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Aligning Individual and Organizational R&D Goals for Self-Sustainability: Investigating Preferences of Researchers in Selected CSIR-Laboratories, India

Abstract

Purpose: This paper intends to explore the measure for aligning the goals of researchers towards achieving organizational R&D targets. The paper also explores the significance and ordering of R&D outputs and the factors that influence generation of R&D outputs, from the perspective of researchers working in the Indian public sector organizations.

Design/methodology/approach: Data was collected in five Indian R&D laboratories and Weighted Average Method; Spearman Correlation Coefficient and Rank Regression were utilized for the analysis.

Findings: The findings indicated that various groups of researchers prefer to target different R&D outputs and not all the factors are considered as equally significant in influencing the generation of R&D outputs. Further, the R&D organization should include preferred real factors while policy making for achieving collaborative efforts towards fulfilling organizational objectives. The set of selected R&D outputs and influencing factors were also ordered according to the average rankings given by the researchers.

Practical implications /Research limitations: The findings can help R&D managers to identify the expectations of the researchers and include their preferences in R&D Planning. The study could be extended to a larger dataset of researchers working in other government as well as private R&D organizations.

Originality/value: Hardly any studies were found that explored the preferences of researchers with respect to R&D outputs and influencing factors with respect to the Indian public sector R&D laboratories.

Key Words: Public funded R&D, Self-sustainability, Man-days Involvement[a], Productivity Factors, R&D Outputs Ranking, Productivity Determinants, R&D Productivity Model.

[a]- A gender neutral term referring to the extent of engagement of researchers in terms of working days (1 Man-day =8 hours) in R&D projects

Aligning Individual and Organizational R&D Goals for Self- Sustainability: Investigating Preferences of Researchers in Selected CSIR-Laboratories, India

1.0 Introduction

The Council of Scientific & Industrial Research (CSIR), India is a society with a chain of 38 national R&D Laboratories working in various domains of science viz. Metals & Materials, Glass & Ceramics, Medicine, Leather, Coal & Petroleum and others. These laboratories are primarily engaged in *a) developing technological solutions for the R&D problems of industries, b) hand-holding of entrepreneurs and c) contributing to the development of society by providing R&D solutions that are accessible to the masses viz. clean drinking water and low-cost medicines.* The scientific and technological findings of any public sector R&D must be implementable for solving the current and future industry needs as well as should substantially uplift the living standards of the common people (Bolton, 2003; Thornhill, 2006; Linna, Pekkola, Ukko and Melkas, 2010; Chaturvedi and Srinivas, 2012). The CSIR laboratories are mandated to align their goals with the national goals related to self-reliance, industrial development, entrepreneurship development, skill development and others (Sahni Girish, 2018). Moreover, changing government policies and increasing global competitiveness have set additional responsibilities for such laboratories i.e. *to enhance their own earnings and reduce dependability on government funding, so as to meet their own expenses and achieve self-sustainability in the long run* (Jacob and Lefgren, 2011; Patil and Biswas, 2014). Hence, the laboratories have to develop strategies that can help them to earn more through industrial funding and other means. viz. by *enhancing the count of their saleable R&D outputs* (like intellectual property rights and products) and *commercialization of their R&D outputs* (viz. processes, know-hows, technologies, patents and products) (Mauleón and Bordons, 2006; Jyoti, Banwet and Deshmukh, 2008; Kim, 2015).

R&D is a systemic process, and is primarily conducted by the researchers and governed by the policies designed and controlled by the management of the laboratory and the government. It is extremely vital to create such policies which can confirm the prosperity of all stakeholders of the organization in the process viz. customers and researchers. The customers may be interested in the final output of a successful R&D endeavor viz. a technology of TRL 6[1] , whereas the researchers are the primary executers of the laboratory's

R&D Planning as well as the primary stakeholders in the overall process. Hence, it is crucial for the laboratories to focus on the factors that determine the productivity and overall wellbeing of the researchers. These considerations must form a part of the organizational policy (Roy and Dhawan, 2002).

