The Chinese steel industry in transition: industry perspective on innovation policy

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There is little empirical research on how the Chinese Government should function in innovation management, particularly during its critical period of economic transition. This study explores and investigates the Chinese Government's innovation management structure, procedures and functions by interviewing government R&D management officials and industrial innovation managers and users. Questionnaires were distributed to industrial innovation practitioners and users of new steel products to solicit their perspectives on innovation policy issues. Findings indicate that current government innovation management procedures have received a tepid welcome from the industries. While there was general agreement that the government should maintain some involvement in industrial innovation, opinions regarding just how the government should intervene differed significantly between producers and users. Producers generally favoured more indirect government involvement. Policy implications are discussed.

1. Introduction

State-owned enterprises in China have been the cornerstone of the Chinese economy, and their performance is central to the outcomes of current economic reform. As one of the key Chinese industries, the steel industry has not only been important to national economic development, but has also played an important role in most key national innovation projects over the last 40 years. The new products developed by the steel industry have been widely used by many key industries, including sea-water corrosion-resistant steel plate for the ship-building industry, engine-grade high temperature resistant alloy for machinery industries, high pliability and high strength alloys for the aviation industry, and corrosion-resistant alloy for the chemical industries. Thus, the role of the Chinese Government in managing innovation in the steel industry during the economic transition is an important area for research.

The importance of innovation to a nation's competitiveness is well acknowledged. Governments play a crucial role in formulating innovation policies, funding innovation projects and co-ordinating innovation activities. Differences in governments' support of innovation have contributed significantly to differences in the competitiveness of nations (Porter, 1990; Ali, 1992; Branscomb, 1992; Crow and Nath, 1992; Eilon, 1992; Booth and de Seoane, 1993). The key role of government involvement in innovation is well acknowledged both in theory and in practice. Innovation policy targets three areas: the supply of innovation, the

demand for innovation, and the interfaces between innovation suppliers and users (Ali, 1992; Branscomb, 1993). However, the degree and nature of this government involvement is unresolved. Furthermore, China faces additional issues and challenges during its transition to a socialist market economy, and the Chinese steel industry poses some particular problems due to its mature, supply-driven nature.

Currently, the Chinese Government is faced with two key innovation policy issues in the steel industry. The first issue is, to what extent, should the Chinese Government be involved in the innovation process? Past evidence has suggested, on the one hand, that too much government intervention in industry innovations may result in 'government failure' (Berliner, 1976; Huang, 1986; Cox and Kriegbaum, 1989; Wang, 1993). On the other hand, a *laissez-faire* innovation policy may result in market failure, particularly in today's international competitive environment (Nilson and Wright, 1994). Currently, the Chinese Government is heavily involved in the innovation processes. However, there is little research on whether the government should be as heavily involved in the innovation process following economic reform, or how industrial practitioners perceive the nature of this involvement.

The second issue facing the Chinese Government is the nature of the government involvement it should pursue with its innovation policy. There are two broad approaches to government involvement in the innovation process: direct and indirect. The long history of central planning in science and technology (S&T) has cultivated among government officials, whether consciously or unconsciously, an attitude that innovation should be tightly controlled by government. As economic reform progresses, and more and more management responsibilities are delegated from the government to enterprises, a key issue is whether the Chinese Government should continue to use direct intervention in managing the innovation process.

Indirect government involvement in innovation can take on a variety of forms, including development of industry policy to provide economic incentives, stimulation of demand, facilitation of information flows, and networking of actors in the innovation process (Parkinson, 1982; Gardiner and Rothwell, 1985; Håkansson, 1989; Porter, 1990; Lundvall, 1991; Ali, 1992; Branscomb, 1993). Currently, one of the key functions the Chinese Government performs is co-ordination. However, do industrial practitioners regard this function as desirable in China's new market-based economy?

The major goal of national innovation policy is to increase industries' competitiveness (Branscomb, 1993). Industries, particularly suppliers and users of innovation, are the major actors in the innovation process. It is their performance in producing and using innovation that determines the success of innovation policy in any country. A considerable amount of research has stressed the importance of organising national innovation policies around industries (Ali, 1992; Branscomb, 1993). However, these publications are prescriptive in nature, and little research has been undertaken to examine innovation policy empirically from the perspective of industry. Hence, industry inputs should provide a key source of information for formulating innovation policy.

