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*Synergy of R&D and Marketing*


# Interfacing R&D and Marketing: Tacit Knowledge and S&T Manpower Deployment in CSIR, India

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**Abstract** : Interfacing research and development (R&D) and marketing is an issue that is principally seen as being related to the issue of transfer of technology from the R&D organizations to the industry. However, this issue cannot be seen in isolation, it is an integral component of the management of technological innovation projects being undertaken in these organizations. The present study probes into the deployment of scientific and technical (S&T) personnel, the knowledge workers, in the laboratories under the Council of Scientific and Industrial Research (CSIR), India, in different functional areas. These knowledge workers are strategic assets for CSIR, more so because of the tacit knowledge they possess as a result of actively pursuing their specific functional objectives over long periods of time. Data from 31 CSIR laboratories have been analyzed. In the study, the different functions carried out by the S&T personnel have been divided into six categories. The specific functions carried out by the S&T personnel have been analyzed in order to know the internal strengths and weaknesses of individual labora tories in different functional areas. The significance of this functional deployment in establishing an effective interface between R&D and marketing and for successful transfer of technology has been discussed.

**Keywords** : *Interfacing R&D, Marketing, Tacit knowledge, S&T manpower, CSIR, India.*

## INTRODUCTION

In India, scientific and technological research is primarily concentrated in public-funded institutions like the Council of

Scientific and Industrial Research (CSIR) where the demand for profit, growth and accountability respectively require that research activity is directed, at least in the long run and more often in the short run, towards the solution of practical problems. These external tasks provide, to a great extent, the stimuli, growth and justification of scientific work. The traditional task of individual researcher to determine what scientific questions he wishes to pursue is being significantly affected by the requirements of funding agencies, as well as by the change in the R&D organizational structure. The scientist is no longer a free individual concerned solely with what he can find. Now he is concerned with what he ought to do.

Interfacing research and development (R&D) and marketing is an issue that is principally seen as being related to the issue of transfer of technology from the R&D organizations to the industry. Technology transfer is the process by which technological innovation efforts initiated in the R&D laboratories fructify, get commercialized and contribute to the national economy. Technology transfer is an active and intentional process to disseminate or acquire knowledge, experience and the related artifacts. However, this process is not an isolated one and cannot be managed as such. Management of research and development (R&D) projects is becoming an increasingly complex task both in technical and in organizational terms. This research emphasis has resulted in a growing body of knowledge on the factors contributing R&D project management effectiveness. Technology transfer is one vital link in the innovation chain without the success of which the innovations fail to fructify. For public-sector R&D laboratory system like that of the Council of Scientific and Industrial Research (CSIR) in India, the issue of technology transfer cannot be looked in isolation, it is a part and parcel of the overall management of the research and development projects taken up in these laboratories.

After a study of literature on the innovation process, Dodgson and Hinze (2000) have pointed out the importance of managerial factors-in strategy, organizational structure and choices about technology-in determining the sources, nature and outcomes of innovation. Innovation is, therefore, a manageable process. It is poor decisions rather than technical or informational deficiencies that influence the success of innovative efforts. The present study probes into the deployment of scientific and technical (S&T) personnel, the knowledge workers, in the laboratories under the Council of Scientific and Industrial Research (CSIR), India, in different functional areas. These knowledge workers are strategic assets for CSIR, more so because of the tacit knowledge they possess as a result of actively pursuing their specific functional objectives over long periods of time.

