International Journal of Enhanced Research in Science, Technology & Engineering, ISSN: 2319-7463
Vol. 2 Issue 7, July-2013, pp: (152-163), Available online at: www.erpublications.com

Exploring new trends in R&D and evolving KM strategy framework for effective R&D performance (A pilot study of CSIR R&D Laboratories)

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Abstract: R&D Organizations are becoming increasingly aware of the need for innovative approaches to responding more effectively to client's demands and changes in the market place. Knowledge Management (KM) is central to this and is increasingly recognized as an integral part of the organization's strategy to improve R&D performance. There is therefore a need for R&D performance based approach to KM. Carrillo et al (2000)[1] suggested that KM could be integrated into key performance indicators. Indian organizations today face a challenging situation. There has been a sea change in their business environments since 1991 when the first step towards liberalization was taken. The WTO regime, foreign competition, increased consumer awareness and stringent regulatory mechanisms have put immense pressure to improve product performance. Many organizations now are investing in their R&D activities with expectations to improve organizational competitiveness. Technology Management is becoming increasingly important as managing technological change becomes a top priority for management and technology is recognized as a key asset. (Twiss 1992) [2]. Research is becoming more complex and thereby increasing both the cost and financial risks of performing research. As an effect, the evaluation of R&D interventions and identifying the contribution of R&D becomes sensitive and crucial.

Keywords: R&D Management, Knowledge Management, KM Strategy, R&D Performance.

1.0 Exploring new trends in R&D

An analysis of the new concepts and trends in R&D organizations can be found in Gassmanna and Maximilian von Zedtwitz (1999)[3]. Their results are based on 195 semi-structured research interviews in 33 technology-based companies between 1994 and 1998 in the electrical/ electronics, automotive/ turbines/ heavy machinery, and chemicals/ pharmaceuticals industries with home bases in Europe, USA and Japan. Based upon this work and empirical observations, Gassmanna and Maximilian von Zedtwitz discerned five ideal forms of structural and behavioral orientation in international R&D organization. These are as follows:

1. Ethnocentric Centralized R&D
2. Geocentric Centralized R&D
3. Polycentric Decentralized R&D
4. R&D Hub Model
5. Integrated R&D Network

In the (1) ethnocentric centralized R&D organization, all R&D activities are concentrated in the home country. It is assumed that the home country is technologically superior to subsidiaries and affiliated companies in other countries, a notion which also defines the asymmetrical information and decision structures between home base and peripheral sites. Central R&D is the protected 'think tank' of the company, creating new products which are subsequently manufactured in other locations and distributed worldwide (e.g., Toyota in Great Britain, Volkswagen in China, Nippon Steel, Microsoft). The core technologies, which ensure long-term competitiveness of the company, are retained as a 'national treasure' in the home country base. Besides providing protection against uncontrolled technology transfer, this concept demonstrates high efficiency due to scale and specialization affects, which results in lower R&D costs and reduced overall development times. An efficient R&D unit therefore requires a certain critical mass of capital and personnel. Physical collocation of R&D employees, standardized management systems and a common understanding of R&D vision and values promote the flow of information between scientists at the R&D centre and facilitate the control of R&D activities. The main drawbacks of ethnocentric centralized R&D are the lack of sensitivity for signals from foreign markets and its insufficient consideration of local market demands. Furthermore, the Not-Invented-Here syndrome occurs frequently, and the organizational structure tends to be very rigid.

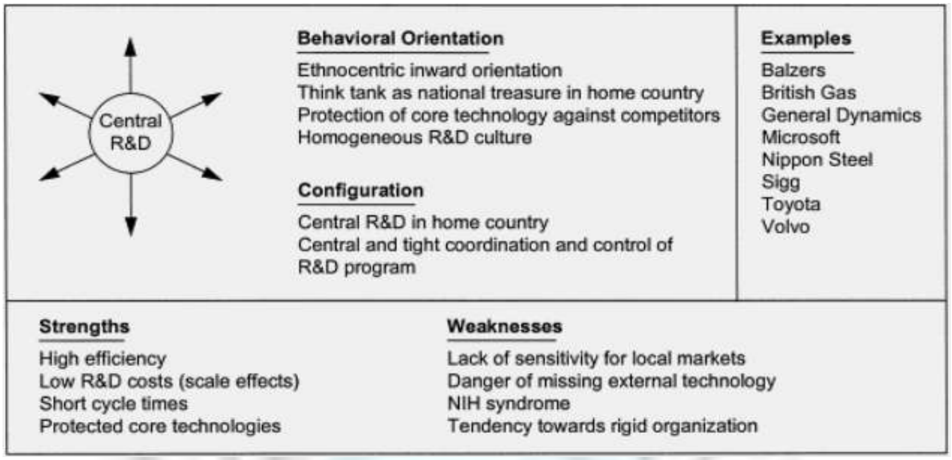

Figure 1: Ethnocentric centralized R&D is characterized by a lack of transnational R&D processes as all R&D activities are concentrated at the home base.