This paper reports the results of a study of innovation policy in China from the perspective of steel product users and producers. Such an investigation is warranted since its findings provide meaningful insight to assist the government in formulating innovation policy and managing its national innovation processes in the future. Before we present our research methods and findings, it will be helpful to briefly describe the Chinese S&T system and its innovation management procedures.

2. The Chinese science and technology system and innovation management procedures

2.1. The Chinese science and technology system

Currently, the S&T management system is controlled mainly by key government departments, with various industry organisations providing specific ancillary services. The S&T management system in China is shown in Figure 1.

As can be seen from Figure 1, the State Council is the supreme decision-maker and co-ordinating body for the S&T system. The second layer consists of three major functional decision-makers. The State Planning Commission (SPC) is responsible for key activities, such as co-ordinating the State S&T Commission (SSTC) and the other ministries to set up medium- and long-term plans for S&T, setting the priorities of S&T programs, and co-ordinating the implementation of national key S&T programs (S&T Commission of China, 1993). The S&T and Industry Commission for National Defence (S&TICND) is responsible for managing S&T activities in the areas of military and defence. SSTC is a functional ministry of the S&T system within the government. It is responsible for formulating national S&T strategies, allocating S&T projects and funds to other ministries, and managing other S&T related functions at the national level.

Industrial ministries, such as the Ministry of the Metallurgical Industry (MMI), are major co-ordinators of S&T project implementation. They receive S&T projects mainly from SPC, SSTC and S&TICND, and allocate these projects to other organisations under their supervision, such as firms, universities, and R&D institutes. Moreover, they oversee the progress of these projects and co-ordinate other S&T projects generated by the organisations within the ministry. Therefore, they play a crucial role in facilitating and co-ordinating nation-wide S&T activities.

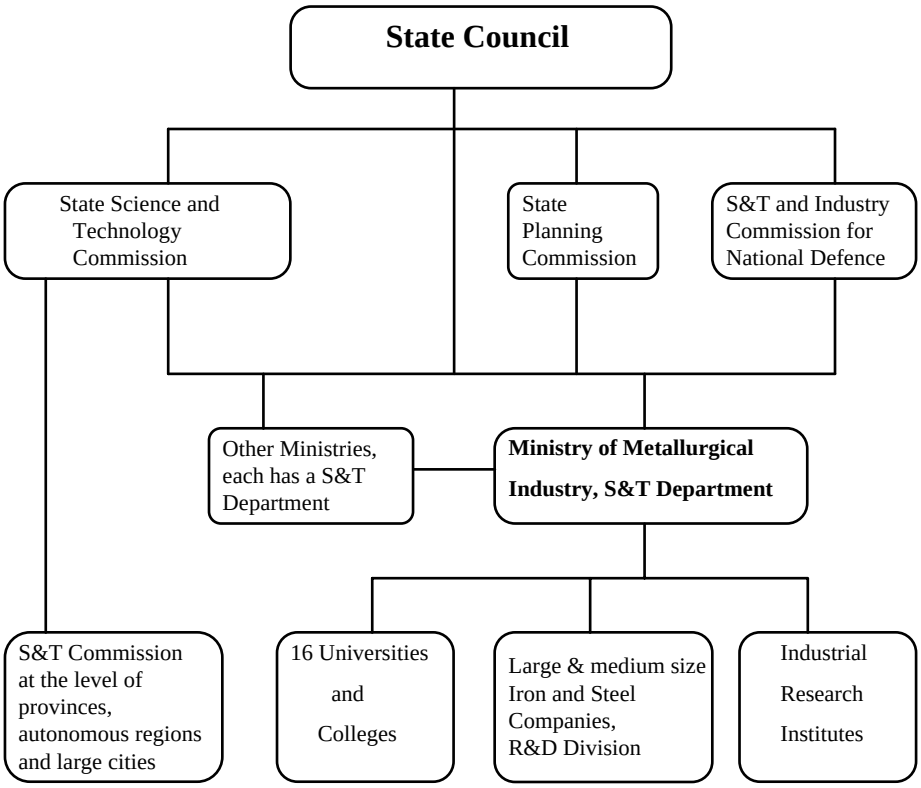


Figure 1. China's science and technology management system.