## STRATEGIC MANAGEMENT OF R&D ORGANIZATIONS

Strategic management of R&D organizations has assumed criticality in recent times. Information from studies on R&D and innovations management has had significant effects on the management practice. Hammer and Champy (1993) have argued that the essence of business re-engineering lies in the ability to challenge old assumptions about technology, people, and organizational goals. Nakano et al. (1997) have referred to the importance of formulation of R&D strategy that must be understood and shared by all researchers of an organization. According to Mintzberg (1994), most successful strategies are visions and not plans and so he advocates strategic thinking. After the third generation R&D Management was described and implemented, the possibilities of the fourth or even the fifth generation of R&D (Rothwell, 1996) are also heard. Many organizations are confronted with dynamic and uncertain environments due to the accelerated rate of technological change coupled with increasing competitiveness in the global marketplace. Effective performance, therefore, depends to a great extent on the success of the innovative activities within the organization and particularly on the way they are managed (Saleh et al., 1983). Much of current concern with issues such as core competences (Coombs, 1996), downsizing, simultaneous engineering and, particularly, business process re-engineering (BPR), is based more on felt need than it is on knowledge on how best to do it (Brockhoff, Koch and Pearson, 1997).

According to Fusfeld (1995), the R&D environment today has specific and well-defined characteristics that include strategic use of external resources, dispersion of corporate technical activity, emphasis on effective integration of total corporate technical resources, organized pursuit of technical intelligence globally, integrated R&D to expand markets, and merging of technical strategies with corporate strategies. The character of economy and enterprise also require global strategic approach, management of knowledge and development of multiple skills.

From the early focus on the development of technologies for self-reliance and of import substitution products, CSIR in the recent era have made attempts to confront the threats of liberalization and globalization. A report of a Committee chaired by Mashelkar (1993) entitled 'Creating an Enabling Environment for Commercialization of CSIR Knowledgebase: A New Perspective' brings out the issue of globalization discourse by pointing out the global emergence of an 'order' reflected in the 'gradual consolidation of a new technological and development paradigm, characterized by the predominance of production processes that are increasingly science-based and technology-intensive, as well as by a very high rate of technological change'.

## TACIT KNOWLEDGE - A STRATEGIC ASSET

Human resources are considered to be one of the key strategic assets. They cannot be easily imitated. Yet, traditional human resources strategy offers little concrete guidance to practicing managers on the process of developing human resources - and in the context of a strategic plan. Knowledge is an important factor for achieving a sustainable competitive advantage and it can be harnessed by focusing on increasing human capabilities through the process of increased communication, cooperation and linkages, both within the organization as well as across different knowledge producing organizations Strategic human resource planning and development involves linking business strategy and organizational strategy to the current and emerging pool of skills and competencies, thus identifying key shifts and gaps and areas for intervention.

As mentioned earlier, the scientific and technical personnel, the knowledge workers, are strategic assets for CSIR, more so because of the tacit knowledge they possess as a result of actively pursuing R&D activities in different functional areas over a long period of time. Tacit knowledge has been recognized as a major input to any technological innovation effort. The strategic technological agenda is linked to the organization's technical and managerial knowledge and assumptions. This knowledge is largely experiential, cumulative and often tacit. Much of this tacit knowledge is held in decentralized units and structures, often non-disseminated and immune to external challenge (Pitt and Clarke, 1997). Studies of innovation, technology transfer and technology diffusion identify tacit knowledge as an important component of the knowledge used in innovation. Tacit knowledge is a source of competitive advantage. Dutta and Weiss (1997) have argued that the protection of tacit technological knowledge from potential opportunism is of importance to technologically innovative organizations. Tacit know-how has become recognized as playing a key role in organizational growth and economic competitiveness. It forms an important element in an organization's knowledge base and has a central role in organizational learning (Howells, 1996). The generation of tacit knowledge is an inevitable adjunct to advances in science and technology, and organizations acquire such knowledge to support innovation in a purposive manner. In the study presented in this paper, we have used functions being performed by S&T manpower as indicators of their tacit knowledge.

Hamel (1998) has argued that in a discontinuous world, strategy innovation is the key to wealth creation. Strategy innovation is the capacity to re-conceive the existing industry model in ways that create new value for customers, wrong-foot competitors, and produce new wealth for all stakeholders. It stresses upon resource creation, vital for success in the face of resource disadvantages. Thus, unique resources could provide competitive advantage if they are non-tradable, non-imitable and non-substitutable.

