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Linking KM Strategy to R&D Performance: An Empirical Study of CSIR R&D Laboratories

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Abstract: 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.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.

Keywords: KM Strategy, R&D performance, Strategic Objectives.

1.0 Methodology

The present study encompasses the problem of linkage of R&D Performance with KM & KM Strategy in particular in an R&D Organization. The attributes of such problem were identified by multi criteria approach. An extensive literature review facilitated theory development and constitution of framework. The literature search included several journals, articles, books, newspapers and magazines. The principal collection data methods used were a combination of analysis of literature, statistical data from secondary sources, questionnaire survey and content analysis.

1.1 The instrument and field survey

Data collection for testing the hypothesis was done by a questionnaire method. The questionnaire was designed and categorized under two facets of KM Strategy –a) knowledge flows b) KM modeling 20 questions were developed in two sets of questionnaire. These questionnaires covering 10 knowledge flows and 10 KM Interventions as integral part of KM strategy identified in the developed KM Strategy framework were administered to the research institutes to rate them against high/medium/low.
In, addition a separate questionnaire was designed to assess the performance of the R&D organizations.
The questionnaires were administered to 38 national laboratories under the Council of Scientific and Industrial research (CSIR); an autonomous organization under Ministry of Science and Technology, Govt. of India.
The present study is a three staged study that includes case studies of R&D organizations like IIRS, FRI, DEAL and IIP, a pilot study of 15 CSIR R&D laboratories and a main study of 38 CSIR R&D laboratories,
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 expanded the universe for this study and included 38 CSIR research institutes,

1.2 KM Strategy, R&D Performance & Strategic Objectives

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)[3],theUnited Kingdom(Harris and Kaine,1984;[4] and Finland (Luwel et al., 1999),[5] show a growing interest in evaluating performance (results).With reference to the model on research laboratory evaluation (Coccia, 2001)[6], 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).

2.0 Model for Measuring the R&D performance

The measurement of industrial R&D effect 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].Many R&D effectiveness studies have country specific Lee et al.(1996),Coccia (2001), with no study done for Indian Industrial R&D. In Italy, the science sector is doing a strategic restructuring due to budget cuts. Thus, the measure and evaluation of research performance of its units (public research units) is needed. Two general models to assess the R&D performance of a public research lab are presented here. These models could provide indications about the performance and then productivity of research labs. The Model II, an evolution of Model I, is successfully applied to 200 public research institutes belonging to the Italian National Research Council. (Mario Coccia, 2002) [9] The debate on the restructuring of the research sector in many European countries has recently become more important, both due to the reduction in public funding, and due to the domination of the United States and Japan in the field of new technology(Senker,2001)[10]. Research is discussed both in terms of the method of public financing, and in terms of production Etzkowitz and Leydesdorff (2000) [11] with their theory of the triple helix state that the universities and the public research bodies today play a fundamental role in the production of inventions and innovations, necessary for the development of a competitive industrial system, in a society that is increasingly knowledge based. The public research sector is formed, according to Senker (2001), by those institutions that deal with civil research and where the majority of the funding is from public resources; these organizations are public property or under the control of public authorities and their principal aim is to spread the results of their research. In Italy, there is a worry that the national system of innovation is not working satisfactorily and that the dedicated resources are insufficient for strengthening the Italian scientific network in terms of production and diffusion of scientific results in the economic system. The studies on these institutions in many countries, including Italy (Coccia e Rolfo,2002),the United Kingdom(Harris and Kaine,1984; Senker,2001) and Finland (Luwel et al;1999), show a growing interest in evaluating performance(results).

3.0 Research Organizations and their performance Indicators

The Model I function (Coccia, 2001), 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 users
- 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.

3.1 Pilot Study

3.1.1 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; Lee et al; 1996 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[12], tipping et al; 1995.[13] 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), the United Kingdom (Harris and Kaine, 1984; Senker 2001 and Finland (Luwel et al 1999), 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.