The ethnocentric organization becomes inappropriate when a company becomes more dependent on foreign markets and local competencies. The (2) geocentric centralized (or physically centered R&D) organization overcomes the ethnocentric home-base orientation while retaining the efficiency advantage of centralization. This requires extra investments in R&D personnel in order to increase their international awareness. At the central R&D site, knowledge of worldwide and externally available technologies is accumulated. R&D employees' sensitivity for international markets increases. This can be achieved by sending R&D employees abroad to collaborate and intensively communicate with local manufacturing, suppliers and lead customers. International awareness can be further improved by recruiting multi-lingual or foreign engineers with working experience abroad (Figure 3). [Examples: Nissan, Kubota] Geocentric centralized R&D offers a quick and inexpensive way to internationalize R&D without giving up the advantage of physically centralized R&D (figure 2).

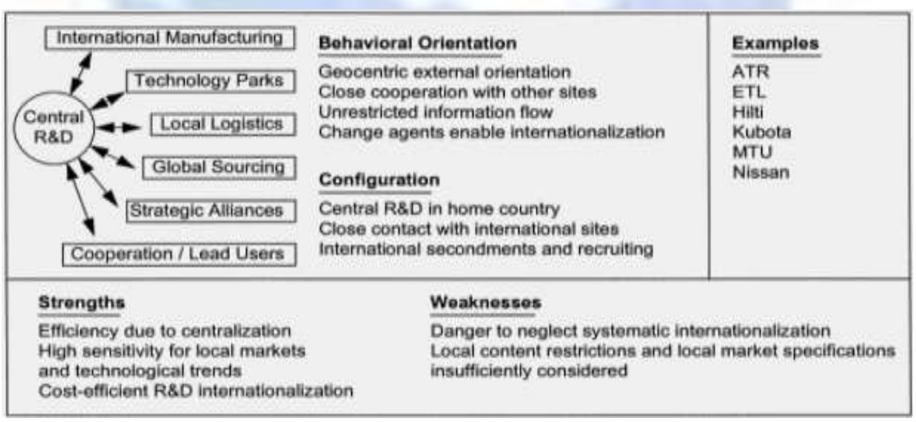

Figure 2: Geocentric R&D organizations overcome the lack of market sensitivity

Frequently, companies with a strong orientation towards regional markets (e.g., many European MNCs in the 1970s and 1980s) adopt a (3) polycentric decentralized R&D organization. Local R&D laboratories have been established by local distribution and manufacturing units, mainly in order to respond to customer product adaptation requests. Some firms exhibit a polycentric R&D structure because they have been formed by M&A activities and the synergy potential in R&D reorganization was not exploited. The organizational structure is characterized by a decentralized federation of R&D sites with no supervising corporate R&D centre. Information flow between foreign sites and the home base is limited with reports on current R&D activities being late (figure 3).

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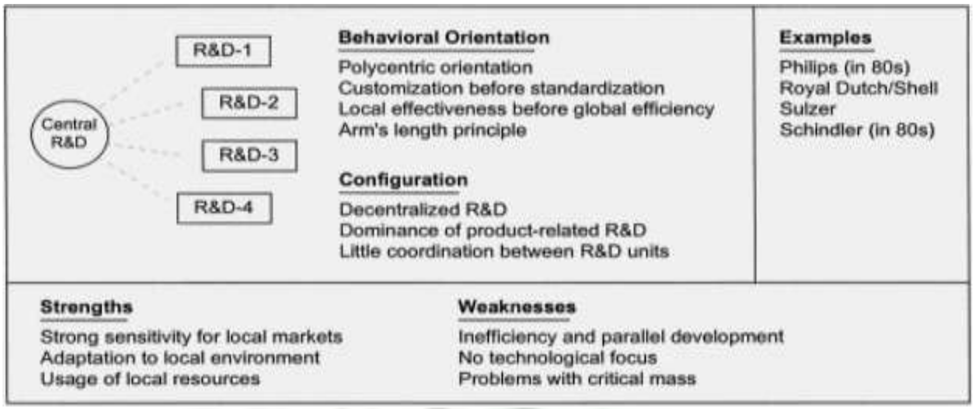

Figure 3: The major challenge of polycentric decentralized R&D organizations is to overcome the isolation of formerly independent R&D units and to integrate them into a wider R&D network.