## METHODOLOGY

*Functional Scheme for Scientific and Technical (S&T) Personnel*

Based on our understanding of the various scientific and technical activities being carried out in CSIR laboratories, the different functions carried out by the S&T personnel were grouped into six categories.

It may be noted that function 2 and function 6 are not same. Function 6 (research support functions) includes all residual functions not mentioned in the list of other functions. S&T personnel categorized under this functional classification could include computer programmers, data entry operators and the like.

We have not made an attempt here to divide the functions performed by S&T personnel into different categories of structured and less-structured functions. The scheme outlined above reflects the actual S&T staffing pattern in various CSIR laboratories. A group of personnel in a particular category may perform some structured functions and some functions which are not so structured.

*Functional Scheme for S&T personnel*

| | |
|---|---|
| Function 1 | Research and development work. |
| Function 2 | S&T services including testing, survey, data processing, field work, liaison, planning and co-ordination. |
| Function 3 | Infrastructure including workshop, animal house, instrumentation, equipment maintenance, special functions such as glass blowing, printing and reprography, etc. |
| Function 4 | Pilot plants, experimental field stations and Demonstration units |
| Function 5 | Engineering and design units. |
| Function 6 | Research support functions. |

Data from 31 CSIR laboratories were available for this study. For analyzing such categorical data, the methodology of correspondence analysis has been used.

*Correspondence Analysis (CA)*

Correspondence analysis is an exploratory statistical study which displays the rows and columns of a rectangular data matrix as points in a scatter-plot, often called a 'map'. It is powerful graphical tool in many situations involving categorical data (Greenacre, 1984, 1993; Greenacre and Blasius, 1994). The data set is in the form of categorical variables in a contingency table. The important characteristics of a contingency table is that each respondent, or sampling unit, occurs in only one cell of the table, so that the grand total of the table is equal to the sample size. Correspondence analysis looks at the association, or interaction, between two categorical variables. The maps of correspondence analysis provide a view of a data table in a continuous framework, in terms of new dimensions on continuous scales. The methodology is particularly helpful in analyzing cross-tabular data in the form of numerical frequencies, and results in an elegant but simple graphical display that permit more rapid interpretation and understanding of the data. In our present study, correspondence analysis has been carried out using SIMCA-2 (Greenacre, 1990) software.

The laboratories are referred to in the correspondence analysis maps as two capital letter abbreviations. The list of the participating laboratories along with the respective abbreviations is given in Table 1.

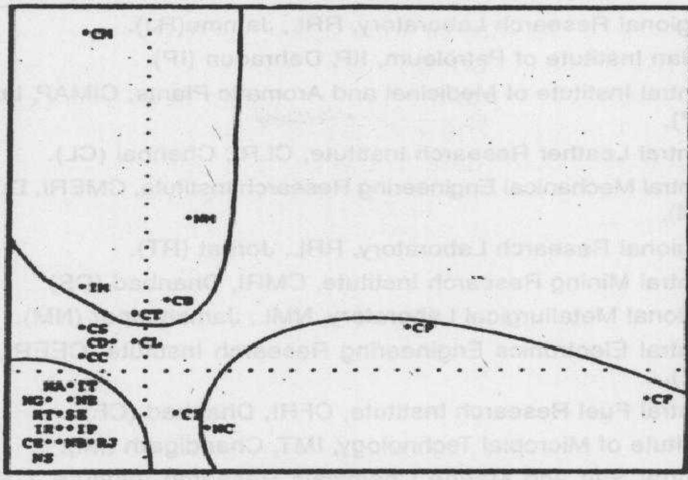
Table 2 presents the raw data of scientific personnel in different CSIR laboratories belonging to Group IV, categorized into various functions they perform as defined above.