Organisations at the fourth layer undertake S&T activities. Steel companies, for example, carry out innovation projects allocated mainly by MMI, but also by SPC and SSTC. Since the economic reform, they have also been allowed to take S&T projects directly from other organisations.

Several problems have been identified relating to this type of organisational structure, such as the separation of research and production, difficulties in technology diffusion, and low efficiency of utilising R&D human resources (S&T Commission of China, 1993). Certain actions have been taken over the last decade, such as merging production and R&D institutes, in order to address these problems.

2.2. Innovation management procedures

Before economic reform, innovation projects, particularly new product ideas, were generated by different sources, such as users, scientists in the R&D institutes, the government élite, academics, and the steel companies. These ideas were first submitted to their corresponding supervising ministries. If approved by the ministry, the ideas would be forwarded to SSTC or SPC, and would be used when formulating annual S&T plans. The projects would then be allocated to the ministries whose subordinate firms were considered to be suitable candidates to conduct the project. Finally, the ministries allocated these projects to the individual firms. Appropriate funds and other resources were also allocated to these firms. The prices of the new products were set by the government. The steel firms were required to accept these projects with little input. In addition, for some large and complex new product projects, inter-industry teams were set up with participants from producers, R&D institutes, universities and users.

The reform of the enterprise responsibility system since 1979 has focused on control of price, material flow among the firms, and investment. The government has gradually reduced its control over these areas, which means firms have more and more responsibilities in deciding what products to produce and/or to use, and what prices to charge and/or to pay. As a result, firms are allowed to undertake new product projects initiated internally or taken directly from users, and may develop new products for the market, while at the same time accepting new product projects from the government.

3. Research methods

Both on-line and manual literature searches in both Australia and China showed only few publications, mostly in English, on innovation management in China. Given the fact that little research has been done on innovation management in China, coupled with the uniqueness of its transitional economy, a two-stage methodology is used. In the first exploratory

stage, unstructured interviews were conducted in Mandarin with 12 government officials from relevant ministries, 19 managers and engineers from six Chinese steel companies, and three users. The main purpose of these interviews was to understand the innovation process and to provide insights into key issues of innovation policy and management practice.

The second stage involved a quantitative study, to gain a more representative view of industry practitioners' perceptions of government involvement in the innovation process. Questionnaires were developed based on the interviews, and were written in Chinese. They were pre-tested, and distributed to both steel companies and their new product user organisations. A total of 280 questionnaires were distributed to 21 companies, which were considered by the government officials to be the major players in product innovation, by either personal delivery or mail with telephone follow-up, resulting in 190 questionnaires being returned from 18 steel companies. The size distribution of the sample producers is shown in Figure 2. In 1993, these 18 steel companies produced 36.45 million tons of crude steel, which was 41.1% of the total industry output (The Editorial Board of *The Yearbook of the Iron and Steel Industry of China*, 1994). The annual sales of these 18 companies ranged from 1.05 to 18.9 billion yuans (US$1 = 8.30 yuans) in 1993.

The respondents were those working in the R&D divisions of the steel companies, including section managers, project team leaders and project team members. The age, educational qualifications and background of the respondents from the steel companies are summarised in Table 1. As can be seen from Table 1, the educational qualifications of respondents were quite high, because they were working in the R&D section, which is usually dominated by university graduates in State-owned large or medium enterprise in China.

Questionnaires were distributed to users of steel products at a national new product ordering meeting. A total of 600 questionnaires were distributed and resulted in 243 useful responses. The industry profile of these user organisations is shown in Figure 3.

These respondents were managers in purchase or technology divisions in their organisations. The profile of respondents from these organisations is shown in Table 2.

