Factors Influencing Choice of Business Strategies By Government Research Laboratories Under Pressure to Increase External Earnings: An Exploratory Study

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Abstract

Concerned by the seeming lack of accountability of government research laboratories, governments the world over have adopted fiscal control measures to make them more business-like and responsive to user needs. These have typically consisted of expecting them to generate a portion of their revenues from actual users of their services. In this study we examined the strategies adopted by five government research laboratories in India in response to a policy directive that they should generate at least one third of their budget from external sources, particularly industry. The performance of these laboratories, functioning under the aegis of the Council of Scientific & Industrial Research, was studied over an eight-year period after the policy was proposed. All the laboratories studied worked in areas where they could develop product or process technologies for use by industry.

The major finding of this study was that the strategies adopted by the laboratories were influenced substantially by the founding conditions, early leadership and the resultant organizational culture of the laboratory and these appeared to play a bigger role than the structure of the industry served by the laboratory or the nature of the technology involved. The main implication of this is that control measures like external earnings targets are unlikely to achieve policy objectives if they are applied across-the-board without attention to the history, culture and competencies of individual laboratories.

1. Introduction

The government research laboratory or "national laboratory" is an organizational form found in many countries. It is typically set up by the government to overcome market failure such as in the case where existing industries are unable or unwilling to invest in what they consider to be a risky long-term activity (Mansfield, 1968). The government may wish to set up such laboratories to help small and medium companies, which are unable to conduct independent R&D (Toren & Galai, 1978; Tisdell, 1981). In planned economies, national laboratories were intended to be the sources of prototypes and designs for products and processes that would subsequently be produced by other entities. National laboratories have been particularly significant in developing countries where they are seen as specialized agents to provide technological information, means and understanding to firms, and thereby help them acquire technological capability (Dahlman, Ross-Larson & Westphal, 1987; Lall, 1987). At a later stage of development of these countries, national laboratories could shift research direction to meet national requirements for "future-oriented, original and core technology" (Lee, Bae and Lee, 1991) which is in the growth and introduction stage in advanced countries and hence not easily accessible to firms in developing countries. Even in developed countries, national laboratories are seen as potential contributors to competitiveness of firms in the international arena though this role is not universally accepted (Cohen and Noll, 1994).

The performance of national laboratories is dependent on a number of factors. It is generally believed that "the scientific and technological characteristics of different industrial sectors will

greatly influence the nature and intensity of the links between industrial firms and the government-financed scientific and technological infrastructure" (Pavitt and Walker, 1976 : 45). The laboratory's interaction with industry is a function of the industry's R&D orientation that is typically dependent on the size of the industry, type of industrial sector and the degree of market competition. Larger companies tend to spend more on R&D and often give research projects to national laboratories in non-critical areas or to take care of "peak-load problems" (Toren & Galai, 1978). While science-based and research intensive branches of industry invest a higher percentage of their resources in R&D than do traditional industries, Toren and Galai (1978) point out that the rapidly changing technology environments characterizing the former make firms prefer intra-mural research so as to promote confidentiality and to minimize technology transfer problems in going from the laboratory to the production line.

At the organization-level, Pavitt and Walker (1976) point out that the effectiveness of national laboratories in response to the needs for the typical services provided by them depends on the way in which they are organized and managed.

More recent work has looked at the ability of national laboratories to contribute to competitiveness in an institutional framework of "national innovation systems" (Nelson, 1993). This body of research implies that factors as diverse as country size, factor endowments, export orientation of industries, the way firms are governed, social attitudes and patterns of labour, a nation's system of schooling, training and re-training all affect the innovation climate in a country and hence the potential effectiveness of a national laboratory (Nelson and Rosenberg, 1993).