## ANALYSIS OF CORRESPONDENCE ANALYSIS (CA) MAPS

Figure 1 presents the two-dimensional map constituted by factor 1 (¢1) and factor 2 (¢2) axes for the CSIR laboratory points and Figure 2 presents the same for the various function points - both for the case of the Group IV (scientific) manpower, which should be read and interpreted simultaneously. The representation of functions and laboratories in different maps has been done to avoid cluttering of the points in the same map. However, it is possible to superimpose these two maps.

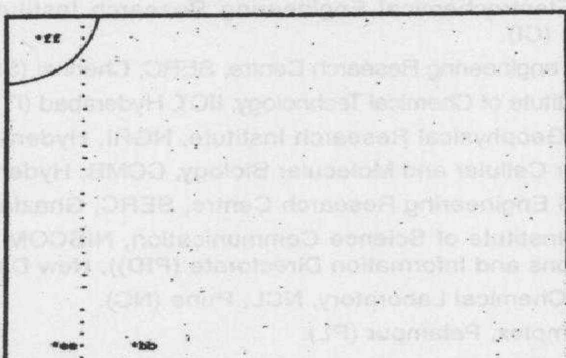
Figures 1and 2 could be interpreted as follows.

Eigenvalues obtained from the correspondence analysis of the data indicate that the total variance (å li = 0.474769) is quite large, which implies considerable deviations from the average in the profiles of the laboratories as far as their scientific manpower deployment among the various functions is concerned. The first three factorial axes, accounting for 91.07% of the total variance in the multi-dimensional system, yield the most parsimonious representation of the data. The remaining axes, accounting for successively smaller accounts of variance, represent information of an idiosyncratic nature, which does not have




Horizontal axis is dimension 1 with inertia = 0.2970 (62.6%) vertical axis is dimension 2 with inertia = 0.1002 (21.1%) 83.6% of total inertia is represented in the above map

Fig. 1 : *Two dimensional map constituted by factor 1 (¢1) and factor 2 (¢2) axes*




Horizontal axis is dimension 1 with inertia = 0.2970 (62.6%) vertical axis is dimension 2 with inertia = 0.1002 (21.1%) 83.6% of total inertia is represented in the above map

*Fig. 2 : Two dimensional map constituted by factor 1 (ϕ1) and factor 2 (ϕ2) axes for various function points*

**Table 1:** *List of CSIR Laboratories in the Study*

1. Regional Research Laboratory, RRL, Jammu(RJ).
2. Indian Institute of Petroleum, IIP, Dehradun (IP).
3. Central Institute of Medicinal and Aromatic Plants, CIMAP, Lucknow (CP).
4. Central Leather Research Institute, CLRI, Chennai (CL).
5. Central Mechanical Engineering Research Institute, CMERI, Durgapur (CM).
6. Regional Research Laboratory, RRL, Jorhat (RT).
7. Central Mining Research Institute, CMRI, Dhanbad (CS).
8. National Metallurgical Laboratory, NML, Jamshedpur (NM).
9. Central Electronics Engineering Research Institute, CEERI, Pilani (CE).
10. Central Fuel Research Institute, CFRI, Dhanbad (CF).
11. Institute of Microbial Technology, IMT, Chandigarh (IM).
12. Central Salt and Marine Chemicals Research Institute, CSMCRI, Bhavnagar (CR).
13. National Botanical Research Institute, NBRI, Lucknow (NB).
14. Indian Institute of Chemical Biology, IICB, Calcutta (IB).
15. National Environmental Engineering Research Institute, NEERI, Nagpur (NE).
16. Central Electrochemical Engineering Research Institute, CECRI, Karaikudi (CI).
17. Structural engineering Research Centre, SERC, Chennai (SE).
18. Indian Institute of Chemical Technology, IICT, Hyderabad (IT).
19. National Geophysical Research Institute, NGRI, Hyderabad (NG).
20. Centre for Cellular and Molecular Biology, CCMB, Hyderabad (CC).
21. Structural Engineering Research Centre, SERC, Ghaziabad (SC).
22. National Institute of Science Communication, NISCOM (formerely, Publications and Information Directorate (PID)), New Delhi (NI).
23. National Chemical Laboratory, NCL, Pune (NC).
24. CSIR Complex, Palampur (PL).
25. Central Building Research Institute, CBRI, Roorkee (CB).
26. National Institute of Oceanography, NIO, Goa (NO).
27. National Aerospace Laboratory, NAL, Bangalore (NA).
28. Industrial Toxicology Research Centre, ITRC, Lucknow (IR).
29. Central Food Technological Research Institute, CFTRI, Mysore (CT).
30. National Institute of Science, Technology and Develop ment Studies, NISTADS, New Delhi (NS).
31. Central Drug Research Institute, CDRI, Lucknow (CD).