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	01	-	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

3.1.2 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 38 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

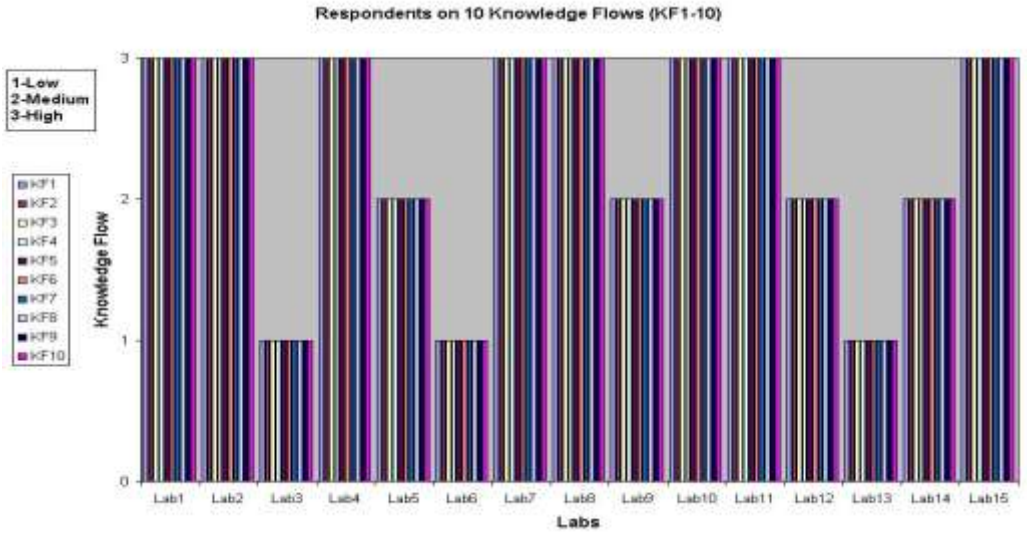
- ♦ Increase in patents granted in India (07)
- ♦ Increase in patents granted abroad (11)
- ♦ Increase in national publications (05)
- ♦ Increase in international publications (03)

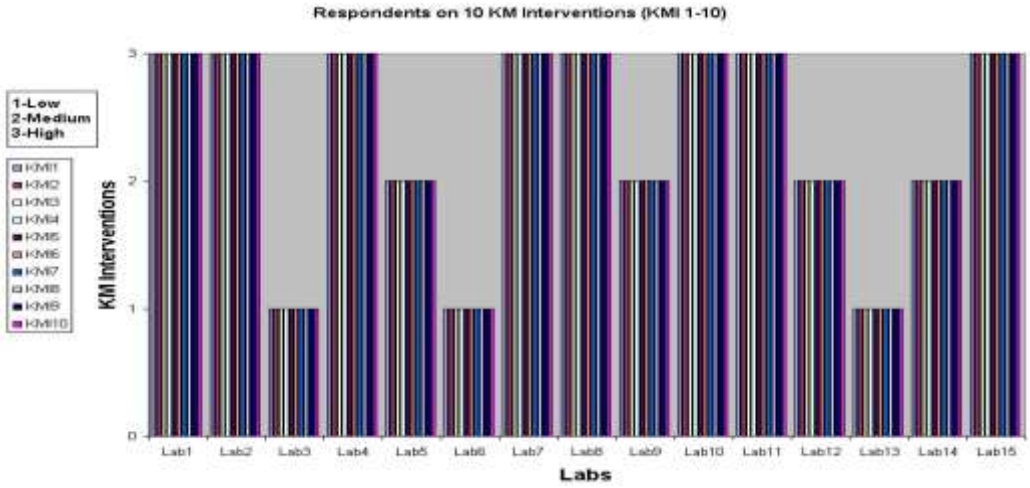
For research laboratory 10

- ♦ 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%)





3.1.3 There has been a significant impact of high knowledge flows and high KM interventions
In Set A respondents (High productivity laboratories) on increase in number of patents, increase in number of publications, technology transfer as percentage of technology developed, which are illustrated as follows:

CSIR Laboratory 1

- ● Increase in Indian patents (02)
- ● increase in foreign patents (13)
- ● increase in national publications (22)
- ● increase in international publications (11)

CSIR Laboratory 2

- ● increase in Indian patents (16)
- ● increase in foreign patents (8)
- ● % technology transfer (30%)

CSIR Laboratory 11
- increase in foreign patents (04)
- % technology transfer (40%)

CSIR Laboratory 15
- increase in Indian patents (03)
- increase in foreign patents (05)
- % technology transfer (54%)

CSIR Laboratory 16
- increase in national publications (09)
- increase in international publications (01)
- % technology transfer (50%)

CSIR Laboratory 21
- increase in national publications (06)
- increase in international publications (01)
- % technology transfer (20%)

CSIR Laboratory 25
- increase in national publications (02)
- % technology transfer (20%)

CSIR Laboratory 28
- increase in national publications (22)
- % technology transfer (35%)

Impact Assessment of High knowledge flows and High KM interventions in set A respondents

Respondents	Increase in patent(Indian)	Increase in patent(foreign)	Increase in publications(national)	Increase in publications(international)	% technology transfer
Lab 1	02	13	22	11	30%
Lab 2	16	08	-	-	23%
Lab 11	-	04	-	-	40%
Lab 14	02	06	NA	NA	20%
Lab 15	03	05	-	-	54%
Lab 16	-	-	09	01	50%
Lab 21	-	-	06	01	20%
Lab 25	-	-	02	-	20%
Lab 28	-	-	22	-	35%

Respondents on KF																							
	LAB 1	LAB 2	LAB 3	LAB 4	LAB 5	LAB 6	LAB 7	LAB 8	LAB 9	LAB 10	LAB 11	LAB 12	LAB 13	LAB 14	LAB 15	LAB 16	LAB 17	LAB 18	LAB 19	LAB 20	LAB 21	LAB 25	LAB 28
KF I	high	high	medium	high	medium	medium	medium	medium	low	high	high	high	high	high	high	high	medium	high	medium	high	high	high	high
KF2	high	high	medium	medium	low	low	low	low	low	high	high	medium	high	high	high	high	low	medium	low	medium	high	high	high
KF3	high	high	high	high	high	high	high	high	medium	medium	high	high	medium	high	high	high	medium	medium	medium	high	high	high	high
KF4	high	high	high	high	high	high	high	medium	medium	medium	high	high	medium	high	high	high	medium	medium	medium	high	high	high	high
KF5	high	high	high	high	high	high	high	medium	medium	high	high	medium	medium	high	high	high	medium	medium	medium	high	high	high	high
KF6	high	high	high	high	high	high	high	high	medium	high	high	medium	medium	high	high	high	medium	medium	medium	high	high	high	high
KF7	high	high	high	high	high	high	high	high	medium	medium	high	medium	high	high	high	high	medium	medium	medium	high	high	high	high
KF8	high	high	high	high	high	high	high	medium	medium	medium	high	high	high	high	high	high	medium	medium	medium	high	high	high	high
KF9	high	high	low	medium	low	low	low	medium	low	high	high	medium	low	high	high	high	medium	low	low	medium	high	high	high
KF10	high	high	low	medium	medium	low	low	medium	low	medium	high	low	low	high	high	high	low	low	low	medium	high	high	high
KF	Knowledge flows																						
LAB	CSIRlaboratory																						
high	3																						
medium	2																						
low	1																						