The principal lever available to policy-makers to influence the performance of national laboratories is through the allocation of financial resources to the laboratory (Toren and Galai, 1978). While core funding is likely to facilitate long-term, open-ended research, project-specific funding facilitates management control. Industrial funding is likely to be for more short-term and time-bound research than state funding (Schwarz, et.al., 1982). A contentious issue is the control by sponsors over the dissemination of research results. Such control could come into conflict with the "public" nature of the laboratory. Alternately, it could affect the individual researcher's belief in the need to share findings with the scientific community.

Dissatisfaction with the tangible output of national laboratories and the growing trend towards rolling back the boundaries of the State have contributed to a global trend of demanding greater accountability of these organizations. This has taken the form of external earnings targets to promote links with users as in Australia (ASTEC, 1994), funding cuts as in China (Simon & Rehn, 1988; Maruyama, 1990; Jingyuan, Yuhe and Zheng, 1988), requirements that the laboratories "operate as a business" as in the Netherlands (ASTEC, 1994), or legislation requiring transfer of technology by laboratories as in the U.S. (Schriesheim, 1990; Radosevich and Kassicieh, 1993; Coursey and Bozeman, 1992). While at the aggregate level these policy measures appear to have achieved success, there have been concerns regarding their unintended consequences. For example, in Australia, while closer links were developed with users overall, there was a decrease in interaction with small and medium enterprises (ASTEC, 1994). In the Netherlands, while the Applied Research Organization (TNO) was able to earn 70% of its total

revenue from non-government sources within a decade, it also faced challenges in maintaining its knowledge portfolio (ASTEC, 1994).

2. Objectives of the study

Our earlier discussion suggests that there are many factors at the individual laboratory level that would affect the response of the laboratory to policy measures such as a requirement to increase external earnings. A better understanding of how these factors work would throw light on the appropriateness of such policy measures applied across-the-board to a group of national laboratories. There is also little published work on how national laboratories manage greater technical and market uncertainty, market technology in a competitive environment, and sustain researcher motivation while making such a transition to a greater commercial orientation. This is of particular interest as the conventional values and beliefs of scientists in the laboratory may actually conflict with such a reorientation.

The objective of this study was to determine how different national laboratories respond to pressures to increase external earnings and to understand what drives the choice of such responses. An opportunity to study this phenomenon was provided by the acceptance by India's Council of Scientific & Industrial Research (CSIR), in 1988, of a recommendation made by the fourth review committee of the CSIR (1986) that the CSIR should earn one-third of its expenditure from outside the government grant. The CSIR is a network of forty national laboratories in diverse areas ranging from Physics and Chemistry to Molecular Biology, Instrumentation, and Aerospace. Though no specific targets were set for individual CSIR

laboratories, the implicit assumption was that every laboratory would try to enhance its external earnings to achieve this level.

3. Methodology and choice of laboratories

The case method of research (Yin, 1984) was used to answer the research questions posed. Given the complexity of the phenomenon due to the large number of inter-linked variables likely to affect the response of a laboratory, a multiple case study design was adopted.

With the expectation that the possible response by a laboratory would be strongly influenced by the nature of technology, the laboratories were chosen on the basis of the nature of technology and technological change in their areas of specialization using a categorization proposed by Nelson and Rosenberg (1993). Category 1 is an area in which there are complex systems technologies characterized by continuous product innovation such as airplanes and computers; category 2 is an area in which there is discrete product innovation and continuous process innovation thereafter such as fine chemicals; and category 3 is an area characterized by lack of product innovation but incremental process innovation such as traditional areas like the dairy industry.

Five laboratories – one falling in category 1 (hereafter referred to as Lab1), two in category 2 (Lab2A and Lab2B) and two in category 3 (Lab3A and Lab3B) - were chosen from among seventeen CSIR laboratories identified by Nayar (1983) as industrial research laboratories, i.e. laboratories that have the possibility of product/process development for industry. These

laboratories were identified in consultation with senior scientists at CSIR headquarters to give a good mix of laboratories exhibiting a wide range of responses to the pressure to increase external earnings.