The R&D director of a subsidiary in a polycentric decentralized R&D organization reports to local management. Although this configuration is optimal for local market sensitivity and the exploitation of local resources, its disadvantages are high autonomy and little incentive to share information with other R&D units (in particular central R&D) in early project stages. Efforts to preserve autonomy and national identity impede cross-border coordination, and therefore lead to inefficiency on a corporate level and redundant R&D activities. Furthermore, the company is in danger to lose the focus on a particular technology and technology convergence is difficult to achieve. [Examples: Royal Dutch/Shell, Phillips (in the 80s), Schindler] (4)The R&D hub model with its tight central control reduces the risk of suboptimal resource allocation and R&D duplication. The R&D centre in the home location is the main laboratory for all research and advanced development activities, retaining a worldwide lead in relevant technological fields. Foreign R&D which usually evolves from technological listening posts sites focus their activities on predefined technological areas. The R&D centre tightly coordinates decentral R&D activities by means of long-term R&D programs as well as resource and personnel allocation. This model guarantees an efficient technology transfer and permanent technical assistance. An R&D centre may be formed as a legal entity which owns all of the technological knowledge and intellectual property (Figure 4). [Examples: Daimler–Benz, the United Technologies Corporation, Sony]

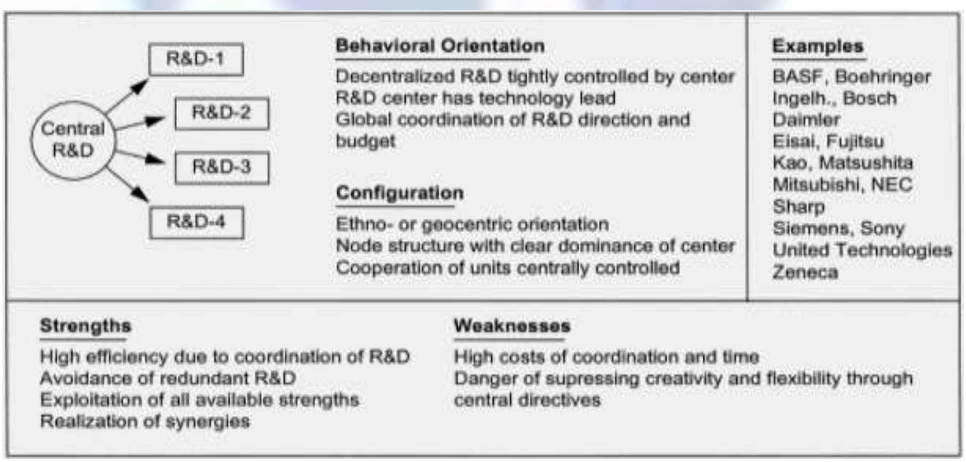

Figure 4: Hub model is usually a reaction by centralized companies to the internationalization of resources.

In the **(5) integrated R&D network** model, domestic R&D is no longer the centre of control for all R&D activities. Central R&D evolves into a competency centre among many interdependent R&D units which are closely interconnected by means of flexible and diverse coordination mechanisms (Figure5).

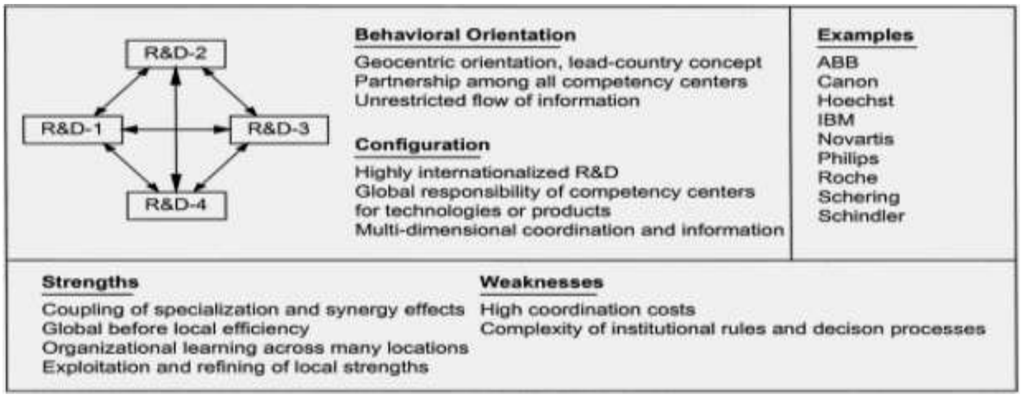

Figure 5: The Integrated R&D network is characterized by authority for technology or component development based on individual

2.0 Trends in Organizational Structure of R&D Firms

MNCs that assumed a network organization were often organized along a hub or polycentric configuration. In contrast to the hub model, foreign R&D units in the integrated R&D network assume strategic roles affecting the entire company: A competence centre should not only act as a sensor for possible change in its respective area, but should also engage in defining appropriate strategies and new business development. While the major effort in this case is to improve the authority and competency of R&D units, the shift from a polycentric to a network configuration is based on exploiting potential synergy between newly connected R&D sites. A prerequisite condition for effective network operations is a sophisticated global information technology infrastructure. [Examples: Nestlé, Philips (in the 90s), Bayer, Hoffmann-La Roche, Novartis, Hoechst and Schering].

Gassmann and Zedtwitz (1999) further observed five principal trends in the organizational structure of R&D firms. These are as follows:

1. Orientation of R&D processes towards international markets and knowledge centers;
2. Establishment of tightly coordinated technology listening posts;
3. Increase of autonomy and authority of foreign R&D sites;
4. Tighter integration of decentralized R&D units; and
5. Increased coordination and re-centralization of R&D activities in fewer leading research centers in order to improve global efficiency.