*Table 2 : Scientific personnel in different CSIR laboratories*

| Name of the 1 | Function 2 | Function 3 | Function 4 | Function 5 | Function 6 | Lab. Function |
|---|---|---|---|---|---|---|
| RRL, Jammu | 131 | 2 | 2 | 6 | 3 | |
| IIP, Dehra Dun | 147 | 7 | 5 | 1 | | |
| CIMAP, Lucknow | 38 | 20 | 7 | 29 | 4 | |
| CLRI, Chennai | 77 | 23 | 3 | 5 | 3 | 1 |
| CMERI, Durgapur | 67 | 16 | 4 | | 2 | 26 |
| RRL, Jorhat | 126 | 6 | 5 | | 7 | |
| CMRI, Dhanbad | 119 | 28 | 2 | | | 5 |
| NML, Jamshedpur | 105 | 25 | 20 | 20 | 8 | 18 |
| CEERI, Pilani | 155 | 3 | 2 | | 1 | |
| CFRI, Dhanbad | 97 | 31 | 8 | 167 | | |
| IMT, Chandigarh | 13 | 2 | 2 | | 1 | 1 |
| *CSMCRI, Bhavnagar | 94 | 7 | 8 | | 1 | |
| NBRI, Lucknow | 96 | 8 | | 1 | | |
| IICB, Calcutta | 90 | 5 | 9 | | | 1 |
| NEERI, Nagpur | 127 | 12 | 9 | | | |
| CECRI, Karaikudi | 156 | 10 | 14 | 21 | | |
| SERC, Chennai | 70 | 5 | 3 | | | |
| IICT, Hyderabad | 237 | 23 | 10 | 1 | 19 | |
| NGRI, Hyderabad | 177 | 2 | | | | 7 |
| CCMB, Hyderabad | 51 | 2 | 14 | | | 1 |
| SERC, Ghaziabad | 30 | 1 | 1 | | | |
| **NISCOM, New Delhi | 75 | 2 | 3 | | | |
| NCL, Pune | 301 | 12 | 13 | 53 | 2 | |
| CSIR Comp., Palampur | 16 | 1 | | | | |
| CBRI, Roorkey | 100 | 30 | 10 | 12 | 7 | 5 |
| NIO, Goa | 208 | 9 | 3 | | | |
| NAL, Bangalore | 282 | 14 | 8 | 2 | 11 | 7 |
| ITRC, Lucknow | 87 | 5 | 1 | | | |
| CFTRI, Mysore | 187 | 31 | 10 | 14 | 13 | 11 |
| NISTADS, New Delhi | 46 | 1 | | | | |
| CDRI, Lucknow | 200 | 33 | 21 | 8 | | 8 |
| Total | 3705 | 376 | 197 | 340 | 82 | 91 |

*CSMCRI, Bhavnagar: Pilot plants included in Function 1, i.e. research and development work

**NISCOM, New Delhi: Research and development work means science editing and publishing.

much bearing on the structure of the multi-dimensional data. The first two axes, accounting for 83.6% of the total variance, represent the main features of the multi-dimensional data. The third axis, accounting for 7.43% of the variance, represents complementary data for further analysis.

**Factor 1 ($\phi_1$):** The first factorial axis, accounting for 62.55% of the total variance, constitutes the most important element of the multivariate structure of relationships between CSIR laboratories and the functional areas of scientific manpower.