Lab1 works in the area of scientific instrumentation and designs and develops optical instruments, analytical instruments, medical instruments and instruments for microelectronics. Both Lab2A and Lab2B are chemical laboratories – while Lab2A focuses on catalysis, polymers, organic chemistry and biochemistry, Lab2B has agrochemicals, drugs, and chemical process engineering as its main areas. Lab3A is a leather research institute, while Lab3B works on salt, marine chemicals, inorganic chemistry, and new materials.

A case study, covering the period 1987-1995, was constructed for each laboratory based on published and unpublished documents and semi-structured interviews with laboratory directors and division heads.

4. Conceptual Framework

To analyze the cases, a conceptual framework for environmental adaptation to environmental change applicable to national laboratories was developed. The development of this framework was inspired by the view of Pettigrew (1987) that theoretically sound and practically useful research on strategic change should involve the continuous interplay among ideas about the context, the process and the content of change. The framework was designed to be specific to the context of national laboratories and to (a) focus on the main choices to be made by a public R&D

laboratory; (b) have explicit links to government policy; (c) provide for the influence of both the market and the institutional environment on the choices made by the laboratory; and (d) allow for a variety of industrial environments. A diagrammatic representation of the framework is shown in Figure 1.

Figure 1 about here

Drawing on Miles (1982), this framework (i) conceptualized the strategy formation of a laboratory as a set of decisions and actions in three inter-related areas – mix of R&D projects, mix of R&D-related activities and marketing strategy; (ii) conceptualized the "character" of the laboratory as arising from its values and beliefs, pattern of responsiveness and distinctive competencies; and (iii) identified environmental factors likely to affect the response of the laboratories.

For a national laboratory, the key elements of strategy are the choice of areas in which research is to be undertaken, the nature (objective, level of uncertainty, duration, deliverable and source of funding) of projects to be done, and how the output of the laboratory is to be marketed. For instance, a competence-gaining project in a new area today may be a source of a major technological breakthrough tomorrow though it may not offer any immediate financial returns. Routine projects with predictable outcomes may be important for short-term earnings and interaction with industry, but doing these alone could preclude the laboratory from ever making a

major breakthrough. The third important dimension of strategy for a laboratory is its marketing strategy and consists of choices related to the product (e.g. sale of complete technology package vis-à-vis ideas demonstrated only at laboratory-scale), place of sale (within the country or internationally), price, and whether exclusivity would be allowed or not.

The character (Miles, 1982) of an organization influences how it will respond to environmental change. For a national laboratory this character is the result of interplay between the dominant values and beliefs, the distinctive competence of the laboratory and the pattern of responsiveness demonstrated by the laboratory in the face of earlier environmental changes. The prevalent values and beliefs can often be traced to those held by the top management in the formative years of the laboratory. Some of the typical values and beliefs referred to here are those related to the importance of basic science, the relationship between science and technology, and the role of national laboratories. Distinctive competencies influencing the response of the laboratory include the ability to scale up technologies, technology forecasting, and an intuitive understanding of user needs, apart from specific research competencies. Borrowing from Nutt and Backoff (1992), we propose that the responsiveness of the laboratory today is likely to be a function of its responses to past policy changes, and the feedback it received from key stakeholders regarding these responses.

The environmental factors affecting a laboratory's response are government policy, the economic and social environment, the nature of technology and technological change, the structure of the (relevant) industry and its orientation, the competitors in the technology market, the orientation of universities and other institutions of higher learning and the orientation of

engineering and design consultancy organizations. In addition, boundary conditions such as organizational slack and domain choice flexibility were expected to affect the extent of adaptation by the laboratory. Finally, the executive leadership of the laboratory was expected to play a key role in formulating and implementing strategy, changing relationships with the environment, and leveraging the slack available to the laboratory. The domain choice flexibility of the laboratory was also expected to be affected by the credibility of the leadership and initiatives taken to increase this flexibility.