3.0 Studies on Indian R&D:

(i) Globalization of R&D and its impact on industrial R&D in India:

Hirwani, (2004)[4] studied how the globalization process has affected the industrial R&D in India and its impact in terms of evolution of content level of R&D. According to the framework adopted in this work, domestic R&D evolves from technology support function to technology up-gradation to technology capacity exploitation in foreign markets. This framework is illustrated with the example of Indian chemical Industry.
Major findings of Hirwani's study are given below.

1. Data suggests there is an increase in FDI in R&D in India for which both market, availability of human capital and technology oriented factors are important.
2. Many subsidiaries of TNCs established R&D units in India to support local manufacturing operations. (Unilever, ICI). With change in the global strategy theses R&D units are integrated to their worldwide R&D network of innovation.
3. The domestic organic chemical units involved in manufacture of drugs and pharmaceuticals, agrochemicals, fine chemicals and intermediates are beneficiaries of this phenomenon. The Indian Patent Act of 1970 that

recognizes only the process patent has helped them to build world class skills in organic synthesis and process chemistry. Their current R&D portfolio reveals a movement away from imitative research to original research.

4. With a few exceptions foreign affiliate R&D and domestic R&D are practically at the same level of evolution, possibly due to inward looking restrictive environment in which MNCs operated in India between 1960 and 1990. Foreign affiliate's incentives to create new technology were muted in such an environment.
5. Only a few publicly funded research and technology organization in India have been able to exploit the opportunities of globalization. These organizations are now playing an increasing role of supplier of R&D services to the MNCs outside India.
6. Patent data analysis shows that Indian organizations, including some pharmaceutical companies have been obtaining increasing number of product patents.
7. There is increasing generation of innovation funded by foreign organizations and exploitation of domestic technological capabilities by way of export of high tech products and R&D services.

(ii)TIFAC (Technology, Information, Forecasting, Assessment Council, Government of India) Study – FDI in the R&D Sector: Study for the Pattern in 1998-2003[5]

The purpose of this study has been to list the major players in R&D sector and analyze their behavior in terms of investment, R&D effort, choice of industry, employment and future plans. In addition, the relation of the S&T policy in India and FDI is to be analyzed in the light of study findings. 100 top companies making FDI in R&D in India have been studied, out of which 53 are from USA, 7 each from Japan, Germany and UK, 5 from France, 3 each from Netherlands Canada and Korea, 2 each from Switzerland, Sweden, Mauritius and China, 1 each from South Africa, Norway, Denmark and Australia. Information for many of these companies on their planned investment and workforce are given in this report.

(iii) DST (Department of Science and Technology, Government of India) Study – Research and Development (R&D) in India: A Prospect and Validity Study [6]

This study especially focuses on R&D activities (by both domestic and foreign firms, public or private) in the following sectors – Chemicals and Pharmaceuticals, Nanotechnology, Engineering & Automotive, Electronics and Biotechnology. It gives a comprehensive view of the present situation in R&D in these sectors in India and the activities of the key stakeholders in India's R&D setup. The key stakeholders are identified as government ministries, government science and technology departments, in house R&D by private companies – R&D centre, alliances with public research institutions etc., contract research organizations, independent research institutes.

4.0 Pilot Study

4.1 Data Analysis and Research findings

The measurement of R& D effectiveness is a difficult and complex process because it involves a variety of complex uncertain process with no commonly accepted methods (Szakonyi, 1994a; [7]Lee et al; 1996[8] It was found that the use of either qualitative or quantitative metrics singularly not sufficient to capture the R & D effectiveness. A variety of integrated methods have been developed and reported in literature such as Foster et al; 1985[9], tipping et al; 1995.[10] Many R & D studies have been country specific Lee.et.al; 1996,, Coccia;2001.There was a need to conduct similar studies for a developing country like India. Further the setting up of corporate R& D centres in India by many internationals highlights the need for such a study. The studies on R& D institutions in many countries, including Italy (Coccia e Rolfo, 2002)[11], the United Kingdom (Harris and Kaine, 1984;[12] Senker 2001[13] and Finland (Luwel et al 1999)[14], show a growing interest in evaluating performance. The first methodological step is to identify labs represented by High productivity research institutes'HPI' (Belonging to set A).The institutes belonging to set A from various scientific fields were organizations that combined scientific excellence and High international visibility. The second step is to identify low productivity research institutes'LPI' (Belonging to set B).The institutes belonging to set B belonging to various scientific fields possess a level of scientific production lower than set. Set A comprise of laboratories 1, 2,4,7,8,10,11,15.

Set B comprise of laboratories 3,5,6,9,12,13,14. The research institutes forming set A are rated high on 10 knowledge flows and 10 KM Interventions. The research institutes forming set B are rated medium and low on 10 knowledge flows and 10 KM Interventions.(10 knowledge flows and 10KM Interventions are taken from the KM framework developed and have been incorporated as questions in the questionnaires developed on knowledge flows and KM Interventions administered to the research institutes for rating each of them as high/medium/low.