On the cloud of functions, the first factorial axis represents a polarity (bi-polar) between function 4-pilot plants, experimental field stations, etc. and function 1-R&D work. Function 1 is projected on this axis with negative coordinate, whereas function 4 is projected on this axis with positive coordinate. This implies that laboratories which emphasize R&D work for their scientific personnel and deploy their scientific manpower in this area tend to de-emphasize their work related to pilot plants, etc., and vice-versa.

The laboratories projected on this axis can be classified into two clusters, depending upon whether they are projected with positive coordinates (correlated with function 4) or negative coordinates (correlated with function 1).

**Cluster 1** (positive coordinates): CIMAP, Lucknow; CFRI, Dhanbad; NCL, Pune.

**Cluster 2** (negative coordinates): RRL, Jorhat; NGRI, Hyderabsd; IIP, Dehradun;

CEERI, Pilani; CSMCRI, Bhavnagar; NBRI, Lucknow; IICB, Calcutta; NEERI, Nagpur; SERC, Chennai; SERC, Ghaziabad; NISCOM, New Delhi; CSIR, Complex, Palampur; NIO, Goa; NISTADS, New Delhi; National Aerospace Laboratory, Bangalore; ITRC, Lucknow.

**Factor 2 ($f_2$)**: The second factorial axis, accounting for 21.09% of the total variance, constitutes the second most important element of the multi-dimensional data.

On the cloud of functions, the second factorial axis is unipolar-both function 2 - S&T services including testing, data processing, field work, planning and coordination etc. and function 6- research support functions, are projected on the axis with positive coordinates. This implies that the laboratories which are projected on this axis with positive coordinates emphasize the function of working in the areas of S&T services and research support functions for their scientific personnel and deploy scientific manpower in these areas whereas laboratories, which are projected with negative coordinates on this axis, de-emphasize these roles for their scientific manpower.

The laboratories projected on this axis can be classified into two clusters, depending upon whether they are projected on this axis with positive coordinates (correlated with both function 2 and function 6) or negative coordinates (anti-correlated with both function 2 and function 6).

**Cluster 1** (positive coordinates): CMERI, Durgapur; NML, Jamshedpur; CFTRI, Mysore; IMT, Chandigarh; CBRI, Roorkee.

**Cluster 2** (negative coordinates): CECRI, Karaikudi; CEERI, Pilani; SERC, Ghaziabad; NISCOM, New Delhi; RRL, Jammu; NCL, Pune; NIO, Goa; ITRC, Lucknow; NISTADS, New Delhi.

**Factor 3 ($f_3$):** The third factorial axis accounts for 7.43% of the total variance.

On the cloud of functions, the third factorial axis is a bi-polar axis of function 2 - S&T services including testing, field work, planning and coordination, etc. and function 5 - engineering and design units on one side (projected on this axis with negative coordinates) and the function 6 - research support functions on the other side (projected on this axis with positive coordinates). This implies that laboratories that emphasize the functions of S&T services, planning and coordination, and the work related to engineering and design units for their scientific manpower and deploy this manpower in these areas of work, tend to de-emphasize their work related to research support functions, and vice-versa.

On the cloud of laboratories, it is found that the laboratory NGRI, Hyderabad is projected on the axis with positive coordinate whereas laboratories CLRI, Chennai, IICT, Hyderabad and CBRI, Roorkee are projected on the axis with negative coordinates.

## CONCLUSIONS

The present trend towards globalization and international competition implies that a major reorientation of research strategy towards process and product-development must take place. This strategy can be pursued in a single laboratory or in a consortium of laboratories and can involve basic research, applied research, and incremental/engineering research, including quality improvement. This is more so because transfer of technology is not an isolated occurrence that can be tackled only by looking at the final stage of transfer of the technology from the public-funded R&D laboratory to the industry. It encompasses the entire gamut of technological innovation management and therefore, can be considered only in its totality. Thus, it becomes imperative to appreciate the paradigmatic shift towards strategy innovation for survival, maintenance and growth of CSIR. The corporate character of CSIR is almost entirely built upon the performances and functioning of the laboratories functioning under CSIR.

