factors, the limitation was attributed to the weak industrial structure and lack of economic incentives. Furthermore, the final system orientation of military R&D and industry tended to outsource a large portion of subsystems, parts, components, materials and equipment from abroad, and therefore reduced potential opportunities for dual-use technology sharing with local industry (Chiang, 1999, pp. 268-69).

President George Bush announced that the US would sell 150 F16 A/B MLU fighters to Taiwan (Tien, et al., 1992; Ding, 1997, p. 18). The total number of IDFs that AIDC would produce was reduced from 250 to 130. The prospect for military R&D was gloomy.

As a consequence of changes in external and internal circumstances, the idea of commercialising and privatising military technology swiftly gained ground inside and outside the government in the early 1990s. Among other things, conversion of the aviation industry and military technology for private industry was seen as a sensible strategy (Ding, 1997, p. 18). The lucrative niche found in the military R&D system was aircraft manufacture, which included design, analysis, simulation, manufacturing, assembly, engine-testing and maintenance, all conducted in the AIDC. A twenty-two-member committee for Aviation and Space Industry Development was formed at the cabinet level in 1990 to take charge of the promotion of the civilian aircraft industry (Chan, 1996, p. 77). In 1993, the NSC for the first time established aircraft engineering as an independent discipline (NSC, 1994, p. 160). Although the MND tried to speed up its contracting of projects and technology transfer to private firms, under severe pressure from financial shortages and public opinion, the MND was left with no choice but to surrender control of its research institutes. After a three-year reorganisation, the AIDC was converted into a state-owned corporation under the MOEA in July 1996 and prepared to enter a privatisation process. This move excited further expectations about the privatisation of the whole of the CSIST.

At this point, the well-tailored transition began to meet challenges, this time not from outsiders but insiders. In the past, the MND had used high incentives to attract excellent manpower into the AIDC and the CSIST, without placing them under the national employment protection system. Conversion led to the AIDC's specialists and staffs facing redundancy and lower pensions based upon a rigorous cost-benefit analysis. The loyalty of the institute-based scientists and technicians swiftly collapsed. Five thousand employees of the AIDC and their families organised a series of protests during the conversion operation and demanded their agreed pensions, which was unprecedented (*Central News Agency*, 7 May 1996). Anxiety regarding the personnel problem and the future of military R&D soon spread to the specialists in the CSIST, some of whom later joined in the protests. The privatisation of the CSIST was likely to cause even more severe problems because its civilian staffs numbered around 8,000, about 80 per cent of its total employees. After a one-year dispute, pressure from legislators and constant protests eventually forced the MND to pay more than NT$1 billion (US$30 million) in pension provision in relation to the conversion of the AIDC (*Central News Agency*, 23 May; 24 July 1997). The high cost of privatisation in terms of loyalty, morale and economic effectiveness cooled the fever for the privatisation of military technology.

In the meantime, the pressures of privatisation and a shrinking budget have led CSIST specialists to catch the wave of dual-use civilian-military technology exploitation and to act as an independent unit seeking possible commercial niches for their research. Evidence shows that considerable grants have been transferred from the MOEA to the CSIST to boost dual-use technologies via the Technology Development Programme. The value of grants from the MOEA and MOTC began at NT$318 million (US$12 million) in FY 1995, rose to NT$2.25 billion (US$82.5 million) in FY 1996, and in FY 1999-2000,[59] increased to over NT$2.47 billion (US$78.7 million) (Yang, 1995, pp. 9_72-73; *Legislative Gazette,* 88 (28), p. 177). With the pattern of political

[59] Since FY 2001, the fiscal year has been shifted to start from January. The FY 1999-2000 is a transition starting from July 1999 to December 2000.

connections changing, the MND can no longer dominate military research. As a result, it has found not only that the commercialisation of military research is inevitable, but also that it might lose its control over the CSIST and military research capacity. In a 1998 meeting, a representative of the CSIST revealed that the MND blocked the Executive Yuan's original attempt to privatise the CSIST in view of the above anxieties (Chen, et al., 1998, p. 12).

As a result of these developments, the veil over military research was torn away and MND's declining power even threatened its research foundation. Now, not only has military technology been opened to civil use, but also the power to decide the focus of military research has to be shared with civilians and elected officials. Since 1997, military research has been subjected to NSC review, although its scope is still limited (NSC, 1998a, p. 28).

The STAG and Synergy for Industry

The above analysis confirms the increasing power of the NSC and yet reveals a concomitant tension in relation to its co-ordinating role. This section further probes the tension by illustrating the interaction between the NSC and the STAG.

Under Li Kwoh-ting's leadership the STAG built up the power to orchestrate the knowledge stream from research to industry using the principle of application orientation.[60] This function was far beyond its original mission of meeting with foreign advisors and offering policy advice. At this point, the STAG was seen as a powerful and leading mechanism in the national innovation system that could establish synergy through networking with various agencies and private sectors, especially by

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[60] One of the best examples can be seen in the case of the Hepatitis B Control Programme (Lin, 1994, pp. 159-60).

commanding the resources of the MOEA and Ministry of Finance. Of course, with the waning of Lee's influence and the changing policy environment, the STAG could never again be the same as it was in the 1980s. Still, its function in orienting S&T for the purpose of economic and industrial development remained. Thus, the aforementioned integration of the NSC and the STAG under Hsia' control created an integrated mechanism to streamline science and industry at cabinet level. However, throughout the 1990s the STAG position was subject to change.

In 1990, Premier Hau Pei-tsun appointed Kuo Nan-hung, Minister without portfolio, as head of the STAG, restoring its independent leadership. This move indicated a frank intention to restore the Executive Yuan's own authority in scientific affairs with an eye to restricting the NSC's power at the time of the ongoing controversy over space policy and the SSC project.

Kuo, like Hsia, had had long experience in university administration since the 1970s. He was a former President of Chiao Tung University (1978-1987), and had been Minister of the MOTC (1987-1989) and Minister without portfolio (1989-1993). Kuo, however, could no longer call on the organisation's power of co-ordination as in the Li Kwoh-ting era. For example, the Electronics and Communications Technology Review Board set up in the STAG during the 1980s was devolved to the MOEA and the MOTC in 1992, and the STAG now only played a co-ordinating role by holding Strategic Review Board Meetings to create a synergy between government and industry (Chung, 1999). In the SSC controversy, the lower-profile of Hsia Han-min, then Convenor of the STAG, whose decision was overruled by the NSC Chairman Kuo during the latter part of the controversy, also revealed the fragility of the STAG as an ad hoc organisation whose power always depended on the premier's authority.

Nevertheless, once empowered by the premier, the STAG could enjoy a strong mandate to counterbalance the power of the NSC. For instance, partially due to Kuo's auditing, the NSC was forced away from its domination of the space programme at the time of early planning.[61] Under the premier's special commission, the STAG's non-statutory status has not impeded it from continuing its role in co-ordinating the cross-departmental scientific establishment for application, although it has been limited to authorised areas. In 1992, Kuo started to direct a task force to promote the Nan Kang Economic Park, which involved massive constructions in Taipei to boost the software industry and trade centre and drew out collaborative efforts from the MOEA, the MOTC and Taipei City (Li, 1999).

In 1993, Kuo exchanged posts with Hsia, becoming the Chairman of the NSC, a fact which intriguingly increased the friction between the two. Evidence shows that certain agencies were able to bypass the NSC review to secure their S&T projects by appealing to the STAG for support, undermining the NSC's function of policy co-ordination (*NSC Monthly*, May 1993, pp. 478-79; April 1994, p. 300). Furthermore, Kuo was embarrassed by the legislators due to the fact that Hsia, Convenor of the STAG, took charge of the National Information Infrastructure Programme in 1994, a large programme to establish nation-wide Internet construction and application, with the power to co-ordinate almost all ministries and departments (*SciTech Reports*, June 1995, p. 26; *Legislative Gazette,* 84 (17), p. 49). These facts somehow indicated that the relation between the NSC and the STAG was mutually beneficial but essentially competitive.

With the STAG perceived in some quarters as duplicating functions carried out elsewhere, in 1993 the budget for the S&T advisory affairs of the Executive Yuan, the source of STAG funding, was cut in the second reading and only passed in the third

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[61] See discussion in Chapter Six, B.

reading as the result of protracted party negotiation (*SciTech Reports*, June 1993, p. 11). Thereafter, the STAG had to fight for its survival each year.[62] In a survey conducted at that time, of one hundred elites from government, industry and the scientific community, 63 per cent believed there was overlap between the functions of the NSC and the STAG, and 61 per cent suggested that while the STAG should not be abolished, its functions should be adjusted (*SciTech Reports*, June 1993, p. 11).

After Kuo and Hsia both left the cabinet in 1996, the close relationship between the new leader, NSC Chairman Liu Chao-shiuan, and the STAG Convenor, Yang Shih-jian, eased the tension between the two bodies. The amicable relationship ironically reduced the scope of STAG's authority as the NSC had the power and resources to expand its governance without worrying about its own backyard. Even in its function of delivering advice and audit on agency-sponsored projects and performance, based on advisors' reviews, the STAG now preferred to keep in a low profile in order to focus synergy efforts on key areas (Lin, Ji-shing 2000, interview). The best-known effort of the STAG at the end of the 1990s was to take charge of the Biotech Industry Steering Group to regenerate Taiwan's biotech industry (NSC, 1997c, sec. 4.9).

Integrated and Centralised Power

Liu Chao-shiuan, who had administrative experience in the NSC (Department Chief, 1977-82), Tsing Hua University (President, 1987-93), and the MOTC (Minister, 1993-96), took charge of the NSC in June 1996. Based on Premier Vincent Siew's strong desire to build 'a science and technology island', NSC power reached a peak. Liu declared his intention to restore the integration function of the NSC Board, and thus

[62] For example, see a motion for reconsideration in 2000 (*Legislative Gazette,* 90 (5), pp. 33-34).

downgrade the STAG, in order to resolve the problem of responsibility for S&T planning and the contest between different policy priorities.[63] In 1996 and 1997, for the first time, Academia Sinica's projects and military R&D were placed under NSC scrutiny (*SciTech Reports*, January 1998, p. 1; NSC, 1997a, p. 17). At the same time, the NSC's large-scale and general projects were subject to the STAG's overseeing (*NSC Monthly*, October 1998, p. 1248). In this way there was synergy and balance at the top of the administration of science which seemed to be streamlined within a better structure. This was particularly exemplified in the Action Plan for Building a Technologically Advanced Nation approved in 1998, where it was stated that "the function of the NSC Board will be strengthened" (Executive Yuan, 1998c, sec. 6.1.3.1).

However, as already mentioned, so long as the agency status of the NSC remained, criticism of its role as 'a player and referee at the same time' was unavoidable. Despite the strengthening power of the NSC, some signs suggested that complaints would continue to arise whenever the NSC's project review and growing remit led to intrusions into the jurisdiction of other agencies (*SciTech Reports*, September 1996, pp. 10-12). In particular, agents of the MOEA believed that they themselves had more comprehensive contacts and understandings of the needs of applied technology and industrial development than scholars mobilised by the NSC (*Legislative Gazette*, 86 (44), p. 104).

At the end of the 1990s, a tendency towards power centralisation in science policymaking gradually emerged, becoming particularly apparent when Liu was designated as vice premier in 1999. This was the first time a NSC chairman had been

[63] See *SciTech Reports*, November 1996, p. 6. The NSC Board Meeting at that time consisted of crucial scientific and political elites such as Wu Ta-you (Advisor to the president), Li Kwoh-ting (Advisor to the president), Chiang Yan-shih (Advisor to the president), and Lee Yuan-tseh (President of the Academia Sinica) among other

promoted to a formal top post in the cabinet. Moreover, in 1998, the STAG reorganised the traditional overseas advisory structure by enrolling six local advisors, led by Chief Advisor Lee Yuan-tseh. Bringing the newly enrolled local advisors together with the vice premier, NSC chairman and other relevant ministers, Premier Vincent Siew held bimonthly S&T Meetings to deliberate on national science policy in a more systematic manner (STAG, 1999). The pattern of highly empowered support and centralisation was reconfirmed by the 1999 Fundamental Science and Technology Act, which concentrated decision and funds control in the Executive Yuan itself (Office of the President, 1999a, art. 10, 11). Whether the centralisation of power will further complicate the functioning of the NSC remains to be seen.

On the whole, it is gradually becoming clear that capacity of the science administration is being strengthened by a process which relies on agency power consolidated through political changes on the one hand, and the scientific authority generated by the scientific community on the other. From this point of view, the NSC has a political responsibility not only to deliver policy as an agency but also to bring about the ascendancy of the authority of science in the public sphere as a key element in the social institutions of science. Hence, in Taiwan the strengthening of NSC power represents one dimension of the rise of scientific authority in society. In this framework, the administrative power is just as much as part of scientific authority as scientific autonomy and expert knowledge. The dual character of the NSC's role leads to a mixing of features in policy formulation. The NSC as a key element in the social system of science embodies a relative autonomy which helps it to steer away from an exclusively application-oriented approach and engage in the promotion of scientific

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ministers and officials.

foundation and the establishment of scientific authority in the political-social sphere. On the other hand, its administrative character, in contrast to the relatively segregated system of governance and funding found in many Western countries, imposes a direct obligation to ensure the social relevance of policy, but also leaves it open to power intervention. The structure gives the NSC a capability to integrate pure science establishment and social demands, but at the cost of the lack of a counterbalance in the policy process.

B. The Legislature as Policy Actor

The revitalisation and vigorous political involvement of legislators has made them key policy actors. It is important that the legislators play an intermediary role of feeding diverse science-related demands into the national policy arena, while the power of governmental and societal actors grows. Legislators have proved able to push S&T policy issues and newly emerging or desired reforms onto the agenda and help to open a window for new policy formation. The legislature pursues its own preferences and concerns, and also acts as carrier of issues, reflecting and taking forward the main policy issues raised by major policy communities discussed so far.

The Rise of Legislative Power

As Adam Przeworski has pointed out, one of the most important institutional features that make for the success of democratic transformation is the reinvigoration of the legislature (1995, p. 43). In Taiwan, the opposition continuously targeted legislative seats as prizes of political contestation, eliminating the extreme of rebellion and establishing party politics as its favoured arena of political struggle.

As late as 1988, 216 out of 301 legislative representatives elected in Mainland China in 1947 still remained in position on the basis of the Temporary Constitutional Provisions which suspended further elections. This allowed the KMT to dominate political agendas and policy directions in general (Tien, 1989, p. 142; Wu, 1998, p. 106, Pang, 1992, p. 73). Tien Hung-mao, current Minister of Foreign Affairs, pointed out at the time that "the Legislative Yuan has seldom disagreed with the Executive Yuan on the proposed annual budget and government bills," because high ranking KMT members tightly controlled the actions of the Legislative Yuan (1989, pp. 142-45). The main avenue for policy debate on the legislative floor was through questions addressed to ministers, but the proceedings were highly formalised (Tien, 1989, p. 142).

With the progress of democratisation and the increased number of Taiwan-elected representatives in the Legislature from all parties, those newly elected legislators who recognised the importance of public support started to speak out on various public issues and moved away from their previous rubber-stamping role. For example, during the sessions in 1987, legislators asked 3,744 questions on policies and measures, nearly twice as many as in 1986; NT$12.6 billion were cut from proposed government budgets and legislators even introduced ten bills (Meaney, 1992, pp. 105-6).

The first comprehensive legislative elections in 1992 initiated Taiwan's stable and by now apparently irreversible democratic development. Table 4.3 shows how limited the supplementary elections were up to 1989, allowing the KMT to enjoy the prerogative of dominating the legislature. Scrutinising Table 4.3 and 4.4 together, we can see how vast the impact of comprehensive elections would be, when the near 30 percent voting share of the Tangwai/DPP was directly reflected in seats of the Legislative Yuan. In 1992, the DPP won 30.8 percent of the votes and 50 contested seats out of 161 total seats in the Legislative Yuan, clearly signalling the possibility of a turnover of power in the future.

Table 4. 3 Seat Distribution in the Legislative Yuan (1980-98)

Seats		1980	1983	1986	1989	1992	1995	1998
Elected Members	KMT	56	61	58	72	96	85	123
	Tangwai/DPP	6	6	12	21	50	54	70
	New Party	--	--	--	--	--	21	11
	Others	7	3	2	8	15	4	20
	Total	69	70	72	101	161	164	224
Entire Chamber		406	368	324	287	161	164	224

Source: Fu and Chu, 1992, pp. 184-85; Central Election Commission, 1999.

Table 4. 4 Voting Share in the Legislative Elections (1980-98)

Party	1980	1983	1986	1989	1992	1995	1998
KMT	71.7	69.4	66.7	59.2	52.5	46.1	46.4
Tangwai/DPP	15.3	18.9	24.6	29.9	30.8	33.2	29.6
New Party	--	--	--	--	--	13.0	7.1
Others	13	11.7	8.7	10.9	16.7	7.8	16.9

Source: Tien, 1997, p. 151; Central Election Commission, 1999.

The falling numbers and proportion of KMT legislative members and the emergence of competitive party politics had a great impact on the operation of the legislature and the national policymaking process through the 1990s. Closer examination of the budget, lengthy questioning, public hearings and cross-party coalitions became popular tactics used by legislators to amend or oppose cabinet-proposed policies, although these also caused inefficiency. The power of cabinet officials further suffered from the lack of a clear popular mandate and of consolidated discipline in the ruling party. Instead, given the mushrooming growth of the media, legislators could easily advocate political views and policy ideas inside and outside the chamber. In particular, by using public hearings, individual legislators were able to bring public concerns and various interests into the political sphere. The active role of legislators also showed in science policy area as already mentioned in many cases.

However, the newly restored legislative power was also threatened by hidden financial interests. Legislators' coalitions and bargain building based upon social ties, interest trading, and shared commitments became important mechanisms for passing government bills (Tien, 1997, p. 152). This opened up opportunities for corruption and undermined professionalism in legislative practice.

In sum, the Legislative Yuan, as an arena for political competition, has played a crucial role in policy debates and has effectively limited the extent of the executive monopoly.

The Power of the Legislature in Science Policy

Basically, the main functions of the legislature are the approval of bills, review of the budget and policy debate through its three-readings procedure. Theoretically, ordinary bills can either be introduced by the executive or the legislature. The first and third readings take place during a full sitting of the Yuan, allowing all members to attend, whereas the second reading is handled in a committee consisting of no more than 21 lawmakers. The second reading is normally considered a crucial arena where policy issues can be placed under deeper scrutiny. Other than in the case of law and budgetary bills, resolutions made by the committees on the second reading have direct legal power, compelling a related department to carry them out. The executive sectors bear the obligation to present administrative statements and performance reports during two legislative sessions every year. The administrative statements always accompany the budgetary bill, while the performance reports are broken down by department and are subject to examination by the appropriate committee at the time of the non-budget review session.

At one time, legislators' policy debates on science were peripheral. In general, science issues were simply beyond lawmakers' concern and competence (Lin, 1982, p. 205). In April 1990, when legislators questioned Chairman Hsia on the satellite programme, DPP Legislator Cheng Uy-cheng admitted: "it is rare that this Legislative Yuan can do anything about scientific bills. Years ago, legislators almost approved scientific programmes without saying a word" (*Legislative Gazette*, 79 (72), p. 11). Dissenting opinions were easily suppressed by the KMT's overpowering majority of seats. During the period 1975-1982, only in 1981 and 1982 did small parts of scientific budgets face legislators' cuts (Lin, 1982, pp. 190-91). According to Lin Chung-shan's research in 1982, both in Yuan Sittings and Committee Questions, legislators paid little attention to scientific policy (p. 198). This of course was related to legislators' degree of professionalism and competence as well. Lawmakers proved incapable of introducing a single science-related bill in the same period of time; even though amendments were made, most of them were insignificant (p. 189). While lawmakers' competence in science affairs was always relatively weak, as it is elsewhere, Lin particularly pointed out that the poor functioning of the Legislature resulted from its lack of support mechanisms, such as public hearings and senior administrative officers. From his investigation, it would appear that no science policy was deliberated in public hearings (Lin, 1982, p. 176). As a result, certain shortcomings in its functions continued to limit its policymaking capacity during the 1990s. A clear example was the fact that central science-related affairs under the NSC jurisdiction were mainly scrutinised by the Education Committee of the Legislative Yuan before the Science, Technology and Information Committee was set up in 1999.

The impact that democratisation has brought about is the obligation of lawmakers to reflect the interests of their own constituency and wider society, which affects both their reputations and the support they receive from the public. Although this is a simple principle of democracy, intense electoral competition, with turnout of over 65 per cent in each election in the 1990s, has pushed legislators to actively involve themselves in public affairs and give voice to social interests, as already seen in many cases.

One consequence is that interactions between lawmakers and professionals have increased considerably. In the late 1980s young educated representatives started to build up their connections with the scientific community as scientists increasingly appeared in public affairs. For example, in December 1989, just before winning his first campaign as a legislator, Ting Shou-chung, now a senior KMT legislator specialising in the science-related policy area, appeared in a conference held by Science Monthly to discuss S&T policymaking, and committed himself to scrutinising science policy (*SciTech Reports*, January 1990, pp. 18-19). A few months later, he and his fellow legislator Chu Fong-chi (KMT) held public hearings to increase public involvement in the satellite programme. In April 1990, the legislative Budget Committee organised a public hearing on space science research in which 23 legislators joined (*SciTech Reports*, May 1990, p. 35). Since then, the involvement of experts and scientists in legislative deliberation has come to be normal. Lawmakers are getting better at using public hearings to gather expertise, although this should not be exaggerated.[64] In addition to formal channels, it became apparently in my interviews

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[64] Peng, 1993, pp. 306-7. Since the holding of legislative hearings was not ratified until 1999 (Office of the President, 1999b, art. 54-59), the exact number of scientific hearings including those off the record is impossible to calculate. During the 1990s, according to my search through the web database of *Legislative Gazette,* sixteen public hearings placed on the legislative record were concerned with science-related policy. Those issues included space research, the Teachers' Law, elections for university presidents, nuclear power plants, air pollution, subsidies and donations for private universities, medical disputes, the Pursuit of Excellence Programme for

that those legislators who are able to debate scientific issues in depth in the chamber always have close personal relationships with certain experts and scientists (Su, 2000, interview; Ker, 2000, interview). All this gives legislators greater competence to engage in science policy.

However, this is not to suggest that lawmakers' individual competence in science policy deliberation has radically improved.[65] On the contrary, the professionalism of the legislature is far from adequate, a matter to which I will return later. However, the increase of legislative power also lures scientists and experts to feed information to lawmakers. Thus, this is a two-way interaction. How legislators' attention can be drawn to issues has become a continuous source of anxiety to scientists (*SciTech Reports*, March 1993, p. 13). In the Fifth National Science and Technology Conference, the low turnout by lawmakers annoyed both the NSC and the scientific community in that their policy deliberation might prove pointless without the support of the Legislative Yuan (*SciTech Reports*, September 1996, p. 1). With political and professional power, the legislators now play an unprecedented role in the science policy arena.

Certain visible evidence has indicated the progress of legislative competence in science policymaking. In March 1993, sixteen legislators organised a non-statutory S&T Promotion Coalition with an eye to enhancing legislative competence in S&T

University Research, science-based industrial park management, community colleges and the educational budget.

[65] Of the 21-member Science, Technology and Information Committee in the sixth session of the fourth term (the second half of the 2001), only six had a science and engineering background. Furthermore, due to the fact that legislators can actually move around different committees during their tenure, individual legislators' professionalism is never solid.

policy control and the examination of relevant budgets.[66] This was a predecessor of the later formal scientific legislative committee, later called the Science, Technology and Information Committee, inaugurated in 1999. It is worth noting that the group was a cross-party alliance, indicating a nascent cross-party legislative professionalism. Through a series of public hearings and with the help of the STAG and the Rand Company in 1995, the group published the first systematic non-governmental version of a national S&T budget: *Probing the National S&T Budget* (Chiang and Ting, 1995). The establishment of the Science, Technology and Information Committee represented a milestone in the professional development of the legislature on science policy.

In addition, the lawmakers' competence in introducing bills has progressed, although such opportunities are few. In 1997, the NSC proposed the Fundamental Science and Technology Act (NSC, 1997e). At the same time, five other versions were introduced by five groups of legislators including the DPP and the New Party. Through joint deliberation, several substantive principles proposed by legislators were included in the Act, such as strengthening ecological protection (Office of the President, 1999a, art. 1), fixing government expenditure at a certain proportion of GNP (art. 3), planning national S&T blueprints through National Conferences (art. 4), restricting governmental assistance to R&D sectors rather than firms (art, 5), setting up open assessments for government funding (art. 12), and introducing flexible tax incentives for private R&D (art. 18). Furthermore, taking the latest legislative initiatives as an example, from November 2000 to October 2001, three out of six approved science-

[66] See Chiang and Ting, 1995, pp. 2-3. The group includes legislators Chu Fong-chi (KMT), Ker Chien-ming (DPP), Chiang Ping-wei (KMT), Liu Kuo-chao (KMT), Wu Tung-sheng (KMT), Jao Yung-ching (KMT), Rober Hsu (Democratic Alliance), Yu lin-ya (DPP), Lee Tsung-cheng (KMT), Wang Shien-mig (KMT), Lin Kung-hua (DPP), Su Huan-chih (DPP), Lo Chwan-jinin (KMT), Hung Tung-kuei (KMT), Hsieh Chi-ta (New Party) and Lin Ming-i (KMT).

related amendments or new bills were introduced by legislators (Legislative Yuan, November 2001).

Table 4. 5 Disparities between Executive Budget Bill and Final Budget

Budget Cut (%)	1994	1995	1996	1997	1998	1999	1999-2000
To proposed S&T budget	5.5	2.3	0.7	1.8	1.5	0.1	1.2
To proposed NSC budget	0.7	1.2	0.9	0.8	0.5	0.4	0.7

Note: The figures are based on the originally approved budgetary bill, not the final re-allocation.
Source: recalculation from DGBAS, 1994-2000.

Perhaps the most tangible change in the strength of the legislature is manifested in the examination of the budget. The cutting of a single accounting item can be lethal since it can immediately terminate a relevant executive function such as in the case of the STAG crisis of 1993, as already mentioned. In FY 1994, the MOEA budget for the Technology Development Programme was slashed by NT$2 billion (US$75 million), or 20 per cent of the item. This dampened the triumph of the government's state-led strategy and resulted in pressure upon government-supported institutes for cost-effectiveness in applied technology research. Legislators saw this move as a symbol of the power of the legislature and a means of influencing policy (Chiang and Ting, 1995, p. 1). Thanks to party negotiation and bargaining, in most cases budget cuts are made as a percentage cut from the budget as a whole, leaving a certain flexibility for reallocation.[67] Table 4.5 shows that although budget cuts happened in almost every

[67] For example, a total NT$449.9 million (US$12.7 million) cut from the FY 1999-2000 NSC budget was proposed in the second reading. The amount was then reduced to NT$50 million (US$1.6 million) in the third reading by party negotiation (see *Legislative Gazette*, 88 (30), pp. 115-17).

single legislative review, cuts of over 5 per cent of the government's overall S&T budget and 1 per cent of the proposed NSC budget have been rare. Yet the fact that constant budget cuts have almost become part of the budget process indicates that any negligence might lead to severe damage to a specified appropriation, immediately affecting the agency's mission or performance. In 2000, the legislators slashed NT$160 million (US$5.1 million) from the ROCSAT-3 fund, about 60 per cent of the figure proposed by the NSC (*Legislative Gazette*, 89 (74), p. 13; 90 (1), p. 102).[68]

Whether it involves examination of budgets or deliberation over bills, the second reading plays a decisive role. A standing committee typically has around twenty members, which means that a handful of resolute legislators can amend or block government proposals. When the DPP became the incumbent in 2000 without a majority in the legislature, budgetary bills were particularly vulnerable.[69] In addition, strong subsidiary resolutions from the committee, attached to the budget bill, can have a profound influence on policy. Certain critical non-budgetary policy changes were in effect passed through this channel, such as the CSIST privatisation plan which was forced to be completed within three years, the re-engineering of the Development Centre for Biotechnology, and the focussing of research resources on earthquakes, global warming and acid rain (*Legislative Gazette*, 88 (30), pp. 113-15; 116-17). Limited by time, in the third reading, only a few previous resolutions containing high priorities are the subject of amendments. From this point of view, incisive debates and

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[68] However, this cut was also due to the deadlock of the ROCSAT-3 project at that time. See Chapter Six, F.

[69] Based on one committee resolution, in 2000, the legislature decided to hold back an allocation of approximately NT$4.4 billion (US$126 million) out of NT$5 billion (US$151 million) for FY 2001 Academia Sinica budget (*Legislative Gazette,* 90 (1). Pp. 99-100; 90 (5), p. 320; *Taipei Times*, 6 January 2001, no. 68606). The budget was not allocated until Yuan-tseh Lee delivered a report to the legislature later.

questions in the second reading form an effective arena for legislators to give voice to diverse public opinions and interests. Bargaining and the earmarking of funds, even for specified universities and institutes, are therefore openly expressed at this stage (for example, *Legislative Gazette,* 86 (44), p. 88; 88 (21), p. 211).

Policy Issues in the Legislature

An analysis of the content of legislative debates may help to demonstrate some trends found significant in relation to science-related policy changes. This section takes four committee questions on the second reading concerning affairs under NSC jurisdiction as a sample to reveal policy issues that legislators are concerned with. As mentioned, due to the sufficient time and the limited number of participants, questions and discussions during the second reading may reveal many sophisticated policy issues in width and depth. In particular, the following sample focuses on issues presented by lawmakers in the Education Committee right after the NSC performance reports, where policy issues are not confined to budgetary matters. However, after the setting up of the Science, Technology and Information Committee in 1999, committee deliberation has shifted to specific measures. A broad debate can only occur in a committee meeting after the annual NSC administrative statement, which has to be presented before examination of the budget. Thus the selected samples of legislative debates are committee questions immediately after the NSC performance reports of October 1991, September 1994, October 1997 and after the NSC annual statement of March 1999. The selected sessions are in a time sequence at about the midterm of four different NSC chairmen in the 1990s. Table 4.6 gives the results of the sampling, which is based on a total of 254 issues raised by a total of 65 legislators in four committee meetings.[70]

Table 4. 6 Issues in Legislative Committee Questions

No	Issues	1991	1994	1997	1999	Total
1	emphasis on basic research	--	4	2	--	6
2	scientific education	--	--	4	--	4
3	cultivation of talent	6	3	7	--	16
4	insufficient resource and budget for science	5	1	4	3	13
5	duplication of science administration	3	10	7	5	25
6	legalisation of scientific establishments	3	2	6	1	12
7	Efficiency and efficacy of NSC project review	4	1	1	7	13
8	bias of facility and resource distribution	1	1	3	1	6
9	funding biases in age, areas, and institutes	3	3	1	2	9
10	biases in peer review	5	7	2	1	15
11	quality control of public research	3	6	10	3	22
12	Research priority and directions		1	4	1	6
13	Personnel problems on satellite programme	1	6	2	5	14
14	Efficiency and efficacy of satellite policy	2	5	5	13	25
15	International scientific co-operation	--	--	2	--	2
16	Scientific reciprocation with China	5	4	2	3	14
17	Research on industrial applications	7	4	7	9	27
18	Promoting private R&D investment	--	--	2	1	3
19	Localisation of research	4	4	1	1	10
20	human concerns in scientific research	1	1	3	4	9
21	public access to research results	--	--	2	--	2
22	health and security concerns of research	--	1	--	--	1
	Total	53	64	77	60	254

Note: Issues directly concerning with the management of science park are excluded.
Source: *Legislative Gazette*, 80 (83), pp. 199-224; 80 (89), pp. 405-21; 83 (63), pp. 316-57; 86 (44), pp. 65-107; 88 (14), pp. 205-69.