4.2 Respondents on R&D Performance

Respondents	Patent Indian 03-04	Patent Indian 08-09	Patent Foreign 03-04	Patent Foreign 08-09	Publ Nat'l 03-04	Publ Nat'l 08-09	Publ Int'l 03-04	Publ Int'l 08-09	Tech Dev.	Tech Transfer/ licensed
Lab 1	-	02	-	13	129	151	08	19	28	08
Lab 2	-	16	-	08	NA	NA	NA	NA	17	04
Lab 3	1	-	03	01	83	62	03	02	16	-
Lab 4	-	-	-	-	168	204	03	06	NA	13
Lab 5	02	-	-	-	-	12	-	02	NA	03
Lab 6	-	04	-	13	10	10	-	-	20	-
Lab 7	-	15	-	48	405	452	04	03	NA	NA
Lab 8	-	07	-	11	-	19	-	-	NA	38
Lab 9	-	-	-	-	69	57	05	-	04	-
Lab 10	-	02	-	02	50	55	-	03	NA	09
Lab 11	-	-	-	04	195	91	-	-	11	04
Lab 12	-	35	-	32	NA	NA	NA	NA	07	NA
Lab 13	-	03	-	13	65	61	02	01	-	-
Lab 14	-	02	-	06	-	174	-	124	10	02
Lab 15	-	03	-	05	NA	NA	NA	NA	35	19

4.3 Research Findings

The objective of this study was to provide a snapshot of linkages of KM strategy to R&D performance. A need to identify metrics to assess the impact of KM strategy on R&D performance is also attempted. The pilot study conducted is actually the part of two staged study that includes a pilot study and a main study with elements of qualitative and quantitative techniques. The pilot study of 15 CSIR research institutes was conducted to establish linkage and assess impact of KM strategy on R & D performance.
The main study would expand the universe for this study and shall include 36 CSIR research institutes representing diversified scientific research arena. The research hypothesis for the main study shall be

H 0 There is no impact of high knowledge flows and high KM Interventions on R&D performance of research laboratory/R&D centre.

H 1 There is significant impact of high knowledge flows and high KM interventions on R&D performance of research laboratory/R&D centre.

There has been a significant impact of High knowledge flows and High KM interventions in set A respondents (High productivity institutes) on increase in number of patents, increase in number of publications, technology transfer as percentage of technology developed; which are illustrated as follows:-

For research laboratory 1

- ♦ Increase in patents granted in India (02)
- ♦ Increase in patents granted abroad (13)
- ♦ Increase in national publications (22)
- ♦Increase in international publications (11)
- ♦ Technology transfer as percentage of technology developed (30%)

For research laboratory 2

- ♦ Increase in patents granted in India (16)

- ♦ Increase in patents granted abroad (08)
- ♦ Technology transfer as percentage of technology developed (23%)

For research laboratory 4

- ♦Increase in national publications (36)
- ♦Increase in international publications (03)

For research laboratory 7

- ♦ Increase in patents granted in India (15)
- ♦ Increase in patents granted abroad (48)
- ♦ Increase in national publications (47)
- ♦ Increase in international publications (01)

For research laboratory 8

- ♦ Increase in patents granted in India (07)
- ♦ Increase in patents granted abroad (11)
- ♦ Increase in national publications (05)
- ♦ Increase in international publications (03)

For research laboratory 10

- ♦ Increase in patents granted abroad (04)
- ♦ Technology transfer as percentage of technology developed (40%)

For research laboratory 15

- ♦ Increase in patents granted in India (03)
- ♦ Increase in patents filed abroad (05)
- ♦ Technology transfer as percentage of technology developed (50%)

5.0 Need for performance based approach to KM.

R&D Organizations are becoming increasingly aware of the need for innovative approaches to responding more effectively to client's demands and changes in the market place. Knowledge Management (KM) is central to this and is increasingly recognized as an integral part of the organization's strategy to improve R&D performance. There is therefore a need for R&D performance based approach to KM. Carrillo et al (2000) suggested that KM could be integrated into key performance indicators. Indian organizations today face a challenging situation. There has been a sea change in their business environments since 1991 when the first step towards liberalization was taken. The WTO regime, foreign competition, increased consumer awareness and stringent regulatory mechanisms have put immense pressure to improve product performance. Many organizations now are investing in their R&D activities with expectations to improve organizational competitiveness. Technology Management is becoming increasingly important as managing technological change becomes a top priority for management and technology is recognized as a key asset. (Twiss 1992).Research is becoming more complex and thereby increasing both the cost and financial risks of performing research.

As an effect, the evaluation of R&D interventions and identifying the contribution of R&D becomes sensitive and crucial. KM Strategies need to be aligned to strategic objectives. These links will enable an assessment of the effectiveness of KM in terms of the degree to which strategic objectives are realized. The framework shows the possible relationships between KM strategy, R&D performance and strategic objectives.