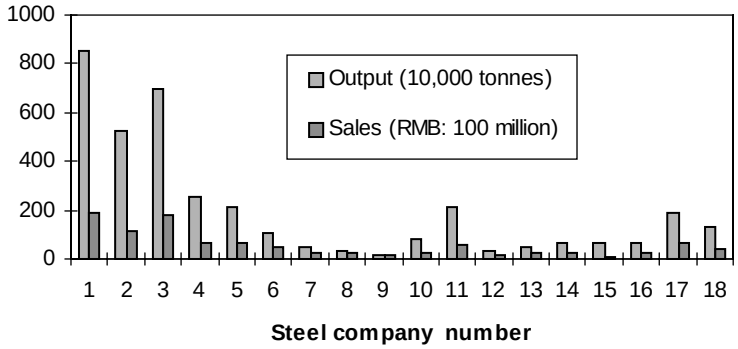


Figure 2. Outline of the sales and output of the producers in the sample.

Table 1. Age, educational qualifications and background of respondents from the steel companies.

Experience (years)	(%)	Age	(%)	Highest Qualification	(%)	Background	(%)
<1	1.2	<20	0	Post-graduate	5.1	Engineering	86.1
1–3	13.9	20–34	29.3	Degree	78.9	Science	12.5
3–5	10.2	35–50	22.4	Diploma	11.4	Arts	0.7
5–10	19.3	>50	48.3	Asso. diploma	4.6	Management	0.7
>10	55.4			Below Asso. diploma	0	Other	0

Table 2. Age, educational qualifications, and background of the respondents for the users.

Experience (years)	(%)	Age	(%)	Highest Qualification	(%)	Background	(%)
<1	0	<20	0	Post-graduate	20.6	Engineering	44.5
1–3	6.4	20–34	22.2	Degree	50.7	Science	36.2
3–5	17.9	35–50	51.5	Diploma	19.3	Arts	6.4
5–10	38.1	>50	26.3	Asso. diploma	7.2	Management	6.9
>10	37.6			Below Asso. diploma	2.2	Other	6.0

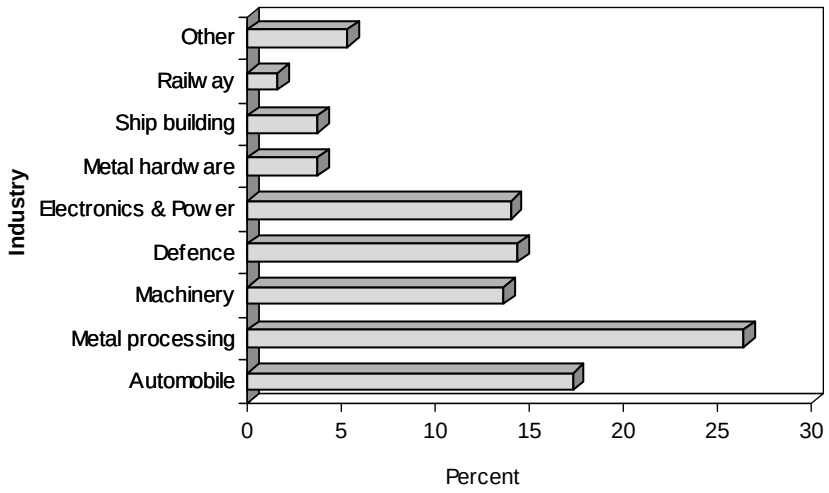


Figure 3. Industry profile of the users.

4. Findings and discussion

4.1. Current innovation management structure and procedures

4.1.1. Key problems identified. The exploratory research identified several perceived problems with innovation management in the Chinese steel industry. The first problem is investment control. Currently, industries are allowed to use one per cent of their gross sales for innovation, including both process and product innovation. Given the capital-intensive nature of the steel industry, this allowance is inadequate. In addition, major investment in technology has to be approved by either the state or provincial governments, depending on the level of expenditure (Wang, 1994). The tedious procedure and uncertainty involved in this process have not only slowed down the pace of technology development and innovation, but have also caused a serious problem in strategic planning for innovation in the industry. This is partly because the producers tend to leave these issues to governments, as was indicated by several industrial managers during the interviews.