5. Findings

The broad findings of the study were as follows:-

All the laboratories studied managed to increase their external earnings considerably during the period of study (See Table 1). The laboratory with the highest proportion of external earnings from among the laboratories studied, Lab2A, earned 36.6% of its income for 1994-95 from external sources compared to 18.8% in 1987-88. Lab3B, with the lowest proportion, increased its external earnings as a proportion of total earnings from 4.8% in 1987-88 to 15.4% in 1994-95. However, in 1994-95, external earnings from industry were less than 20% of total external earnings for both Lab1 and Lab3B, with most of the external earnings coming from government-funded projects. Lab2A, Lab2B and Lab3A earned more than 50% of their external earnings from industry in 1994-95, with the figure for Lab3A being more than 80%. A substantial proportion (exact figure not disclosed by the laboratory) of Lab2A's industry earnings was from multinational corporations (MNCs).

Table 1 about here

The strategies adopted by the laboratories in responding to the pressure to increase external earnings fell in three categories. One laboratory (Lab2A) focused on selling R&D and related services to MNCs whose needs matched the competencies of the laboratory in certain parts of the R&D value chain. These strong competencies in research owed their origin to a strong culture of excellence in research that was built in the laboratory right from its inception. While Lab2A was good at generating innovative new ideas and demonstrating these in the laboratory, it lacked the resources to scale these up to industrial scale. MNCs, on the other hand were willing to pay for good ideas and award research contracts without insisting on complete technology packages as they have the appropriate competencies and resources to scale-up ideas with high commercial potential. Obtaining U.S. patents and protecting intellectual property were important facets of this approach – while Lab2A did not file a single international patent application in 1987-88, thanks to a sustained focus on patenting thereafter, in 1994-95 it filed sixteen U.S. patents and was awarded nine patents. Lab2A's strategy was formulated by the top management team and elaborate support measures such as changes in the organizational structures (e.g. a new Project Planning and Development Unit for integrated R&D and business planning attached to the Director's Office, and a Scientific Management Information System to track patent information) and reward systems (e.g. medals for scientists obtaining U.S. patents, and an award for the best technology developed) were used to facilitate implementation of the strategy. The externally-

oriented economic policies announced by the government of India in 1991 provided the policy framework to make this strategy possible.

Two laboratories (Lab2B and Lab3A) intensified their existing activities of providing process technologies and consultancy services to industry clients and made small investments in the development of new technologies. For these laboratories, the pressure to increase external earnings and thereby demonstrate responsiveness to user needs was consistent with the traditional philosophy of the laboratory. They had been pioneers in developing complete technology packages along with the required engineering support thanks to a strong user-orientation stressed right from their formative years. For example, it was said that the pioneering director of Lab3B was happier to find his scientists at the site of one of their industrial clients than inside the laboratory. Inter-divisional competition within the laboratory was encouraged to increase external earnings. The response of the laboratories was coterminous and continuous with the announcement of the external earnings target.

The other two laboratories (Lab1 and Lab3B) searched for alternate government clients to sponsor research projects and focused on providing R&D-related services such as training and testing services to industry. The Research Councils (advisory bodies constituted from industry, academia and government) played a more prominent role than in the case of other laboratories. These laboratories had neither managed to create a strong culture of excellent research work, nor had they managed to build strong relationships with user organizations. The absence of a strong culture could be traced to problems at the time of their founding including their location and the lack of an inspiring leadership. These problems were compounded by the fragmentation of the

user industries. The response of these laboratories to the external earnings target was principally after 1991, with the realization that the survival of routine activities within the laboratory could be at stake in the wake of the government of India's new economic policies encouraging private initiative and reducing restrictions on import of technologies and products.

In all the laboratories, we found that the founding conditions, initial leadership, and the resulting organizational culture of the laboratory played a major role in shaping the organization's response to the pressures to increase external earnings. This culture, reflected in the predominant values and beliefs in the laboratory had historically influenced the responsiveness of the laboratory to industry needs as also the competencies developed within the laboratory. Where there was a match between the competencies of the laboratory so developed and the needs of the relevant Indian industry (influenced by the industry's structure and orientation), laboratories displayed the kind of response shown by Lab2B and Lab 3A described above. Where such a match was not strong, but excellence within the laboratory (again engendered by the strong belief system within the laboratory) enabled the laboratory to target other markets, the laboratory displayed the response exemplified by Lab2A. The failure by laboratories such as Lab1 and Lab3B to create deep expertise of value to industrial clients left them with no other option than to try to obtain government projects or provide training and testing services.