The productivity of researchers contributes towards for the performance of any R&D laboratory and the performance of researchers depends upon several determinants. The determinants of productivity for the researchers can belong to three categories viz. individual, organizational and environmental (Koch and Steers, 1978; Babu and Singh, 1998; Turner and Mairesseb, 2005; Carayol and Matt, 2006; Post, DiTomaso, Farris and Cordero, 2009). Researchers in a national laboratory belong to different cultural backgrounds with different qualifications and have varying goals in life. Hence, it is obvious that different determinants affect each researcher differently e.g. incentives and promotions vs. awards and recognitions. In such a scenario, it can be extremely difficult for an organization to frame one common policy that can align all the researchers towards the organizational goal.

The productivity of researchers in an R&D organization is estimated by the R&D outputs generated per unit of inputs (Pritchard, 1995; Tangen, 2002; Coelli, Rao, O'Donnell and Battese, 2005). The R&D outputs can be patents, publications, technologies and others. Researchers would prefer generation of those outputs that would fulfill individual goals rather than organizational goals. This could affect the performance of the organization and attaining self-sustainability for the organization would be difficult. Hence, the two main constituents in drafting an effective R&D Plan as well as an efficient organizational policy could be a) the determinants of productivity at both individual and organization levels, and b) a set of select R&D outputs that are easily achievable.

With this preface, the relationship between the researchers' preferences and their productivity can be conceptualized. Further, in order to prevent and minimize the chances of deterioration in the R&D performance of the organization, understanding and including the preferences of researchers in the organizational policies is essential. It is extremely important for any R&D laboratory to create an enabling and fulfilling research environment in the organization and implement mechanisms to encourage the researchers. This paper has investigated and analysed the preferences of researchers of five CSIR laboratories. The paper has modeled the measures/ factors that can help in aligning individual and organizational objectives for achieving the ultimate goal of self-sustainability. Further, it has focused on identifying and analyzing preferences of the researchers for the factors that influence their productivity in turn the relevant R&D outputs. Finally, the paper has tried to determine whether considering preferences is sufficient for the organization or there are additional factors that can lead towards its better positioning. This paper has been further structured as per the following sub sections: Conceptual Framework, Theoretical Background, Methodology, Objectives of Study, Hypothesis, Results, Findings and Implications, Conclusions, Limitations and Future Direction of Research.

[TRL 6[1]] Technology Readiness Level 6

2.0 Conceptual Framework

2.1 CSIR-India Laboratories

The CSIR laboratories on the basis of their domain expertise, have been clustered under various themes viz. 1) *Aerospace, Electronics and Instrumentation & Strategic Sector, 2) Civil Infrastructure and Engineering, 3) Mining, Minerals, Metals and Materials, 4) Chemicals (including Leather) and Petrochemicals, 5) Energy (Conventional & Non-Conventional) and Energy Devices, Ecology, 6) Ecology, Environment, Earth & Ocean Sciences and Water7) Agri, Nutrition and Biotechnology, 8) Healthcare – Chemical, Drugs, Phyto-pharmaceuticals, Bio-pharmaceuticals and Regulatory (Source: http://oldweb.cgcri.res.in/4m/about.php#themeclusters).* These CSIR laboratories are involved in both basic and applied research. Their output could be publications, patents, copyrights, cash flow and technologies.

2.2 Challenges Faced by CSIR-India Laboratories

CSIR-India is the largest chain of public funded research laboratories employing more than 4600 scientists in 38 laboratories located at different parts of the country (Bhanu Verma, Sukumar Mallick, NR Rajagopal (2003). The institution shoulders a huge responsibility to meet the expectations of the country and uphold the targets set for the benefit of the country. In 2015 targets like 'self-reliance', 'self-sustainability', 'digital-India', 'skill-India' and 'health & hygiene' were set for the institution. These targets called for a total revamp of the functioning and availability of new facilities that could make possible the development and commercialization of such desirable technologies, products and workable business plans. Further in February, 2020, the institute was mandated to focus upon modern areas of R&D viz. *Virtual Labs., Artificial Intelligence, 5G and Affordable Utilities for masses*. In order to meet the targets the institution must develop strategies and competencies to overcome challenges like *create good working environment, provide job satisfaction, talent management, take innovations to market, managing IP, avoid cost and time overrun, deal with the economic and social changes , better accountability and quality R&D performance* (See Table 1).