Besides investment control, the government is also criticised both by its own officials and by industry managers for their over-controlling of the innovation process. Control of price, order taking and project allocation were all criticised.

There are also organisational problems affecting innovation. For example, there is no innovation-related performance evaluation of managers in steel companies. Moreover, the tenure of top management in the steel companies is usually three or four years, while most product development has only long-term impacts. Thus, there is little incentive for managers to give priority to innovation management.

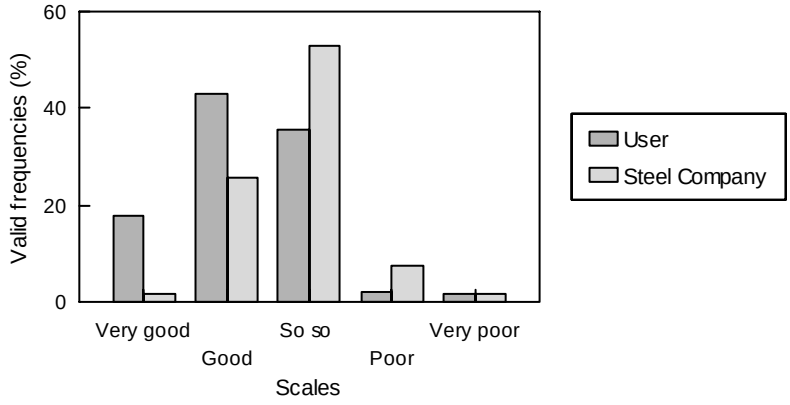
4.1.2. The perception of the current management procedure. Government officials believe that there is an urgent need for the government to adjust its role within innovation management, and economic reform and the streamlining of government organisations at the State level over the last five years have imposed great pressure on them to do so. For example, the number of staff in MMI was reduced by two thirds, from about 900 to 300 at the end of 1993. This downsizing demanded organisational restructuring and a review of the government's functions in managing innovation.

Figure 4 presents the results from the questionnaires. These results echo the basic findings from the interviews. Overall, the State innovation management procedure received a tepid review from the industries, particularly from the producers. This implies that there is a demand from the producers for the government to improve its management procedure for industrial innovation.

4.2. Opinions on the level of government involvement in the innovation process

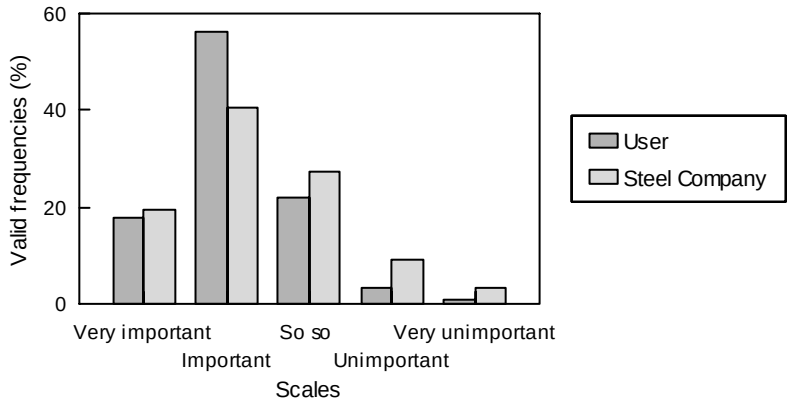
Government officials believe that the Chinese Government should continue to be involved in innovation. Of course, this finding is naturally in their own self-interest. Although some senior government officials were still concerned with the government's failure in managing innovation, particularly due to inaccurate market forecasts, the biggest concern from government officials was the possibility of market failure if innovation is totally deregulated.

At the industrial level, most respondents, representatives from the steel companies as well as users, believe the government should maintain some involvement in innovation. The results of this question are shown in Figure 5.



Question: In your opinion, the existing State innovation management procedure is:
t test for two sample means: *t*-value = 6.017, significant at alpha = 0.001 (*t* = 3.291, df = 452, two tails) with Very good = 1, Good = 2, So so = 3, Poor = 4, Very poor = 5.