First of all, the total twenty-two issues roughly cover the challenges and changes which the major scientific policy community have encountered, as discussed so far, indicating that legislators do convey significant issues onto the central policymaking agendas. The nature of the issues spotlighted, such as the administrative structure, the

[70] Coded in this way, the sample cannot exclude biases. Despite the continuing lack of professionalism on the part of legislators, extrinsic events, the definitions of issues, and the domino effect in questioning may affect the sample. However, without resorting to excessive statistical analysis, it is apparent that the sample does reveal

governance of science, and the application of science, suggests that they are interlocked just as science and politics are intermingled together (Table 4.6, no. 5, 11, 14, 17). Enormous pressure from legislators to question NSC capacity to harmonise and co-ordinate the national scientific establishment has highlighted the issue of the effectiveness of publicly funded research. In particular, suspicions have arisen about the NSC's power in contrast to the STAG, the Academia Sinica, the MOEA and the MND (Table 4.6, no. 5, 7). These concerns did not attenuate even after the promulgation of the Fundamental Science and Technology Act and the centralisation of science decision-making. When President Chen Shui-bian set up the Consultative Committee on Science and Technology under the Office of the President, legislators again proposed the strengthening of NSC power (*Legislative Gazette*, 90 (4), p. 99). They suspected that the centralised and non-statutory body might undermine the NSC's function and introduce much more political distortion. From the legislators' point of view, ill-organised synergy has been a factor that blocks national S&T development, when the boundaries between basic and applied science, and civil and military technology are increasingly blurred (Table 4.6, no. 4, 5, 6, 7, 8, 11, and 12).

Questions about scientific education (Table. 4.6, no. 2) talent cultivation (no. 3), budget allocation (no. 4), research quality (no. 11) and research priority (no. 12) drew attention in 1997, when Chinese overseas scientist Chu Li-wen won the Nobel Price. Anxiety about local scientific accomplishments was rekindled.

With the increasing importance of science in daily lives and society, the governance of funding regularly attracted the lawmakers' attention. While suspicion about the bias of peer review seems to have declined with reform (Table 4.6, no. 10), the justice and fairness of funding and resource distribution are likely to be kept on the

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some trends about issues raised in the legislative chamber.

agenda (no. 7. 8, 9, 12). For example, Kuo Nan-hung recalled that a crucial impetus for setting up the Southern Science-based Park was the legislators' great concern about the inequality of resource distribution between the south and the north (Kuo, 2000).

Considerations rooted in local identity have also been reflected in the issue of research localisation (Table 4.6, no. 19). Legislators now demand that scientific research should resolve Taiwan's local problems, from indigenous diseases to the mitigation of earthquakes, and also promote indigenous specialities, such as Chinese medicine and ocean ecology. This has led to a very conspicuous tendency: by contrast with the relatively sober voices on the supply side of the scientific establishment, such as basic research (Table 4.6, no. 1), education (no. 2), and international co-operation (no. 15), the demand side of pressures, such as industrial applications (no. 17), private R&D (no. 18) and project applications (no. 14), have increasingly gained in significance. In other words, legislator pressures have forced science policy to address a cost-benefit criterion. In particular, the link between scientific research and industrial applications has been the most heated issue in the chamber, reflecting not only the fundamental concerns of Taiwan's industrial structure, but also the increasing influence of industry. Given the lawmakers' intimate relationship with industry, business groups, and the local community, a sort of cross-party pragmatist viewpoint has formed shared values in the chamber (Hau, 2000, interview; Ker 2000, interview, Su, 2000, interview). Recently, several legislative motions have strongly signalled this tendency. The April 1999 motion to force the CSIST to devise a plan for its privatisation within three years, mentioned before, is a case in point. In a similar vein, in 2000, committee resolutions attempted to make 50 per cent of academic research funding and the entire Technology Development Programme subject to bidding (*Legislative Gazette*, 89 (75), p. 241; 90 (5), p. 309, 312;). Those moves highlighted a belief that the principle of cost-effectiveness was more important than peer review.

Problems of Legislative Professionalism

Given the pragmatist viewpoint of the legislators, issues regarding human concerns, ethical problems, and the public understanding of science have been raised only in a rather moderate fashion (Table 4.6, no. 20, 21, 22). It is not possible to discern from the data whether the above phenomenon is due to the ephemeral nature of issue-oriented social mobilisation or the lawmakers' lack of comprehension of the social impacts of science. However, bearing in mind that relevant issues have been formalised in various scientific regulations as shown in Chapter Three, it is striking to find that few issues in relation to scientific regulation are the subject of legislative questions. One reason for this is perhaps that lawmakers judge science-related issues from non-scientific perspectives and are therefore unable to raise such issues in debates on science policy. In other words, they introduce different values into science-related regulations, but the relationship between scientific validity and regulatory policies has not been fully recognised. Hence, although as already mentioned, progress in legislative professionalism is witnessed, lawmakers have not been sufficiently concerned about their competence to address the evaluation and regulation of science. For instance, in one case, without knowing the different functions of observation and communication satellites, one lawmaker used news reports to define his questions (*Legislative Gazette*, 88 (14), pp. 234-35). Early on, legislators applied civil service criteria to temporary research assistants who were subsidised by government-funded projects, and restricted their maximum tenure to three years (*SciTech Reports*, February 1994, p. 21). The side effects of this seriously impaired basic science research, most of which was done in universities and public institutes where there were insufficient formal research assistant posts. This in turn placed serious obstacles in the way of young researchers and technicians in their early careers since, in Taiwan, research assistant posts provide postgraduates with financial support and training. The aforementioned legislative attempts to set bidding as a funding mechanism, again, expressed their anxiety to tighten funding criteria and remedy the bias of peer review, and yet ignored possible side effects and interest interventions. This move shocked the scientific community and provoked severe criticism from 30 university presidents (Chen, Kuo-cheng 2000; Lin and Huang, 2001). Apparently, to deal with increasingly complicated science-related issues political power alone is inadequate and a standing advisory mechanism is needed. However, this has not been established so far. Although public hearings have allowed some progress, their functions have been limited by their lack of teeth even after improved legalisation (Office of the President, 1999b, art. 59).

The weakness of legislative professionalism is also related to the particular background of Taiwan's democratisation. As a central focus of the opposition movement, lawmakers, especially DPP representatives, from time to time brought Taiwanese-mainlander sub-ethnic problems into science-related debates, a unique dimension of the science policy debate in Taiwan's legislative sector. The ideas involved are not simply confined to upholding the political ideology of independence, but are transferred into a set of connected criteria concerning science policy issues. Issues such as research localisation, the fair treatment of personnel, the recruitment of overseas 'Taiwanese' scientists and security problems in scientific co-operation with China, are associated with political conflicts in relation to national and ethnic identity (Table 4.6, no. 13, 16, 19).

Table 4. 7 Issues in Legislative Committee Questions by Party

No	Issues	KMT	DPP	NEW	others	Total
1	emphasis on basic research	3	1	2	--	6
2	scientific education	3	1	--	--	4
3	cultivation of talent	9	6	1	--	16
4	insufficient resource and budget for science	7	6	--	--	13
5	Duplication of science administration	10	13	2	--	25
6	Legalisation of scientific establishments	6	5	1	--	12
7	Efficiency and efficacy of NSC project review	7	5	--	1	13
8	bias of facility and resource distribution	1	5	--	--	6
9	Funding biases in age, areas, and institutes	3	5	1	--	9
10	Biases in peer review	8	6	1	--	15
11	quality control of public research	7	14	1	--	22
12	research priority and directions	1	5	--	--	6
13	personnel problems on satellite programme	2	12	--	--	14
14	efficiency and efficacy of satellite policy	5	19	1	--	25
15	international scientific co-operation	1	1	--	--	2
16	scientific reciprocation with China	6	7	1	--	14
17	research on industrial applications	11	14	2	--	27
18	promoting private R&D investment	--	3	--	--	3
19	localisation of research	4	5	1	--	10
20	human concerns in scientific research	2	4	--	3	9
21	public access to research results	--	2	--	--	2
22	health and security concerns of research	--	1	--	--	1
	Total	96	140	14	4	254

Note: Issues directly concerning the management of science park are excluded.
Source: *Legislative Gazette*, 80 (83), pp. 199-224; 80 (89), pp. 405-21; 83 (63), pp. 316-57; 86 (44), pp. 65-107; 88 (14), pp. 205-69.

Coded by party category, Table 4.7 shows that the presentation of issues in the legislature has not been totally governed by party allegiance, although there is some variation between lawmakers with different party backgrounds. In general, DPP lawmakers, as the opposition, have paid more attention to dissent or issues which are neglected, such as public understanding of science, security problems in science, private research and research effectiveness (Table 4.7, no. 11, 14, 18, 21, 22), which helps to reflect certain emerging social concerns of science. However, at the level of specific projects, there has begun to be a marked disparity. In the dispute over personnel for the satellite programme, DPP lawmakers were particularly concerned with ethnic issues (Table 4.7, no. 13). As to the pros and cons of scientific reciprocation with China, KMT and DPP legislators were almost opposite to each other (no, 16). As a result, legislative deliberations on science policy have inevitably been distracted by political conflicts.

In sum, there is no doubt that legislators have played a powerful role in conveying diverse issues into the central policymaking arena. The legislative power as shown in many cases plays a crucial role outside the administration to cultivate science debates and to delineate social accountability in science. However, this has increased the need for professionalism on the part of lawmakers. Unfortunately, from the above analysis, it seems that the political power of the legislature has not been matched by its scientific authority. Today social demands from various interests require legislators to act not just as a carrier transmitting issues and ideas, but also as an arbiter of value. Thus, a challenging task for the future is to strengthen the professionalism and scientific validity of the legislature's participation in science policy.

C. Conclusion: Constructive Policy Issues

The analysis in Chapters Three and Four has demonstrated how with Taiwan's progress to democracy the power restructuring of different policy communities has gradually changed the policymaking framework and the principal policy considerations. Decision-making in science policy, which was once mainly dominated by political elites and economic technocrats, has been transferred to complex interactions among the lay public, the scientific community, industry, the legislature, and the science administration. In the process, the power restructuring of policy communities has redefined the relationship between science and society along with the interaction between the 'politicisation of science' and 'scientification of politics' and therefore generated an impetus to policy change.

With democratisation, the most conspicuous change was of course the emergence of a more pluralistic style of policy participation. We have seen that the general public has energetically raised issues concerning the social impacts of science, while the legislators have pressed the criteria of effectiveness and local relevance upon publicly funded research. The scientific community has actively involved itself in public affairs, and business influence has pervaded policy circles, searching for niches in knowledge production. Those actions may not appear in a systematic way, but they have proved to be politically effective. In a democratised society, the increased willingness and capacity of these policy actors to express their interests and concerns has imposed growing accountability upon science. This transformation is identified here as a process of 'politicisation of science'. Science-related policy demands have been raised with the relevant actors' increased participation in the political sphere and then developed into a set of policy justifications through the political system.

As a result, their voices have lead to the diversification of policy considerations. In addition to the traditional policy concern for industrial applications, bottom-up non-economic concerns about scientific impacts upon pubic daily life have been raised, including issues of health, ethics, environment, ecology, and human values. The scientists' active participation has generated reflections and challenges upon their own social responsibility. Issues concerning the social contribution of research have thus been raised. The legislators' pragmatism has highlighted problems regarding the cost-effectiveness of funding and the localisation of publicly funded research. Along with diversification, traditional policy considerations have faced new challenges. A link between science and industrial application has been demanded, in order to promote private R&D. The exploitation of dual-use technology has been put on the agenda and military R&D can no longer avoid civilian scientific scrutiny. Although some of the above issues might have been addressed before, they did not gain the momentum they have now until a fundamental shift in the balance of political power had taken place.

At the same time, the relationship between expert knowledge and political power has been part of the power restructuring process, producing a phenomenon of the 'scientification of politics'. The scientification of politics has developed with the increasing adoption of expertise in public debates, the expanding role of scientists in public affairs, the growing significance of basic research for industrial application, the increasing demand for legislative professionalism, and the institutionalisation of the science administration. In other words, the growth of the social accountability of science has interacted with actors' concerns with regard to scientific production and verification per se.

The increasing activism and autonomy of the scientific community has brought out issues about the rationality of government decision-making, the justice of funding, and the commercial exploitation of academic research. In the same dimension, the legislators raise concerns about the justice of resource distribution, the validity of peer review, the domestic achievement of scientific research, and the function of policy co-ordination. In particular, the NSC as a pillar of the scientific production system has dealt with funding procedures, project review, priority setting and controversy resolution. By appealing to scientific authority the NSC has increased not only its power in the political sphere but also autonomy and the obligation to ensure scientific achievement. To legitimate scientific values the NSC strives to improve the co-ordination, validity and achievement of scientific production.

Findings from the preceding two chapters thus delineate the changing relationship in Taiwan between science and society, and reveal several compelling trends of policy issues. The diversifying social accountability of science has obliged science policy to take account of new expectations with regard to the resolution of social, economic, and security issues, while the growth of scientific authority in society has led policy to respond to governance problems in relation to quality, and procedures and co-ordination of funding. Such policy issues therefore are the products of the continuous interactions between political and knowledge power.

CHAPTER V

Evolution of Science Policy

In the face of the growing concerns over the social relevance of research and the increasing demands for the validity and achievement of scientific production, Taiwan's science policy has been adjusted to facilitate both scientific authority and the social accountability of science. In this chapter, a systematic interpretation is given to demonstrate this transformation.

Focusing on policy changes, I start by providing an overview of Taiwan's science planning and its outcomes for the last decade in order to clarify the position of science policy in the national public policy sphere. Then, analysis is focused on emerging policy trends in the area of the governance of science, including scientific achievement, the validity of scientific practice, and the co-ordinating power of planning in the overall government context. I argue that the growing policy emphasis on science governance is accompanied by increasing demands for social accountability. Restricting the scope of observation to science policy, the analysis reveals that the reallocation of responsibilities has led to rather explicit policy direction in relation to the issues of private R&D, national security and the public good. The conclusion recognises that the above policy evolutions have converged towards integration, and to the better co-ordination of governance and delivery.

A. Overall Development

Governmental efforts and measures for scientific development have sometimes been described as 'ambitious' planning to achieve international status (Campbell, 1997, pp. 9-10). The importance of S&T development is constantly emphasised in the eloquent statements of politicians, to such an extent that it seems to have become an official slogan everywhere. Following previous initiatives such as the Six-year National Development Plan initiated by former Premier Hau Pei-tsun (1990-1993), and the Asia-Pacific Regional Operations Centre promoted by Premier Lien Chan (1993-1997), Premier Vincent Siew (1997-2000) pledged himself to construct 'A Science and Technology Island' (*China Times*, 3 April 1998). These plans relied largely on science and technology, although with different emphases across a range of public policy areas. In this climate, science and technology have been perceived as robust engines for driving national development and solving social and economic problems.

Planning and Legitimacy

The four national objectives for S&T development set out in the Long-term Ten-year National Science and Technology Plan of 1986 and re-emphasised throughout the 1990s were 'promoting economic development', 'enhancing the quality of life', 'establishing an autonomous defence capability' and 'raising science and technology standards'. However, the previous chapters have suggested that there is far more to the formulation of policy changes than coining a few slogans.

Since Premier Lee Huan (1989-90) authorised the NSC to prepare the 1991 Fourth National Science and Technology Conference, the leading role of the NSC in national S&T programming has been confirmed.[71] The agenda of the Fourth Conference was allegedly derived from the proposals of a wide range of representatives, including academics, industry, and agencies in almost 200 preliminary meetings. Yet it was agreed that the NSC agents and various department heads would still play core roles in filtering the issues and framing the agendas of the conference (Liu, 1991, p. 10; Wang, 1994, pp. 76-78, Lin, Fu-song 1995). Through the top-down and bottom-up negotiations, the conference itself validated the NSC's status as the highest authority for science administration. Based on the conference's conclusions, the NSC sketched out the Long-term Twelve-year National Science and Technology Plan in July 1992, as part of a much broader national development plan – the Six-year National Development Plan. While the Twelve-year Plan was set out as a blueprint, the Mid-term Six-year National Science and Technology Plan contained 299 specific sub-projects with twenty agencies involved in executing them (Executive Yuan, 1992a; 1992b). The plan topics covered nearly every dimension of S&T policy and related issues, including research infrastructure, basic research, applied technology, key components, talent cultivation, private R&D, the harmonisation of the humanities with science, and government support. In particular, the issues of science administrative management and harmonisation with the humanities were raised officially for the first time.

The Fifth National Science and Technology Conference of 1996 emphasised three agendas: the efficient treatment of S&T resources, the establishment of a high-tech innovation system and state modernisation through S&T (NSC, 1996c, p. I). As in the

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[71] The fact that Lee's endorsement was reiterated in several NSC official documents at that time showed that it was critical to the confirmation of the NSC position and the establishment of a policymaking convention, for example see NSC, 1991, p. 1. The Third Conference was the first case where the NSC was fully in charge of S&T

Fourth Conference, this conference again acted as a mechanism to address issues raised by various agencies and legitimised government policy directions. It highlighted several crucial issues, such as budget stabilisation, innovation legalisation, dual-use technology, frontier research, national-level projects and genetic medicine research. After the conference, a *White Paper on Science and Technology* was published for the first time in 1997, providing a far-seeing blueprint looking well into the next century.

In conjunction with the Fifth Conference and the White Paper, the NSC issued its Action Plan for Building a Technologically Advanced Nation in April 1998. Comprising eight strategies and 97 individual measures, the Action Plan sketched out a blueprint for national S&T development until 2010. Apart from existing policy measures, the National Information Infrastructure Programme was highlighted in the hope of linking research organisations, manufacturers, service sectors, science-based industrial parks, and science cities into an integrated network, making Taiwan a 'science and technology island' (Executive Yuan, 1998c, sec. 3).

After ten years of debate, consensus was finally reached on ratifying the Fundamental Science and Technology Act in 1999 with an eye to solving longstanding legal and administrative impediments, such as an unstable government budget, rigid regulations on the ownership of government-funded research results, neglect of social and environmental impacts, improper restrictions on scientists and technicians in the process of public sector recruitment (civic sectors and universities) and their inter-sector transfer (public vs. private and academic vs. business), and inferior incentives for overseas visiting researchers and specialists (Office of the President, 1999a, art. 1, 2, 3, 6, 8, 17). Based on the Fundamental Act, a series of subsidiary laws have been revised and implemented by a wide range of agencies, which are expected to overcome

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planning.

obstacles caused by existing regulations (*Liberty Times*, 30 December 1998, p. 9). The following provides an overview of the results of the above grand plans in terms of manpower, expenditure and research results.

Manpower

Based on an average growth rate of 10 per cent during the last two decades, manpower cultivation has increased dramatically. In 1998 the number of scientific researchers reached 64,699, compared to 10,419 in 1982; the number of full time scientific researchers accounted for 29.6 of each 10,000 population (see Table 5.1). The proportion of researchers holding a masters degree or higher rose from 34.9 per cent in 1989 to 46.4 per cent in 1998 (NSC, 1999a, pp. 32-33). With the proliferation of higher education and science-related institutes, the quantity of well-educated manpower is expected to expand further.

Table 5. 1 Growth of Researchers

Year	Researchers	Researchers per 10,000 population	Corresponding figures for Japan		Corresponding figures for U.K.	
1982	10,419	7	--	--	--	--
1985	20,074	10.4	--	--	--	--
1987	23,541	11.9	--	--	--	--
1990	32,910	16.2	--	--	129,000	--
1993	40,944	19.6	541,139	43.4	135,000	23.2
1995	54,280	25.5	574,501	45.8	148,000	25.3
1996	60,985 (57,368)	28.4 (26.9)	586,936	46.6	146,000	24.8
1997	64,580 (58,796)	29.8 (27.1)	606,784	48.1	--	--
1998	71,118 (64,699)	32.5 (29.6)	614,282	--	--	--

Note: Taiwan's figures after 1984 include researchers in the arts and social sciences; researchers in the military sector are excluded. For the purpose of comparison, estimated figures shown in parentheses are based on available data which exclude researchers in arts and social sciences.

Source: NSC 1993b, pp. 86-87; 1997b, pp. 15, 36-37; 1999a, pp. 15, 30, 63, 71, 130-31.

Research grant distribution and industrial recruitment, however, do not equally reflect such an increase, indicating Taiwan's structural weakness. Taking 1997 as an example, each researcher was granted only US$63,000 for R&D, while the corresponding figures in South Korea and Japan were US$102,000 and US$174,000 respectively.[72] In 1998, private industry, which employed 54.2 per cent of all the researcher population, enrolled just 9.4 per cent of total researcher population with PhDs (NSC, 1999a, pp. 28-29, 32). Both those facts imply that besides public funds, support for research from the private sector is rather limited and the gap between scientific education and industrial manpower demands has not diminished. The rapid expansion of high education raises another worry about quality control. Furthermore, there is a heavy reliance on the return of overseas Chinese scientists or excellent students with degrees or work experience abroad. If such recruitment becomes difficult, the relevant gains reflected above are likely to disappear (Swinbanks, and Cyranoski, 2000, p. 424).

Expenditures

By international standards, Taiwan's R&D expenditure is rather low. While the share of overall R&D spending in GDP was 1.39 per cent in 1989, most Western nations and Japan had already achieved 2.0 or even 2.5 per cent in the mid-1980s (NSC, 1996b, p. 24). In 1998, this share eventually crawled up to 1.98 per cent, still lower than whatever targets government had previously set (Table 5.2). In 1999, the government budget for S&T was just NT$44.8 billion (US$1,427 million). According to the

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[72] See NSC, 1999a, pp. 130-31. Note that Taiwan's figure includes researchers in the field of humanities and social sciences, so the accurate figure for scientists must be somewhat higher in view of the fewer funds received by researchers in arts and social sciences.

Directorate General of Budget, Accounting and Statistics (DGBAS), the science budget accounted for 4.4 per cent of total central government expenditure in 1999 (DGBAS, 1999). The 15 per cent increase per year in the government S&T budget, set out in the White Paper, has not been achieved (NSC, 1997c, sec.3.2; Table 5. 2). In other words, the priority given to science and research in budgeting does not reflect government slogans. In addition, once there is an overall stringency in the economy, government funds for research are vulnerable to reduction. The sharply declining growth rate of government spending on science during FY 1993-5 clearly illustrates the tendency (Table 5.2).

Table 5. 2 Overall R&D Expenditures

NT$ Million

FY	Overall R&D expenditure		% GDP	Government expenditure (Defence included)		Government expenditure (Defence excluded)	
		Growth rate			Growth rate		Growth rate
1989	NT$54,789	5.0	1.39	32,052	16.9	15,161	2.7
1990	71,548	30.6	1.66	37,986	18.5	20,320	34.0
1991	81,765	14.3	1.70	43,183	13.7	24,987	23.0
1992	94,828	16.0	1.78	42,713	-1.1	30,878	23.6
1993	103,617	9.3	1.75	42,167	-1.3	32,928	6.6
1994	114,682	10.7	1.77	40,971	-2.8	33,035	0.3
1995	125,031	9.0	1.78	41,247	0.7	32,931	1.8
1996	137,955	10.8	1.80	47,390	14.9	38,531	17.0
1997	156,321	13.3	1.88	48,229	1.8	39,822	3.4
1998	177,054 (US$5,495)	13.3	1.98	48,214 (US$1,496)	--	41,068 (US$1,294)	3.1
1999	--	--	--	51,807 (US$1,650)	--	44,805 (US$1,427)	9.1

Note: Figures include humanities and social sciences; government expenditures with defence R&D investment of 1998 and 1999 are estimated.
Source: NSC, 1997b, pp. 18-19, 146-47; 1999a, pp. 18-19, 124-25, DGBAS, 1998, 1999.

However, Taiwan's endeavour to invest in R&D continues to be evident. By

1998, total R&D expenditure amounted to NT$177 billion (US$5.5 billion) in comparison to NT$54.7 billion (US$2 billion) in 1989, representing a more than threefold increase and 15 per cent annual growth over the previous ten years (Table 5.2). In particular, private R&D expenditure surpassed public funds by a ratio of 6:4 in 1998, signifying the start of lively private R&D activity. The decline in public expenditure against private input does not mean a substantial drop in government investment. Rather, the decline caused by the shrinking military R&D budget was compensated for by increasing funds for civilian scientific research. As Table 5.2 shows, this fundamental budgeting restructuring took place during the first half of the 1990s. Of course, there is a gap between budget allocation and actual commitment of funds by government, which always provokes severe criticism from the scientific community.

Research Results

With the rapid adoption of Western techniques of research assessment, particularly under the NSC funding review and university merit-based promotion system, there has been a dramatic increase in the past few years in the number of scientific papers produced by Taiwan based authors. The output of papers in the Science Citation Index (SCI) from Taiwanese researchers leapt from just over 3,000 in 1991 to more than 8,000 in 1998, ranking Taiwan within the top twenty since 1994 (see Table 5.3).

However, the quantitative progress encouraged by a blanket award system does not necessarily bring about qualitative improvement. Research quality still remains low, at least in terms of its impacts or average citations per paper (*Nature,* 389, pp. 113-17). In fact, the government has recognised the importance of research excellence and adopted various strategies, especially exploiting strength in applied research to overcome the deficiency. Patent point statistics, compiled by the US Patent and Trademark Office, show that the number of US patents granted to Taiwan's inventors has grown every year (Table 5.3).

Table 5. 3 Science and Technology Output Indicators

Country	Year	SCI Papers		Patents Granted in USP	
			Rank		Rank
Taiwan	1990	2,724	27	--	--
	1991	3,247	25	--	--
	1992	4,359	23	--	--
	1993	4,767	22	--	--
	1994	5,802	20	1,814	7
	1995	6,555	19	2,087	7
	1996	7,392	18	2,419	7
	1997	7,742	19	2,597	7
	1998	8,592	19	3,805	5
S. Korea	1998	9,497	16	3,362	8
China	1998	16,559	12	89	27
Japan	1998	66,929	2	32,119	2

Source: NSC, 1999a, p. 146 (data from U.S. Patent and Trademark Office).

Whilst there is overall growth in manpower, expenditures and results, some defects and weakness are still visible. The evolution of policy, reflecting the strengths and weaknesses, constitutes the main focus of this chapter.

B. The Domain of Policy for Science

As shown in Chapters Three and Four, the various science-related issues, filtered through the power structure, virtually converge into two broad sets of concerns: the expansion of scientific authority in society and the growing accountability of science.

This section concentrates on the domain of 'policy for science' to shed light on how policy measures have been transformed in relation to the governance of scientific production and practice, when science has expanded its role in society and the social responsibility of science has increased and diversified.

This research identifies an explicit trend to enhance research achievement and scientific validity, representing a profound step in scientific development. Ensuring that scientific research works well is both a symbolic and substantial foundation for the justification of science policy. To initiate the active governance of science also means that the mechanisms and management of scientific practice will be reengineered with a view to meeting the diverse demands of policy communities. Three themes are presented to illustrate the policy change: the pursuit of excellence, the reform of funding, and the strengthening of co-ordination.

The Pursuit of Excellence

By the end of the 1980s, it was obvious that large scientific projects and facilities were gradually being established, with the help of outstanding overseas Chinese scientists. In addition to the Precision Instrument Development Centre, during the 1980s eight regional instrument centres had been set up under the aegis of the NSC in eight prominent universities to offer precision instruments for a variety of research in different fields (NSC, 1993a, p. 45). Moreover, approval was given for the establishment of five national laboratories, including the Synchrotron Radiation Research Centre (1983), the National Animal Breeding Laboratory and Research Centre (1988), the National Nano Device Laboratories (1988), the National Centre for High Speed Computing (1988), and the National Centre for Research on Earthquake Engineering (1989). In addition, several integration strategies were introduced, such as inter-university research, local S&T resource integration, and large integrated research (*NSC Monthly*, November 1987, p. 1752; May, 1989, p. 484-6; October 1989, pp. 813-14).

On several occasions, then NSC Chairman Hsia Han-min announced "the promotion of selected areas which fitted international standards and national demands" (*NSC Monthly*, August 1898, p. 823; February 1990, p. 174; Hsia, 1993, pp. 20, 67-70). What he intended, among other things, was to set in motion 'new' scientific research areas including space, ocean and synchrotron radiation. Examples are the enthusiasm for high temperature superconductor research in 1989, which resulted in the issuing of the Basic Research Programme for New Technology Development and Innovation and the return of Wu Mau-kuen, a prominent world-class scientist in the field. A goal was set to produce 25 to 50 patents through a five-year support programme, based on an annual fund of NT$50 millions (US$1.9 million) (*NSC Monthly*, September 1989, p. 995; *SciTech Reports*, January 1989, p. 3, 5). At about the same time, the NSC launched a space programme to explore another scientific frontier, which will be discussed in detail in the next chapter. However, at that stage, policy measures for pursuing excellence were not yet crystallised. For example, the fashion for superconductor research resulted from a contingent event – the discovery of 90k superconductivity by the US-based scientists Chu Ching-wu and Wu Mau-kuen. Later this sort of random selection of research was much less in evidence.[73] Yet, a series of systematic measures had been developed at the same period of time.

National discipline planning, which aimed to investigate manpower, resources, capacity, and research niches in each discipline and seek promising areas for research,

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[73] The superconductor research was somewhat downgraded by the termination of its special fund after 1994 (NSC, 1995a, p. 142).

was firstly conducted in 1986 with an eye to overcoming the weak foundation of basic research. The investigation initially focused on pure science, such as mathematics, physics, chemistry, earth science, atmospheric science and oceanography. This was important, because the results of the planning allowed scientific administrators to organise research teams and integrate resources in the direction of promising large-scale research. One NSC agent ascribed the initiation of large-scale earth science research to the results of the first discipline planning exercise (*NSC Monthly*, August 1989, p. 813). The first effort was then followed by the second large-scale planning exercise, a full-scale review and a re-evaluation in 1993, 1995 and 1996 respectively (NSC, 1997c, sec. 4.1).