The studies on R&D Institutions in many countries, including Italy (Coccia e Rolfo,2002),theUnited Kingdom(Harris and Kaine,1984;Senker,2001) and Finland (Luwel et al., 1999), show a growing interest in evaluating performance (results).

With reference to the model on research laboratory evaluation (Coccia, 2001)[15], measured R&D performance on various dimensions and gave a single output: the R&D performance score.

The following variables that concern the principal output produced in the public research laboratory are considered the proxy of the research performance.

*Patents (national & international).
*Publications (national & international).
*Self financing from education training and consultancy.
*Self financing from technology (technology development and licensing).

5.1 Putting KM at the heart of R&D Organizations

Karl-Erik Sveiby pointed to 10 strategic issues for knowledge management that are based on making knowledge flows more effective (Sveiby 2001; 2002)[16]. He argued that knowledge flows are the source of value generation in organizations and, in general, these flows take place within and between three broad categories (or families) of knowledge resources. He defined these as :

External structure – relationships with customers and suppliers (including reputation, brand names and trademarks).

Internal structure – the business processes, ways of organizing, culture, systems and the people in those functions such as finance, IT and HR that supports the operation of the organization.

Individual competence – the competence of all the people who have direct contact with customers or who directly produce the goods and services offered to customers. The knowledge flows, together with the ability to integrate all of them into a coherent system, provide potential opportunities for organizations to deliver value from knowledge resources.

This model clearly recognizes the interdependencies and relationships that are essential for an organization to function and achieve its objectives.
It balances internal and external perspectives and places the generation of value from knowledge at its core. Each effective knowledge flow is potentially a source of value generation, while a blocked or ineffective knowledge flow cannot deliver value and potentially undermines the value generating potential of the whole system. The model therefore meets our needs very effectively as a starting point for this project. We modified Sveiby's categories slightly, adopting the term "Individual Employees" (abbreviated to"I"rather than "individual competence", and extending it to encompass all the employees of the organization. This defines knowledge workers in very broad terms and recognizes the potential contribution from employees with a variety of forms of practical and intellectual expertise . We also extended "external structure" to encompass all the external players in the industry (customers, suppliers, strategic partners, key members of the industry, regulators etc) and termed these "External Relationships" (abbreviated to "E").

This is in line with thinking about the extent of an organization's "value net" .We adopted the term "Internal Organization" to describe the systems, processes, culture and other "Structural capital elements of the knowledge available within the formal boundaries of the Organization (abbreviated to O).

The nine knowledge flows that result from this model can be grouped into three sets based on the source of the knowledge involved.. The shorthand terminology is used to describe the initiator of a knowledge flow (first category) and the direction of that flow. So, for example, I-O represents individual employees sharing their knowledge widely through the organizational systems, processes and culture, while I-I represents individual employees sharing knowledge directly with other individual employees.

The extent to which all the flows work together in a synergistic and complementary way to add value to the organization is the final consideration in this model – effectively forming a tenth component that represents the overlap between the I, O and E flows. When all the flows are effective, then the overlap increases.

If knowledge flows are potentially a source of value for the organization when they work well, then our next question was to look at what enables and what blocks the effectiveness of these knowledge flows. We would then be in a position to translate this general understanding to specifics relating to each individual flow. Here we returned to the second factor that shaped our thinking: the importance of context and perception in determining value and application of knowledge.

Our starting point in thinking about context and perception was the; "logical levels" model. This model was based on work by the anthropologist Gregory Bateson (1972) [17] to describe levels of learning and change in individuals; a person feels harmonious when elements considered to be important at each level in a specific context are aligned. The levels are described as sense of identity, values and beliefs, skills and abilities, behavior and environment.
They are interdependent and can reinforce or conflict with each other. So, for example, if an individual believes that knowledge is power, they are unlikely to share meaningful knowledge with others even if they have the skills to do so and if the working environment encourages it. Their behavior may even appear to be compliant, but their lack of commitment to the idea means that they will share very little of real value.

When all of the factors are reinforcing each other, they can be described as being aligned and there is a "coherent point of view" (Bierly.P and Daly.P; 2002[18].. More generally, the idea of coherence is a way of describing how we make sense of a situation and our role within it. Our recognition of the way that knowledge outcomes depend on individual and collective perception in a specific context meant that his approach appeared to be highly relevant to our exploration of the factors that may influence the effectiveness of knowledge flows. Our application of the approach involved viewing "identity" as the strategic business purpose of each flow and then exploring what the remaining four factors would look like for each one:

i) The motivation (based on their beliefs and values) that drives those involved in achieving the purpose of that knowledge flow.
ii) The skills and knowledge required by those involved to achieve the purpose of the flow.
iii) The action required by those involved for the flow to be successful (evidenced by their behaviors).
iv) The environment that helps those involved in achieving the purpose of the flow.
v) Alignment between the factors was viewed as implying that the knowledge flow was more likely to be effective and deliver value to the organization, while misalignment implied a blockage that could undermine the flow.