6. Implications and conclusions

The objective of setting an external earnings target for national laboratories is to increase their user orientation and thereby make them more accountable to society. Looking at the responses of the laboratories investigated in this study, we see that the response of Lab2B and Lab3A was most consistent with the policy objective. The response of Lab2A was justifiable in terms of its earning performance, but providing R&D services to multinational companies may not be fully consistent with the overall mandate of national laboratories. However, its response is consistent with India's overall effort, post-1991, to increase external orientation and to overcome the bias against exports and foreign markets which existed before 1991. It may also be justifiable in terms of its learning value for the laboratory and spin-offs to the laboratory's interaction with Indian industry.

Of greater concern is the response of Lab1 and Lab 3B. India has an industrial base in both the areas in which these laboratories work though it is arguably not very strong. In spite of the existence of this industrial base, both these laboratories were unable to target industrial customers largely due to their failure to develop strong competencies. In both these cases, we found a history of lack of strong leadership and direction and the absence of dominating values, beliefs or orientation (such as "research excellence" or "partnership with industry"). External earnings targets only make such laboratories turn towards activities which do not strictly fall under the category of "R&D" such as training or testing services. While providing such services may be part of the broad mandate of these laboratories, it is not their principal goal. Providing

such services will only take them further from their mandate of developing technologies products or processes – for Indian industry.

This suggests that no single control measure (such as an external earnings target) can make national laboratories more business-like, and at the same time consistent with the overall policy objectives for which the laboratories were set up. Control measures like external earnings targets are unlikely to achieve policy objectives if they are applied across-the-board without attention to the history, culture and competencies of individual laboratories. Laboratories which lack a supportive culture may need to be taken through a phase of internal transformation towards deepening expertise, improving work practices, and changing attitudes before they can be expected to respond to such control measures in a manner consistent with policy objectives. This would imply making considerable resource commitments to such laboratories in the short- and medium-term to make them more capable of contributions in the long term. If such resources are not available, other options like laboratory closure, merger or restructuring would need to be considered.

While the R&D management literature has stressed the importance of the nature of the technology and the structure of the user industry in influencing the potential effectiveness of a national R&D laboratory, this study suggests that internal factors are just as important. The organization theory (Selznick, 1957; Stinchcombe, 1965) and strategic management (Boeker, 1989) literature have stressed such internal factors as founding conditions, influence of the early leadership and organizational culture in affecting organizational change and these were reflected in the character variables in our conceptual framework. This study suggests that policy-makers

and laboratory directors need to pay greater attention to such internal factors in devising new policy instruments to influence laboratory performance.

This study consisted of an in-depth look at five laboratories in a single country. Though some of the features of the context (such as resource scarcity, lack of sophistication of Indian industry) in which the laboratories in this study operated make the findings particularly relevant to the developing country context, the strong influence of founding conditions, initial leadership and the resulting organizational culture established in this study has important implications for efforts to transform government research laboratories anywhere. It would be useful to verify the findings of this study by researching a larger number of laboratories in those countries where external earnings targets have been used as the policy lever to increase accountability of the laboratories. The framework of analysis proposed in Section 4 could be the basis for such a study