Further strategies were developed in two related directions: 'integration' and 'excellence'. Regarding the former, since the end of the 1980s, the NSC has encouraged a series of large-scale integrated research projects which are characterised by team research, multi-participants (institutions) and interdisciplinary projects, especially in conjunction with topics or areas targeted by the NSC. To name conspicuous projects, for instance, in 1991 there were five-year projects relating to the project of the Kuroshiro Current and East China Sea Continental Shelf Exchange Process, and the Global Sea Circulation Experiment project in the area of oceanography, and integrated research on Chinese Huber, the Dengue Virus, and Hepatitis B in the medical sciences (NSC, 1992, pp. 86-88, 188-200). A consistent characteristic of those large-scale research projects was the focus on a combination of 'localisation' and globalisation. Since 1995, a kind of vertically- or horizontally-integrated research has been formally introduced into academic funding categories in which approved projects can incorporate several sub-projects and may be funded on a three to five year basis instead of being subject to annual grant renewal (NSC, 1995a, p.

15). One underlying consideration of this was to encourage team work, which had been less appreciated in the Taiwanese scientific community but is important in leading frontier research.

Regarding excellence, since 1997, the NSC has started to allocate a block fund for focused, cutting-edge research in the natural sciences, the so-called Frontier Research Programme (NSC, 1998a, pp. 125-26). The current targeted topics include number theory, non-linear systems, electronic systems, new chemical materials, chemical dynamics, sugar biochemistry, gene expression and control, neurology, aging and gerontology, structural biology and cognitive science (NSC, 1997c, sec. 3.2.3). In an interview, Steve Hsieh, former Vice Chairman of the NSC, addressed one of the topics in the following terms: "we ask ourselves who is there of world-class excellence in the life sciences in Taiwan?" (Campbell, 1997, p. 9) Under this scheme, selected proposals must fit with international standards and each recipient will be supported with a five-year grant of NT$3.5-8 million per annum (US$0.1-0.2 million), which represents three or four times the average level of grants (*Nature*, 394, p. 603). In addition, the Centre for Theoretical Studies and the Centre for Ocean Research have formally operated since 1997 in the hope of training outstanding young scholars and students to pursue basic research led by world-class scientists recruited from overseas (NSC, 1998a, pp. 59-60).

Those measures clearly indicate that scientific excellence has become a policy objective in order to justify science investment which fits with the increasing expectation of scientific values and verification in the public sphere as already outlined. Rather than appealing to immediate utility, pursuing excellence emphases scientific prestige, achievement and distinction. According to the White Paper, the perspective of the Frontier Research Programme is described as follows:

> It is hoped that these projects can make scientific breakthroughs, be published in prestigious international journals, win international awards, or result in the principal investigators being invited to international conferences (NSC, 1997c, sec. 4.1.1).

This marks a significant shift from the dominant policy idea of the 1970s and 1980s when the strong instrumentalist consideration of science for industrial upgrading pervaded policymaking circles. Attempts to pursue scientific excellence therefore cannot be understood merely as a logical step of intellectual development. They have to be attributed also to the transformation of policy actors surrounding scientific knowledge.

Can the administrative planning and assessment of elite scientists ensure the rationality of planning and the development of promising areas? Taiwan's recent initiative in gene research reveals the inextricable influence of political manipulation. After Lee Yuan-tseh, President of the Academia Sinica, called for more attention to be focused on biotechnology, prompting great anxiety from legislators and industry, President Shui-bian Chen promised a NT$10 billion (US$0.3 billion) annual budget for genome research (*Central Daily News*, 9 May 2000, p. 4; *Taipei Times*, 15 May 2001, no. 85851). However, due to the intimate relationship between Chen and Lee, the larger part of the fund has been earmarked by the Academia Sinica for its Genome Research Centre. Furthermore, the exceedingly dispersed research areas proposed by the Academia Sinica, an attempt to fit with its current capacity in biotechnology, threaten the ultimate efficacy of Taiwan's genome research (Chou, 2001).

Funding Reform

To direct research towards excellence, not only is a set of programmed strategies necessary but also the institutionalised mechanisms of scientific practice are involved. Only in the last decade have Taiwan's funding mechanism been fundamentally reformed. As shown in Chapters Three and Four, the funding mechanism reform occurred due to the increasing autonomy of the scientific community and science administration. However, any attempt to change the funding system – the material base and the essential mechanism of the social institutions of science – is seen as a challenge to scientific integrity and autonomy. Contests among interests and ideas are thus inevitable.

The focus here is placed on the Science and Technology Development Fund of the NSC. This is a major source of funds for the subsidising of academia in which the majority of scientific research is produced. The NSC does promote a set of mission-oriented projects in its own right. But this fund is significant in also providing material support for academic research and more so in granting scholarly prestige and assuring research autonomy, which distinguishes it from other agencies' sponsorship. The distribution of this fund is one of the central tasks of the NSC. In FY 1998, the fund, which reached over NT$10 billion (US$0.3 billion), represented nearly 68 per cent of the NSC total budget (*NSC Monthly*, October 1998, p. 1251).

As shown in Chapter Three, although funding effectiveness was constantly addressed in order to encourage excellence, the fundamental defects concerning obscure criteria, lax fund distribution and biases in the peer review had not been fully resolved in the 1980s. A serious reform agenda was established at the end of the 1980s. However, the implementation was sluggish.[74]

An essential reform took another four years to achieve. In 1993 and 1994,

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[74] Chou Mei-chu, an agent of the NSC, ascribed the halfway reform to an 'immature reform environment' (*NSC Monthly*, December 1995, p. 1114. See also Chapter

extensive, if not fundamental, changes eventually took place (*NSC Monthly*, October 1993, pp. 1149-50). It was announced that Awards would highlight the high quality of research, while Assistance would encourage officially focused projects or large-scale integrated research (*NSC Monthly*, December 1993, pp. 1335-36). By applying a different set of criteria to each of the two different schemes, a strict demarcation between 'Research Grants' (now Research Awards) and 'Project Assistance' was established, and project support seekers could no longer acquire a personal bonus (award) on the basis of their proposals.[75] This meant that NSC funding took a further step towards supporting excellent research, departing from its previous role of providing financial aid. The optimisation of funding was further addressed by several measures, including terminating the poorly defined 'Excellence Award',[76] adding an integrated research category into the Project Assistance scheme to encourage large-scale co-operative research, appending Special Contract Research (with special multi-year grants and a monthly NT$20,000 personal bonus, approximately US$750) to the Project Assistance scheme to stabilise research funds for successive (three times) Outstanding Category winners, and streamlining the accounting procedure in order to improve the efficiency of funding (NSC, 1996a, pp. 18-19; *NSC Monthly*, December 1995, pp. 1114-15). Figure 5.1 outlines the current NSC dual funding scheme.

Three's relevant discussion.

[75] See NSC, 1995a, p. 18, *NSC Monthly*, December 1995, pp. 1114-15. The term 'Research Grants' was replaced by 'Research Awards' to fit the reform's purpose. However, as discussed in Chapter Three, the substance of the scheme remained a bonus for research performance.

[76] The Excellence Awards were granted to those whose research performance scored in the top 5 to 15% of overall winners of Ordinary Awards in each discipline at professor and associate professor level. However, this obscure category situated between the Outstanding and Ordinary Awards was precarious and always caused

Figure 5. 1 NSC Dual Funding Schemes

Project Assistance

General Projects:
individual research and integrated research (one- to three-year projects)
Special Contract Research Projects:
a multi (three)-year project subsidy plus a personal award for successive (three times) Outstanding winners
Young Investigator Grants:
for young scholars who have assumed teaching or research positions within the last five years
Pioneer Projects:
innovative research meeting international standards

Research Awards

Ordinary Awards:
one year grant of NT$144,000 for applicants in professor, associate professor, assistance professor, or corresponding posts; one year grant of NT$90,000 for lecturers and research assistants; block grants for young investigators

Outstanding Awards:
selected from top 5 per cent of Ordinary Awards winners; two-year grants totalling NT$600,000

Source: NSC, 1999b; 2000b

More significantly, several advanced measures were introduced into the funding evaluation process, including an appeal procedure, a referee system, regulations to deal with conflicts of interest, and public information on review commentaries and panel reviewers (*NSC Monthly*, December 1993, pp. 1336-41; NSC 1995a, pp. 15-19; NSC 1996a, pp. 18-19). Figure 5.2 illustrates the process of funding evaluation. Those measures represent clear commitments to diminishing funding cronyism and peer review bias, and introducing transparency.

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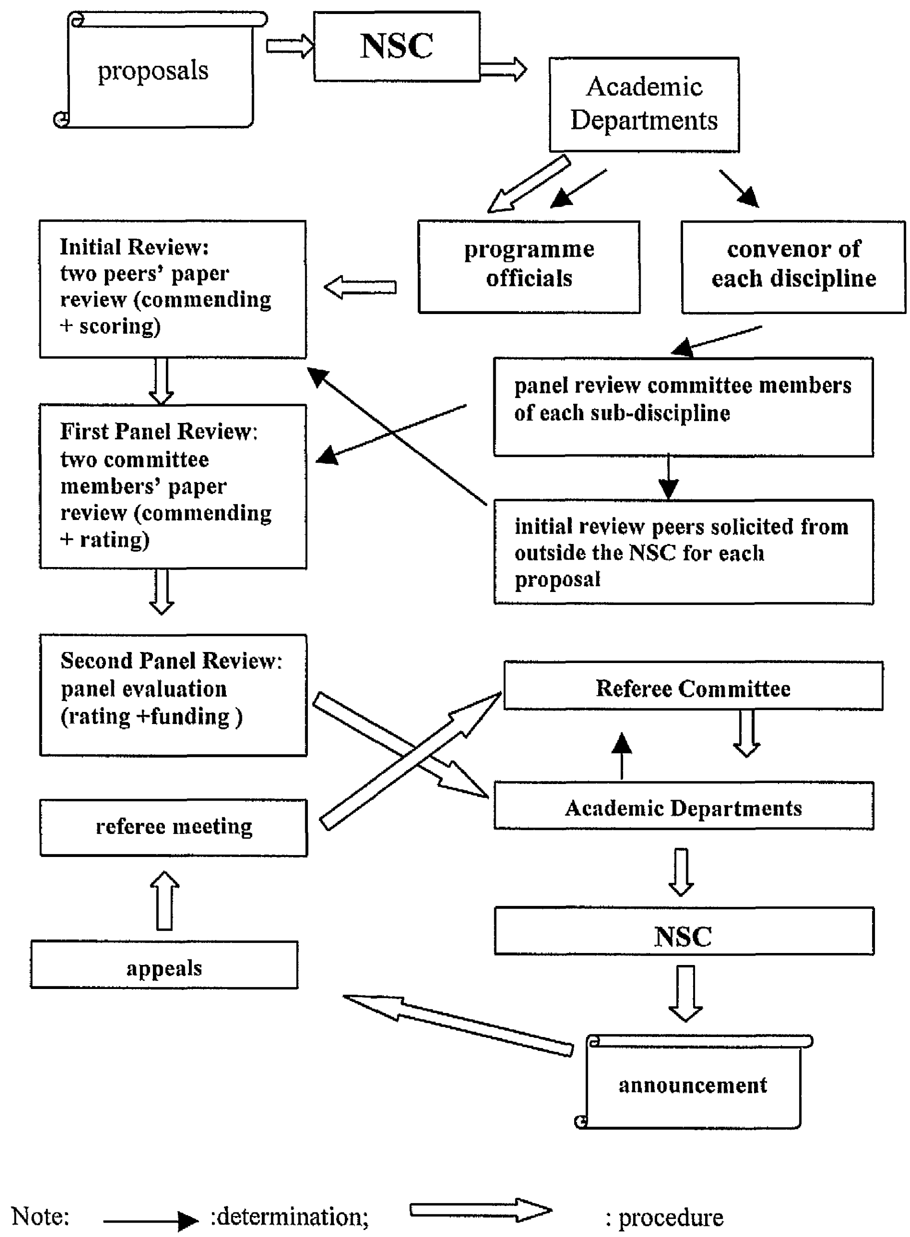
scepticism (*NSC Monthly*, December 1995, p. 1113).

Figure 5. 2 NSC Peer Review Procedure for Project Assistance



Source: NSC, 1999b, 1999c.

Later, to optimise the research environment for excellent research, some additional measures were brought in, including setting up special grants for young investigators, opening multi-year grants for all types of research proposals, and relaxing restrictions on multiple project applications (*NSC Monthly*, November 1996, pp. 983-84; also see Figure 5.1). In this way, relatively rational arrangements and norms have been institutionalised into the process of knowledge production. Accordingly, the current funding system and peer review procedures are formulated as shown in Figures 5.1 and 5.2.

Today, the principles of NSC evaluation are so influential that they have spread to the evaluation practices of other agencies, universities and funding institutions. However, the funding reform has not proved able to remedy entirely the still fragile scientific ethos and the intrinsic inadequacy of the peer review.[77]

In Taiwan, these difficulties are exacerbated when evaluation on merit, bibliometric measures, and the pursuit of excellence are emphasised on one hand, and the number of researchers and institutes increases rapidly on the other. When the number of grant recipients is declining in a system with a relatively high proportion of applications funded (see Table 5.4 and 5.5), disappointments and humiliations generated by intensive competition and excessive expectations naturally frustrate a relatively large proportion of the research population.

[77] The problem has been pointed out in many studies. A comprehensive account can be found in Chubin and Hackett, 1990, although their proposals are of debatable merit.

Table 5. 4 NSC Project Assistance Outcome

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000
Total Proposal	7,302	8,501	9,946	10,976	11,302	13,758	15,596	16,044	17,466
Approved (%)	81.9	81.1	76.5	74.2	75.7	72.3	66.1	64.8	62
Funded (%)	--	--	--	--	--	--	50.3	50.1	48.3
Funds (NT$ billion)	4.02	4.38	4.75	5.14	5.01	4.37	6.21	6.66	7.10
Grants per Proposal (NT$1,000)	67.2	63.4	62.5	61.6	58.5	48.9	60.3	64.0	65.6

Note: Lacking complete data, figures for 1992-1997 are inferred from the five major funding departments of the NSC.

Source: *NSC Monthly*, April 1996, p. 288, 290; November 1999, p. 1362; NSC 1998a, pp. 17-18.

Table 5. 5 NSC Research Awards Outcome

FY	1985	1991	1992	1993	1994	1995	1996	1997
Total Applications	--	--	--	--	--	--	9,121	8,780
Ordinary Award	2,480	3,864	4,270	4,552	4,040	3,436	4,852	4,512
Excellence Award	--	479	527	583	619	516	--	--
Outstanding Award	77	126	136	139	150	142	108	110
Award Rate	--	--	--	--	--	--	54.4	52.6

Source: *NSC Monthly*, December 1995, p. 1116; November 1997, p. 987; NSC, 1996a, p. 33.

Thus, early suspicions regarding the old boy network, cronyism and prejudices still remain in the scientific community (Su, 2000). On the floor of the legislature, the NSC chairman is still besieged by allegations of funding discrimination and biases, especially in relation to the researchers based in the rural and southern areas and private universities.[78] The NSC can hardly ignore those criticisms, since the institution

[78] For example, see *Legislative Gazette*, 86 (44), p. 105; 87 (7), pp. 69, 100; 88 (14), pp.

of peer review and the funding system were based on the devolution of administrative power, as shown in Figure 5.2 above. A recent conspicuous case occurred when under the Pursuit of Excellence Programme for University Research, an extra fund worth NT$13 billion (US$0.4 billion) was made available by the Ministry of Education and the NSC. When they were invited to express their opinions on the legislative floor, most presidents of private universities claimed that this programme had been deliberately earmarked for prestigious professors and public universities in view of the rushed decision process, the clandestine release of information, the rigorous evaluation criteria and the high entry cost (*Legislative Gazette*, 88 (5) pp. 313-18).

In response, the current selection and appointment of convenors and panel reviewers for each discipline were cautiously balanced by factors relating to length of tenure, geographical dispersion, private-public institutional affiliation and professional competence (*NSC Monthly*, November 1999, pp. 1358-59).

The issue of abolishing the Research Awards scheme, which had been said to encourage short-sighted track record production and reduce willingness to undertake more complex investigations, has not been resolved (Tseng 2000a; *SciTech Reports*, February 2000, p. 24; Liu, 2000). Investigators are still keen on the Research Awards and complain about the declining award rate. Although such voices are rather subdued in the climate of the pursuit of excellence, from time to time they appear in the media and the Legislative Yuan. Despite its cautious orientation (*SciTech Reports*, June 1996, pp. 10-12; *Legislative Gazette*, 87 (7), p. 69), the NSC has recently been forced by pressure for reform to place the issue under review again (NSC, 2001). However, the NSC will not make a reckless decision. Here the dilemma between excellence and mediocrity in the funding system is evident.

238, 266; 88 (24), pp. 174-76.

In retrospect, the above reform undoubtedly displays a farsighted improvement in the hard core of scientific production. It is fair to say that any government strategy for science promotion will be pointless, if shortcomings in the internal assessment mechanism remain untouched.

Co-ordination Capacity

Having the power to direct, manage and regulate knowledge production also implies that the science administration will inevitably expand its jurisdiction both vertically and horizontally. As discussed in Chapter Four, while there are several government agencies in charge of R&D to different degrees and for different purposes, the NSC is constantly struggling in its overall co-ordination role to respond to various social expectations. Significantly, the science agency bears great responsibility not only for scientific promotion but also for the accomplishment of political ends.

As mentioned, the essential predicament of the NSC's jurisdiction is that on the one hand it has the responsibility to assess and co-ordinate overall national scientific development, while, one the other, the NSC itself is just one ministry-level agency whose authority is subject to the collective decision-making of the NSC Board, made up of various ministers. Therefore, despite being the seemingly highest level of science administration, the NSC can be easily manipulated or isolated by strong agencies such as the MOEA and the MND, or powerful scientific institutes like the Academia Sinica. Therefore, critics constantly wonder whether, institutionally, a science ministry or even a higher authorised independent organisation is needed in order to legitimise the mechanism for the co-ordination of national science policy.[79] Although it is naive to

[79] Particularly during and after the Fifth National Science and Technology Conference of 1996, the debates heated up again. The detail can be found in legislative

presume that an independent ministry can produce a better performance, the NSC does face legitimacy problems.

The government's review of science projects is an administrative task which organises scientific experts to evaluate, co-ordinate and oversee whole government science projects. It has been granted to the NSC since 1980 (Executive Yuan, 1979, sec. 2.1). During the 1980s, the NSC helped various ministries and departments to set up and run their own evaluation systems. Up to 1990, a two-stage review mechanism was developed; at the first stage, each department was responsible for its own project evaluation and priority setting; then those 'major' projects worth over NT$10 million (US$0.4 million) in a single financial year were reviewed by the NSC at the second stage, where the NSC asked scientists to determine the efficacy, feasibility and coherence of various government projects. Finally, the NSC would send the Executive Yuan a synthetic proposal concerning major government project priorities and budget appropriation (*NSC Monthly*, May 1989, pp. 453-56). After the Executive Yuan's final scrutiny and budget allocation, certain major agency-sponsored projects were selectively placed under the supervision of the NSC on the authority of the Executive Yuan.

In principle, this task relied on review scientists' micro and macro knowledge and capability to pin down duplication, to decide priorities and to optimise resource distribution. In practice, it required the means and political leverage to intervene in the jurisdiction of other agencies. Unsurprisingly, NSC in-house reports constantly revealed that the NSC was not powerful enough to do the job properly (*NSC Monthly*, May 1989, pp. 456-57; April 1990, pp. 419-33; May 1993, pp. 478-79). Certain

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questioning (see, for example, *Legislative Gazette,* 85 (48), pp. 433-82) and different scientists' comments (see for example, *SciTech Reports*, September 1996, pp. 10-12;

agencies could secure their projects and budgets after NSC rejection via the Minster without portfolio responsible for S&T (the head of STAG since 1990) or the head of the DGBAS.[80] It was not even compulsory for those agencies to accept the verdict of NSC review. In fact, the NSC had no power to terminate projects on which performance was poor. Furthermore, the review did not cover NSC-funded projects, partial industrial technological research, and research conducted by the Academia Sinica and the MND.

Without the power to allocate resources, then, technical review was meaningless. Given existing institutional restrictions, the NSC tried to consolidate its authority by changing the review procedure. In 1993, it required that departments' annual S&T budgets should be submitted alongside their annual S&T projects. The NSC review would then proceed on the basis of overall national S&T budgeting, which was subject to the deliberation and the consensus of a meeting at deputy minister level with the NSC Board (*NSC Monthly*, April 1994, pp. 284-91). In this way, the NSC attempted to keep departmental project budgeting under supervision before going on to S&T project reviews. However, the effectiveness of this was limited, because the S&T budget was determined by the bargaining between each agency and the DGBAS. The NSC was inevitably inclined to produce a recommendation based on technical rather than policy/political merit. Friction and strife were thus unavoidable, though they surfaced in a subtle form (for example see *NSC Monthly*, April 1994, pp. 300-301).

In 1996, with the Executive Yuan's support, and Chairman Liu Chao-shiuan's strong advocacy, a breakthrough occurred. Firstly, the national S&T budget as a whole

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February 1997, pp. 5-7; March 1997, pp. 14-16).

[80] This was particularly the case when the NSC Chairman and the Minister without portfolio did not get along, as with the friction between Hsia Han-min and Kuo Nan-hung. See the related discussion in Chapter Four, A.

would now be assessed as an appropriation that could only be released with the endorsement of the NSC review and the NSC Board (*NSC Monthly*, October 1998, p. 1248). In line with this, the STAG, the DGBAS, and the Ministry of Finance were formally invited to play a role in the review process. Equipped with budget control, the NSC could now use its power to subject agency-sponsored projects to expert review. Furthermore, in 1998 the S&T projects of the Academia Sinica and the MND began to be reviewed by the NSC, although still in a limited way (NSC, 1998a, pp. 27-28). To safeguard its legitimacy, the NSC's own mission-oriented projects were also obliged to compete with other agency-sponsored projects in the review system (*NSC Monthly*, August 1999, p. 842).

Secondly, the Science and Technology Development Fund has been transformed into a cyclical fund since 1997 (NSC, 1998a, p. 16), which gives the NSC the leverage and flexibility to assist any agency-sponsored project without regard for annual budgeting restraints. This leverage together with the above budgeting control enhances the NSC's capability to oversee long-term government scientific investment. Now relevant agencies are asked to stretch the period of their S&T budgeting and scientific projects to a four-year base as a result of which policy coherence and resource integration can be further enhanced by NSC review (NSC, 1998a, pp. 25-27; Executive Yuan, 1998a). Major agency-sponsored projects worth NT$0.1 billion (US$3 million) can now be given the go-ahead before the year of execution of the project (Executive Yuan, 1998b, art. 3.5).

Thirdly, to consolidate the NSC's co-ordinating power, Chairman Liu Chao-shiuan particularly stressed the restoration of the functions of the NSC Board (Liu, 1997; *Legislative Gazette*, 85 (48), p. 437). In his view, instead of creating a scientific ministry, the focus should be on effective integration.[81] In a legislative debate, he contended as follows:

> Seemingly, a single ministry for S&T might achieve centralised control. Yet S&T everywhere is sponsored by various agencies. It is impossible to promote S&T through a single agency, because a range of policy instruments employed by different agencies are needed to back up the scientific establishment. Therefore, the most important issue here is how to integrate those diverse resources (*Legislative Gazette*, 85 (48), p. 437).

The link between science and society, scientific expertise and administrative responsibility, the government scientific establishment and national goals has so far been resolved, then, by way of NSC review. Yet it is not clear how far this institutional arrangement can be sustained.

In Taiwan, the increasing desire and expectations for applied science have further strengthened centralised policy control. So, we witness that a cabinet-level S&T Meeting was set up in June 1998 as already mentioned. Headed by Premier Vincent Siew, the non-statutory meeting also aimed to integrate and direct national S&T development. In November 2000, similar to the S&T Meeting, a new Consultative Committee on Science and Technology consisting of 12 convenors and groups was established by President Chen Shui-bian and headed by Vice President Annette Lu, despite criticism from Lee Yuan-tseh, the President of the Academia Sinica, and other

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[81] The issue of creating a scientific ministry did appear on the agendas of the Fourth and Fifth National Science and Technology Conferences and was conceived as a crucial dimension in the Six-year Projects (Executive Yuan, 1992a, p. 3_17). In fact, a piece of special topic research funded by the NSC managed to clarify the predicament of the NSC authority and the feasibility of setting up a new scientific ministry (*SciTech Reports*, February 1997, p. 7).

scientists.[82] The tendency towards centralisation suggests that demands for justification and rapidly rising expectations have compelled top political leaders to take direct charge of S&T planning. Here a mixed phenomenon has emerged. In line with this tendency, it is expected that the NSC will gain considerable political support in implementing scientific promotion and come under direct pressure to make scientific research socially accountable; yet scientific planning will become vulnerable to partisan considerations and the encroachment of political interests, which ironically undermines scientific authority in decision-making and limits the functions of the NSC.

Measures addressing scientific values, scientific validity and policy co-ordination have gradually justified and strengthened scientific authority in policy domains. In the process, science policy has built up its own content and territory, set science up as a long-term enterprise, and moved away from being a merely subordinate instrument serving industrial development. At the same time, the ongoing centralisation also implies that the evolution of science policy is attributed not only to supply side concerns but also to broad expectations of utility accentuated by societal diversification. Thus we see that the power to make decisions over science policy has been moved to the top of the executive in order to orchestrate the best outcomes for science production. Enormous social obligations have been imposed on science along with the construction of scientific authority and the science establishment. In the next section, we shall see how science policy has been driven to fulfil other domains of public policy.

[82] See Wang, Chien-chuang 2000. The major goals of the Task Force for the most part duplicated and violated those of the NSC (Huang, 2000).

C. The Domain of Policy through Science

To draw out policy trends towards the strengthening of scientific authority is not to suggest that Taiwan's science policy has developed along a clear-cut and self-sufficient trajectory. In Taiwan, there is no such era as the triumph of big science which once took over in Western countries. Rather, confined by cross-strait stalemate and the economic structure, Taiwan's science policy had stood in a subordinate position for a long time. Those constraints thus constituted a significant background to the changes of Taiwan's science policy over time.

Yet again, as repeatedly emphasised before, different perceptions of science applications parallelled with the restructuring of policy actors' power have redefined the relationship between science and society. Hence, in the domain of 'policy through science' a set of new policy directions has emerged with the diversified and expanded expectations of scientific knowledge. However, the more intense the expectations of science, the more unavoidable the ambiguity between science and its utilisation.[83] This section reveals how science policy has been driven to address private sector R&D, national security and the public good in order to reflect the changing social desires discussed in Chapters Three and Four.

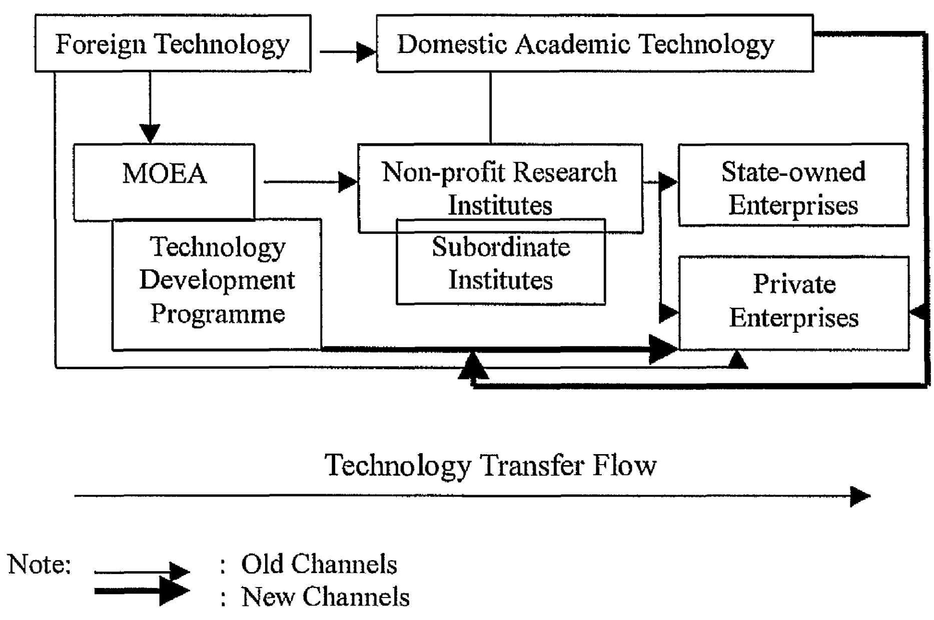
Encouraging Private Research

In Chapter Two, I have shown that the diversification of overall S&T policy during the 1970s and 1980s had an intimate connection with the elite idea of technology-push for economic development, the result of which provided firm ground for boosting high-

[83] Ziman once argued that "the prime characteristic of a basic research project is that it is not directed towards such benefits at all, and thus has no definable social or

tech industry later, particularly in the fields of information and semiconductors. S&T in Taiwan thus generally appeared to be related to its high-tech industry. The inseparable structure of science and the state-led economic structure is particularly obvious when looking at Taiwan's hybrid institutional arrangements: the MOEA is in charge of the dynamics of Taiwan's most powerful applied research institutions – the ITRI and the III, while the NSC manages Taiwan's locus of high-tech production – the HSIP. However, it is naive to presume that the linkage between upstream scientific activities, midstream applied research and downstream utilisation and commercialisation has been well harmonised.

Figure 5. 3 Industrial Innovation System for Technology Transfer



The formulation of the technology-push strategy has been mainly used to address the essential weakness of Taiwan's industrial structure. The SMEs, as the majority of

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technological merits in itself" (1984. p. 163).

industrial entities, have notoriously been either unwilling to undertake R&D or incapable of doing so. Over the past two decades, a unique industrial innovation system has been in place, as illustrated in Figure 5.3, to help technology transfer for local firms. Under this innovation system, industrial technology research was largely embarked on by non-profit research institutes under the sponsorship of the Technology Development Programme of the MOEA. Those institutes acted like mediators to exploit and develop useful know-how or near-market advanced technology into something that might be of use or interest to domestic industry. This system together with various incentives and government ventures created critical forces in the successful restructuring of Taiwan's industry.[84]

As shown in Chapter Three, however, this industrial innovation system might remedy Taiwan's inferior industrial structure but not necessarily enhance technological competence. While Taiwan's private enterprises gradually became involved in innovative research with their increasing political influence, they questioned the efficacy of technology transfer channels that had so far been entrenched in the state-led innovation system. They demanded more flexible and open government assistance and co-operation with academic research in order to obtain direct benefits and technology niches. New channels were placed in the policy agenda, as indicated in Figure 5.3.