Organizing information of this nature for strategic planning and decision-making for an R&D organization like CSIR, therefore, has assumed criticality. The present study is an attempt to address this problem. Organization of information in this manner could provide the corporate managers and decision-makers at the CSIR level an invaluable input for making policy decisions depending upon the strengths and weaknesses of the laboratories in different functional areas in terms of their scientific manpower-the knowledge workers, and provide a strategic perspective to the issue of interfacing R&D and marketing. According to Brockhoff, Koch and Pearson (1997), the problems identified in effectively organizing the R&D process fall into a number of major areas, for example, the duration of R&D projects, the explosion of total R&D costs and the loss of competitive edge. Maintaining credibility will require R&D managers to leverage internal R&D capabilities with external resources, deliver long-term as well as short-term value, facilitate rapid learning, and to focus on speed in the commer-cialization of new technology. As business environments become more dynamic through deregulation, increased competition and technological changes, organizations face increasing pressures to become more organic (Nilakant and Ramnarayan, 1998).

Considering a few examples from the results of the correspondence analysis presented above would illustrate the point further. Quite often it is found that the laboratories that emphasize R&D work for their S&T manpower do not emphasize work on pilot plants, experimental field stations and in the engineering and design units. This is a very serious lacuna in the management of these laboratories. Rajan et al. (1981) in their study have highlighted the importance of pilot plants in successful technology transfer. According to them, any reservation in incurring expenses at the pilot plant/bench scale and demonstration stage can lead to severe bottlenecks. Even if the technology is passed to a genuine entrepreneur, the work at the pilot plant level goes a long way to check premature or exaggerated claims of the R&D scientists and thus avoids later failures of the technology.

It is important to associate design engineers from industry with the R&D investigations at the early stages of the laboratory so that difficulties in designing the plant, machinery and equipment installation etc. could be avoided at the time of technology transfer. This would also help to improve the quality of the product in response to market changes. For successful technological innovation resulting from the work being carried out in the laboratories of CSIR, adequate attention needs to be given to the aspect of design engineering in new technology development. CSIR, viewing itself as a corporate, should, therefore, realize its core competencies, and evaluate its strengths and weaknesses in different R&D and allied areas and functions necessary for initiating technological innovation. Training of scientific and technical manpower in different fields of their activities, potentialities and interests could play a vital role in this regard. In a survey of CSIR directors, marketing/business development managers, and senior scientists (Bhojwani and Gupta, 1998), it has been found that there is little systematic planning done to assess the training needs of R&D manpower. About 38% of the respondents of their questionnaire indicated that they have to worry about their own training needs. This is a cause for concern requiring urgent attention at the corporate strategy level at CSIR.

This study provides us with a map with groupings of laboratories possessing an in-built strength in basic research or an in-built strength in engineering services or in the working of pilot plants or in other R&D thrust areas. The task of devising a strategy involves determining one's (potential) source of competitive advantage (Price, 1996). The role of tacit knowledge in technological innovation has already been emphasized. What we see in such correspondence analysis maps are displays and profiles of such tacit knowledge in different functional areas. Tacit knowledge is a source of competitive advantage (Choo, 1996). Therefore the significance of the objective of strategic deployment of knowledge workers with such ingrained tacit knowledge cannot be underestimated. CSIR has to conceive, or rather re-conceive itself as a multi-business conglomerate with the potential of pitching in, nationally and globally, in a select few areas of strength and competence through a network mode of consortia of laboratories and other actors in the innovative effort. The study results and the correspondence analysis maps are a guide to forge such alliances by identifying strategic groupings of laboratories as also identifying the stand-alone ones. Both basic as well as applied research thrust areas are crucial to any innovative effort. Thus, this assessment of the strengths and weaknesses of CSIR regarding the functional deployment of its knowledge workers across the different laboratories could prove immensely useful to the decision-makers in R&D strategy formulation, planning and management.