Figure 4. Users' and steel companies' perceptions of the current government innovation management procedure.



Question: In your opinion, State involvement in innovation is:
t test for two sample means: *t*-value = 2.870, significant at alpha = 0.05 (*t* = 1.96, df = 455, two tails) with Very important = 1, Important = 2, So so = 3, Unimportant = 4, and Very unimportant = 5.

Figure 5. Users' and steel companies' perceptions of government involvement in innovation.

The response from the users in this study shows that they have a more favourable attitude to government involvement in innovation, compared with that of the steel companies. This can be attributed to the current seller's market structure, and the government innovation management mechanism, which gave power to the users.

4.3. The nature of government involvement

4.3.1. Overview of findings. During the interviews, many government officials said that they have been hard pressed to change their innovation management practices. While they know that change is certain, they are not clear how to implement it and what the industrial practitioners expect them to do.

Results of the surveys of producers and users are shown in Table 3. The priorities for which functions the government would perform were very different for the users and the steel companies respectively. Representatives of the steel companies regarded the highest three priorities of government in managing innovation to be: to formulate policies for innovation and to delegate more responsibility to firms; to provide a service to the industry, particularly in communication and networking; and to co-ordinate activities among companies and different industries, respectively. Central control of innovation activities, which historically has been the most important task for the Chinese Government, was ranked last. In contrast, representatives of user organisations had an almost opposite view. While both users and producers agreed that communication was very important, the other functions ranked highly by producers were ranked as quite unimportant by users. It should be noted that although users may have similar mean scores as producers in some functions, the overall ranks are very different. Again, the current market conditions (a seller's market), together with government innovation practices that empower users, are likely causes of these differences.

Table 3. How should the government function in innovation: perspectives from the users and the steel companies.

Government functions in innovation (7 scales: 1 – Very important; 7 – Very unimportant)	Steel company		User organisation	
	Mean	Rank	Mean	Rank
Delegate more responsibilities to firms	1.82	1	2.31***[a]	6
Formulate policies for innovation	2.01	2	2.89***[a]	16
Communicate relevant market information to firms	2.08	3	2.20	4
Communicate relevant technical information to firms	2.11	4	2.11	1
Help producers promote new products	2.34	5	2.74*	12
Organise channels for producers and users to meet together	2.45	6	2.88**	15
Help producers find markets for new products	2.47	7	2.68	10
Help users find appropriate producers of new products	2.54	8	2.52	8
Select new product projects for producers	2.57	9	2.80	13
Co-ordinate innovation activities among firms	2.66	10	2.15***	3
Organise annual sales and ordering meeting for new products	2.68	11	2.66	9
Co-ordinating activities among ministries	2.80	12	2.49**	7
Allocate new product projects to producers	2.91	13	2.72	11
Help to build the linkage between R&D institutes and producers	2.99	14	3.13	17
Evaluate new products and grant awards	3.12	15	2.81*	14
Monitor the innovation process	3.36	16	2.25***	5
Centrally control industrial innovation	3.66	17	2.13***[a]	2

t-test for two independent sample means. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.
a: The Mann-Whitney test for skewed items.

4.3.2. Indirect intervention. Delegation and policy formulation are the most important government functions from the perspective of the steel producers. This gives a clear indication that producers would prefer a 'hands-off' approach by the government. Rather, the importance of these two functions suggests the desire for government to focus on policy making and to develop a clearly defined division of responsibility between government and industry.

Again the users' views paint quite a different picture to those of the producers. The two indirect functions ranked highest by the producers were ranked lower by users. In particular, policy formulation was ranked second last. This again may be understood given the current market structure and government innovation management procedures. As can be seen from Table 3, users ranked the government central control function much higher than the function of policy formulation.

Deregulation is consistent with the overall direction of economic reform in China, as the Chinese Government gradually delegates management responsibilities to the state-owned enterprises to make them more accountable for their performance. However, the need to establish a market environment to stimulate innovation must not be overlooked.