As to the linkage between academia and industry, suspicion surrounded the question of whether domestic S&T capability had been fully explored though those intermediary institutes and officially targeted projects that were totally based on

[84] According to the statistics of the Taiwan Institute of Economic Research, the relative proportion of technology-intensive product exports climbed from 25.72% in 1990 to 35.07% in 1995, and the proportion of high-tech product exports climbed from 35.87% in 1990 to 45.50% in 1995 (NSC, 1997c, sec. 2.4.2).

marketing considerations.[85] According to Professor Yang Deng-kuei's account, the academics working on industry-related R&D sponsored by various measures of the MOEA were rather few, with less than 1 per cent of the population of relevant academics (1994, p. 38). In other words, after so many official clichés and numerous capital investments, the relationship between academia and industry remained surprisingly detached. Despite assistance offered by the NSC, the outcome of diffusing academic research results was small. During the period 1987-1992 total patents acquired from NSC funding projects numbered just 114 (*NSC Monthly*, July 1993, pp. 644-47). In the period 1990-1992, only seven research outputs were directly transferred to local firms, while just one was marketed in 1993 (*NSC Monthly,* September 1993, pp. 1069-72). Taking advantage of its control of the science-based park, the NSC launched its Regional S&T Resource Integration Programme during the period 1987-1992 in response to the advocacy of the National Industrial General Union to promote integration between local universities, firms and local governments (*NSC Monthly*, May 1989, pp. 484-86). Yet the programme also faced difficulties in building mutual trust and interests (Lee, 1998, pp. 34-35).

Since 1990, there has been a clear policy shift towards emphasising private R&D, marked by various industrial upgrading measures, such as the Statute for Upgrading Industries and the Regulations Governing Assistance for the Development of Leading New Products initiated by the MOEA in 1991. For absorbing advanced technology, in addition to measures regarding consortia, offset programmes of public procurement, and government-funded private research, policy issues relating to academic-industrial co-operation again became the subject of heated debate.

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[85] Lin Chung-hsi pointed out that in fact those research institutes were never concerned about the linkage between basic science and industrial technology, according to their

In this atmosphere, in 1992, the NSC initiated Academic-Industrial Co-operative Research Projects. In the next year, a task force was set up to encourage academics and private firms to involve themselves in joint research projects. This research was characterised by explicitly mission-oriented three-year integrated projects, joint academic-industrial personnel, a public-private joint contribution (85:15%), project evaluation by industry, awards as encouragement for researchers, and special incentives for employing PhD investigators in the contracted firms (*NSC Monthly*, September 1993, pp. 833-34; NSC, 1995b). The participating private firms could either apply for non-exclusive licensing, or for three- to seven-year exclusive licensing if contributing over 30 per cent of total research funds; the private firms had to pay a licensing fee and royalty for access to technology after it was developed; 50 per cent of related profit was distributed between the NSC and the firms according to their contribution proportion while another 40 per cent went to the researchers and 10 per cent went to the participating university (NSC, 1995b). By 1997, the NSC had given support of over NT$1.45 billion (US$45 million), while enterprises had invested nearly NT$0.4 billion (US$12 million), 21 per cent of the total contribution (Lee, 1998, p. 11). In the period 1993-2000, 107 projects were approved through which 59 items of technology were transferred to private industry (see Table 5.6). As for the Academia Sinica, 10 patents had been approved in the US three years after the set-up of its technology office in 1995 (Swinbanks and Cyranoski, 2000, p. 419). Before that, the academy failed to secure a single patent.

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public statements (1995, p. 14).

Table 5. 6 Results of Academic-Industrial Co-operative Research Projects

Year	Projects Applied for	Approved Projects	Approved Patents	Technology Transfer
1993	7	7	--	--
1994	18	17	2	--
1995	23	17	20	4
1996	43	22	13	7
1997	14	11	13	11
1998	23	13	10	16
1999	12	13	13	11
2000	24	7	34	9
Total	164	107	105	58

Source: *NSC Monthly*, December 2000, pp. 921-27.

Interestingly, while the idea of academic-industrial collaboration triumphed and various strategies were introduced, suspicion that scientific funds might find their way into applied research also arose during the period 1993-5.[86] This again revealed the rift between science and its application, as mentioned in Chapter Three.

The evidence indicates that the rise and fall of applications for the Academic-Industrial Research Projects roughly reflected the serious tightening of the S&T budget during the period 1993-1995 (compare Tables 5.1 and 5.6). This implies that the search for funding, rather than the existence of a mature interactive network and a co-operative culture, was the crucial impetus behind projects in this initial stage.

In addition to restating support for basic science pending the dispute, the then NSC Vice Chairman, Hu Ching-piao, made clear the considerations underlying the co-operative research: "the NSC had been distressed in competing for resources with

[86] See *NSC Monthly*, November 1994, pp. 1509-13, 1529-38; *SciTech Reports*, February 1994, pp. 1, 9, 19, 21; July 1995, p. 20; December 1995, pp. 4-5. See also the related discussion in Chapter Three, D.

other agencies while confronting constant suspicion about whether NSC funding could contribute to the economy" (*SciTech Reports*, October 1995, p. 1). The pressure referred to by Hu mainly came from the legislative floor.[87] With an increasingly stringent budget, scientific officers took advantage of the favourable political climate to create the legal framework for exploiting the availability of academic research (*Legislative Gazette*, 85 (48), p. 447; Lee, 1995, p. 21).

When drafting the Fundamental Science and Technology Act, which humiliated the MOEA's fruitless ten-year efforts at deliberating on similar legislation, the NSC set out to galvanise the interaction between academia and industry. Heavily influenced by the legislators' pragmatic approach, the Fundamental Science and Technology Act clearly defined guidelines regarding the release of publicly funded research results to private firms, institutions and individual researchers (Office of the President, 1999a, art. 6). Based on these guidelines, the NSC made its funding project results, other than restricted by special contacts, freely available to participating academic institutes (*NSC Monthly*, September 2000, p. 734). Given its status as a fundamental law, profound effects are expected from it. In 2000, an amendment was issued to further expand academic-industrial research, which included extending the funding scope from pre-market research to directly applied technology, devolving industrial partnership contract selection to researchers, relaxing the technological threshold of participating firms, releasing research results to individual academics, and raising industrial contributions to 25 per cent in the hope of meeting the World Trade Organisation's regulation with regard to future market competitiveness (*NSC Monthly*, December 2000, pp. 921-22).

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[87] For example, 12 out of 26 lawmakers talked about the linkage between basic research and industrial technology when the legislative debate on scientific affairs

Regardless of the conflicts in value, the trend towards academic-industrial collaboration is overwhelming. In fact, the above academic-initiated collaboration mirrors a broader co-operative approach in the second half of the 1990s. Since 1996, the pillar of state-led technology strategy – the Technology Development Programme – has been opened to private-initiated co-operative research through which certain technology demanded by firms can be quickly put into the innovation process (MOEA, 1996, art. 15-17). By 2000, over 46 'incubators' promoted by the MOEA had been set up around the island, 41 of them located in universities and colleges (NSC, 2000a, pp. 33-35). This managerial strategy fosters not only a private disposition towards R&D, but also academic entrepreneurship. To boost this trend, the NSC issues a *Booklet for Researchers in Spin-off Business* and offers assistance with patent exploitations (NSC, 2000a). Significantly, a new challenge arising from the new wave of higher education reform in which universities have to be self-sufficient in revenue as shown in Chapter Three, has driven university managers to seek financial resources through a variety of channels, and has associated universities with private firms, leading towards a relationship of mutual dependence. Among other things, exploiting academic knowledge via research consortia, strategic alliances, centres of excellence, venture funds and spin-off firms has increasingly boosted the entrepreneurship of universities.[88] In this regard, policy measures encouraging private research are

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took place on 30 September 1996 (*Legislative Gazette*, 58 (48), pp. 433-82).

[88] For example, in January 2000 the first University Business Research Centre was set up in Chiao Tung University on the basis of collaboration between the university, local government and local firms, IBM, and HSIP (*Central Daily News*, 12 January 2000, p. 4). The biggest ever donation, worth over NT$0.7 billion (US$21 million), went to Chung Hsin University to build the first University Chip Design Centre in central Taiwan (*Central Daily News*, 14, December 2000, p. 4). While Taiwan University venture capital largely relied on donated funds, Tsing Hua University created the best Incubator on the island, and Cheng Kung University has set up four venture capital funds by exploiting university-owned intellectual property and

expected to expand further.

From 1999, according to the Government Procurement Law, the contracting of overall agency-sponsored research has to be based on a bidding process. This change represented a prelude to a new wave of conflict between scientific autonomy and social accountability (*Liberty Times*, 5 July 2000, p. 6). Academicians in the Convocation of 2000 denounced it by asking: "can knowledge be bidden?" and "do not purchase our research!" (*United Daily News*, 4 July 2000, p. 6) However, a recent legislative move has diverted all 'funded' projects subsidised by the Technology Development Programme to 'sponsored' projects which are then subject to contract bidding; and a similar move even places NSC funding projects under threat (*Legislative Gazette*, 89 (75), p. 241; 90 (5), pp. 309, 312). These moves will inevitably divert public funds from government-sponsored institutes to private research units and universities, and introduce principles of market value, cost-profit effectiveness, and quality control into both scientific research and technological innovation. It is apparent that the benefit of private interests will continue to be a principal policy justification, and science policy has to face the challenge of balancing knowledge production and its economic utilisation.

Bearing Security Responsibility

National security has long been a central consideration for Taiwan's overall public policy from defence, diplomacy and the economy to education, but historical constraints have cast a veil of mystery over the relevant domestic decision-making. In S&T, as we have seen, military technology activities were almost segregated from

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academic-industrial research (*Central Daily News*, 23, November 2000, p. 6; 31 January 2001, p. 6; *Commercial Weekly ePaper*, 27 April 2000).

national scientific or technological activities. Although there is some evidence to suggest that the civilian scientific base has played a role in the activities of military R&D, the characteristics of most such activities did not go beyond domination by the elites, and dependency on the US and an insulated military technology system. This section draws out certain changes in civilian policy measures relating to national security issues, including international co-operation, the cross-strait relationship and defence technology.

With the dramatic socio-economic changes taking place alongside the growing strength in science administration, science policy in relation to security concerns has become more active, systematic and diverse. The salient policy change first appeared during the last quarter of the 1980s, when the NSC took an active approach to establishing scientific relations with Europe. From 1988 to 1991, the NSC expanded co-operative scientific relations with the Austrian Science Foundation (FWF, Austria), the Swiss National Science Foundation (SNSF), the Swedish Natural Science Council (NFR), the Irish Science and Technology Agency, the Netherlands Scientific Organisation (NWO), the Royal Society (in the UK), and the International Foundation for Science (*NSC Monthly*, December 1990, pp. 1835-39; NSC, 1993a, pp. 54-59). The overthrow of the Soviet Union and the Eastern European communist regimes brought another strong thrust in Taiwan's expansion of external scientific relations. In 1991, science co-operation agreements were signed with the Hungarian Academy of Science (HAS), the Czech Academy of Science (ASCR) and the Russian Academy of Engineering.[89]

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[89] *NSC Monthly*, October 1990, pp. 1428-31; August 1991, pp. 1082-83; October 1992, pp. 1407-8. Regarding the possibility that high-tech products might flow into the then Eastern European communist bloc by way of Taiwan, the US had actually asked Taiwan to sign a Products Export Control Agreement at that time (Hsia, 1990, pp.

The European Community (EC) was another partner that Taiwan could not afford to ignore. The NSC started collecting information about the EC and its single market issues and tried to approach Luxembourg for exchange of data and reports (*NSC Monthly*, December 1992, pp. 863-64). Confined by China's intervention and lacking a traditional relationship, even in the matter of science co-operation, building up relations with European countries and the then EC was never easy. Of course, those efforts were not solely relevant to scientific affairs. A significant consideration underlying the new actions was how to facilitate 'scientific diplomacy'. One NSC officer explained the situation as follows:

> In view of the current EC emphasis on local industrial technology, it is not the best channel for scientific interchange. Furthermore, as the EC has become a crucial political platform, China's intervention is expected, so our attempts to establish a substantial relationship with the EC face difficulty. Still, S&T looks relatively neutral and is a better means to overcome the current obstacle. Thus, if scientific diplomacy is set as a goal, economic benefit can be sacrificed (*NSC Monthly*, May 1992, p. 600).

Not all these new relationships did go as smoothly as expected. For example Taiwan-Russia academic reciprocity was impeded by political turbulence in Russia, while Taiwan-Germany scientific interchanges were hindered due to lack of government-level support during the first half of the 1990s (*NSC Monthly*, August 1994, pp. 966-67). However, while cross-strait stalemate did not fundamentally change, scientific relations did secure or even create alternative windows for contacting the outside world. In addition to the prevalent climate of international reciprocity, the

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1644-45).

success of the above outward looking policy inspired Taiwan's science administration to further extend its international scientific relations. The S&T Groups, overseas accessory units of the NSC, extended to Brussels in 1993, and London and Ottawa in 1995 (NSC, 1996a, pp. 61-63). Now, Norway, Finland, Poland, Australia, New Zealand, Vietnam, the Philippines, Indonesia, Latvia, and the Ukraine have formal scientific interchanges with Taiwan. The number of co-operative counterparts has reached a total of 54, most situated in the United States and Europe (*NSC Monthly*, October 2000, pp. 739-40). In FY 1999-2000 international scientific co-operation based on bilateral and multilateral agreements involved the spending of over NT$20 million (US$0.6 million), with activities ranging from personal exchange visits and conferences to research projects.

The development of domestic scientific excellence has also pushed forward this trend towards in-depth international research co-operation. A recent example is that the impressive results of the Taiwanese team working on high-energy research have attracted Japanese attention over the last couple of years, as in the case of B factory international research (*NSC Monthly*, September 2000, pp. 694-704). As a result, a project for a high-energy synchrotron radiation beamline co-produced by Taiwan and Japan was initiated in December 2000, marking the first time that Taiwan managed to break China's diplomatic embargo to forge a joint venture with Japan in the high technology field (*Taipei Times*, 16 December 2000, no. 65710).

Theoretically, addressing Taiwan's security problem through international co-operation is less effective than through direct communication with China. Before 1990, only prominent overseas Chinese scientists had the privilege of moving across the Taiwan Strait. In the progressive climate of cross-strait dialogue, academic exchanges and direct visits by China's scientist began to be seen during 1992-4, and gradually came to form a crucial government measure in cross-strait interaction (*NSC Monthly*, December 1995, p. 1127). Thereafter, the NSC's position in mitigating cross-strait tension became much more active. For example, even immediately after the serious 1996 Taiwan Strait missile crisis, the NSC implemented the deregulation of general visiting by China's scientists, whereas previously only Chinese scientists taking part in Taiwan's research were allowed (*NSC Monthly*, December 1997, p. 924). The next year, regulations on subsidising China's visiting researchers, supporting Taiwanese scientists' resident research in China, and sponsoring cross-strait academic conferences were also promoted (*NSC Monthly*, December 1997, pp. 924-27). The collaborative activities included disaster prevention, medical sciences and global climate change, as well as general basic sciences, humanities and social sciences. This shows that scientific interchange has played a relatively active role in crisis mitigation. However, in-depth co-operations were absent from the above repertoire of interchanges (*China Times*, 27 October 1999, p. 8). Some reasons for this were the sensitivity of some scientific fields in both official-run education and research systems, but even more important was the setback to cross-strait talks prompted by increased Taiwanese demands for a independent status in international society.

President Lee Teng-hui's 'don't be hasty, be patient' and 'southward policy' conducted with the hope of diverting domestic attention from China to Southeast Asia, as part of the intricacies of cross-strait relations, affected not only political and economic policy but also the direction of research. In his first speech on the legislative floor, Lee Yuan-tseh, President of the Academia Sinica, highlighted Southeast Asia as a vital research area and a partner in the future research activities of that institute (*Legislative Gazette,* 83 (21), pp. 324-25). Dancing to the same tune, the NSC financed a series of integrated researches on relevant topics, such as South Sea research and

Southeast Asia regional studies (*NSC Monthly*, December 1994, p. 1722; November 1998, pp. 1388-92).

What was striking was that such localisation and Taiwanese-centralised orientations were likely to extend to the hard core of scientific research and thus serve a political ideology. In recent years, the upsurge of genetic research on Taiwanese ethnic origin is one salient example. Based on current linguistic and archaeological evidence and theories, Taiwan's various aborigines are regarded as the origin or part of the large Austronesian family comprising 1,200 languages, possibly the largest family among the 6,000 languages of the modern world (Diamond, 2000). This has triggered Taiwanese scholars in various disciplines to rush to explore the above hypothesis by using genetic analysis. By emphasising hybridity or origin, some, such as Professor Chen Shuen-sheng and Doctor Lin Ma-li, go further to infer that current Taiwanese ethnic groups have diverged from the Han ethnic group which represents the major population in China (Chen, 1996; *Central Daily News*, 29 April 2001. p. 4). Are such research interests free from the influence of the old hegemony or do they embrace it in a new paradigm?

Closely associated with the above cross-strait issue was the autonomy of military technology. Although the concept of civil-military integration was far from novel, the integration that took place during the 1980s largely conformed to the MND's calculation of the demands of military operations and progress in arms procurement. Any violation of the segregation of civilian and military R&D systems was unthinkable (NSC, 1996c, p. 115).

With democratisation, the power of the military has sharply declined in the broad political context. In addition, a new policy priority focusing on public welfare and the economy has led directly to severe cuts in the military budget, which have seriously affected the prospects of military R&D, as shown in Table 5.1 above. The budget crisis of military research, aggravated by the opening of the opportunity to procure F-16s and Mirage 2000s in 1992, forced the CSIST to reduce its isolation and start a new phase of civil-military technology integration, as already mentioned (Wu, Huang, Sung and Yung, 1995, p. 9_49).

In 1991, the NSC sensitively invited military delegates to attend the Fourth National Science and Technology Conference, despite the lack of any special topic concerning military R&D (*NSC Monthly*, February 1991, pp. 236-37). Also in the Fifth Conference in 1996, there were two topics directly related to issues of military technology development in which the topic of converting the CSIST into a non-profit research organisation was raised (NSC, 1996c, pp. 115-31). A proposal for a Dual-use Civil-military Technology Development Fund to the value of NT$0.1 billion (US$3 million) was rapidly agreed by the executive and the legislature in 1994 in order to speed up the spin-off of CSIST technology. Since 1994 the MND has been forced to adopt several unprecedented measures including technology conversion, the provision of facilities, the extension of manufacturing, and offset programme stimulation and privatisation, which have almost entirely restructured the military R&D system (MND, 2000, sec. 3.2.1-2).

Strongly driven by the need to seek funds and marketing niches, the above strategy led the MOEA and MOTC rather than the NSC to be major allies of the MND and the CSIST in dealing with the exploiting dual-use technology.[90] The interface

[90] At a very early stage, it seemed that the reorganisation of the CSIST to exploit dual-use technology still needed the NSC chairman's consent (Wu, Chen and Wei, 1995, p. 9_38). However, due to budget stringency, the NSC did not fund CSIST's first year (FY 1995) dual-use technology research proposals, while the CSIST obtained funding for six projects from the MOEA to the value of NT$216 billion (US$8 million) and for seven projects worth NT$102 million (US$4 million) from the

between military technology and academic science is still maintained by the Defence Technology Academic Co-operation Scheme initiated in 1985. Judging from recent activities in the scheme, co-operative funds for promoting military-related academic research from the NSC and the CSIST accounted for NT$120 million (US$3.8 million) in FY 1999 (*Legislative Gazette,* 88 (28), p. 178). The scale, of course, appeared rather small in comparison with the dual-use technology collaboration between the CSIST and the MOEA/MOTC, which obtained over NT$1.5 billion (US$46.6 million) in FY 1999 (*Legislative Gazette,* 88 (28), p. 177).

Nonetheless, the NSC did assert its authority over the MND at the science administration level. The lack of civilian scientific review of military projects had subjected every NSC chairman to a barrage of questions from legislators. Eventually, with the restructuring of the military research system, Chairman Liu Chao-shiuan successfully brought the Minister of National Defence onto the NSC Board in 1997 and the NSC was then authorised to review military research projects and the CSIST's internal evaluation system (NSC, 1998a, pp. 24, 28). Restricted by security classifications, the NSC review has so far covered 15-17 per cent of military research projects at a cost of around NT$500 million (US$15.5 million).[91] This arrangement has a two-way impact. On the one hand, military research is no longer all kept top secret due to the greater level of screening by civilian scientists. On the other hand, the NSC, as the highest national science administration, is now obligated to take overall security considerations, including military technology autonomy, into account when plotting

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MOTC. The areas included aerospace, automatic machinery, electronics, optics, special chemicals, materials, quality engineering, GPS, high-speed craft, autonomous navigation, and geographical data integration (Wu, Chen and Wei, 1995, p. 9_40; Yang, 1995, p. 9_72).

[91] So far, only military technology categorised as 'secret' has been subject to NSC review (*Legislative Gazette,* 88 (28), p. 177).

national science policy.

Above all, there is a fundamental dilemma regarding the institutional adjustment of military R&D. That is, how to tap the benefits of military technology without losing the national autonomy of defence R&D. Having converted the AIDC to a state-owned company and opened three sub-institutes of the CSIST to deliver technology services for private firms, economic agencies seem very keen to push forward the transformation of the CSIST into a 'full non-profit research institute', embracing both civilian and military R&D (Chen, et al., 1998, p. 119). Moreover, a decision has been made by legislators to demand that by 2003 the CSIST finds a proper approach to restructuring itself into a non-profit institute (*Legislative Gazette,* 88 (30), p. 114). As mentioned, the MND has rejected the proposal of a full restructuring plan for fear of losing R&D autonomy after privatisation.[92] To compromise, the NSC has advocated 'partial restructuring' which has so far been reflected in the White Paper and the Action Plan, although how market- and mission-oriented functions are to be co-ordinated in one research organisation has not yet been settled (*Legislative Gazette,* 88 (28), p. 179; NSC, 1997c, sec. 3.2.12; Executive Yuan, 1998c, sec. 6.6). All this implies that the NSC has actually been involved in controlling the development of military technology at national policy level.

Expanding the Public Good

The all-out pursuit of economic development imposed from the state apparatus has

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[92] See Chen, et al., 1998, p. 119. In fact, a side affect of the commercialisation of military technology has emerged. The CSIST has recently withdrawn from the MOEA-sponsored wireless communication programme after near forty researchers in the array radar unit, part of the Sky Bow air-defence missile programme, transferred to the private sector, which represents a serious threat to the progress of the CSIST's main projects (*Yi Guang*, 1 January 2001, p. 2).

also spawned increasingly powerful social movements drawing nation-wide attention to issues such as welfare, health, the environment, and ecology. I have argued that this public awareness has given a strong momentum to constituting the public good as a significant and explicit aspect of science policy. This section aims to illustrate the development of this policy trend. Of course, the meaning of the public good is always vague, and, as I have demonstrated, is subject to a specific social context and policy actors' interpretations. However, the fluid, sometimes manipulated, contents do not overshadow a clear tendency for policy legitimacy to revolve around a set of non-economic social concerns.

Through the 1970s and 1980s, the eight areas defined as national research targets (energy, materials, information, automation, biotechnology, opto-electronics, food technology and hepatitis prevention) were heavily inclined towards industrial upgrading, although they contained implications for public health and quality of life. According to Lin Chung-hsi's in-depth studies, even in the case of hepatitis prevention, the NSC's vigorous support as well as other agencies' efforts were strongly associated with the inauguration of Taiwan's biotechnology and pharmaceutical industry (1994, pp. 97-199). Therefore, the inclusion of further key areas, namely disaster prevention and environmental protection technology, in the 1986 Long-term Ten-year National Science and Technology Plan, marked the moment when the consideration of science policy for the public good was put into practice rather than being a mere political slogan.

Similarly, while the then NSC Chairman, Kuo Nan-hung, once admitted that the benefits of academic research into earthquakes and geology were not properly utilised, now earthquake research has been selected as the subject of an inter-departmental National-level Project (*Legislative Gazette*, 82 (61), p. 423; *NSC Monthly*, August

1997, pp. 543-49).

On another aspect, the idea of "broadening science education and public awareness" was clearly expressed in the Long-term Ten-year Plan to "win public support for government efforts in scientific development," which in a sense strongly exposed the government's patriarchal attitude to the matter of the public understanding of science (Executive Yuan, 1986, p. 6; Lee, 1991a). However, in 1991, comprehensive measures were stressed in the Mid-term Six-year National Science and Technology Plan, such as adding social concerns to science policy, balancing education in the sciences with that in the humanities, strengthening the interaction between science and society, exploiting science for the public wellbeing, and encouraging culture-embedded innovation and the public understanding of science (Executive Yuan, 1992a, pp. 9_1-13). All the above have constituted a new and significant dimension to Taiwan's science policy evolution in the 1990s.

Close examination indicates that NSC funding of environmental conservation research increased to NT$110 million (US$4 million) distributed over 188 projects in FY 1991 while in FY 1984 the relevant figures were NT$12 million (US$0.3 million) and 48 projects (*NSC Monthly*, July 1992, p. 858). In 1988, the NSC launched a task force to advance large-scale projects on environmental conservation in which emphasis was particularly placed on solving the practical problems of the urban environment and the prevention of industrial pollution. Environmental concerns became one of the crucial criteria in funding projects.

The NSC's task force for Global Change was also formed in 1991 to team up scientists to engage in long-term ecological research in conjunction with projects of the International Geosphere-Biosphere Programme and the World Climate Research Programme, including the Past Global Change project, the Taiwan Station of the

Climate and Air Quality project, the Tropical Ocean-global Atmosphere Experiment project and the project of the Kuroshio Edge Exchange Process. In the period FY 1992-1994, those projects were funded with over NT$0.2 billion (US$7.5 million) (*NSC Monthly*, July 1994, p. 839). The effect of such endeavours has of course been immense. For example, the original limited research in relation to forests has been advanced to the extent that Taiwan's scientific teams are now capable of embarking on long-term forest ecology research (*NSC Monthly,* September 2000, pp. 682-83).

In 1991, 'social impact' started to be brought into the NSC review criteria to evaluate the official scientific projects proposed by various agencies (*NSC Monthly*, May 1993, p. 474). In addition, the NSC initiated a one-year science-humanity dialogue forum during 1996-1997 to galvanise public discourse about science-related issues, such as the Internet, medicine, sexuality, culture, language, the humanities and so on. Several science-society-integrated research projects have been set up in the following areas: cognitive science, scientific impacts on daily lives, human capital cultivation, science-related crime and legal problems (NSC, 1997c, sec. 3.2.9).

More recently, the above mentioned global change, environmental research and society-related studies have been integrated into a new phase of research schemes – Sustainable Development. In 1997, the Executive Yuan set up the National Sustainable Development Committee to organise relevant mission-oriented projects. Those projects were based on three pillars, global change, environmental conservation, and social impacts, and have been establishing a set of integrated indicators, an assessment system, and a foresight model as guidelines for future national development (*NSC Monthly*, August 1999, pp. 921-24; January 2001, pp. 5-8). From issue-concerned research to the establishment of a mission-oriented model, the scheme reflects a systematic policy effort to address the principle of the public good.

In a wider context, the tendency for policy to harmonise science, the public good and economics is particularly salient in recent government endeavours to support the biotechnology industry. Although the versatile use of biotechnology had been recognised since the early 1980s, the results of relevant government measures have proved disappointing, in contrast to those of electronics industry policy (Hung, 2000b, p. 8). In the last five years, however, the government has shown a strong commitment to bolstering biotechnology research and related industry by drafting a promotion plan, setting up the National Health Research Institute, and investing start-up funds of NT$20 billion (US$614 million) over the five years since 1997 (*Taipei Times*, 29 October 1999, no. 8631). As to research policy, the NSC has selected agricultural biotechnology and pharmaceutical biotechnology as two out of four National-level Projects. Gene research, now set as a Pioneer Project receiving NT$400 million (US$12 million) in funds from the NSC and the Department of Health (DOH), will be upgraded to a National-level Project in 2001 (*Central Daily New*, 13 February 2001, p. 3). Despite still being surrounded by suspicion and uncertainty,[93] all these government actions suggest that biotechnology has now become an officially targeted sector. In view of the increasing impediments to balancing growth and conservation, the biotechnology industry is considered by policymakers to be a promising sector that fits their social and economic goals as well as to taking advantage of prospective gene science. Yin Chi-ming, Vice Minister of the MOEA, once legitimised these government initiatives by claiming that "increased government spending on biotechnology is part of our bid to develop Taiwan into a green silicon island" (*Taipei*

[93] The potential failure of these efforts in biotechnology is again rooted in Taiwan's industrial structure, the dilemma of inferior private R&D and the low level of harmonisation of up-, mid-, and down-stream linkages which other sectors confront (*Taipei Times*, 29 October 1999, no. 8631; Hung, 2000 a; 2000b; 2000c).

Times, 4 December 2000, no. 64145). Such considerations are based on an assumption that the biotechnology industry, unlike other industries, is of advantage to the environment, human capital, and public health and is thus less controversial in operation. A newly initiated effort on genome research, accompanied by research into social, ethical and legal impacts, has also focussed on Taiwan's high rate diseases, such as liver cancer, nasopharyngeal cancer and black foot disease (NSC, 1997c, sec. 4.11.2).

Furthermore, the principle of the public good has also been introduced in regulatory policy domains. As shown in Chapter Three, more comprehensive science-related regulatory measures have been adopted in a wide range of public policy areas throughout the 1990s. In 2000, the NSC managed to amend the Guidelines for Genetic Recombination Experiments that were first issued ten years ago, to expand the scope of the regulations from micro-organisms to genetically modified organisms, embryonic stem cells and host-vector systems in view of the flourishing of genetic research and increasing related concerns (NSC, 2000c; *NSC Monthly*, September 2000, pp. 708-9). In the same year, a specialist review committee and a regulation were set up by the Council of Agriculture to monitor the farm trail of genetically modified plants (Council of Agriculture, 2000a; 2000b).

Apparently, the policy trend has reflected a set of non-economic science-related concerns and values in response to the continuously redefined relationship between science and society in the democratised and pluralist environment. However, as we have seen, the process of redefinition has taken place more in the political arena than through debates among scientists, and substantial policy measures designed for the public good have largely relied on the interpretation of government officials and scientists. This is particular evident in the regulatory policy domain. For example in formulating the government regulation on genetically modified products, mild terms such as 'genetic decoration' (hsiu-shih) or 'genetic improvement' (gia-liang) were officially preferred to 'genetic modification' (gai-tsao) or 'cloning' (chuan-chih) in order to secure public confidence (*NSC Monthly*, September 2000, p. 709; NSC, 2000c; *Central Daily News*, 22 September 2000, p. 4). Despite the fact that some review mechanisms have involved non-scientists, most governmental reviews and evaluations are based on elite scientists' insights and deliberations, rather than investigation or survey by authorised external scientific institutes. In the cases in which external investigations were involved, such as nuclear energy and space policies, agency-sponsored research and evidence unhelpful to the government were routinely covered up.[94] As a result, only in a few cases have full-scale reports or evaluations been conducted that can be publicly accessible and put under external scrutiny. The immature nature of civil society and the still shallow scientific base make those defects more serious. In the case of labelling food with genetically modified ingredients, the regulation of the Department of Health (DOH) appeared to be so authoritative that previous public suspicions were assuaged, as already mentioned. In extremely controversial cases, these 'player as arbitrator' mechanisms have been prone to failure in providing conciliation and communication functions able to earn public trust.[95] Entwined deeply within governmental administration, scientific advice lost its independent character and acted as an endorsement for official decisions in the name of scientific validity.