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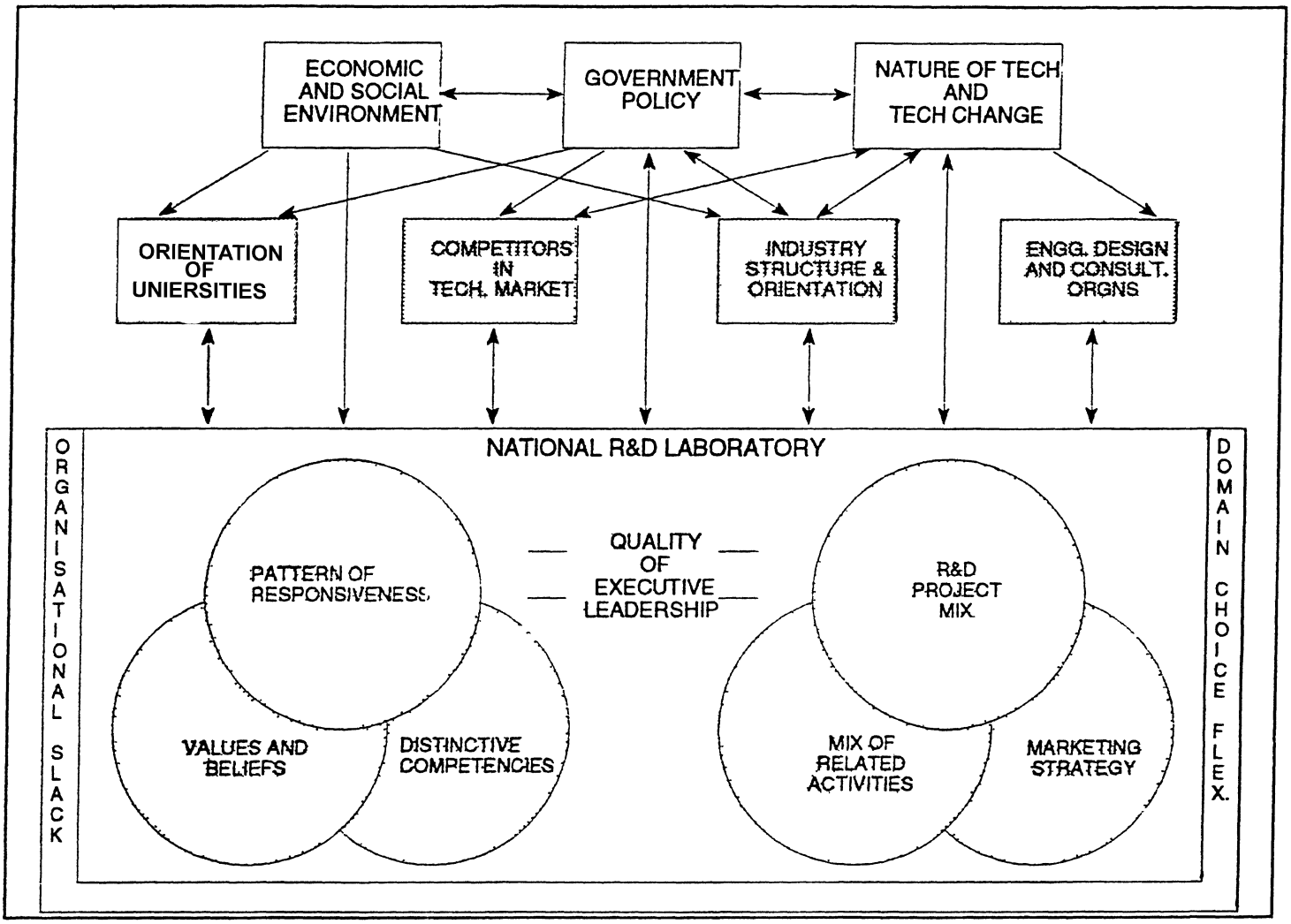

Figure 1 : Framework for Strategic Adaptation of National R&D Laboratories to Environmental Change

Table 1External earnings as a percentage of total income

	87-88	94-95	Industry as % of external earnings
Lab1	12.1	25.6	<10%
Lab2A	18.8	36.6	>50%
Lab2B	14.3	23.9	>50%
Lab3A	10.6	27.6	>80%
Lab3B	4.8	15.4	<15%