4.3.3. Facilitation and co-ordination. Another important, but indirect, role of government in innovation management is to act as a facilitator and co-ordinator on behalf of industry (Lundvall, Dalum and Johnson, 1992). On this question, there is, overall, little disagreement between producers and users. Specifically, communication as a government function is ranked highly by both users and producers. It may be more important to the users than to the producers because users have more incentives and less power in the process.

Co-ordination among the different actors in innovation is important, and is even more critical in a socialist country (Pelikan, 1988). Interestingly, linkages among the steel companies, R&D institutes and universities was ranked low by both producers and users. The interviews confirmed that to get funding from the government, universities are usually more active in initiating collaboration with steel companies. However, the steel company is often regarded only as a 'supporting actor' in the joint research project. Thus, the motivation to research jointly is lost from the industry, according to our interviews with managers from the steel industry.

4.3.4. Direct intervention. Overall, the government officials interviewed believed that the government should still have some control of innovation in the steel industry while the steel companies should take the major responsibility. At the industrial level, the users and the steel companies hold almost opposite views. The users believe that the State should retain major responsibilities in innovation management. The producers ranked direct intervention functions, such as monitoring, evaluating, and centrally controlling projects, last.

One reason behind this is that these direct intervention functions may depress rather than promote the industry's innovation activities. For example, project evaluation often involved too many meetings and too much bureaucratic procedure, which wasted the firms' resources and gave them no real benefits (Conroy,

1992). This idea is reinforced by several industrial managers, who stated during the interviews that it is totally unnecessary for the government to be involved in monitoring and evaluating innovation projects.

5. Conclusions and policy implications

This paper investigates the role of the Chinese Government in managing innovation in the steel industry. Based on the findings, several conclusions are drawn and some implications for future innovation policy are suggested.

We demonstrate that the current government management system and procedures for industry innovation have received a lukewarm approval from both the steel producers and users. However, continued government involvement in industry innovation is considered desirable by both the producers and users, a view that was also echoed by the government officials.

At the industrial level, users had a more favourable attitude than producers to the government's involvement in innovation management. Further, there were considerable differences in perceptions between users and producers of steel products regarding government functions in the innovation process. From the producers' point of view, the most important functions of the government are to formulate innovation policy and to delegate responsibility to the industry. Other functions the government may perform are to service the industry and to co-ordinate interfaces between the industries and other innovation-related sectors, such as universities and R&D institutes. However, direct control or intervention is considered least important. On the demand side, while users also perceive the importance of facilitation and co-ordination performed by the government, they have quite an opposite view of other government functions, such as central control of the innovation process and policy formulation.

These findings are quite understandable given the economic transition occurring in China. Producers wish to establish control of their own innovation activities, as they are now becoming responsible for their own market performance. However, users want to maintain their considerable power in the innovation process in order to ensure the supply of steel innovations required for their own economic prospects.

In developing innovation policy, the Chinese Government must recognise the divergent needs and views of producers and users. Overall, emerging policy from the Chinese Government in innovation management must be balanced, recognising that a correct climate on the supply side, the demand side and their interface, is required to ensure innovation activities that provide real economic benefits and improve the global competitiveness of the Chinese steel industry.

Both users and producers recognise the important role the government plays as the industry interface with functions such as facilitation, communication and co-ordination of the innovation process. These functions include such things as assisting firms' organisational capacities, upgrading information technology and infrastructure, communicating market and technical information to producers, providing network opportunities for different innovation sectors and their personnel, and encouraging collaboration. The government clearly should maintain these activities.

The government may also consider releasing its control over technology investment and fund-raising. By and large, innovation in the steel industry in a developing country like China is incremental in nature. Given the fact that the steel industry is technology-intensive, technology plays a key role in innovation. To encourage more initiative in innovation from industry, and a quicker response to new knowledge, firms should be given more autonomy in decision-making in innovation-related areas, such as technology investment.

Finally, with regard to the government's direct control in innovation, the former Soviet Union has offered a lesson in this function (Berliner, 1976). While the Chinese Government may gradually reduce direct involvement in innovation, such as central control and evaluation of projects, it is important for the government to provide the participants with incentives in order to keep them actively involved in the innovation process. At the same time, the government must not distort market forces nor constrain competition.

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