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[94] See *SciTech Reports*, January 2001, p. 6 and Chapter Six, E.

[95] One aspect of this problem is that leading scientists and their research themselves might have violated or neglected human values and ethical issues. For example, in certain genetic research the blood and DNA of aborigines were obtained without informed consent (Chen, Shu-cho 1998; *Taipei Times*, 29 August 2000, no. 50974; *China Times*, 6 July 2000, p. 15).

Therefore, with the increasing impact of science upon daily lives and human values, it is urgent to improve the current formulation of science policy, in particular when the public good has been an important justification for it.

D. Conclusion: Integrated Policy

The above analysis reveals that Taiwan's science policy over the last decade has made a great advance in two directions. One is to set scientific development as a target and to place the emphasis on scientific excellence, credibility, and governance; the other is to respond to diversified social demands and extend the role of science to address private R&D, security issues and the public good.

It should not cause surprise that conflicts might be found between the two policy trends or even in different measures within the same trend, especially in micro-level decision-making. For example, the tension between basic science and research for industrial applications as seen in the controversy over academic-industrial co-operative research; or the tension between scientific excellence and the effectiveness of public science investment prompted by pragmatic legislative pressure.

However, the two policy trends reflect the underlying impetus of policy changes as a continuous interaction between the growth of scientific authority and the expansion of the social accountability of science. The development of the two trends is therefore far from unconnected. In recent years, the integrated consideration of policy and resulting measures has lead to a convergence of the two policy trends.

The National-level Projects provide a good example of the convergence. The subject of National-level Projects was brought up in the Fifth National Science and Technology Conference immediately after Chairman Liu Chao-shiuan came to office. Observation of the well-tailored project definition and procedure in the Discussion

Outline of the Conference (NSC, 1996c, pp. 139-56), indicates that the concept of National-level Projects reflected the prudent deliberation of government scientists and the science administration for the purpose of raising scientific standards and enhancing the effectiveness of funding resource. To prevent the contests for resources and ostentatious programming seen in other grand plans, the projects employ a comprehensive and rigorous funding procedure based on peer and merit reviews. The projects are substantially directed by an approved master research plan, carried out through a principal researcher, a programme office, research teams, and an advisory group, and monitored by an internal consultant team, an inter-department steering committee (consisting of representatives from government, industry, and academia), and the NSC Board, and finally appraised by external (overseas) experts (NSC, 1997d, *NSC Monthly*, November 1998, pp. 1383-87; NSC, 1998c). In their responsibility for project and personnel selection, the NSC Board and the inter-departmental steering committee have to integrate the diverse interests of national goals, social welfare and the long-term autonomy of technology. The approved projects, so far including the National Information Infrastructure, Disaster Mitigation, Agriculture Biotechnology, and Pharmaceutical Biotechnology, all involve strong social relevance and social concerns, or include ethical and legal sub-projects, and at the same time target certain crucial promising frontier technologies, including, for example, international mobile telecommunication 2000 (IMT-2000), real-time seismology, biochips and genetically modified aquatics. The presentation of scientific advances and the fulfilment of social demands together constitute the main elements of the National-level Projects.

It should be emphasised here that while democratisation offers the channels for introduction of new policy issues and justifications, given the still immature and fragile status of knowledge power across society, the scientific administration plays a decisive role in the nourishment, governance and demonstration of scientific authority and therefore has the capacity to bring a closer link between science and society and to promote scientific development and the social relevance of science at the same time. As seen in the government ambition to re-initiate biotechnology research, integrated policy will be carried on in the future. However, over-reliance on the science administration and governmental scientists will generate its own disadvantages and therefore undermine policy legitimacy. As seen in many cases, problems are particularly salient in micro-level policymaking processes or in controversial and sensitive cases. In the next chapter, we will see that conflicts between different justifications and values have been substantial elements in the evolution of Taiwan space policy and have therefore exposed shortcomings in the current framework of science policymaking.

CHAPTER VI

Space Frontier Pursuit: A Critical Analysis

A. Introduction

At Taipei time 8:34 am, 27 January 1999, ROCSAT-1, the first satellite of the Republic of China, was successfully launched from Cape Canaveral, Florida. Hwang Jenn-tai, former Chairman of the NSC triumphantly declared that "Taiwan has become the fifteenth member state of the world's space club" (1999, p. 715). But, why space technology? Has Taiwan's science base reached the scale to pursue this 'new' frontier? Such queries are compatible with the main themes of this research. The case study in this chapter is intended to deepen my research in two aspects. Firstly, Taiwan's space programme as a typical technological project subject to diverse policy considerations provides a confined sub-policy area to verify my arguments about the dynamics of Taiwan's science policy evolution and the relationship between science and society. Secondly, by probing a sub-policy dimension with a singular field and specific actors and networks, the case study also compensates the necessarily rather general nature of the meso-level analysis applied so far.

Space activities have long been looked upon as just another area of esoteric research, the practical applications of which could be left to the superpowers. The main reasons of this are the characteristics of space technology and its establishment. It should be made clear at the outset that space technology is not just another area of technology that widely affects our daily lives. From its infancy in the 1950s to its adulthood in the 1990s, space technology has occupied an unusual position at the frontiers of science as an impetus for many other areas of applications, ranging from technology, economics and politics, to military affairs and symbolism. The contributions of space S&T are directly evident in communications, surveillance, security, resource exploitation and scientific experiment. More subtly, the unique need for large system integration in the space establishment paves the way for boosting scientific talent, lifting research capability, and offering industrial additionality. However, high start-up costs, continuous investments, solid government involvement, major risks, still monopolistic but competitive space services and component markets, and the requirements for well-qualified manpower and an excellent industrial base, all constitute rigid barriers to the newcomer. In particular, the sensitive usage of outer space, the large scale of space investment, and the expansion of space commercialisation have made it impossible for national space policy to ignore international co-operation, collaboration, and regulation (Papp and McIntyre, 1987, pp. 3-5). In view of Taiwan's rather shallow scientific base and awkward international status, the benefits of space activities seem limited. This case study explores actor interactions and policy evolution in the light of these unique features of space activity.

I start from examining the initiative stage of the Taiwanese space programme, the very point that as seen elsewhere exposes most crucial national considerations, constraints and diverse interests. Then, attention is focused on obstacles, conflicts, and progress around the operation of the National Space Programme Office (NSPO) and Taiwan's first satellite, ROCSAT-1. The third part continues the account of changing policy ideas and policy evolution alongside planning for ROCSAT-2 and -3. At the end of the chapter, the policy implications are drawn out.

B. First Initiatives

The official start-up of Taiwanese space planning dates back to the inauguration of the Research Team for Satellite Applications and Development (hereafter Research Team) in November 1988. This was the very moment that turbulence, crisis, and challenges were emerging around almost every aspect of the society at the dawn of political and social transformations, as discussed before. The authoritarian regime came to an end with President Chiang Ching-kuo's death in January 1988, while a new social order and national direction were yet to be established under the governance of his successor Lee Teng-hui, who was weak in relation to the KMT and the military. Economically, the serious devaluation of New Taiwan Dollar, triggered by US pressure for fair trade, and social disorders provoked by political and environmental issues, had led to a serious hollowing-out of industry and an unprecedented fever of stock speculation. In retrospect, it was a turning point for Taiwan's further development, while no one could predict where it would go. Under such circumstances, how could a highly uncertain science programme impose itself upon policy agendas?

From Science to Politics

The Research Team was created by Hsia Han-min, head of the STAG as well as the NSC, to study the feasibility of a space establishment, in accordance with the Feasibility Research Report on ROC Satellite Applications and Development which was finalised in May 1989.[96] Perhaps due to its top-down nature, or its character as a feasibility study, the move did not immediately raised great concerns. On the contrary,

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[96] See STAG, 1989. Note that in the period 1988-90, Hsia Han-min was appointed as Convenor of the STAG and Chairman of the NSC. Thus, at this stage, the policy idea

it was Hsia who as Chairman of the NSC systematically advocated the programme to crucial policy actors, for example the Central Standing Committee of the KMT, the Legislative Yuan, and the China Mechanical Engineering Association (*NSC Monthly,* January 1989, p. 59; *Legislative Gazette,* 78 (32), p. 223; Hsia, 1993, pp. 68, 84).

Table 6. 1 Research Team for Space Programme Initiative

Name	**Institute**	**Mission**
Chao Ji-chang	Institute of Aeronautics and Astronautics, Cheng Kung University	Convenor
Chang Chin-fu	S&T Advisor Office, Ministry of Education	Planning
Chu Sheng-tsz	S&T Advisor Office, MOTC	Planning
Shih Yen-hsiang	S&T Advisor Office, MOEA	Planning
Wang Chiung-chung	Engineering, Taiwan University	Planning
Yang Jih-chang	Energy and Resource Laboratories, ITRI	Satellite Bus
Chen Jer-jiun	Centre for Space and Remote Sensing Research, Central University	Ground Facility
Yang Jing-you	Electronic Laboratory, CSIST	Launch System
Liau Da-niou	Forest Bureau, Council of Agriculture	Applications

Source: STAG, 1989, p. i.

The ad hoc Research Team was composed of nine academics and agents, roughly representing the then major institutes that had capability and interest in space technology and applications (Table 6.1). Professor Chao Ji-chang and Yang Jing-you represented the island's then most prestigious institutes in aerospace technology. Particularly, Yang had been involved with the development of ballistic missiles and Tien-Chien, the air-to-air missile project, being probably the only members who possessed relevant experience in large-scale space system integration. The absence of an industrial representative was understandable considering the industrial situation at

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was common to the Executive Yuan and the NSC.

the time, although this later caused problems with the viability of the study.

After a six-month study, the Research Team produced a draft feasibility study that urged the government to engage in space activities. The draft set completely local manufacture as a future target and suggested a first step of launching a low earth orbit (LEO) scientific satellite within five years, with funding of NT$7-11 billion (US$420 million). After the first five years, the direct benefits of the programme were expected to establish the capability for developing rocket projection, and enhance production ability in medium range ballistic missiles (MRBMs), electronics, communication, materials, navigation control, system integration, and industrial upgrading (*SciTech Reports,* September 1989, p. 9). Those original optimistic prospects were crucial, not only because they thereafter underpinned official views of the programme, but also because they were interpreted differently with time. In particular, the building of a launcher, perceived as the main mission in this stage, was abandoned later, weakening the initial policy justification.

On 4 May 1989, the draft was presented to a special session, part of the Eleventh Meeting of Science Advisors convened by the STAG.[97] Not surprisingly, major advisors such as Mr. Bob O. Evans, Dr Pierre Aigrain, Dr. Robert L. Sproull, and Dr Frederick Seitz expressed their doubts and took a rather conservative attitude, although they agreed that the satellite programme might inspire the nation and encourage scientific activities. Dr Aigrain simply asked: Do you need a satellite? "If yes, buy it." He worried that it might cause a problem for small and medium sized countries like Taiwan to concentrate a large proportion of scientists and expense to a particular project (STAG, 1989, p. 42). Dr. Sproull and Dr Seitz (STAG, 1989, p. 43) commented:

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[97] The content of the meeting regarding advisors' remarks on the study was omitted by government publicity (see *NSC Monthly*, June 1989, pp. 611-12).

- A much deeper evaluation is needed. "Once you have embarked upon a project, there will be no choice left because you would then be driven by the economic situation."
- "Launching is a buyer's market. ROC should consider taking advantage of it."
- "Many technologies are developed on the ground and then incorporated into space technologies, not the other way around."
- "It is difficult to identify the fallout from space technology, although it does exist."

Considering later developments, the above advisors' remarks proved only too true. But more surprisingly, there also emerged negative opinions within the Research Team. According to Professor Wang Chiung-chung, some members believed that there was no urgency to develop satellites, and that the space programme needed to taken industrial capability into account.[98]

To conciliate the above disputes, Chao Ji-chang, Convenor of the Research Team, revised the suggestion of the formal Feasibility Research Report on ROC Satellite Applications and Development (hereafter Feasibility Report) by adding three advantages and three disadvantages without advocating the programme as directly as the draft did. The advantages referred to S&T integration, industrial upgrading, and national prestige, while the disadvantages included unclear economic benefits, limited competence in key components, and an expected dilemma between small achievement via small-scale investment and resource distortion by full-scale commitment (STAG, 1989, pp. 39-40). But the Feasibility Report kept the original conclusion, that is, the recommendation to launch a 200-pound scientific satellite within five years at the

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[98] See Gung, 1994, p. 15. Gung's work is so far the only comprehensive research with regard to the initiative phase of Taiwan's satellite programme. However, due to the news report style, some crucial detail lacks reference. To ensure accuracy here, only clearly identified sources will be used.

expense of NT$10 billion, 'if' the government chose to establish a space enterprise (STAG, 1989, pp. 40-41). Sensitive objectives such as the construction of MRBM were excluded in the report, but the development of a launching system was still conceived as the centre of the space programme. The Feasibility Report was never made public. The decision would now be left to political considerations.

Despite the disadvantages identified, a policy consensus was swiftly built up among top policymakers in the NSC and the Executive Yuan. This was evident when Hsia indicated space technology as one of new selected directions in a KMT meeting on 3 July, right after the finalisation of the Feasibility Report (*NSC Monthly*, August 1989, p. 823). Interestingly, on 10 July, a special aerospace discussion panel was arranged in another government advisory meeting, the National Construction Meeting. This panel too suggested that Taiwan should actively develop satellite and space technology (*NSC Monthly*, August 1989, p. 821). Two months after he took office, Premier Lee Huan announced that "[the NSC] should actively plan satellite research and development" (*NSC Monthly*, September 1989, p. 994). All administrative gestures suggested that this was not just a preliminary feasibility study, but a real preparation for a space programme, with considerable impetus behind it.

On 19 September Premier Lee addressed his executive statement to the Legislative Yuan, where he completely endorsed the optimistic side of the Feasibility Report and stressed the need to embark on the space programme. The announced scale and cost were exactly as in the Feasibility Report. Going beyond the report, his statement sketched out a somewhat exaggerated timetable in which two or four satellites could be put into orbit every year of the programme, the results of which would expected to benefit 'high orbit' satellite applications, solar research and a wide range of public policy from weather forecasting to diplomacy (*NSC Monthly*, November 1989, 1327-28; *SciTech Reports*, October 1989, p. 14). In October, the NSC embarked on detailed planning, marking Taiwan's initiation of a space establishment. The planning and advisory groups were lead by NSC Vice Chairman Deng Chi-fu and were composed of scientific experts, government agents and industry.[99]

The policy initiative so far did not intrude upon the authoritarian decision-making rituals practised at that time (Lin, Chung-his, 1993, p. 20). A policy consensus was built up among core policymakers on the basis of a scientific study. In addition, it might be argued that a pluralistic decision model was hardly likely to be employed upon such highly technical policy issue with such profound implications.

From Politics to Science

As mentioned before, however, democratisation had brought a need for public justification of all science policy. The scale of this project quickly attracted the scientific community's attention and soon provoked unexpected controversy.[100] *SciTech Reports* soon became a forum for the pros and cons debated by academics (*SciTech Reports*, September 1989, pp. 3-6). Furthermore, the journal started to publish part of the unpublished draft and final versions of the Feasibility Report (*SciTech Reports*, September 1989, pp. 6-9; November 1989, pp. 5-10). Subsequently, Science Monthly took up a position at the heart of a rival camp, giving rise to a new type of policy participation by scientists. The public debate not only put an end to the one-

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[99] This time domestic entrepreneur Stan Shih, President of Acer Group, was invited to be advisor, and industrial representatives with a space background also joined the planning group, such as Dr Chu Shin of Yulon Motor Co. and Dr. Chian Yuan-chung of Microelectronics Technology Inc. (*Legislative Gazette,* 79 (72), p. 17).

[100] Taking NT$2 billion as an annual average of the five-year programme, this was equivalent to 30% of the total budget of the NSC and 40% of the Science and Technology Development Fund in FY 1990 (*SciTech Reports*, May 1990, pp. 8-14).

sided domination of policy information, but also revealed the unsophisticated nature of the feasibility study and the lack of open scrutiny recommended by foreign advisors. The most problematic issue was that the policy was politically predetermined not scientifically decided.[101] Lee Yuan-tseh, now Present of the Academia Sinica, stated a preference for opto-electronics rather than space technology, if a choice had to be made between them (*SciTech Reports*, October 1989, pp. 16-17). Academic rivals not only criticised perfunctory decision-making and priority setting, but also cast doubt upon the viability of the scientific study.[102] The Feasibility Report fell seriously short of a proper cost-benefit analysis, if it was regarded as a blue print for a new policy initiative. For the outsiders, it was difficult to understand how the programme scale and cost were determined. It was indicated in a single one-line statement made by Yang Jing-you in the Feasibility Report.[103] Given the still shallow technological foundation, with Taiwan incapable of producing engines for any type of vehicle or aeroplane, developing space technology seemed to be over optimistic. Despite these criticisms, however, advocates insisted that a space establishment was a technology that could not wait for every condition to be ready (*SciTech Reports,* October 1989, pp. 3, 5-6; Chao, 1989; Jia and Chiou, 1989). In November, members of Science Monthly initiated a signature campaign to call for reconsideration and open debate, in which 311, and later 410, scientists participated (*SciTech Reports*, November 1989, p. 1). At the same time, an open letter proposed by supporters in the scientific community called

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[101] See *SciTech Reports*, September 1989, p. 4; October 1989, pp. 10-11; November 1989, pp. 1, 10-11, 20, 21-22; January 1990, p. 9; Liu, 1989.

[102] See *SciTech Reports,* October 1989, pp. 8-9; November 1989, pp. 4-5; March 1990, p. 1; April 1990, pp. 5-7, May 1990, pp. 27, 31-34.

[103] See STAG, 1989, pp. 2_6-7. According to the draft of the Feasibility Report, the scale and cost referred to another feasibility study made by the MOEA (*SciTech Reports,* September 1989, p. 9). But none was made in public.

for an end to disputes and for united progress on space planning (Lin, Chung-his 1993, p. 24). As mentioned, this scientific controversy marked an emerging scientific autonomy, the characteristic of which was that dissenting scientists were centred on an organised scientific group, differing from previous scientists' activism in which defiant scientists were organised by non-scientific organisations, as seen in the case of opposition to nuclear power plants. Interestingly, certain traditionally relevant space associations such as the Aeronautical and Astronautical Society did not make any response.

These scientific debates soon dragged the media and legislators into the controversy, imposing unexpected political pressure upon the executive. News coverage of the issue was greatly increased and certain specialised journalists closely examined the progress of the space programme thereafter, such as Yang Wei-min and Lee Tzung-you of *China Times*, Peng Guo-wei of *Liberty Times*, Han Shang-ping of *United Daily News* and so on. In addition, certain newly Taiwan-elected legislators not only absorbed different opinions from the media but also held public hearings to create platforms for policy debates (*SciTech Reports*, May 1990, pp. 35-36; June, 1990, pp. 23-26; July 1990, pp. 39-42). Judging from their remarks, legislators took account of civilian scientists' opinions on policy debates, especially newly elected lawmakers, regardless of their partisan backgrounds (*SciTech Reports*, February 1990, pp. 1, 5-6). Under increased pressure, Chairman Hsia convened twelve meetings with scientists and two briefings with legislators to justify his position.

With debates growing, suspicions and pressures spread to other areas. First of all, the US expressed serious concerns about the potential military uses of the programme, especially the launcher. The NSC quickly confined the first satellite to a bizarre altitude of '200 km' (*NSC Monthly*, February 1990, p. 181; *Legislative Gazette*, 79

(72), p. 9). However, this could not ease the US's suspicion, since a launcher capable of placing a satellite at low orbit, say 200 km, could still deploy MRBMs with a range of 800 km.[104] Sensing the US's concerns, Hau Pei-tsun, Chief of the General Staff, forbade the CSIST's involvement in order to secure ongoing US-supported IDF upgrading (Hau, 2000, pp. 1493, 1507). At the same time, the MOEA and MOTC had also conducted their own satellite plan or feasibility study, the results of which challenged the orientation of NSC satellite planning.[105] The MOTC was satisfied with satellite channels on lease in the first stage, favoured an internationally co-operative investment in its mid-term perspective, and expected to launch Taiwan's own satellite only in the final stage. The MOEA's study pointed to local technological incompetence and uncertain returns in the indigenous space establishment, and suggested the expansion of commercial potential first, with the development of either ground receiving operations or satellite sub-component manufacture by way of international co-operation. Losing the support of other departments, the NSC was now left alone to face a possible boycott from the legislature.

From this apparently desperate position, in February 1990, the NSC still sketched out the Five-year Scientific Satellite Research Programme (hereafter Five-year Programme) and released it at a press conference. The Five-year Programme virtually endorsed the Feasibility Report (*SciTech Reports*, April 1990, pp. 10-14). But without the MND's backing, the manufacture of satellite spacecraft and space launch vehicles (SLV) now relied on foreign transfers and services, which in turn weakened the legitimacy and feasibility of the programme. Confronting strong criticism, Premier Lee

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[104] Here, reference to missile and re-entry vehicle characteristics comes from Feigl, 1991, p. 135.

[105] Those reports were not publicised but were explored by Science Monthly; see *SciTech Reports*, January 1990, pp. 3-8.

asked for enhanced departmental synergy but agreed to wrap up its first year budget of NT$1.5 billion (US$55 million) in the annual executive budget package (FY 1991) without a formal ratification (*Legislative Gazette*, 80 (64), pp. 108-9; *SciTech Reports*, July 1990, p. 41). The decision stirred up a serious controversy in the scientific community. A second wave of conflict arose, in which rival signature campaigns registered 985 supporters and 751 opponents of the programme (*SciTech Reports*, May 1990, pp. 24-29).

Debates thus moved onto the legislative floor. Picking up the opinions of rival scientists, certain legislators such as Ting Shou-chung (KMT), Chu Fong-Chi (KMT), Chang Chun-hsiung (DPP) and Chen Che-nan (DPP) were anxious about viability and applications problems, and called the Five-year Programme into question. However, considerations in the legislative Yuan were mixed and went beyond purely technical issues. For some lawmakers national prestige, security, and scientific development had sufficient legitimacy to win their support (*Legislative Gazette*, 79 (103), pp. 13-56; 79 (89), pp. 161-83). Legislators thus did not reach a consensus. Furthermore, a dramatic political storm arose in May. Military leader Hau Pei-tsun was appointed as Premier, beginning mainstream against non-mainstream confrontations within the KMT. Facing political turbulence, legislators were not in the mood for more debates over the space programme, whose first year budget was then oddly passed through party-to-party negotiation with a cut of only NT$0.2 billion.

After assuming his post, Premier Hau, having previously refused participation in the space programme, appointed Kuo Nan-hung, Minister without portfolio, to replace Hsia Han-min as Convenor of the STAG. The Five-year Programme was then placed under review by the STAG and the Executive Yuan (*SciTech Reports*, August 1990, p. 1). In September 1990, the White House confirmed the US stance opposing Taiwan's

SLV development.[106] In October, Premier Hau ordered the freezing of SLV planning and stretched the original five-year programme to a fifteen-year long-term programme (*Legislative Gazette,* 80 (64), pp. 84-85). In terms of policy, this was a U-turn, which rebuffed not only the previous political decisions and scientific assessments but also the legislative budget bill. Furious legislators asked Hsia to resign and passed a motion to prohibit any change to the space programme, leading to a serious six-month stand-off between the executive and the legislature (*Legislative Gazette,* 79 (91), pp. 2-27).

Losing its ground, the NSC proposed an independent five-man Planning Committee to take charge of the programme in November 1990.[107] One year later, the Planning Committee finalised the Long-term National Space Technology Development Programme (hereafter Long-term Programme) which then earned the Executive Yuan's ratification in October 1991. According to the Long-term Programme, a Space Technology Steering Committee, consisting of 5 members from academics and related ministries, would audit and direct the programme, and recommend the appointment of high-ranking personnel.[108] The National Space Programme Office (NSPO), subordinate to the NSC was set up for programme implementation (Executive Yuan, 1991, p. 14;

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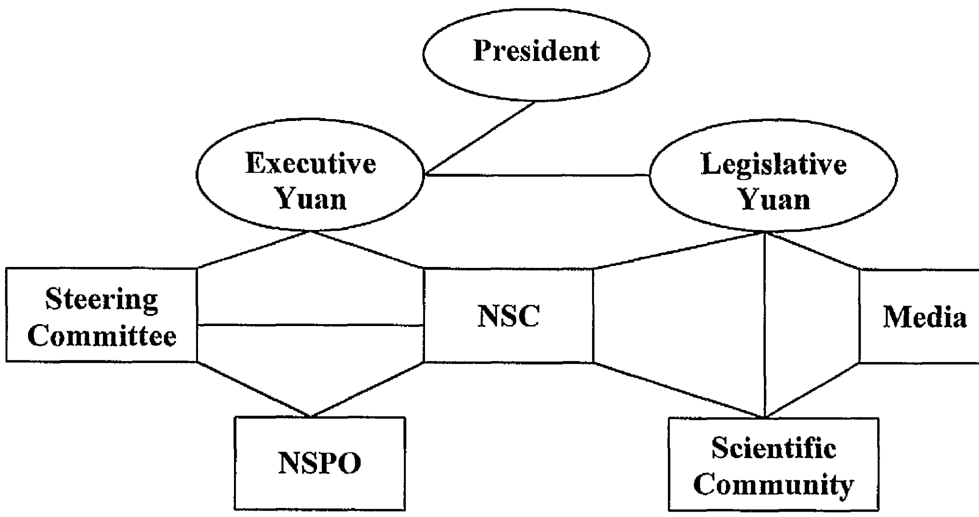
[106] Such speculation was first confirmed by legislator Ting Shou-chung. He personally contacted officials of the White House and received a clear reply that "the US government would not offer any assistance in Taiwan's attempt to develop launch capability" (*SciTech Reports,* November 1990, p. 16).

[107] Members included Huang Tsung-hsiao (former Pro-President of CSIST), Morris Chang (Chairman of Taiwan Semiconductor Manufacturing Corp. and ITRI), Liu Chao-han (President of Central University), Pau Yih-hsing (Dean of the Institute of Applied Dynamics in Taiwan University), and Lo Tung-bin (Vice President of the Academia Sinica).

[108] During 1991-1996, major committee members were Liu Chao-han (President of Central University), Stan Shih (Chairman of Acer Group), and the NSC chairman. After Chairman Liu Chao-shiuan came to office in 1996, the vice ministers of the MOEA and MOTC were then replaced by the convenor of the STAG and the president of the ITRI. Since 2000, two additional members have been included – the president of the CSIST and the director of the Institute of Astronomy & Astrophysics

see Figure 6.1). Later developments proved that the political responsibility carried by the NSC always overruled the collective advisory authority of the Steering Committee.

Figure 6. 1 Main Policy Network of Taiwan's Space Programme



The Long-term Programme targeted the establishment of space infrastructure in the first phase (six-year) and the creation of a capability for satellite manufacture and operation within fifteen years at a total cost of NT$13.6 billion (US$530 million) (Executive Yuan, 1991, pp. 7, 25). It expected to meet a local content ratio of 25 per cent for the first satellite, and 50 per cent and 75 per cent for the second and third small satellites (Hsia, 1993, pp. 233-35).

The Puzzle

It was assumed that Hsia's strong advocacy for the programme reflected President Lee's consent, but this explanation remained a puzzle at that time. President Lee had

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in the Academia Sinica (NSPO, 2000c).

personally denied the conjecture (*SciTech Reports*, June 1990, p. 5). In disputes, Hsia reiterated that the issue of the creation of a space establishment had been built up over time, but as Professor Liu Yuan-jiun, a key figure of Science Monthly and now President of Soochow University, pointed out, the relevant issues had never attracted the government's attention (1989). So, why then?

In relation to such sensitive technology, security concerns cannot be ignored. By 1980 the testing of the Ching Feng Battlefield Short-Range Ballistic Missile had been carried out by the CSIST (CSIST, 1999). Reverse-engineered from the American Lance missile, the Ching Feng Missile with a range of 150-300 km was said to be in service from that point (*Jane's Defence Weekly*, 28 August 1993, p. 7; 14 April 1996, p. 43). Unfortunately, a follow-up project developing the Tien Ma MRBM with a range 950-1000 km was forced to close in 1982 under US pressure.[109] However, at the end of the 1980s, CSIST capacity was supposed to include critical technology in two-stage solid fuel missiles and initial guidance, which had led the CSIST and relevant scientists to feel able to develop a SLV.[110] Given such missile capability, it was not totally out of the question to establish space technology with launch ability. A graduate of the Naval Academy and President of Chen-kung University for eight years, Hsia naturally felt confident to embark on the space programme as long as political support was strong enough. Besides, according to the original planning, further applications and commercialisation programmes would be followed up with an eye to create niches and a complete network from production to market (Jing 1997, p. 3; Hsiao 2000,

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[109] See Lu, 1999; *Jane's Defence Weekly*, 10 March 1999. p. 4. This programme reportedly also included the construction of military satellites and SLVs at the cost of NT$18 billion.

[110] Executive Yuan, 1991, pp. 2-4; Jia, 1989; NSC, 1998b, pp. 22-23; Jing, 2000, interview; Hsiao, 2000, interview.

interview).

As to external factors, China had launched an experimental geo-stationary earth orbit (GEO) communication satellite in 1984; AsiaSat-1, a commercial GEO communication satellite, was successfully put into orbit by China's Long March Rocket in 1990, verifying China's maturity in SLV services and long-range ballistic missile technology (Chen, 1999, pp. 43-47, 82-84, 164-68). Another neighbouring country, South Korea, announced a fourteen-year long-term space development programme in 1987. The situation, in the view of politicians, was urgent and required a response in spite of the predicament of the space establishment. Legislative Yuan support in those controversial debates partially reflected intense concerns regarding security and national prestige.

Given the circumstances, it was important for President Lee and Chairman Hsia alike to give the public the impression that things would be under control even after ending authoritarian leadership. In this regard, that the MOEA, the MOTC and the NSC conducted their satellite assessments at the same time was not a coincidence. Hau Pei-tsun has recently confirmed that it was President Lee who initiated the space programme (Hau, 2000, pp. 1507, 1514). It is reasonable to presume that President Lee's support was largely based on security concerns, rather than scientific and industrial upgrading. In fact, the intention was very much consistent with his later conspicuous pro-independence gesture when he advocated 'Taiwanese consciousness' and the 'Two State Theory'. Thus, knowing President Lee's position, Hsia could dare to urge lawmakers to support his five-year programme after it had been turned down by his superior Premier Hau (*Legislative Gazette,* 80 (64), pp. 116-17).