On-going research by Karl-Erik Sveiby and Roland Simons into collaborative climate (defined as the non-physical environment in an organization for knowledge sharing and therefore encompassing these factors) is starting to show that this has significant impact on business performance (Sveiby and Simons 2002).[19]Now, need is to have a basic framework for an integrated approach to knowledge management of nine knowledge flows that deliver value to an organization.

6.0 Research Organizations and their performance Indicators.

The Model I function (Coccia, 2002)[20], measured R&D performance on various dimensions and gave a single output: the R&D performance score. The latter synthesis zed the financial, technological and scientific aspects of the research organization.

The Model II applies the discriminant analysis which helps to assign differing weights to the various indices in order to obtain a more reliable measuring tool. The first methodological step of Model II is to identify two groups of labs represented by High productivity research institutes (HPI) and Low productivity research institutes (LPI). Once the two sets or groups of the institutions are fixed, it is investigated whether it is possible to predict the location of an institute, taken from a given population, in one of the above subsets A or B, on the basis of key variables. The following five key variables that concern the principal output produced in the public research laboratory are considered a proxy of the research performance:

- Self financing deriving from activities of technological transfer from the institute to outside user
- Training represented by the number of persons trained within the institute
- teaching representing the number of courses held
- International Publications that appear in journal listed in Social Science Citation Index
- National Publications that have appeared in journal distributed nationally.

International Journal of Enhanced Research in Science, Technology & Engineering, ISSN: 2319-7463
Vol. 2 Issue 7, July-2013, pp: (152-163), Available online at: www.erpublications.com

6.1 R & D performance Matrix: KM Strategy framework

KM Strategy(cause)		Effect
Knowledge flows/transfer	KM Interventions	R&D Performance
I-I(transfer of competence between employee and employee)	1.staff meetings 2.education/training 3.enabling culture	Patents
E-E(knowledge transfer among external parties)	1.seminars 2.joint meetings 3.quality workshops	
O-O(integration of systems, tools and processes)	1.office technologies 2.intranet 3.DBMS	Publications
I-O(conversion of individually held competence to systems, tools and templates)	1.databases 2.tool development 3.templates	
O-I(improving individual employee's competence through systems, tools and templates)	1.e learning 2.knowledge sharing 3.KM system	Education/training/consultancy
I-E(contribution of individual employee's to improve the competence of external parties)	1.training programs 2.print/other material 3.reporting	
E-I(external parties improving the competence of individual employee)	1.entertaining 2.joint ventures 3.client projects	Research projects
O-E(contribution of systems, tools and process to improve the competence of external parties)	1.extranet 2.client helpdesk 3.system manuals	
E-O(contribution of external parties to improve the systems, tools and process)	1.joint development of tools and process 2.external databases 3.direct communication	Technology developed
I-O-E(maximize value creation)	1.R&D ventures 2.training 3.quality staff recruitment	Technology licensed/ Transfer

There are 10 knowledge flows and 10 KM Interventions identified in the R&D performance Matrix: KM Strategy framework.

7.0 Conclusion

7.1R&D Laboratories-New Approach

The first phase of capability building, creating patent portfolios in the main technological areas in which CSIR laboratories is positioned; creating changes in the organizational structures, and guidelines for covering different phases of the innovation chain has been met to large extent. The next phase is consolidation of its IPR portfolio and appropriation from this. A number of steps have been initiated to leverage from the intellectual property CSIR has created. CSIR need to make efforts for valorization of its IP portfolio by forming partnership with international IP licensing firms, exploring licensing opportunities with IP attorneys internationally. CSIR need to involve management institutes, international agencies to discuss and evolve new mechanism for technology transfer of its patented technologies. In the process of technology transfer with IPR, formulation of material transfer agreement will help define the rights of the licensor and the licensee with respect to the materials and any derivatives that are transferred.
It is required to revaluate technologies/processes/know-hows/designs developed in CSIR labs that have not yet been licensed/commercialized.

7.2 R&D Laboratories-Challenges and hurdles

Commercialization has to be understood in a broad context. Characteristics of market play an important role. It is much easier for value to be attached to an intangible commodity such as patent in highly technologically competitive market. On the other hand ,in a less technologically driven market, an R&D driven organization/business entity has to orient the industry and the market to appreciate the importance of patented technology. It would be important to collect exhaustive information on the licensed patent technologies (whether the technology has gone in for production/commissioning etc.). Financial burden in IPR protection internationally can be very heavy.

7.3 R&D Laboratories-Approach to Effective Knowledge Management

Knowledge Management is still a relatively young field with new concepts emerging constantly. Knowledge Management is complex and multifaceted; it encompasses everything the organization does to make knowledge available to the business, such as embedding key information in systems and processes, applying incentives to motivate employees and forging alliances to infuse the business with new knowledge. Effective Knowledge Management requires a combination of organizational elements -technology, human resource practices, organizational structure and –culture in order to ensure that the right knowledge is brought to bear at the right time. The focus need to be placed on the way knowledge is used to build the critical capabilities a laboratory needs in order to succeed-on the core processes and activities that enable it to compete.