Respondents on KMI																								
		LAB 1	LAB 2	LAB 3	LAB 4	LAB 5	LAB 6	LAB 7	LAB 8	LAB 9	LAB 10	LAB 11	LAB 12	LAB 13	LAB 14	LAB 15	LAB 16	LAB 17	LAB 18	LAB 19	LAB 20	LAB 21	LAB 25	LAB 28
KMI 1	a	high	high	medium	high	medium	medium	medium	medium	low	high	high	high	high	high	high	high	medium	high	medium	high	high	high	high
	b	high	high	medium	high	medium	medium	medium	medium	low	high	high	high	high	high	high	high	medium	high	medium	high	high	high	high
	c	high	high	medium	high	medium	medium	medium	medium	low	high	high	high	high	high	high	high	medium	high	medium	high	high	high	high
KMI2	a	high	high	medium	medium	low	low	low	low	low	high	high	medium	high	high	high	high	low	medium	low	medium	high	high	high
	b	high	high	medium	medium	low	low	low	low	low	high	high	medium	high	high	high	high	low	medium	low	medium	high	high	high
	c	high	high	medium	medium	low	low	low	low	low	high	high	medium	high	high	high	high	low	medium	low	medium	high	high	high
KMI3	a	high	high	high	high	high	high	high	high	medium	medium	high	high	medium	high	high	high	medium	medium	medium	high	high	high	high
	b	high	high	high	high	high	high	high	high	medium	medium	high	high	medium	high	high	high	medium	medium	medium	high	high	high	high
	c	high	high	high	high	high	high	high	high	medium	medium	high	high	medium	high	high	high	medium	medium	medium	high	high	high	high
KMI4	a	high	high	high	high	high	high	high	medium	medium	medium	high	high	medium	high	high	high	medium	medium	medium	high	high	high	high
	b	high	high	high	high	high	high	high	medium	medium	medium	high	high	medium	high	high	high	medium	medium	medium	high	high	high	high
	c	high	high	high	high	high	high	high	medium	medium	medium	high	high	medium	high	high	high	medium	medium	medium	high	high	high	high
KMI5	a	high	high	high	high	high	high	high	medium	medium	high	high	medium	medium	high	high	high	medium	medium	medium	high	high	high	high
	b	high	high	high	high	high	high	high	medium	medium	high	high	medium	medium	high	high	high	medium	medium	medium	high	high	high	high
	c	high	high	high	high	high	high	high	medium	medium	high	high	medium	medium	high	high	high	medium	medium	medium	high	high	high	high
KMI6	a	high	high	high	high	high	high	high	high	medium	high	high	medium	medium	high	high	high	medium	medium	medium	high	high	high	high
	b	high	high	high	high	high	high	high	high	medium	high	high	medium	medium	high	high	high	medium	medium	medium	high	high	high	high
	c	high	high	high	high	high	high	high	high	medium	high	high	medium	medium	high	high	high	medium	medium	medium	high	high	high	high
KMI7	a	high	high	high	high	high	high	high	high	medium	medium	high	medium	high	high	high	high	medium	medium	medium	high	high	high	high
	b	high	high	high	high	high	high	high	high	medium	medium	high	medium	high	high	high	high	medium	medium	medium	high	high	high	high
	c	high	high	high	high	high	high	high	high	medium	medium	high	medium	high	high	high	high	medium	medium	medium	high	high	high	high
KMI8	a	high	high	high	high	high	high	high	medium	medium	medium	high	high	high	high	high	high	medium	medium	medium	high	high	high	high
	b	high	high	high	high	high	high	high	medium	medium	medium	high	high	high	high	high	high	medium	medium	medium	high	high	high	high
	c	high	high	high	high	high	high	high	medium	medium	medium	high	high	high	high	high	high	medium	medium	medium	high	high	high	high
KMI9	a	high	high	low	medium	low	low	low	medium	low	high	high	medium	low	high	high	high	medium	low	low	medium	high	high	high
	b	high	high	low	medium	low	low	low	medium	low	high	high	medium	low	high	high	high	medium	low	low	medium	high	high	high
	c	high	high	low	medium	low	low	low	medium	low	high	high	medium	low	high	high	high	medium	low	low	medium	high	high	high
KMI10	a	high	high	low	medium	medium	low	low	medium	low	medium	high	low	low	high	high	high	low	low	low	medium	high	high	high
	b	high	high	low	medium	medium	low	low	medium	low	medium	high	low	low	high	high	high	low	low	low	medium	high	high	high
	c	high	high	low	medium	medium	low	low	medium	low	medium	high	low	low	high	high	high	low	low	low	medium	high	high	high