Consequently, the initiative of the Taiwanese space programme was not exempt from traditional motivations in space policy elsewhere, which were always propelled by security concerns and national prestige. The difference was that in Taiwan military motives needed to be disguised under the shroud of science owing to the special security problem and political instability. When military utility was ruled out as the source of policy justification, science and economic benefits were highlighted for policy justification, but security and national prestige still hovered in the minds of policymakers and supporters. Practically, neither scientific nor economic motives provided sufficient policy legitimacy. Thus scientific criticism and political pressure could soon create great threats to the plans. The initiative of the scientific establishment was generated from political considerations and yet carried through in the name of science.

C. Institutionalisation

In August 1991, the NSPO started to operate. Since then, the evolution of Taiwan's satellite programme has been paralleled with the development of the NSPO. The nature of the bureaucracy, the characteristics of a scientific institute, and even the conflicts of political power all came to bear on the progress of the programme.

Programme Objective

With the programme under way, the first objective was policy legitimisation. With the participation of CSIST, the construction of a launcher, and a military role ruled out, one previous major justification for the programme was lost. Policymakers and government scientists needed to redefine objectives and strategy in order to strengthen the case for the initiative. Seeking social relevance was the best way to justify the policy. At that time, demands were broadly identified in two areas – remote sensing and communication. In line with these applications, the Planning Committee developed two different approaches for the programme.

As regards remote sensing, earlier surveys showed that over 90 units, mostly public and academic institutes, had expressed a need for satellite data by the end of the 1980s (Liau, 1989, pp. fu3_46-59; Chen, 1995, p. 15). Those demands had led much earlier to the construction of a ground receiving station, which was then brought into the space programme. As a result of user demand and technological development, from the outset, the receiving station had adopted the goal of accessing data from the state-of-the-art satellite systems, such as SPOT, ERS, and JERS-1 (Chen, 1987, pp. 12-15). Under these circumstances, although a Taiwan-owned observation satellite was awaited (Liau, 1989, p. fu3_22), it would require a high-resolution sensor capable of multi-spectral scanning, with a synthetic aperture radar (SAR) which could cope with Taiwan's frequent rainy and cloudy weather.

With regard to the demand for satellite communication, lacking its own communication satellite Taiwan relied mainly on transponders on lease from international organisations such as INTELSAT and INMARSAT. Around 1990, the MOTC attempted to build a GEO communication satellite through international co-operation to meet future needs, largely emerging from direct broadcasting, remote education, and a meteorological data link. These uses were estimated to produce a total demand for 12 various transponders and 293 different digital channels within seven years (Liau, 1989, p. fu3_11-13). Although the spread of optical cable and microwave mobile communication increasingly cast doubt on the viability of a local GEO communication satellite, it remained a priority in Taiwan's satellite programme in term of both technology accumulation and satellite utility.

Taking both applications into account, the scale and the technological complexity of the own-build option were irresistible high. Compared to other substitute approaches such as international co-operation and imagery purchase, apparently, a locally built satellite was not cost-effective. Yet by setting a clear goal, an aggressive approach might give the whole programme a fundamental legitimacy. This idea underlay the 'Plan A' suggested by the Planning Committee. As per Plan A, a NT$28 billion (US$1.03 billion) budget was proposed to construct one small LEO satellite, one medium satellite in sun-synchronous orbit, one large GEO satellite and whole set of ground segments, with a view to creating not only infrastructure but also application value at the end of the programme (Executive Yuan, 1991, p. 2).

Alternatively, a fair infrastructure and technology build-up could be set as a strategy with lower cost which could limit immediate policy obstacles and obtain a promising technology upgrading. On behalf of industry, Dr. Morris Chang, member of the Planning Committee as well as Chairman of the Taiwan Semiconductor Manufacturing Corporation expressed his concern that satellite production was not an aim in itself but a means towards industrial technology upgrading, that is, the creation of design and production ability per se could justify the programme (Gung, 1994, pp. 65-66). From this point of view, the space establishment should be primarily based on an affordable ceiling of spending and scale aligned with the local scientific and industrial base to achieve maximum spin-off results. This incremental approach was the basic idea of 'Plan B'. Plan B suggested the construction of ground segments, two LEO satellites, and key technology at an admissible cost around NT$11.5 billion (US$424 million) (Executive Yuan, 1991, p. 2). However, both plans contained certain unpredictable elements and uncertain outcomes.

Although the satellite programme had been politically determined, neither the Planning Committee nor the various ministers involved were able to reach a consensus on whether plan A or B should be followed. In December 1990, Premier Hau made a final decision that the satellite programme would be based on plan B, but open to pursuing plan A in the future (Executive Yuan, 1991, p. 2). This led to the birth of the aforementioned Long-term Programme at a cost of NT$13.6 billion (US$530 million). The decision was not surprising. Before becoming Premier, Hau once commented that "Mr S of the NSC promoted the satellite programme based on an utterly speculative attitude, which would imperil the CSIST's main projects. I therefore firmly opposed any transfer of manpower from the CSIST to the programme" (Hau, 2000, p. 1514). From his experience in directing indigenous weaponry construction through the 1980s, he was well aware of the difficulty and challenge of sensitive large-scale projects. An incremental approach might be cautious, but it was much realistic with an eye to preventing spiralling cost increases as witnessed in the early experience of the European space establishment. What he did not see though was the growing demands for social relevance imposed upon the programme. This decision had two consequences. Firstly, adopting an incremental approach risked blurring the achievements of the programme. Along with growing public awareness and legislative power, the slower and less dramatic progress of the programme inevitably created a legitimacy problem. Secondly, the open-ended decision gave a certain degree of flexibility but also created the opportunity for further power manipulation.

In this way, the objectives of the Long-term Programme were set to build up fundamental organisation, talent, spacecraft technology, and ground segments (Executive Yuan, 1991). One year later, the objectives were further clarified as the promotion of system integration capability, industrial upgrading, space application, and space science on the base of the construction of three LEO satellites (Hsia, 1993, pp. 223-24).

Autonomy or Isolation

Under plan B, Premier Hau and the Planning Committee originally attempted to organise existing institutes to undertake the programme in order to promote industrial upgrading. Those institutes included the Academia Sinica, Central University, the ITRI, and Cheng Kung University, responsible for space science and technology development. Of course, the CSIST was ruled out here. In this model, the NSPO would be just a programming office without facilities and engineering capability.

But it was arguable that this sort of organisation was incapable of fulfilling its missions, especially for space technology in which system integration and testing was central for technology build-up. Committee members Liu Chao-han (President of Central University), Pau Yih-hsing (Dean of the Institute of Applied Dynamics in Taiwan University), and Lo Tung-bin (Vice President of the Academia Sinica), who previously supported plan A, preferred a strong, independent organisation to absorb and develop skills, knowledge and experience (Gung, 1994, p. 5). After debate the Planning Committee eventually adopted a planning suggestion made by the Applied Physics Laboratory, Johns Hopkins University, and decided to provide the NSPO with autonomous status. The NSPO thus maintained its role in system assembly, testing and operation, as well as project definition, programming and design.

The early NSPO organisation therefore evidenced a mix of moderate and aggressive approaches. Until 1994 the NSPO operated in different sectors scattered around various institutes and locations, even though it had been granted a full mandate. While its headquarters were placed at Taipei, payload and scientific research was carried out in conjunction with Central University at Chungli, main- and sub-system production was situated in the ITRI at Taoyuan, and ground control was developed with the help of Chen Kung University at Tainan (Hsia, 1993, pp. 238-39). The decentralised organisation had the advantage of creating close links with industry and academia, but the disadvantage of creating difficulties for co-ordination and management. Reflecting on this, Chairman Kuo Nan-hung noted "securing organisational centralisation of the programme was one of the priorities when I took office" (Kuo, 2000, interview). In 1994, various sectors of the NSPO and the most important facility – assembly and testing – were reallocated at their current location, Hsinchu. The centralisation of the NSPO, further strengthened by its space research funds and exclusive hardware resources, gradually established it as a centre of space S&T and consolidated its authority both in knowledge and policy domains. Held back by their weak scientific base, neither professional associations nor civilian space organisations emerged to wield meaningful policy influence thereafter, in spite of sporadic academic calls for re-examination of the programme (For example, Huang, 1996). Even the voice of the Science Monthly died down as a result of its lack of professional authority and political influence.[111] Most strikingly, the interaction between NSPO and space academics was not so close as generally thought (Hsiao, 1997, p. 61). As a result, when dealing with controversial and sensitive technology thereafter, the self-reliant organisation tended to cut itself off, as an isolated unit barely open to political influence.

Personnel Problems

Given the goal of building space technology from nothing, the recruitment of the necessary talent was a significant issue. Except for young scientists sent to APL, FIAS Corp., General Science Corp., and Taiwan University for training (NSC, 1994, pp. 87-

[111] In an interview with the author, Professor Chou Chen-kung noted "The result of Taiwan's satellite dispute proved the failure of Science Monthly" (2000, interview).

88), in the initial stage all the top and middle ranking scientists of the NSPO were overseas-based Taiwanese scientists, especially from the US. For example, Director Dai Guang-shiun previously worked in Thompson Ramo Wooldridge Inc. (TRW), Deputy Director Yong Kay came from Aerospace, and Chief Scientist Ip Wing-shiuan was recruited from the Max Planck Institute, Germany.

In order to attract senior overseas scientists with system management experience the salary was increased to two to three times that of normal staff. This would not cause problems as long as their competence was respected. However, alongside questions often raised regarding loyalty, competence, and differential payment, culture shock and administrative constraints caused great problems with their leadership. "Even now I am not used to bureaucratic procedure here" agreed Dr. Yong Kay, now Managing Director of the Aviation Safety Council (Yong, 2000, interview). Their resistance aggravated the situation and led the NSC to tighten its grip on bureaucratic procedure. Former NSPO Director Shyu Jia-ming (1994-9) surprisingly described the situation as so serious that "I was not authorised to treat my visitors to lunch when I came to the office in June 1994. Don't even mention other administrative operations" (2000, interview). In June 1993 Dai and Yong faced Control Yuan investigation for initiating a micro satellite project without following the proper procedure (*Central News Agency,* 10 June 1993; *Legislative Gazette,* 82 (61), p. 427). Their attempt to transfer micro satellite technology from the Swedish Space Corp. was abandoned. Ironically, in the ROCSAT-3 project and in recent programme assessments the micro satellite is now seen as a key niche area to start up Taiwan's space industry.

In addition, those senior scientists were also pursuing an ambition – to begin a new career in their motherland (Ting, 2000, interview; Peng, 1996b). Arrogance and conflicts of interest made it difficult to establish the teamwork that is always crucial in space technology development. Worse, frictions between Taiwanese-American and Mainlander-American scientists, overseas-based scientists and local technocrats, turned personnel discords into factional conflicts and organisational chaos.[112] "It is regrettable to see things like these, but it is unfair to over-stress this kind of scandal which does happen elsewhere," explained Ting Lee-hua, Head of the Mechanical Engineering Section of the NSPO (2000, interview). Faction conflicts regarded as a scandal in Chinese bureaucratic culture forced the agency to close down communication with outsiders and strengthen its hierarchy, aggravating its characteristic as a closed institution. However, personnel problems inevitably weakened organisational cohesion. As we will see shortly, alliances between insiders and outsiders were thus sought in order to secure actors' positions when necessary, ironically generating exclusive channels for policy advocacy, whistle blowing, and, of course, public awareness.

D. Creating ROCSAT-1

In general, a satellite system primarily comprising space and earth segments involves enormously complicated activities and components from design to operation. Those activities and components can be considered at three different levels: equipment, sub-system, and system. To set system integration as a principal target as indicated in the Long-term Programme meant that foreign technology procurement and transfer were essential. In addition, situated in a buyer's market, it seemed sensible for a new entry country like Taiwan to acquire knowledge, services, and equipment by way of off-the-shelf purchase, contracted offset and licensed packages (Shyu, 2000, interview; Hsieh,

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[112] Sub-ethnic frictions could be traced back to a very early stage in this case. For

2000, interview; Yong, 2000, interview; Ip, 2000, interview).

Infrastructure

As regarded ground segments, receiving and control stations were the main requirements. As mentioned before, based on the already scheduled plan, the construction of the Ground Receiving Station went smoothly. After 1994 the Receiving Station was able to acquire licensed data from Landat-5 (USA), SPOT-2, -3 (France), ERS-1 (ESA), and later from Radarsat (Canada), ERS-2 (ESA), IRS-1C (India) and EROS-A (Israel) (Chen 1995, p. 6; 1997, pp. 2). The ground control system including Telemetry, Tracking and Command (TT&C) and the Ground Control Centre maintenance and operation were dependent on equipment and training offered by the Allied Signal Technical Services Corp.[113] To secure the project targets, four local firms joined the software development and mission operation.[114] Ground control systems were designed as an open and modulated framework in order to be used for subsequent satellite projects.

Space segments comprised infrastructure and satellite constructions together with manpower training. The setting-up of the Integrated Testing Building as a key location for picking up know-how was overseen by Intespace (NSC, 1994, p. 83). The necessary equipment used in assembly, integration and testing, and verification was

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example, see *Legislative Gazette,* 82 (50), pp. 591-92.

[113] Consequently, while the Ground Control Centre was placed in the NSPO, the Science Data Distribution Centre was set up in Taiwan Ocean University, and two TT&C units were situated in Central University and Cheng Kung University respectively.

[114] See NSC, 1996b, p. 94; *NSC Monthly*, January 2000, p. 5. Those firms include CTCI Corp., Syscom Compute Engineering Co., Tatung Co., and Taiwan Communication Network Services Co.

purchased from various foreign companies and was completely installed in 1997.[115]

The architecture of a satellite is composed of two prime systems, spacecraft or platform (known as bus) and payload, which are mutually connected. Given the premise of constructing a small LEO satellite for scientific experiments, three categories of on-board scientific payload had been identified by 1993, which involved nine scientific experiments ranging from ionospheric phenomena and telecommunication to ocean environment (Hsia, 1993, p. 240-1; NSC, 1993a, p. 17).

When system requirement and mission definition were underway, the NSPO found it was essential to seek a know-how supplier. As a result, mission definition, concept design, system requirement, programme management, and system engineering were all dependent on the assistance of the Applied Physics Laboratory of Johns Hopkins University, TRW, and Aerospace (NSC, 1994, pp. 83-84).

However appropriate the heavy dependence on foreign technology might have been in its own right, the previous suspicions and anxiety regarding the extent of indigenous competence recurred. In particular, a commission which arranged for Aerospace to draft the ROCSAT-1's Requirement for Proposal at the price of NT$40 million (US$1.57 million) provoked severe accusations from legislators during 1993-1994 (*Legislative Gazette,* 82 (61), pp. 426-27; 83 (04), p. 917; 83 (10), pp. 443-49; 83 (18), p. 202). Former Deputy Director Yong Kay maintained that "building up know-how by transfer was an unavoidable process in terms of Taiwan's scientific base at that time" (Yong, 2000, interview).

The above pressure resulted in two seemingly contradictory but internally

[115] The main Off-the-shelf acquisition includes the Hot Vacuum Chamber from ACS, Electromagnetic Compatibility Equipment from SIDT, Anechoic Camber from Wyle, Acoustic Vibration Chamber from Ling Electronics, and Mass Characteristics Testing Instrument from Space Electronics (NSC, 1996b, p. 93; 1998a, p. 327).

consistent consequences. The first was the change of the ROCSAT-2 mission from a LEO scientific satellite to a GEO communication satellite, an issue which will be addressed below. The second was that the NSPO took a more cautious attitude towards the ongoing ROCSAT-1 project in order to avoid unnecessary risk. ROCSAT-1's payloads were thus reduced from nine to three experiments, in which the Ocean Colour Imager (OCI) naturally was retained in view of its social relevance, and the Ionosphere Plasma and Electrodynamics Instrument (IPEI) and Experimental Communication Payload (ECP) were selected due to their scientific and economic implications for satellite communication.

Payloads

The first completed payload contract was the IPEI in 1994, which, apart from its own scientific significance, aimed to probe the variations of ionospheric plasma and electrodynamics for the better understanding of communication disturbance by taking *in situ* measurements of ion density, temperature, composition and drift velocity (NSC, 1995a, p. 101; Yeh et al., 1999, p. 20). The IPEI was jointly developed by the NSPO, Central University and the University of Texas at Dallas, but the critical part, the electronic sensor package, was built by the University of Texas.

The application purpose of the OCI was to obtain better understanding of marine productivity and potential fishery activities (Li, et al., 1999, p. 86). In conjunction with the payload, a very ambitious effort was made to build up local capacity in design and fabrication of opto-electronic space instrument in order to promote remote sensing technology with the involvement of the Precision Instrument Development Centre (NSC, 1994, p. 84). But contracting with the Matra Marconi Space and German Aerospace Centre (DLR) confronted difficulties in pricing, technology ownership, and payment schedules, which nearly caused cancellation.[116] Although the payload had been selected in 1992, the contract was not settled until 1995, when the ban on bidding from the Japanese company NEC was dropped. Since then, the NSC has never mentioned the results of opto-electronic technology transfer.[117]

The original concept of the ECP was to implement communication testing on L and S bands. In 1993 the concept was altered to work on the Ka band which had advantages in volume and in highly secure data transmission (NSC, 1994, p. 85). In fact, the Ka band experiment was a pre-experiment for a Ka band GEO communication satellite which was then set as the ROCSAT-2 project (Yaung, 2000, interview, Hsieh, 2000, interview). This is why the ECP looked so out-of-place after the ROCSAT-2 project was redesigned in 1996. To secure domestic control of the Ka band experiment, the construction of the ECP was predetermined for awarding a local bidder but allowed sub-contracting (*NSC Monthly*, April 1995, p. 319). However, its complexity and risk led to three failures at contracting-out. Finally Microelectronics Technology Inc., a domestic firm, was selected to build the ECP, which was then subcontracted to NEC, Japan, in 1994 (NSC, 1995a, p. 102). The project was to study the transmission performance in video, voice, data, and fax, and the Ka band propagation effect, the ultimate purpose of which was to benefit the operation of a future Ka band communication satellite by modelling the characteristics of a Ka band satellite link and developing a rain-fade compensation algorithm (Liu, et al., 1999, p. 130; Hsieh 2000,

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[116] See *NSC Monthly*, November 1993, p. 1181; *Legislative Gazette,* 82 (61), p. 424; *Central News Agency*, 8 November 1994.

[117] However, Taiwan's space opto-electronics capacity has been gradually developed with the extension of space research and opto-electronic industry. For example, the AIDC is currently engaged on telescope construction for the Submillimeter Interferometry Project, a co-operative project between the Academia Sinica, Tsing Hua University and the Smithsonian Astrophysical Observatory of the US (Lo, 2000, pp. 14-15).

interview).

From the NSPO's point of view, the aim of ROCSAT-1 was to forge the infrastructure and manpower for further space development. Although payloads acted as magnets to attract related space research, they were not the primary objectives. It was not surprising that the three payloads chosen encountered schedule conflicts among different experiments, which were supposed to be operated at three different orbits (*Legislative Gazette,* 82 (61), p. 406). In particular, the LEO satellite had disadvantages in a short life span and limited experimental time windows (Yeh, et al., 1999, p. 21; Li, et al., 1999, p. 88; Liu, et al., 1999, p. 138).

Platform and Launcher

In the light of the Long-term Programme, it was inevitable that the construction of the ROCSAT-1 bus would be put out to contract. In April 1994, the contract was awarded to TRW (*NSC Monthly*, April 1994, p. 349). To fulfil ROCSAT-1's objective, TRW agreed to offer technology transfer except for the high precision mechanism and sensitive technology (Hsieh, 2000, interview). The NSPO organised a 28-person technology transfer team working in TRW to acquire design, manufacture, integration, and testing knowledge, while a second team did exactly the same work in Taiwan in the course of spacecraft construction (NSC, 1996a, p. 91). The 'learning by doing' model gradually built up NSPO competence and experience, enabling it to gain more independent ability in defining the ROCSAT-2, and -3 projects (Ting, 2000, interview). According to the agreement, the TRW also had to incorporate local firms to conduct a dummy satellite structure and component manufacture capacity.[118] As a result, five

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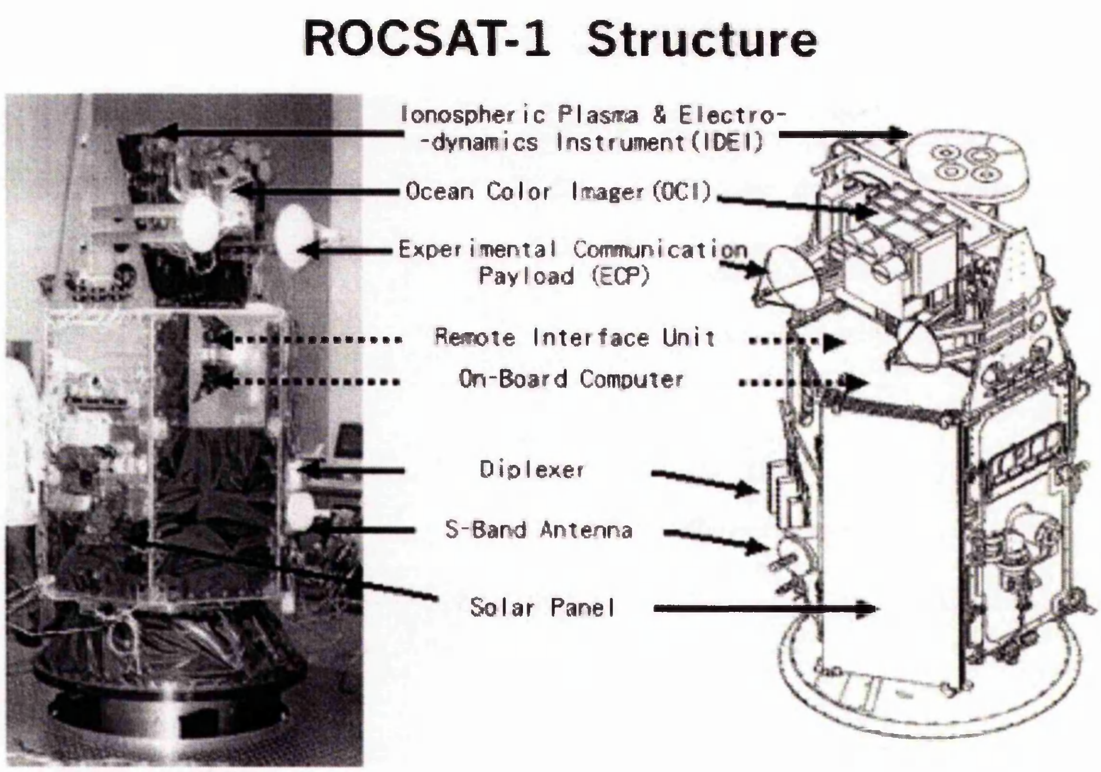
[118] The Structural Test Model was made by Taiwan Aerospace Corp. and the ITRI.

local manufactured components were able to go on board, including the Rmote Interface Unit (TransSystem Inc.), computer (Acer), diplexer (Vicotroy Industrial Corp.), antenna (Vicotroy Industrial Corp.), and solar panel (Shihlin Electric & Engineering Corp.).[119] Figure 6.2 illustrates the basic structure of ROCSAT-1.

Figure 6. 2 ROCSAT-1 Structure and Payloads



Source: NSPO

In 1995, the Lockheed Martin Athena-1/LMLV1 rocket was chosen as the SLV for ROCSAT-1 (*NSC Monthly*, July 1995, p. 660). While its eleven prior missions were given official coverage, the Athena-1's failure record and rather small propulsion

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[119] Except for government-sponsored institutes, most private firms either have a strong commitment to local industrial development or are supported by their managers who have space background. See Lin, 2000, interview; Yong, 2000, interview; Lee, Tzung-you 1999b.

provoked local scientists with regret at not implementing their own rocket construction (Jing, 1999; 2000, interview).

The 395kg ROCSAT- 1 was designed as a simple LEO satellite, orbiting the Earth at an altitude of 600 km with an inclination of 35 degrees, and following six different tracks above Taiwan on which three payload missions were executed (Figure 6.2). With the construction of ROCSAT-1, Taiwan developed a nascent capacity and fundamental base in satellite production and operation with particular respect to large-scale system integration (including mission analysis, system simulation, requirement definition, project control, review and verification, assembly and testing), bus structure, TT&C, and on board units of computer, communication and electricity (*NSC Monthly*, May 1999, pp. 511-19), which meant certain respect in view of the difficult circumstances it encountered.

Disparity in Expectations

When the triumph of the ROCSAT-1 launch in 1999 was celebrated in political rhetoric, the jubilation did not remove the shadows surrounding the project. Sober reflection rather than rejoicing emerged in the major media coverage, for example in special reports of the *China Times* (Lee, Tzung-you 1999a, b; Yang, 1999). The rather low-key reactions were prompted by the tightly-packaged commissions surrounding the ROCSAT-1 construction as shown in Table 6.2, a factor that detracted from public expectation of a Taiwan-owned satellite. In fact, the NSPO sometimes was humiliated by being described as a 'contracting unit'. "We are hailing a firework which is launched by a neighbour; worse, the rocket is not even home-made," DPP lawmaker Su Huan-chih criticised (Su, 2000, interview).

Table 6. 2 Major Foreign Contractors in Space Programme (1991-8)

Phase	Items	Foreign Contractors	Local Participators
Design	Freight Dynamics Facility Planning	General Science Corp. (GSC)	
	Assembling and Testing Facility Design	Intespace	
	System Engineering	TRW	
	Programme Management	TRW	
Requirements	ROCSAT-1 Mission Definition ROCSAT-1 Requirement for Proposal	Aerospace Aerospace	
Construction	Integration and Testing, Technical Assistance and Equipment	Intespace, ACS, SIDT Europe, Wyle, Ling Electronics, Space Electronics	
	Ground TTC and operation control centres	Allied Signal Technical Services Corp. (ATSC)	4 firms
	Ground Receiving Station	MacDonald Dettwiler and Associates (MDA) and Datron	
	ROCSAT-1 Launching Service	Lockheed Martin	
	ROCSAT-1 Spacecraft	TRW	4 firms for components; 2 for bus model
	OCI (Payload)	NEC	
	IPEI (Payload)	University of Texas at Dallas	4 firms
	ECP (Payload)	NEC	1 firm
	Technical Assistance	Telesat	
Operation	Operation and Maintenance	ATSC (three months)	4 firms

Note: For the detail of local major component providers, see Table 6.4 below.
Source: NSC, 1993a, pp. 82-88; 1995a, pp. 91-95; Chen 1995, p. 16. *NSC Monthly*, May 1999, pp. 515-19.

Furthermore, affected by the delays in contracting, a one-year postponement was declared by Chairman Kuo in 1993 soon after he took over the chair of the NSC (*Legislative Gazette,* 82 (61), p. 409). In 1996, Lockheed Martin asked to modify the ROCSAT-1 spacecraft, since serious coupled loads were detected that could cause explosion during launching. The modification might result in NT $200 million (US$7.3 million) extra cost and further project delay. Legal action was prepared against Lockheed Martin (NSPO, 1996b), but after a one-year dispute, the problem proved to be a false one. Lockheed Martin had apparently stipulated an unnecessarily conservative launch requirement owning to the lack of sufficient data for the new type Athena rocket that had experienced several failures in previous missions (NSPO, 1996a). In the end, the crisis led to an additional one-year postponement, as a result of which the NSPO was again blamed for its poor commissioning.

Although the issue is debatable, the NSPO was also widely judged to have failed to achieve the original goal of boosting local technology upgrading, let alone creating an aerospace industry, because the local content ratio of the ROCSAT-1 project was just 5per cent in terms of construction cost, seriously lower than the 25per cent previously promised (*Legislative Gazette,* 88 (24), pp. 187-88).

Soon after the ROCSAT-1 launch, the Control Yuan found that the NSC had concealed the fact that the ECP was incapable of execution (*China Times*, 9 March 1999; 12 March 1999; 17 March 1999, p. 15). This resulted from the US government's strict and prolonged review on the issue of the ECP ground system export permit, partially because of the military implications of the Ka band experiment and the ongoing investigation concerning scientist Lee Wen-ho, who was accused of espionage for leaking top nuclear weapon secrets to China and Taiwan (*China Times*, 25 December 1999, p. 7). The event disclosed not only the sensitivity and difficulty in the acquisition of foreign space technology, but also the closed administrative behaviour of the NSC and the NSPO. In March 1999, the whole programme was threatened with the slashing of its budget by the legislature (*Legislative Gazette*, 88 (18), p. 108). ROCSAT-1's orbital operation got underway against this background of gathering crisis, while Director Shyu left his post to work on planning the next phase of the space programme.

In retrospect, key members of Science Monthly still believed that the satellite programme could never have been a meaningful, useful, and positive programme (Liu, 1994; Liu, 2000, interview; Chou, 2000, interview).

E. Policy Ideas and Legitimacy

Utility Considerations

The incremental approach of the Long-term Programme, with the weaknesses mentioned, could not cope with public expectations and swift external changes during the first quarter of the last decade. The success of STAR TV transmitted by China's AsiaSat-1 gave rise to new demands in relation to remote education, satellite news broadcasting, and commercial TV channels. These new media demands were reinforced by the sense that in a newly democratised society an open media and a wide range of broadcasting were both a principle of a liberalised society and a new source of lucrative business, which had been banned by the previous authoritarian regime. Furthermore, the increasing commercial and social demands for space-based technology were intertwined with security concerns provoked by the penetration of AsiaSat-1 television programmes, and the sophisticated aerospace capability applied in the Gulf War. The MOTC's continuous search for foreign partners to construct a communication satellite also attracted public attention on the ongoing domestic space programme.[120] As time went by, scientific experiments and the creation of a space infrastructure were not enough to justify the programme. A satellite mission needed to contain elements of direct usefulness to society. Pragmatic considerations other than

[120] Rejected by Papua New Guinea in 1991, the MOTC had to give up its original plan

scientific feasibility now reverberated among policymakers. In particular, pragmatic considerations were pressed by legislators who had strengthened their political power as a result of the 1992 comprehensive election.[121] To respond, more than once President Lee expressed the urgent need to promote the utility of the satellite programme (*Legislative Gazette,* 81 (64), pp. 198-99; *China Time*, 18 May 1994).

Communication Satellite

With the Cabinet reshuffle of February 1993, Kuo Nan-hung, Convenor of the STAG, who had previously been a key actor behind Premier Hau questioning the effectiveness of the satellite programme (*SciTech Reports*, October 1990, p. 1), switched posts with Han-min Hsia to take charge of the NSC. Kuo had urged earlier that Taiwan's space programme should take science, communication, and remote sensing applications all into account together (*SciTech Reports*, August 1990, p. 1). "The satellite programme should not have been initiated by the NSC from the start … However, assuming the post, I had to carry on the programme," Kuo frankly explained (Kuo, 2000, interview). While denying any external pressures relating to his judgement, he seemed to predetermine a communication satellite as the best option for future satellite development.