## REFERENCES


(1) Bhojwani, H.R. and Gupta, A.K. (1998) Management of Publicly Funded R&D in India: Case Study of CSIR, Council of Scientific and Industrial Research, New Delhi.

(2) Brockhoff, K.K., Koch, G. and Pearson, A.W. (1997) Business Process Re-Engineering: Experiences in R&D, Technology Analysis and Strategic Management, Vol. 9, No.2, 163-178.

(3) Choo, C.W. (1996) The Knowledge Organization: How Organizations Use Information to Construct Meaning, Create Knowledge and Make Decision, International Journal of Information Management, 16(5), 329-340.

(4) Coombs, R. (1996) Core Competences and Strategic Management of R&D, R&D Management, 26, 345-355.

(5) Dodgson, M. and Hinze, S. (2000) Indicators Used to Measure the Innovation Process: Defects and Possible Processes, Research Evaluation, 8(2), 101-114.

(6) Dutta, S., Wiess, A.M. (1997) The Relationship Between a Firm's Level of Technological Innovativeness and its Pattern of Partnership Agreements, Management Science, 43(3), 343-356.

(7) Fusfeld, H.I. (1995) Industrial R&D - Where it's Been, Where it's Going, Research Technology Management, 38(4), 52-56.

(8) Greenacre, M. and Blasius, J. (eds.) (1994) Correspondence Analysis in the Social Sciences: Recent Developments and Applications, Academic Press, London.

(9) Greenacre, M.J. (1984) Theory and Applications of Correspondence Analysis, Academic Press, London.

(10) Greenacre, M.J. (1990) SIMCA-2: Program and Manual, Department of Statistics,University of South Africa, Pretoria, South Africa.

(11) Greenacre, M.J. (1993), Correspondence Analysis in Practice, Academic Press, London.

(12) Hamel, G. (1998), Opinion, Strategy Innovation and the Quest for Value, Sloan Management Review, Winter, 7-14.

(13) Hammer, M. and Champy, J. (1993) Re-Engineering the Corporation: A Manifesto for Business Revolution, Brealey, London, 1993.

(14) Howells, J. (1996), Tacit Knowledge, Innovation and Technology Transfer, Technology Analysis and Strategic Management, 8(2), 91-106.

(15) Mashelkar, R. A. (1993) Creating an Enabling Environment for Commercialization of CSIR Knowledgebase: A New Perspective, Report, Council of Scientific and Industrial Research, New Delhi.

(16) Mintzberg, H. (1987) The Strategy Concept II: Another Look at Why Organizations Need Strategies, California Management Review, 30(1), 25-32.

(17) Nakano, M, Nobutomo, H., Okada, M., Mizushima, A. (1997) Research on How to Develop R&D Strategies Using the Soft Systems Approach, International Journal of Technology Management, 14(6/7/8), 822-833.

(18) Nilakant, V. and Ramnarayan, S. (1998) Managing Organisational Change, Response Books, New Delhi.

(19) Pitt, M. and Clarke, K. (1997) Frames of Significance: Technological Agenda Forming for Strategic Advantage, Technology Analysis and Strategic Management, 9(3), 251-269.

(20) Price, R.M. (1996) Technology and Strategic Advantage, California Management Review, 38(3), Spring, 38-56.

(21) Rajan J.V. et al. (1981) Transfer of Indigenous Technology: Some Indian Cases, Research Policy, 10, 172-194.

(22) Rothwell, R. (1996) The Challenge of the Fifth Generation R&D, Research Technology Management, 39, 33-41.

(23) Saleh, S.D., Wang, C.K. (1993) The Management of Innovation: Strategy, Structure and Organizational Climate, IEEE Transactions on Engineering Management, 40(1), February, 14-21.