KMI	Knowledge management interventions
LAB	CSIRlaboratory
high	3
medium	2
low	1

4.0 Respondents (CSIR Labs) on R&D Performance - Main Study

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	01	-	01	02	83	62	03	02	16	-
Lab 4	07	-	05	-	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
Lab 16	01	01	-	-	40	49	11	12	32	16
Lab 17	16	-	-	02	NA	NA	NA	NA	NA	NA
Lab 18	02	-	-	-	NA	NA	NA	NA	38	NA
Lab 19	03	01	04	04	NA	NA	NA	NA	22	NA
Lab 20	29	31	13	19	NA	NA	NA	NA	19	NA
Lab 21	08	01	03	03	38	46	7	8	31	10
Lab 22	07	13	29	28	NA	NA	NA	NA	NA	NA
Lab 23	07	03	03	04	NA	NA	NA	NA	28	NA
Lab 24	14	-	01	-	NA	NA	NA	NA	NA	NA
Lab 25	-	-	-	-	22	24	-	-	16	4
Lab 26	-	-	-	04	NA	NA	NA	NA	NA	NA
Lab 27	-	03	-	07	53	62	-	-	NA	NA
Lab 28	-	-	-	17	32	54	-	-	16	6
Lab 29	-	09	-	09	NA	NA	NA	NA	NA	NA
Lab 30	-	-	-	-	NA	NA	NA	NA	NA	NA
Lab 31	-	01	-	-	NA	NA	NA	NA	NA	NA
Lab 32	-	-	-	02	NA	NA	NA	NA	NA	NA
Lab 33	-	01	-	01	NA	NA	NA	NA	NA	NA
Lab 34	-	01	-	-	NA	NA	NA	NA	NA	NA
Lab 35	-	04	-	01	NA	NA	NA	NA	NA	NA
Lab 36	-	02	-	13	NA	NA	NA	NA	NA	NA

NA Not Available

4.1 Impact Assessment of High knowledge flows and High KM interventions in set A respondents

Respondents	Increase in patent (Indian)	Increase in patent (foreign)	Increase in pub. (national)	Increase in pub. (international)	% technology transfer
Lab 1	02	13	22	11	30%
Lab 2	16	08	-	-	23%
Lab 11	-	04	-	-	40%
Lab 14	02	06	NA	NA	20%
Lab 15	03	05	-	-	54%
Lab 16	-	-	09	01	50%
Lab 21	-	-	06	01	20%
Lab 25	-	-	02	-	20%
Lab 28	-	-	22	-	35%

4.2 Impact Assessment of High knowledge flows and High KM interventions in set A respondents

Respondents	Increase in patent(Indian)	Increase in patent(foreign)	ıcrease in publications(national	Increase in publications(international)	% technology transfer
Lab 1	02	13	22	11	30%
Lab 2	16	08	-	-	23%
Lab 3	-01	01	-21	-01	NA
Lab 4	-07	-05	36	03	NA
Lab 5	-02	-	12	02	NA
Lab 6	04	13	-	-	NA
Lab 7	15	48	47	-1	NA
Lab 8	07	11	19	-	NA
Lab 9	-	-	-08	-05	-
Lab 10	02	02	05	03	NA
Lab 11	-	04	-	-	40%
Lab 12	35	32	NA	NA	NA
Lab 13	03	13	-01	-04	-
Lab 14	02	06	NA	NA	20%
Lab 15	03	05	-	-	54%
Lab 16	-	-	09	01	50%
Lab 17	-16	02	NA	NA	NA
Lab 18	-02	-	NA	NA	NA
Lab 19	-02	-	NA	NA	NA
Lab 20	02	06	NA	NA	NA
Lab 21	-	-	06	01	20%
Lab 25	-	-	02	-	20%
Lab 28	-	-	22	-	35%

NA Not available

5.0 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.

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