Only one week after assuming his new post, he announced that the space programme would head towards commercialised applications, by developing a GEO communication satellite (*Central News Agency*, 6 June 1993). Kuo's decision might seem hasty and aggressive, but not perverse. It accorded with the second stage of

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for a communication satellite. It then contacted Singapore for co-operation.

[121] See *Legislative Gazette,* 81 (64), pp. 191-94; 82 (24), p. 167; 82 (43), pp. 41-42; 82 (57), p. 295-96.

MOTC's satellite planning, with which Kuo became familiar while serving in the office of MOTC minister (*SciTech Reports*, 1990, p. 15). In particular, it corresponded with high domestic expectations with regard to exploiting the value of the satellite programme. Taking advantage of Taiwan's strength in computer, communication, and consumer electronics, communication satellites met economic demands and provided a role for local technology development (Kuo, 2000, interview).

However, Kuo's decision apparently ignored the collective advisory function of the Steering Committee. Such a swift change could hardly be imagined if it were not for the tension between Kuo and his predecessor Hsia Han-min, suggesting that the policy reorientation was more or less entangled with political and personal conflict.

Another dimension of the political conflict was the growing confrontation between Mainlander-American and Taiwanese-American scientists within the NSPO. Taiwanese staff were discontented with Mainlander domination. At that time high-ranking scientists such as Director Dai Guang-shiun and Deputy Director Yong Kay were Mainlander-American scientists. DPP legislators in particular criticised the NSPO as a mainlanders' scientific institute (*Legislative Gazette*, 82 (61), p. 409). Later, it became clear that Dr. Chen Chao-jiun, a Taiwanese-American engineer with excellent expertise in US military communication satellites, was leading a group of staff against mainlander leadership. The conflicts were not confined to ethnic friction, but extended to disputes over technology. Based on his expertise Chen actively advocated a communications satellite as the best choice for Taiwan's space development, and played down the effectiveness of a LEO satellite. Such ethnic and professional confrontations were so severe that Kuo had to take personal control of the NSPO when he came to the office (Kuo, 2000, interview). However, Kuo's involvement somehow intensified the conflicts. First, the crippled leadership was further weakened when management control was taken by Kuo (*SciTech Reports*, June 1994, p. 18). Secondly, having the same ethnic background and being a university colleague with Kuo, Chen apparently received stronger support from Kuo and his activism became much more explicit. Consequently, Chen's faction continued to release information about the inferior performance of ROCSAT-1 to the legislature. In October 1993, then lawmakers Chen Shui-bian and Lee Jin-yung asked a series of critical questions about the ROCSAT-1 project in a press conference and in the Legislative Yuan, the first time that such full-scale and in-depth professional criticism had been made openly since the NSPO's inauguration. Criticism included the limited industrial spin-off, poor NSPO competence, the conflicting requirements of the payloads, the low local content ratio, limited scientific significance, lack of practical utility, and the poor cost-effectiveness of the LEO satellite's short life span (*Legislative Gazette,* 82 (57), pp. 443-49). The technological detail of their criticism suggested that they had sources inside the NSPO. Along with those criticisms, they called for the building of a Ka band communication satellite (*Legislative Gazette,* 82 (61), p. 425; *SciTech Reports*, October 1993, p. 1). Ka band communication was still immature in commercial use as a result of its problematic rain attenuation, but it had been installed in a US military satellite, and was the professional area in which Chen himself worked. Given the personal conflicts, it was no surprise to see the exposure of NSPO's wrongdoings.

The network of DPP lawmakers, Chairman Kuo, and Chen gave rise to a strong impetus for policy change. Backed by the expertise of Chen Chao-jiun, Kuo speeded up the progress of the space programme and directed ROSCAT-2 towards the construction of a GEO communication satellite. As a result, the scientific activities of the NSPO were scaled down, following with the resignation of Chief Scientist Ip

Wing-shiuan.[122] To secure justification for the policy the NSPO organised a non-statutory advisory committee to review its project proposals.

After one year of studies, in March 1994, ROCSAT-2 was agreed as a Ka band experimental communication satellite to target multimedia transmission, wide band communication, and high speed Asian information transmission. At the same time, ROCSAT-3 was designed as a remote sensing satellite to execute atmospheric sounding and ocean and land observation (NSC, 1994, pp. 103-4). In May 1995 the Executive Yuan agreed to undertake communication satellite planning (Executive Yuan, 1995). In May 1996, one month before Kuo left the NSC, TRW won the contract to offer technological assistance for the design of ROCSAT-2 at a price of US$0.8 million (*NSC Monthly*, May 1996, p. 443).

The triumph of the GEO communication satellite also meant the loss of Mainlander-American scientists' power. To resolve personal confrontations which still hindered the efficiency of the NSPO's work, in April 1994, Kuo took advantage of the DPP legislators' criticism concerning dual nationality and the dubious loyalty of leading NSPO experts, and removed Dai Guang-shiun from his post, without the involvement of the Steering Committee (*SciTech Reports*, June 1994). A few months later, Deputy Director Yong Kay resigned. Again without the consent of other Steering Committee's members, Shyu Jia-ming was appointed as Director in June 1994. Chen Chao-jiun afterwards became Deputy Director of the NSPO. Unfortunately, this appointment initiated a new round of conflict between local technocrats and overseas experts. At the same time, the programme and personnel changes displayed NSPO's black-box decision-making and group culture.

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[122] In summer 1993, a annual appropriation fund of NT$60 million controlled by the NSPO for sponsoring space science and technology research was cut to just NT$20

Between July 1995 and March 1996, China conducted three series of missile tests near Taiwan, giving rise to what was called the Taiwan Strait crisis. The idea that ROCSAT-2 could play a military role, advocated by Deputy Director Chen, was taken up by DPP Legislator Liau Yung-Lai in response to the crisis. To justify his decision, Chairman Kuo confirmed the military potential on a long-run basis, revealing the significance of military applications, which had been concealed so far, behind the commercial logic advanced for the ROCSA-2 project (*Legislative Gazette,* 84 (58), pp. 187-8). With this, the case for the construction of a communication satellite was expanded from a purely commercial perspective to include a military application.

Policy U-turn

For Taiwan, however, the development of a large communication satellite created some critical predicaments. Apart from the need for much more sophisticated technology and higher costs, Taiwan, not being a member of the International Telecommunications Union, would confront real difficulty in getting a slot for orbiting a GEO satellite. Furthermore, the previous installed assembly facilities and trained staff, almost all for the purpose of assembling and testing small satellites, would be wasted (Ip, 2000, interview; Ting, 2000, interview). Given the frustrations around ROCSAT-1, a communication satellite seemed to place the whole satellite programme under great political pressures and project risks, which annoyed local technocrats such as Director Shyu who were sensitive to Taiwan's political environment (Shyu, 2000, interview). The conflict between Shyu and Chen thereafter represented continuous rivalry between LEO and GEO satellites.

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million (NSPO, 1997, p. 41).

In 1995 a breakthrough in negotiations for a commercial communication satellite (Singapore Telecom-1, known as ST-1) added a new parameter to the ongoing design of ROCSAT-2, and its fortunes started to fade. The ST-1, promoted by then Minister of the MOTC Liu Chao-shiuan, was a co-operative project between Singapore Telecom and Chunghwa Telecom of Taiwan, in which Taiwan could share 8 Ku band channels and 6 C band channels for a shared cost just US$120 million, cheaper than ROCSAT-1 construction. The much cheaper ST-1, which was later awarded to contractor Marta Marconi Space for construction and launch, seemed to pre-empt the commercial ends of ROCSAT-2 (*China Times*, 26 August 1998, p. 7; *China Times*, 27, August 1998, p. 3).

One year later, Liu Chao-shiuan, who acknowledged the limitations of the construction of a Taiwan-owned communication satellite, assumed the post of Chairman of the NSC. Kuo's continuing obsession with a communication satellite even after the successful deal on the ST-1 was given as an critical reason for removing him from his cabinet position without assignment to a new post, according to a high-ranking official of the Executive Yuan who wish to remain anonymous (Interview B, 2000). Although it was hard to confirm whether Liu was appointed in order to change space policy, he declared that he would launch a thorough investigation of NSPO organisation management and its satellite projects, just one month after he took office (*Central News Agency*, 22 July 1996; *China Times*, 21 July 1996, p. 7).

The ROCSAT-2 project for a communication satellite was under threat. The infatuation of Deputy Director Chen with developing a communication satellite intensified his confrontation with Shyu. Losing the NSC support granted by Kuo before, Chen and his faction tried to use the media and legislators to gain political influence. For example, a severe setback to the ROCSAT-1 project caused by coupled loads was leaked by NSPO insiders (*Central News Agency*, 22 July 1996). Conflicting interests mingled with contested technological positions brought a number of poison-pen letters to the desks of NSC officials, lawmakers, and journalists (Peng, 1996a; *Legislative Gazette,* 86 (7), pp. 416-7).

To resolve this impasse Liu commissioned an Evaluation Group composed of ten foreign and local experts to review NSPO's programme and management (Table 6.3). He also warned the NSPO scientists and engineers not to use external influence to sway policy, and declared troublemakers would be severely punished (*Legislative Gazette,* 85 (48), p. 447).

Table 6. 3 Evaluation Group for Space Programme (1996)

Name	**Institute**	**Expertise**	**Origin**
Deng Chi-fu	Chiao Tung University	(Convenor)	Local
Weng Cheng-i	Cheng Kung University	Mechanics	Local
Chiu Huei-huang	Cheng Kung University	Aerospace	Local
Chen, Jer-jiun	Central University	Remote Sensing	Local
Han Gunag-wei	Academia Sinica	Missilery	Local
Wang Hung-chih	CSIST	Mechanics and Materials	Local
Lu Shiue-jing	Chungwha Telecom	Telecommunication	Local
Mang Ching-i	John Hopkins University	Space Physics	Overseas
Wu Shih-chan	Alabama Sate University	Satellite Payload	Overseas
Du Kuei	Lincom	Satellite Communication	Overseas
Fang Ru-fu	Comsat	Communication	Overseas

Source: NSPO, 1996a; *SciTech Reports*, October 1996, p. 27.

In December 1996, Liu unsurprisingly accepted the recommendation made by the Evaluation Group. He halted the existing planning work on the ROCSAT-2 and -3 projects and made a U-turn to resume the development of small LEO satellites, despite maintaining the current communication satellite design (*China Times*, 5 December

1996, p. 9). In October 1997 the Executive Yuan ratified the Amended Long-term National Space Technology Development Programme (hereafter Amended Programme) proposed by Chairman Liu (Executive Yuan, 1997). The Evaluation Group report was again not published. According to the Control Yuan's later investigation the report did not contain any substantial data and evidence to support the policy U-turn (Control Yuan, 1997). The official reasons for the policy U-turn were attributed to the technology gains from the LEO satellite, the prevention of resource wastage in communication satellite construction, and the promotion of a local small satellite industry (*NSC Monthly*, February 1997, p. 114).

The satellite selection argument then burst into the open when Shyu and Chen attacked each other at a public hearing held by DPP lawmakers six months later (*Central News Agency*, 13 May 1997; *China Times*, 14 May 1997). Edged out from the mainstream, Chen claimed the decision was taken behind closed doors, and interfered in by non-professionals. At the same time, in order to consolidate his position and reduce dependence on overseas expertise, Shyu began to introduce talent from the CSIST, where the strong dichotomy between civilian and military scientific institutes had begun to diminish. Behind the scenes, Liu's activism in releasing military research capacity as mentioned in Chapter Five played a crucial role in involving military specialists, such as Wang Hung-chih, former Director of Missile and Rocket Laboratory at the CSIST. Once overseas experts were dispensable, in June, five high-ranking scientists in the NSPO, including Chen and Die were sacked without notice, the arbitrary nature of which was then subject to Control Yuan condemnation (Control Yuan, 1997). The controversial closure denoted the victory of local technocrats and experts, and LEO satellite selection. The internal conflict was thus brought to an end, but the closed organisational culture still remained.

Policy Justification

Liu's decision however was welcomed as necessary for the sake of securing the space programme as a whole (*China Times*, 5 December 1996, p. 9; Ip, 2000, interview). If Liu's manner was arbitrary, it was no more so than Kuo's administrative behaviour. Both Kuo and Liu understood the need to legitimate their positions. For Kuo, the Long-term Programme was just a blue print subject to new social demands, within which it was legitimated to direct ROCSAT-2 towards a communication satellite (Kuo, 2000, interview). And while Kuo's proposal had been agreed by the Executive Yuan, the agreement was just a green light for going ahead with 'design research' but not construction, as interpreted by Liu and Shyu (*Legislative Gazette*, 86 (44), p. 106; Shyu, 2000, interview). Thus, the policy U-turn resuming the LEO satellite project was nothing but a continuation of the Long-term Programme, in which the three projects were defined as a series of small LEO satellites.

Beyond this different reasoning, the similarity in each case was that external experts were called into justify policy changes. Furthermore, rather than having insider support, this time, Liu had to turn to a non-statutory Evaluation Group. So, who would be the real space experts? Did those scientists of the Evaluation Group know better than NSPO experts such as Chen who had been recruited world wide and worked for the programme? Who had the power to appoint those advisors? Had those preferring communication satellites been equally involved in the review? If the suggestion made by the Evaluation Group was only based on individual insight and knowledge rather than deep assessment and scientific evidence, then how could the reliability of their verdict be judged? All such scepticism somehow gave weight to Chen's accusation. Apparently, scientific knowledge here again served political power and the will of the politicians. The 'objectivity' stemming from scientific knowledge conveniently allowed the politicians to reverse the direction of the space programme. But, the considerations involved in the review and evaluation of the programme went far beyond technical ones. Political, economic, social and security factors had to be taken into account. If this was so, one question still remained. Would a much more plural and democratic decision-making process be possible, when the fusing of science and politics was inevitable? In this case, the pressure generated outside the executive branches came from media coverage and legislators' criticism, which were not only inadequate to create a reasonable forum for policy discourse but also insufficient to reinforce political resolution. Therefore, superior political power and position naturally turned out to be the key to the resolution of the controversy. That was why scientific judgement was needed but operated in an unaccountable way. According to the view of Liu and Shyu, for science administration to take full responsibility for policy change was what a democracy was about (Shyu, 2000, interview; *China Times*, 30 June 1997, p. 10).

Of course, the policy U-turn had its own logic and rationality. First of all, the development of small LEO satellites could use existing resources to target the goals set in the Long-term Programme without adding greater risks. Secondly, the demand for a GEO communication satellite was not as strong as previously expected. According to research done in 1995, the potential for satellite news gathering was limited in Taiwan, owing to the small news gathering area and the inadequate capacity of local journalists (Ku, 1995, pp. 9-10). Up to 1995, most domestic and foreign TV programmes via direct broadcasting had been carried by nearby communication satellites such as AsiaSat-1, APSTAR-1, INTELSAT, PAS-2, and so on (Ku, 1995, p. 74). The buyers' market for satellite transponders resulted in crowding out the demand for a Taiwan-controlled communication satellite, in the view of the local telecommunications industry (*China Times*, 27 August 1998, p. 3). In fact the services provided by ST-1 had not been fully exploited. Rather, it was the MND and other intelligence agencies that became the major users of ST-1 (*China Times*, 27 August 1998, p. 3; Yong, 2000, interview). Thirdly, with the explosive popularity of mobile phones and the Internet during the second half of the 1990s, ground-based cellular phone systems and optical fibre network construction became the priority both in private and public investment, which naturally detracted from the value of satellite communication. Finally, even considering the world satellite industry alone, where modularised and standardised micro and small satellites were emerging as the main thrust in future markets, Taiwan's preliminary capability for small satellite manufacturing looked more likely to fit into the global trend (*NSC Monthly*, February 2001, pp. 102-7; *China Times*, 5 December 1996, p. 9). A satellite constellation, like Globalstar, Iridium, ORBCOMM, Teledesic, and SkyBridge, composed of tens and hundreds of satellites in a system, offered great opportunities for Taiwanese participation. In fact, actions had been taken by both public and private sectors to respond to the new era of global mobile communication and related businesses.[123]

However, the considerations underlying the Amended Programme had a significant drawback, in that concern was implicitly centred on securing the programme rather than on identifying long-term prospects. The policy U-turn was made in a negative way, rejecting a communication satellite but not identifying future project missions. The NSC and NSPO had no idea about what ROCSAT-2 and -3's

[123] For example, Taiwan's Pacific Electric Wire and Cable had joined the shareholders of the Iridium network by investing more than US$50 million (Peng, 1996b; *Taipei Times*, 7 September, 1999, no. 1210). Incentives offered by the Executive Yuan also attracted as much public/private capital again to participate in the global consortium to develop Kistler Aerospace's fully reusable K-1 aerospace vehicle, designed to deliver satellites to low earth orbit (Peng, 1996b; Chiao Tung Bank, 1999).

missions would be before the Amended Programme was mapped out six months later (*China Times*, 5 December 1996, p. 9). In the Amended Programme, while self-sufficient manufacture and design capacity as well as scientific research, space utilisation, and industrial upgrade were further emphasised, the conspicuous change was the advocacy of a new policy direction – the proposal to privatise the NSPO. This obviously reflected optimism regarding the future of the micro and small satellite market (Executive Yuan, 1997, pp. 13, 34). Although transforming the NSPO into a legal entity and a spin-off company might not be a bad option for Taiwan's space development, the strategy could be over-optimistic in view of the huge disparity between its nascent status and the prospect of a self-sufficient industry. More seriously, the emphasis on space-related industrial output as the underlying policy idea implied a weak government commitment to upholding space technology development and a reduced concern for social usage. This was verified when Liu Chao-shiuan, then Vice Premier, announced that Taiwanese space development would be fully commercialised at the conclusion of the Long-term Programme and that the NSPO operation would have to rely on its own revenue, although this was later denied (*China Times*, 28 January 1999, p. 2).

F. The Dilemma over ROCSAT-2 and ROCSAT-3

After the organisational reengineering and programme review discussed above, it was crucial for the NSPO to complete its projects and justify its policy. However, while the personnel problems of the NSPO had been resolved, tensions between social accountability and policy justification, scientific development and political considerations still generated dilemmas for Taiwan's space policy.

ROCSAT-2

According to the Amended Programme ROCSAT-2 was designed as a LEO observation satellite (Executive Yuan, 1997, pp. 20-1), the original ROCSAT-3 project. Unlike ROCSAT-1, ROCSAT-2 was restricted from the start in its primary mission to resource planning and exploration, environmental protection, and disaster prevention and relief. This mission was to be carried out by its key payload – a Remote Sensing Instrument (RSI) (NSPO, 1997, p. 20). Alongside the RSI, a subsidiary scientific payload was then solicited. The system requirements indicated in the Amended Programme, such as a maximum resolution under 5 metres, a multi-spectral and panchromatic scanner, data storage capability, and a link with international Geographic Information Systems, were directly reflected in the tender document for ROCSAT-2 (Executive Yuan, 1997, pp. 20-1). This seemed to suggest that demanding requirements were predetermined in order to enhance the technological standard of ROCSAT-2.

According to one internal source, however, the original plan under Kou's direction set much more stringent system requirements in order to fulfil multiple purposes including military use. For example, sensor resolution was originally proposed around 1~2.5 metres, then modified to 3~5 metres, a much more flexible and achievable goal, at the revised planning stage (Interview C, 2000). In other words, the Amended Programme and later review added some flexibility to the original project to facilitate peaceful use and implementation feasibility.

To highlight its association with academic and industrial demands, emphasis was also placed on open information. In October and December 1997, around 200 academics were invited to project symposiums held by the NSPO, revealing a positive enthusiasm for space-relevant research (*NSC Monthly*, March 1998, p. 285). A series of surveys and workshops were carried out to stimulate local industrial participation, in which a local contribution to manufacturing was presupposed. After numerous assessments, in July 1998, the main scientific payload – the Imager of Spirit (Upper Atmospheric Lighting), the first satellite observation for Red Spirit, proposed by Cheng Kung University and the University of California at Berkeley, was selected to underscore the scientific significance of the project (Lee, 2000, interview; *Central Daily News*, 26 March 1999, p. 4).

The Long-term Programme had been running for over seven years by this point. When the ROCSAT-1 launch was counted down in 1998, its debatable achievements called the prospects for ROCSAT-2 into question. Although ROCSAT-2's mission was largely focused on social relevance, its cost-effectiveness was problematic in view of the technological investment required. The earlier NSPO studies clearly showed that all the data that would be generated by the RSI were accessible from international satellite sources, except for those relating to the local agricultural environment and natural disasters (NSPO, 1997, p. 10). The RSI's total time window for observation was just 24 hours since its brief intervals was constrained by low earth orbit, short daylight hours and poor weather, according to Chen Chao-jiun (Interview A, 2000). Even the scientific payload was criticised for its derivative design, which mostly benefited the US counterpart (Jing, 2000, interview). Those factors undermined the credibility of ROCSAT-2.

What is more, issues regarding the project's military application came to the fore in public opinion when cross-strait tensions increased after the 1996 missile crisis. Relations between Taipei and Beijing were plunged into crisis, with China adopting an aggressively nationalist stance on the back of its successful economic growth, military modernisation, and the projected reintegration of Hong Kong in 1997 and Macao in

1999, and with President Lee put forward his 'special state-to-state' formula in 1999. Relevant external events that particularly provoked military expectations with regard to ROCSAT-2 included the increasing number of China's Short Range Ballistic Missiles facing Taiwan,[124] SPOT imagery of a mock-up Taiwanese military airbase built in Xinjiang, China (*United Daily News*, 29 April 1999), China's plan to launch additional surveillance satellites in 2000 (*United Daily News*, 14 March 2000, p. 2), the Ikonos satellite photos of China's missile bases released by the Federation of American Scientists (*United Daily News*, 11 May 2000), and debates surrounding Taiwan's participation in the US-developed Theatre Missile Defence (TMD). It was widely argued that Taiwan had to improve its aerospace-based communication, surveillance, reconnaissance and data-link systems to counteract China's high-tech arm threat.[125]

Accordingly, space specialist and academic comment on the satellite programme swelled again in the late 1990s, very much echoing the earlier pragmatic considerations when Kuo and Chen had advocated the construction of a communication satellite. For example, upholding Chen Chao-jiun's view, Chang Shi-

[124] Concrete estimates of China's missile threat appeared in the press in February 1999 in both Taiwan and the US. In Taiwan, then Defence Minister Tang Fei commented that China had targeted 120 M-group (M-11 and -15) missiles at Taiwan, reported by *United Daily News* on 11 February 1999. According to a classified Pentagon assessment, first reported by the *Financial Times* on 19 February 1999, 150-200 Short Range Ballistic Missile were aimed at Taiwan and the number could reach 650 by about 2005 (CDISS, 1999).

[125] See *Taipei Times*, 12 September 1999, no. 2274; *China Daily News*, 8 October 1999, p. 7; *Legislative Gazette*, 88 (28), pp. 182, 213-6; *Washington Post*, 10 May 2000, p. A03, Article 7; DoD, 1999. p. 5. Those debates led the MND to work on a local low-altitude anti-ballistic missile system, including acquisitions of land-based Patriot III missiles, 1000-km long-range early warning radars, and prospectively AEGIS-equipped destroyers. It is worth noting that the digital link and tracking ability of the AEGIS system would remedy a fatal weakness in Taiwan's C4ISR (Command, Control, Communication, Computer, Intelligence, Surveillance, and Reconnaissance). More importantly, it could form the basis for future TMD deployment.

cheng, now Advisor to the President, denounced ROCSAT-2 as a useless, misguided scientific project which could be supplanted by international satellite imagery and should be replaced by a communication satellite project (*Liberty Times*, 22 December 1999, p. 15). Holmers S. Liao, a research fellow at the Taiwan Research Institute, played down the scientific application of Taiwan's space programme as developed so far and constantly advocated a dual-use commercial-military space application including communication and observation to justify the policy.[126]

The satellite planners thus had to take account of the growing anxiety over security. Under pressure from legislators, Chairman Liu and his successor Hwang Jenn-tai admitted, although reluctantly, that the satellite programme did have the potential for military use (*Legislative Gazette*, 86 (44), pp. 84-5; 88 (28), p. 183; *China Times*, 23 October 1997). This was no doubt why Wang Hung-chih, a missile and rocket specialist from the CSIST, was called to chair the ROCSA-2 project, and later became Director of the NSPO. It was also why the 3~5-metre sensor resolution requirement for RSI was enhanced to 2-metres during contract negotiations, producing what was claimed to be the first agreement to transfer such a high-resolution imaging satellite from one country to another (*Central News Agency*, 30 March 1999; *Legislative Gazette,* 88(18), p. 109). The high-resolution imager particularly pleased top politicians such as President Lee and the Director General of National Security Bureau, as its semi-reconnaissance feature would be able to detect and recognise tanks, radar installations, missile launchers, and so on (*China Times*, 27th January 1999, p. 3; Interview A, 2000; Jasani, 1990). As a result, a society-oriented scientific project was combined with military use. In reality, the semi-reconnaissance function provided no

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[126] See *China Times*, 10 February 1999, p. 15; 22 March 1999, p. 15; 29, April 1999, p. 15; Liao, 1999.

more than a political illusion, rather than a real military function, as it was limited by its single satellite operation, limited repeat cycles, and still inadequate resolution.

In February 1999, the ROCSAT-2 contract was signed by the NSPO and Dornier Satellitensysteme GmbH (DSS) of Germany at price of NT$2.7 billion (US$83 million) (*NSC Monthly*, April 1999, pp. 438-9). The LEO satellite would weight 600 kilos and would orbit at 891km altitude with 98.99° inclination. By operating on a sun-synchronous orbit with a single day repeat cycle, its payloads could carry out remote sensing and scientific observation. With DSS assistance, the NSPO would embark upon two sub-system designs – the bus structure and thermal control. In addition, local firms were allowed to join in manufacturing for four components, including computers, electrical systems, antennae, and radiators, raising local manufactured parts to 23 per cent of the total (*China Times*, 2 March; 8 May 1999). Yet, consent from the German government was still required to prevent a fiasco similar to that befell the ROCSAT-1 project.

Unfortunately, the introduction of a military security aspect exacted a cost. The DSS failed to receive an export permit from the German government by their April deadline. The sensitivity of the situation soon plunged the whole deal into confidential discussions surrounded by obscurity (*Taipei Times*, 7 October 1999, no. 1210). Despite denials by both the NSC and DSS, rumours of Chinese interference kept appearing in German local newspapers (*China Times*, 21 June; 2 July 1999). In May 1999 speculation became intense when China's embassy in Yugoslavia was bombed by NATO. Later, Chairman Hwang confirmed that the delays had been caused by China interference, based on an accusation that Taiwan would use the satellite's high resolution imagery capacity to carry out military surveillance missions (*Central Daily News*, 17 August 1999, p. 4; *Taipei Times*, 26 October 1999, no. 8167) A report in the

Frankfurter Allgemeine Zeitung on 19 September 1999 quoted China's Deputy Foreign Minister, Zhu Quizhen as saying "China would object to anything involving the supply of military technology" (*Taipei Times,* 13 October 1999, no. 6248). After a ten-month suspension, the NSC cancelled the contract with DSS and turned to the French-based Matra Marconi Space to complete the project. The NT$23.7 billion (US$755 million) contract was sealed on 3 December, after the French government issued the high-tech export permit (*NSC Monthly*, January, 2000, p. 49). The satellite's functions, major technical specification, and co-operative arrangements were declared to remain the same as in the previous contract. Six components with a transfer value of over NT$3 million (US$90,000), the same as DSS had offered, would be produced by six local firms (*Legislative Gazette,* 88 (3), p. 276; NSPO, 2000a, p. 56). But, while the highly significant 2-metre resolution was secured, the sensor's swathe was reduced to just 24 km, begging another question about its effectiveness in its most valuable missions in detecting the agricultural environment and effects of natural disasters, which needs no more than a 5-metre resolution but a 50-km swathe (NSPO, 1997, pp. 9-10). Here, the military application distorted the environmental observation mission. Yet, opposition exerted by China continued to put pressure on French government (*Taipei Times*, 13 January 2000, no. 19440; 10 November 2000, no. 60639; Hsieh, 2000, interview).

ROCSAT-3

Compared with ROCSAT-1 and -2, the ROCSAT-3 project seemed to come out of nowhere. It was identified at the time of the Amended Programme, but was put forward as an act of international scientific co-operation without open consultation or tendering (NSPO, 1997, p. 29). ROCSAT-3 was conceived as a constellation of eight (later six) LEO micro-satellites to provide data for a wide range of scientific applications, including meteorology, ionosphere measurement and climate forecast (Lee, Lou-chuang 2000, p. i; Rocken, et al., 2000, p. 22-23). Each of the LEO satellites would track 24 Global Positioning System (GPS) satellites as they passed behind the earth on their orbit, to retrieve up to 500 daily profiles of key ionospheric and atmospheric properties. The proposed first constellation for GPS sounding was jointly initiated by the NSPO and the University Corporation for Atmospheric Research (UCAR), US.

The initiative for the project was attributed to Tsay Ching-yen, then Vice Chairman of NSC, now Minister without portfolio, owing to his close relationship with Taiwanese-American scientist Bill Kuo, who had worked on GPS occultation applications at UCAR, and was then Director of the COSMIC (Constellation Observing System for Meteorology, Ionosphere, and Climate) Project Office of UCAR (Yunk, et al., 2000, p. 10; Interview A, 2000). In 1997, UCAR was desperately looking for sponsorship and international partners. In this regard, the project was not simply a collaborative US-Taiwanese scientific experiment, but also a follow-on project for the 1995-launched MicroLab-1 satellite of the GPS/MET (GPS/Meteorology) project established by USAR jointly with the University of Arizona, the Jet Propulsion Laboratory and other partners (Yunck, et al., 2000; Anthes, et al., 2000, pp. 115-121). Its official name, ROCSAT-3/COSMIC, faithfully indicated its roots and linkage (see UCAR, 2001).

Backed by the US scientific teams, the project development went ahead quickly, almost in parallel with the progress of the ROCSAT-2 project. Of course, adopting already developed technology, involving several crucial US governmental and non-governmental institutes such as the National Science Foundation, the National Air and Space Administration, and the National Oceanic and Atmospheric Administration, could not only secure the success of the mission, but also bring the benefits for local meteorological science and weather forecasting. However, the underlying consideration on the part of Taiwan was to develop the NSPO into a prime contractor for micro and small satellites and to promote local vendors to undertake satellite component manufacturing as a way into the world satellite market (NSPO, 1999, p. 256; 2001a). From that time, a commercial constellation has been seen as a promising area in NSPO's follow-on programme planning.[127] In this NT$2.8 billion (US$90 million) project, the NSPO will undertake system engineering, structure, and thermal control subsystem construction and involve local vendors in component production, expecting to reach a 50 per cent local content share (*Legislative Gazette*, 88 (18), pp. 106, 119).