7.4 Knowledge Management Framework: Work Models & Strategies

Key challenge is the achievement of breakthrough innovation. To drive such innovation, a laboratory needs to encourage risk taking and bring together a variety of knowledge domains, such as research, product development and marketing. Scientists need to focus on capabilities their laboratories need rather than on their component solutions. Markets, customers, technology and competition are always changing. To thrive, the laboratories must change over time as well, or their core capabilities may well become core rigidities that lead to obsolescence. As they strive to move in new directions, Scientists can use the framework to understand the knowledge management systems that new capabilities will require.

Scientists need to experiment with external alliances as a way to bring new knowledge into the laboratory. Using the framework as guide, Scientists need to understand how to improve its current knowledge management systems and at the same time, develop a sense of how it can manage knowledge to forge new capabilities for the long term. Demands of new markets and new competitors shall drive continual shift in strategies. Laboratories will have to build new capabilities more and more rapidly –and so the ability to manage knowledge to support that change will be critical.

8.0 Limitations of Research

The problem that can be raised is whether the performance indicators Alone can be sufficient for evaluating the performance of research Laboratories/centers. The performance indicators are good management tools for R&D laboratories but they do not supply valid support for the scientific and technological policy of a country and the latter, in the field of research is of fundamental importance. This can only be done with specific action on research policy which introduced greater incentives. If we compare the output of the HPI Labs (Set A) with that of LPI in the present work, one can see that the former possess a level of scientific production more than 50%higher than that of LPI (Set B). The LPI labs on the other hand characterized by poor performance are required to be pushed towards an increase in R&D performance by facilitating high degree of knowledge flows and leveraging high degree of KM interventions. The current indicators such as R&D spending and number of research publications or patents filed are too narrow. Alternative higher resolution indicators that reflect the entire innovation spectrum-creation, dissemination and application are needed. Good Governance frameworks that ensure an effective regulatory regime for protecting and transferring intellectual property rights and facilitate efficient knowledge flows should be developed.

Bibliography

[1]. Carillo et al(2000) Managing Knowledge based value systems http:// www.cestee 1.mty.itesm.mx/-I aava/sdsit……ag-base/
[2]. Twiss (1992) Managing Technological innovation 4th edition Pitman Publishing
[3]. Gassman and Zedwitz (1999) New Concepts and trends in International R&D Organizations Research Policy 28:231-50
[4]. Hirwani R.R.; Globalization of R&D and its impact on Industrial R&D, 2004.
[5]. TIFAC Study FDI in the R&D Sector: Study for the pattern in 1998-2003.
[6]. DST Study-Research & Development (R&D) in India: A Perspect and Validity study
[7]. Szakonyi 1994a Technology Management (Hardcover) ISBN-10:0791320626
[8]. Lee et al; 1996 Measuring R&D effectiveness in Korean companies Research Technology Management Vol 39, No.6
[9]. Foster et al: 1985"Improving the return on R&D-1"Research Management Vol.28 No.1
[10]. Tipping et al; 1995"Assessing the value of your technology, Research, Technology Management Vol 38, No 5

[11]. CocciaM, Rolfo, S (2002) Technology Transfer Analysis in the Italian National Research Council" Technovation, n 22 pp 291-299.
[12]. Harris G, Kaine G ;(1984) The determinants of research performance; a study of Australian University economists" Higher Education, n 27 pp 191-201.
[13]. J Senker;(2001),Changing Organization of public sector Research in Europe-Implications for Benchmarking Human Resources in RTD,Science and Public Policy,Vol 28(4),pp 277-284.
[14]. Luwel, M, Noyons C.M and Moed F,(1999) Bibliometric Assessement of research performance in Flanders: Policy background & Implications R&D Management Vol 29,n 2,pp 133-141
[15]. Coccia, M (2001),"a basic model for evaluating R&D performance: theory and application in Italy"', R&D Management, Vol 31,n. 4,453-464.
[16]. Karl-Erick Svieby (2001; 2002) Knowledge based theory of the firm to guide Strategy formulation; Journal of Intellectual Capital, 2001.
[17]. Gregory Bateson (1972) Cultural Contact and Schismogenesis-Steps to an Ecology of mind; Oxford University press p 75.
[18]. Bierly P. and Daly P. (2002) The strategic management of Intellectual Capital and organizational knowledge, Management Journal Vol 17 pp 123-135.
[19]. Svieby and Simons (2002) Collaborative Climate and effectiveness of knowledge work-an empirical study, Journal of knowledge Management Vol 6 pp 420-433.
[20]. Coccio,M(2001;2002),"Satisfaction, work involvement and R&D performance" ,International Journal Human Resources Development and Management,Vol 1,n.2.3.4,pp 268-282.