Then again, adherence to a novel US scientific experiment also means that the ROCSAT-3 project is bound to be heavily dependent, and leaves no scope for alternatives. Given a designated co-operative counterpart, offering not just opportunities for scientific exploration but also prospects for micro-satellite production, the whole ROCSAT-3 construction was assigned to UCAR without open bidding. However, UCAR as a research institute in fact had no manufacturing capability, and had to rely on subcontractors (*China Times*, 27 August 2000, p. 9; Interview A, 2000). According to an inside source, the NSPO contributed US$80 million, almost 90 per cent of the whole ROCSAT-3 project budget, while UCAR was responsible for US$20

[127] During 1999-2000, follow-on space programme planning was conducted by Shyu Jia-ming, then Executive Secretary of NSPO. The planning placed several targets under consideration, including spacecraft modularisation, hyper-spectral satellites, SAR observation satellites, and multi-mission satellite constellations, on the basis of several full-scale surveys across government departments, academia and industry (NSPO, 1999, p. 257). In May 2000, the preliminary direction was set for the next ten-year space programme, in which NT$10 billion (US$300 million) was to be invested in constellation production and operation (*China Times*, 22 May 2000).

million, in which committed assets were counted (UCAR, 2001; Interview A, 2000). Paying the bill for US frontier scientific experiments hardly justifies the project, considering Taiwan's limited resources.

Even judged on scientific merit, the data collected from ROCSAT-3 covering temperature, moisture, pressure, and electron density in the atmosphere provide only parts of the crucial elements for formulating a global weather model. That was why the National Air and Space Administration once proposed a more sophisticated constellation system composed of 12 satellites (*Central Daily News*, 24 October 1998, p. 4). Besides the three US-made payloads,[128] the key part of the COSMIC experiment will be carried out in the COSMIC Data Analysis and Archive Centre located at UCAR in Boulder, Colorado. Can Taiwan's scientists access the facility and develop the simulation system to derive maximum benefit from ROCSAT-3's data in modelling global and regional weather forecasting? It remains to be seen.

It seemed at least, though, that Taiwan would be able to undertake micro-satellite design, production and mission operation. Unfortunately, in June 1999 UCAR shockingly informed Taiwan that the deployment mechanism for the eight satellites in a single-rocket launch infringed the US-filed patent of the Orbital Science Corp. (OSC).[129] Fears for the collapse of the project grew when negotiations between USCAR and OSC stalled. The NSPO had no choice but to involve itself in the controversy. The ensuing tripartite negotiation resulted in a much higher price than the NSPO could afford. In 2000, the NSPO started to consider an open tender for the

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[128] The main payload, a GPS/MET receiver, would be developed by the Jet Propulsion Laboratory on the basis of a previous receiver on the MicroLab-1 satellite; both the tiny ionospheric photometer and the tri-band beacon transmitter would be built at the Naval Research Laboratory (Rocken, et al., 2000, pp. 30-1).

[129] For a brief description of multiple satellite deployment see Rocken, et al., 2000, p. 30.

satellite bus production to avoid the OSC claim, while Surrey UK and the Swedish Space Corporation were ironically found to offer equivalent constellation technology for meteorological soundings (NSPO, 2000a, p. 74; 2000d; *China Times*, 27 August 2000, p. 9). But, due to the presence of US-made payloads on board, the European satellites could not avoid the OSC claim (NSPO, 2000a, p. 75). With an eye to the impending inauguration of Chen Shui-bian as President in May, the Space Technology Steering Committee placed great pressure on the NSPO to resolve the predicament by June or abandon the project (*China Times*, 15 May 2000; 16 June). Interestingly, after the inauguration of the DPP-led government, in November 2000 KMT legislators slashed NT$160 million off the ROCSAT-3 budget for FY 2001, about 60 per cent of the proposed fund (*Legislative Gazette*, 90(1), p. 102; *Taipei Times*, 30 November 2000, no. 63555). Finally the dispute was settled in March 2001 when the OSC won the satellite contract at price of US$56 million (OSC, 2001; NSPO, 2001b).

The current arrangement is that UCAR will take charge of the scientific missions including payload construction, and OSC will oversee the spacecraft construction and launch service. The constellation is trimmed down to 6 micro-satellites constituting three orbital planes with a total of just 2500 sounding profiles, logically decreasing its experimental value. The NSPO has secured local participation in satellite manufacture and orbital control, for which four local firms will make 14 components, worth US$5 million. But whether this arrangement can reach a 50 per cent local content ratio is problematic. In addition, the NSPO role in satellite design will largely decline because OSC plans to use its flight-proven MicroStar spacecraft (forty of which are currently in orbit) as a platform (OSC, 2001; Interview A, 2000). There must be doubt, therefore, whether the NSPO and related local firms will be able to undertake autonomous satellite manufacturing after the Long-term Programme ends in 2005.

G. Review

The development of Taiwan's satellite programme reveals the difficulities inherent in establishing a space programme for a developing country like Taiwan. Difficulties stemmed from the characteristics of space technology as mentioned before. But, the ideas underlying the space policy were far beyond technological conditions. The scientific programme from the outset was mixed with and brought forth by mighty political wills and power confrontations. At the same time, this apparently socio-politically constructed science programme indicated that the profound implications of space technology also made the programme a magnet for various actors' support despite continuous contention. The process of Taiwan's space development therefore clearly exemplifies the hybrid nature of science development in which scientific conditions and political power interacted and mingled together.

The initiation of the space policy firstly verified the growing strength of the NSC in the executive branch and the rising priority of science in the national policy arena. By employing scientific advice and highlighting its technological and military prospects, the NSC forged its political power and expanded its command over scientific affairs and initiated the science programme, the scale of which was largely beyond Taiwan's scientific and economic status at that time. Viewed from the perspective of overall science policy evolution in the last decade, space policy was a landmark of the rise of science enterprise.

While security constraints, industrial circumstances, and the state-led policy model predetermined the policy to some degree, pressures from civilian scientists, the media, industry, and legislators were immense, and imposed various criticisms and expectations upon the programme. In particular, the legislature as an issue carrier actively conveyed criticism and suspicions raised by scientists and the media into policy debates. But predicaments were rooted in the limitations regarding investment scale, technology base and national status, all of which were not well enough to fulfil those diverse expectations. The NSC and NSPO consequently fell into a dilemma. On one hand, to secure the programme the science administration employed an incremental and conservative approach to push forth the project which led to heavy dependency, compromised technology requirements, and slow application returns; on the other hand, facing anxious political and social pressures they tend to exaggerate outputs, disguise obstacles, black-box decisions, yield to contingent political demands and climates which in turn blurred project objectives and hobbled policy implementation.

Thus, although an incremental strategy was assumed to be the optimum approach, and credit should be given for the consistent manner in which it has been followed by Taiwan's space policymakers and government scientists so far, such an approach could not cope with erratic social demands and rapid political changes. Policy justification was inevitability driven and swayed by debate over a variety of issues: MRBM and SLV building, system integration capability, space science promotion, aerospace industry construction, domestic communication linkages, disaster mitigation, weather forecasting, ecological control, ground monitoring, military reconnaissance, micro-satellite component fabrication, and so on. As the programme developed it altered from a whole-package space technology establishment to a satellite-only production, from three LEO-satellites to two LEO plus one communication satellite, and then back to the previous LEO satellite plan with micro-satellite manufacture added. As a result, in the ROCSAT-3 project, efforts to achieve both scientific excellence and the initiation of space industry led to the demise of both. Bringing military objectives into the initially planned civil use of ROCSAT-2 remote sensing nearly jeopardised the whole project and detracted from its main function in environmental observation. The scientific significance and foundational construction of the ROCSAT-1 project were negated by technological incompetence, over-contracting, power struggles, and poor management. Constantly shrouded by various veils generated from political confrontations, Taiwan's space policy became confused, and drifted off course. It is not surprising that the White Paper on the Space Programme once proposed by Chairman Kuo for the promotion of public understanding has not been published (*NSC Monthly*, November 1993, p. 1180).

This record of poor performance and constant predicaments takes us back to the initial controversial issue: why does Taiwan need a space programme? From every perspective, there is no rationale for Taiwan to engage in a space programme, either for commercial profit or for S&T establishment. Only defence autonomy and public welfare could justify the policy. As regards security and public welfare, cost-effectiveness is doubtful, and only a nationally-owned satellite could secure social accountability and political legitimacy. In addition, judging from the policy goals proclaimed, Taiwan's space programme has yet to provide evidence of the prospects for design competence and spin-off effects, not to mention autonomous production and a share in the world market. These remain uncertain, and give policymakers great anxiety (NSPO, 2000a, pp. 8-9). The clustering of space component vendors shown in Table 6.4 after three satellite projects verifies the limited extent of domestic space technology diffusion. The only clear achievement is the continual growth of basic manpower and facilities, but these are easily challenged on cost-effectiveness grounds.

Table 6. 4 Local Component Providers in ROCSAT Programme

Firms	ROCSAT-1	ROCSAT-2	ROCSAT-3
Acer Sertek Inc.	Computer	Computer	Computer, communication board for mission interface unite
Victory Industrial Corp.	Filter/diplexer, antenna	S-band antenna	S- and L-band antennas, S- and L-band filters, S- and L-band converters
Taiwan Aerospace Corp.	Structural test model	Vertically integrated facility	Main structure, structure preparation
Shihlin Electric & Engineering Corp.	Solar array panel	Solar sensor	Sun sensor, battery set, electricity switcher
TranSystem Inc.	Remote interface unite	--	--
ITRI	Structural test model	--	--
Tatung Co.	--	Flight software	--
AIDC	--	Wires	--
Yung Tien Industrial Co.	--	--	Heater

Source: *NSC Monthly*, May 1999, p. 515; NSPO, 2000b; 2001a.

The coupling of science with politics in space policy offers not only an illustration but also a prescriptive implication regarding Taiwan's science policymaking. It shows that despite the plural policy actors and the strengthening science administration, knowledge power outside government was too weak to create a continuous arena for policy deliberation. Especially with the set-up of the NSPO, the policy participation of the general public, the media, the scientific community and even the legislature was seriously hindered by asymmetric information and a closed space planning process. Thereafter controversies were largely resolved by political means. The only movement across political boundaries was undertaken by the science administration itself through seeking scientific review from advisory groups. Because there was no competing knowledge power outside government, the advisory mechanism was used to reinforce political positions and justify given politicians' perceptions. This explains why, despite the weaknesses indicated, the programme could be initiated in the first place and has lasted so long, how different scientific advisers could be found to endorse predetermined policy changes, and why in 1999 the total budget for the Long-term Programme could still be increased from NT$13.6 billion to 19.7 billion (US$615 million) (Executive Yuan, 1999). Consequently, the space policy, seen a new area of Taiwan's scientific exploration, has impaired both scientific authority and the social accountability of science.

Supporters and opponents of the programme are agreed that there is a need to place a clear and practical goal at the centre of decision-making, although the purposes for space policy will never be straightforward (Su, 1997; Chuang 1999; Jing 1999; Liao, 1999; DPP, 1999). According to the still undefined follow-on programme, communication satellite and micro-satellite constellation production are set as the main targets for the future (Interview A, 2000; Yaung, 2000, interview; *China Times*, 22 May 2000), and the NSPO is proposing to turn itself into a non-profit entity for the benefit of private capital (NSPO, 2000c). Based on the above analysis, it can be predicted that Taiwan's space programme will continue to suffer from justification problems and executive predicaments, if market optimism and commercial euphoria pervade policy circles but solid government commitment and investment is lacking.

CHAPTER VII

Conclusion

This is a time in which the abundant productiveness of science and technology is rapidly shaping our daily lives, while scientific production itself has been through a transformation with the changing world. Among other things, policy provides the most crucial momentum to the process. The evolution of Taiwan's science policy is just one part of the broad transition and yet presents a unique local dimension of the interaction between science and society.

This research started from a review of Taiwan's historical and structural constraints and has demonstrated why and to what extent changes in science policy have taken place in the last decade. In the analysis, scientific autonomy, validity and responsibility are perceived as desirable criteria but are recognised to be subject to a continuous social construction. In particular, by observing multifaceted knowledge-power interactions, the study has identified a broader power reconstruction of policy communities and trends of policy evolution, and thus offered an new interpretation of Taiwan's science policy development. In this way, this study also contributes to the feasibility of applying the social studies of science to the policy domain. Focussing on the social institutions of science and the relations between science and society, it is able to add a new dimension to the current over-crowded literature on Taiwan's industry and technology in which science and technology are treated as governmental instruments. Its meso-level analysis examines those confusing, complicated and recurrent debates and controversies surrounding science-related policy issues and finds that the tension between 'knowledge power' – the power derived from the control of knowledge – and the accountability of science is the pivotal dilemma in this area. The analysis of Taiwan's scientific establishment and the various measures taken to fulfil diversified expectations of science indicates that the problems of harnessing science to social goals in Taiwan are no less than elsewhere. In a sense, this thesis also reveals the subtle but vexing limitations of Taiwan democratic consolidation, when it faces the inevitable impact of the development of science.

The final chapter first sums up what I have found critical to the evolution of Taiwan's science policy and policy communities, and then points to a lynchpin of Taiwan's science policy formulation that also causes disadvantages and needs to be addressed in future. In conclusion, based on the observation of this research, some suggestions for future policy are provided.

A. Policy Trends and Convergence

This research has shown that the features of Taiwan's science policy in the 1990s were very different from those in the 1970s and 1980s, when it was characterised by the applied-orientated approach. As policy considerations and directions were diversified, policy measures addressing the excellence of scientific research, the hard core of scientific autonomy, the social concerns of research and the promotion of private R&D were the most conspicuous advances.

Focusing on policy evolution, this thesis synthesised Taiwan's science policy trends into two strands: to promote scientific authority, and to fulfil expectations regarding the social accountability of science. Whilst the former was primarily reflected in various measures in the 'policy for science' category, the latter was in particular shown in the area of 'policy through science'. This research found that the two policy trends reinforced each other and tended towards an integrated consideration, representing a main direction of Taiwan's science policy over the last decade.

To fulfil the diverse expectations of science firstly the national scientific base and research capacity needed to be deepened. Thus, international reputation, academic excellence, paper publications, and patent acquisition were highlighted in policy to justify public science investment, which has more and more relied on social support. To strengthen the science base, measures addressing governance and the co-ordination of research such as discipline planning, large-scale integrated research, funding reform and ethical regulation were implemented. At the same time, systems of scientific verification and advice have become prevalent in research selection and penetrated the boundaries surrounding science-related public policy with the increasing prominence of the NSC in scientific project review. Through these efforts, scientific authority has been strengthened in the public sphere. The imperative of creating a strong scientific establishment made the initiation of certain large-scale domestic and international scientific projects necessary and understandable. Factors in the self-regulation mechanisms of science such as the pursuit of excellence and international prestige explained certain massive investments, large establishments, and pure science promotions which, in certain cases, went far beyond Taiwan's generally conceived status. As has been argued, these developments marked a sharp difference from the previous policy orientation which concentrated on industrial applications.

Likewise, the larger the role scientists and scientific claims play in public affairs, the more accountability is imposed upon science. Thus, policy needed to ensure scientific integrity, credibility and achievement on one hand, and to derive social benefits from scientific applications and utilities on the other hand. Diverse considerations ranging from the economy, security and the public good constituted the main thrusts of policy formulation and sources of policy legitimacy. Thus, while certain principal expectations of science policy might have appeared the same as before, such as economic profits and industrial upgrading, the content of the accountability of science has shifted. As regards economic ends, emphasis has been placed on private corporate research rather than direct state intervention in selected technology, which reveals that the perception of a close link between academic research and industrial R&D is actually misleading. As to security demands, science policy has actively involved scientific diplomacy and the relaxation of cross-strait tension, and at the same time, the research direction has also reflected the emerging political climate of localisation and national identity. Furthermore, the military technology system has been for the first time subordinated to the civilian science administration, the general system of scientific confirmation, and therefore consideration within overall national R&D development. Finally, the principle of the public good has become a crucial criterion for the legitimacy of science policy. Large-scale projects for disaster mitigation, sustainable development, and the eradication of local diseases have been actively promoted. The NSC has taken up a regulatory role to control ethical problems and human concerns in scientific activities and research. In sum, the policy of addressing the accountability of science represents distinct progress from previous policy developments that mainly reflected the perceptions and concerns of the political elites.

This research found that the two reinforced policy trends have also generated a tendency towards integrated policy, in which the government has managed to strike a balance that satisfies the social accountability of publicly funded research, without sacrificing the expansion of scientific achievement and value. The National-level Projects exemplify this effort.

However, policy convergence has not led in every respect to a coherent policy framework. Many cases in my study show that Taiwan's science policy has been fraught with conflicts. Conflicts were found between the two policy trends on many fronts, such as elitism and egalitarianism, international standards and localisation, scientific objectivity and popular expectations, academic freedom and commercialisation, and so on. Tensions also emerged between different objectives in the same policy area as well: between research discipline and scientists' morale, as seen in the debates on Research Awards, between commercial interest and consumer health, as seen in the controversy over genetically modified food labelling, and between military autonomy and dual-use technology exploitation, as seen in the conflict over the privatisation of the CSIST. Contradictory considerations have surfaced in all policy agendas in the newly democratised society. As seen in space policy, considerations including scientific foundations, military implications, business interests, industrial upgrading, and concerns about ecology and social wellbeing, have all been brought into play to justify, direct, or even disguise the character of programme development.

Has science policy given appropriate weight to different issues? How far should certain policy objectives be pursued? These issues require further micro-level investigation. However, my case study of space policy indicates that enquiries of this kind need to take the political manoeuvring of policy actors into account.

B. Constructive Science Policy

One contribution of the research is to focus on policy changes and to trace them by revealing the changing policy issues and constellations of political power. The study has demonstrated that democratisation and the opening of society have triggered a power restructuring of the policy community and a reorientation of science-related policy issues. The above two policy trends, highlighting scientific authority and the accountability of science, represented major forces for change in the policy community. Those transformations, although varying in their policy influence and problems encountered, were derived from actions and interactions of the 'scientification of politics' and the 'politicisation of science' which spontaneously occurred in all policy communities.

The 'scientification of politics' was found in the general public who acknowledged not only the significance of science-related issues but also the importance of scientific verification in the course of challenging the government on health, ethical issues, and the environment. The increasing involvement of scientists in public affairs with their self-examination on the issue of scientific autonomy, private sector pursuit for up-stream scientific niches, the intense legislative scrutiny with the demands placed on the professionalism of the legislators themselves, and strengthened NSC scientific review and governance, all fostered the 'scientification of politics'. In this process, the scientific community, the legislature and the NSC played the main roles. Through challenging the old unsound funding system, scientific ethos, and unaccountable control of research, they increased the weight of scientific authority in the public sphere and refined the content of science policy.

It is significant to realise that the above 'scientification of politics' was grounded in the democratised policy environment. Democratisation brought pluralistic policy participation and the power restructuring of the policy community, producing an intricate and kaleidoscopic issue pool providing diverse justifications for science policy. Those imposed accountabilities were intensified in the process of agenda setting only after the policy environment was democratised and those considerations were sustained by effective political power. This was a process of the 'politicisation of science'. This research has demonstrated that non-economic social concerns were established not simply by the imperative of moral appeals but a series of robust social movements mounted by interest groups. The collapse of authoritarian control and the declining power of the executive at large forced the isolated military institutes to release dual-use technology and subject it to civilian control. At the same time, governance by a professional science administration replaced domination by economic technocrats, and niche-seeking private industry infiltrated the state-led industrial innovation system. The vivid media reports, powerful legislative scrutiny and revitalised social involvement of the scientific community challenged the policy reasoning of the science agency and the scientific judgement of government scientists. All these developments redefined the relationship between science and society and introduced relevant criteria into policy, such as the principle of the public good, the quality of scientific production and the effectiveness of public (military) research. Consequently, the 'scientification of politics' indeed goes hand in hand with the 'politicisation of science' which gave impetus to the aforementioned policy trends.

C. The Imbalance of Scientific Authority

From the accounts of the policy trends and policy construction process this research reveals, in my view, the most crucial feature of the formulation of Taiwan's science policy in the 1990s. The changes of Taiwan's science policy have not merely resulted from the restructuring of political power but from the reconstruction of scientific authority in the policy framework. In particular, the strengthening of the NSC's scientific authority has proved to be the driving force in the evolution of science policy.

We have witnessed that, for the general public, the ephemeral nature of social mobilisation and the lack of widely disseminated understanding of the issues reduced the impact of issue clarification and promotion, which depended heavily on the prompt involvement of the media and legislators, and was inevitably prone to over-politicisation. The judgements of the scientific community, which suffered from its still fragile autonomy and the restricted setting of knowledge production, were inclined to be submerged in political distortion or threatened by commercial intrusion. Restricted by its weak capacity for in-house research, industry had to rely on government support in which public resources and research results were at stake. Although legislators were able to reflect multiple constituents' viewpoints, and convey non-scientific values to enrich policy debates and bridge the relationship between science and society, the lack of professionalism undermined their rationality and the credibility of their scrutiny. In some extreme cases, the involvement of the legislature even led to distortion and misjudgement in relation to scientific affairs. As a result, outside the executive branches, each policy community possessed inadequate scientific authority and inevitably resorted to the mobilisation of political power in order to sway policy to its preferences.

On the other hand, with the overall decline of the executive power and the fading of the paramount policy priority of economic development, the authority of the NSC has been restored and strengthened. It is noteworthy that the rise of NSC authority was not due merely to the rising priority, the reorientation and the administrative rearrangement of science policy, but also to its progressive control over the resources, funds, facilities, discipline, and the recognition of science. Not only did the NSC win scientific authority from the scientific community, but it also made itself a pillar of the stratified system and self-regulation mechanism of science. Furthermore, unlike its predecessor, the peer-run National Long-term Science Development Council, the NSC as a cabinet level agency from the outset appeared to be much better inserted into the bureaucracy. In this sense, the NSC represents a singular compound authority wielding both administrative and knowledge power in the domain of science policy.

What is more, the NSC's authority, based on the intimate ties between science administrators and leading scientific peers and forged through the contests of departmental jurisdiction and the centralisation of cross-departmental review, further extended its influence over a wide range of public affairs and science-related policy areas, by taking on a scientific review function. As a result, whilst political power exerted by elected officials and provoked by the media and social movements could subject the NSC to scrutiny, no other policy actors were capable of counteracting the knowledge power of the NSC. In terms of scientific authority, there was an unbalanced structure – almost a monopoly – in the framework of science policymaking.

So, what is wrong with a science administration equipped with authority coupling knowledge power and political power? As argued by top officials in the context of the space policy controversy: should not the science agency be left with a full mandate and responsibility to make the best decision with the help of appropriate experts? (Shyu, 2000, interview; *China Times*, 30 June 1997, p. 10) In other words, is it the essence of democracy that an administrative performance will be finally judged by vote and, up to that point, that the administration has the right to draw on any legal power it can in order to fulfil its political responsibilities?

Reference here to the imbalance of scientific authority by no means suggests that, after democratisation, Taiwan's science policymaking remained the same as before, mainly dominated by political and scientific elites. The diversification of policy issues and the growing social accountability of science reflect distinct differences. In fact, there has been great progress in policy adjustment to respond to the diverse demands, concerns and values raised by various policy communities in the course of a much more pluralistic participation, which has generated a set of demanding criteria for the justification of science policy. This is progress brought about by democratisation and the advances of the current decision-making structure.

Therefore, in Taiwan, the primary problem in science policymaking is not a lack of pluralistic participation, nor the dual power wielded by the science agency, but the unequal distribution of scientific authority in policy deliberation. The above officials' argument does not tell us why the authorised agency has to rely on scientific claims not only in seeking the help of experts but also in justifying its position and policy legitimacy. Placing the imbalance of scientific authority against the background of Taiwan's entire science policymaking structure, it can soon be realised that due to the agency nature of the NSC, its compound authority would unavoidably be left open to political interventions and manipulations in the absence of any counterbalance. The infertile environment for scientific research in the previous setting led to the creation of a system lacking effective checks and balances over the decisions of the agency and the judgement of governmental scientists. Consequently, the weight of political influence has surpassed the validity of scientific judgement in the making of science policy. Scientific verification and evaluation mechanisms such as advisory systems, expert review and technology assessment applied to the S&T policy process were so centralised within the government that scientific claims appeared to be a prerogative of technocrats and government scientists.

In many cases and dimensions, as shown throughout this thesis, the resulting disadvantages have increasingly threatened the legitimacy of Taiwan's science policy, as science has rapidly intruded into human values and social order, and science policy has expanded its role from production to regulation. We have witnessed various defects, such as over-ambitious planning, inadequate appraisal, political distortion, power intervention, poor verification, and the operation of unsound regulatory mechanisms. Those defects were the by-products of the asymmetrical exercise of knowledge power.

On such a skewed policymaking platform, political responsibility as well as scientific credibility can easily be sacrificed either for routine bureaucratic convenience or to solve thorny controversies. The scientific advisory mechanism operated in the NSC or in relevant agencies in general, which has largely proceeded through closed deliberation and discussion and has had no research or publicity, has been used to support government measures or political commitments. As an instance of intense controversy and political conflict, Taiwan's space policy clearly demonstrated how fragile and vulnerable scientific advice was. Throughout the planning of the satellite programme, different scientific advisory groups were set up over and over again in the name of scientific neutrality and policy rationality in order to endorse powerful political ideas and interests, and then dismissed by new political forces. In the process, the credibility and accountability of scientific claims to exercise responsibility on behalf of the public and society as a whole were seriously sabotaged. Lacking a proper arena of scientific debate, civilian scientists and the general public were forced to stir up political conflicts, which then provoked a policy of muddling through. As a result, scientific controversies have tended to be seen as power contests, undermining not only scientific integrity and credibility but also policy efficiency and legitimacy. Consequently, administrative authority and policy justification have been destroyed by the public mistrust of science. As Professor Chou Cheng-kung warned in *SciTech Reports*, increasing legislative power without the capability of scientific evaluation and increasing the authority of the science administration without giving it the capacity to resist short-sighted considerations can undermine the basis for healthy scientific development (*SciTech Reports*, September 1994, p. 4).

The more sophisticated and diversified the role of science in society, the more scientific controversies and policy contentions there are. In an unbalanced policymaking framework, controversies become subject to political contests and the outcomes always depend on the disposition of power, because there is no alternative and competent adjudicating organisation and authority to clarify policy-related issues, to call for public debates, and to receive alternative scientific opinions and verifications. It is therefore too naive to expect the one-sided deliberations in relation to science policy, which is increasingly full of uncertainty and controversy, to take social accountability and science development seriously and honestly. Given the fragility of knowledge power across society, the singular reliance on political power contests to untangle scientific uncertainty and controversy could lead to bias, ignorance, misdirection, or suppression of alternatives in policymaking. Furthermore, unless action is taken to address the situation, the aforementioned deficits will be passed on by continuously reinforcing political manipulation and the imbalance of scientific authority. When the role of science in the public sphere in Taiwan has expanded rapidly, the costs of policy errors are extremely high and sometimes immeasurable. The one-sided domination of knowledge power in policy deliberation has now become a hindrance to scientific and social development.

D. A Suggestion for Future Policy

Apparently, Taiwan's democratic consolidation has come to the point where it is necessary to address a vexing problem: how to accommodate science in a democracy. This study suggests that building pluralistic settings for scientific production and verification is as important as institutionalising centralised control. A healthy policy environment embracing diverse policy issues and pluralistic scientific opinions is now needed in order to reconcile science and society, and to secure scientific autonomy and the social accountability of science. However, as argued so far, such an attempt might end in disillusion if it ignores the multifaceted interactions between knowledge and political power. Understanding science policy as a constructed entity coupling science and politics, we shall not go back to the traditional prescription of separating the two. Bearing in mind the lack of mature public literacy in science and the fragility of scientific autonomy in Taiwan, cultivating a sustainable forum for alternative scientific verification and deliberation still has to depend on a competent political power.

According to my analysis, the legislature is so far the only adequate site with the capacity to address the current defects in science policy formulation. It has been the most effective platform for bringing public concerns and professional opinions into policy consideration and has been strong enough to audit and control policy. However, lacking professional authority, legislative involvement is prone to turn scientific debates into political conflicts. It is therefore urgent to set up an S&T advisory body in the legislature with a view to restoring checks and balances in science policymaking. More importantly, scientific advisory activities supported by the legislative power could help to penetrate the sanctuary of the government's scientific judgements, encourage civilian scientists and citizens to participate in policy, and build a stronger foundation for the public understanding of science and for scientific debates in society.

As Gary Kass has recently pointed out (2000, p. 325), any such new arrangements should have the following features:

- Independence from government, industry, and academia
- Responsiveness and flexibility in relation to changing social priorities
- Openness and accountability

- Formal insertion into the official policymaking process
- Inclusion of the information, attitudes and values of a broad range of interested and affected parties

In addition, for Taiwan, such an institution should avoid being a costly fully staffed evaluation body in its preliminary stage if we acknowledge that political influence is inescapable. Rather, a feasible organ would be created by bringing together the existing Science, Technology and Information Committee of the Legislative Yuan which on many occasions has shown a certain neutral stance, with members representing civilian scientists, industry and public interest groups, to form an assessment board equipped with certain amount of research funding. It is suggested that the objectives of the institute should be to select meta-scientific topics with which public and parliament are concerned or which have been ignored but are crucial to public life, and to support the scientific community and scientific interest groups to involve themselves in the scrutiny of the work of government. Although such an initiative would provide neither a perpetual solution to the tension between scientific autonomy and the accountability of science nor an interest-free scientific debate arena, as a initial step the crucial benefit of the arrangement would be to allow scientific production and verification to flourish in diverse settings. Unlike the case of developed countries, Taiwan's urgent problem is to promote alternative scientific verification systems rather than to create an ultimate authority for resolving conflicting scientific opinions or to tame the knowledge leviathan in the hope of restoring non-scientific values.

Appendix

Interview Invitation

Professor Philip Gummett, Pro-Vice-Chancellor

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THE UNIVERSITY of MANCHESTER

7 June 2000

To Whom It May Concern

Dear Madam/Sir,

We are writing to confirm that Mr. Chen Shih-jung (Roger), a PhD student in the Department of Government at the University of Manchester, plans to conduct interviews in Taiwan during this summer, as part of his research. His research concerns the evolution of Taiwan's science and technology policy, and its relationship to changes in domestic politics and the international environment.

He intends to take space policy as a case study, and to develop a comparative analysis of the UK, Japan, and Taiwan. His intention is to conduct interviews with individuals who have participated in Taiwan's satellite programme, whether as officials, scientists, legislators, or entrepreneurs. His fieldwork plans have been evaluated and approved by his supervisors and his Supervisory Board, and we would be grateful if you would facilitate his research.

Mr Chen is an excellent research student, making very good progress in his research. He is aware of the sensitivity of the area of research, and will respect any requirement for confidentiality or anonymity.

If you have any further enquiry, please feel free to contact us.

Yours faithfully

P.J. Gummett

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[131] Interviews were conducted from June to August 2000 by the author and have been transcribed in Chinese. The transcripts can be acquired from the author.