"take in table 1"

2.3 Conceptual Models:

The individual researchers often set short-term goals that can get them individual benefits like publications, awards & fellowships and promotions. The organizational goals tend to have wider scope and longer deadlines. Ideally, the bigger organizational goal must be sub-divided and converted into smaller objectives that are achievable by the researchers. In case the organizational objectives are unable to accommodate the aspirations of researchers then outcomes may not be the desirable ones. In fact, every individual accomplishment should contribute to fulfill organizational targets e.g. a low-cost technology with proper documentation can be transferred by an entrepreneur only with the support of the developer /researcher. The link between the individual and the organizational efforts ought to be weak in absence of supporting organizational policies and proper R&D planning (See Figure1) (Roy and Dhawan, 2002).

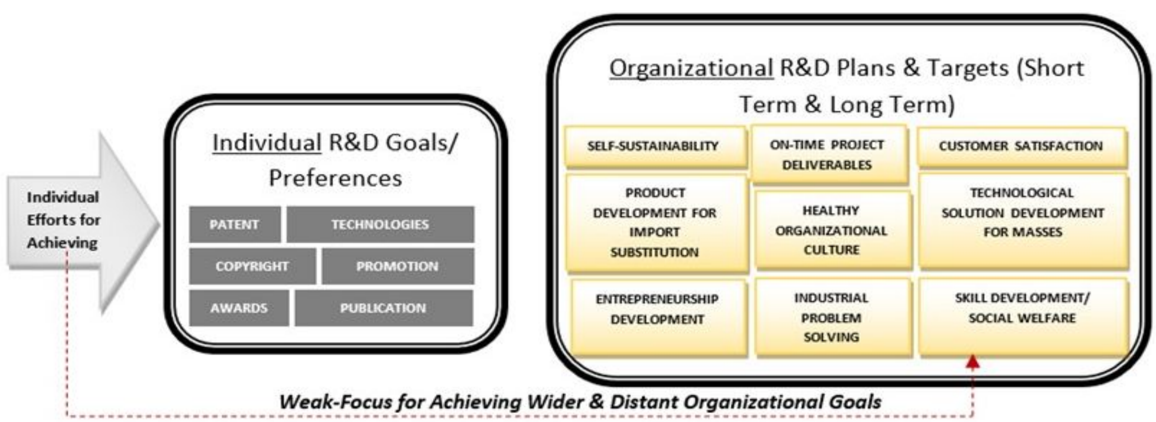

Figure 1: Model 1- Distinct Individual & Organizational Goals

A variety of measures can help in aligning the working preferences of researchers with the organizational goals. Investigating the R&D preferences of researchers can help organizations to plan their goals accordingly and hence achieve the desired outcomes. For instance, clustering researchers based upon their preferences and engaging them in related projects can achieve focused efforts. New core-areas in R&D can be designed as per the interest of the researchers. This will help to plan resources like skilled manpower and equipments for future projects. Participation of researchers in organizational activities can also be achieved by valuing their opinions and taking their inputs in long term R&D planning (Roy and Dhawan, 2002; Rana, Goel and Rastogi, 2013; Jain and Ana 2013; Roy and Mitra, 2018;).

Figure 2: Model 2- Inclusive Factor(s) leading Alignment of Individual & Organizational Goals

3.0 Theoretical Background

Concept and Definition of Productivity

The authors of previous studies (Smith, 1937; Pritchard, 1995; Suito, 1998; Al-Darrab, 2000; Bartelsman and Doms, 2000; Tangen 2002, Tangen, 2005; Boyle, 2006; Phusavat, 2013) have defined productivity as well as productivity of public sector with respect to various elements viz. productive and unproductive labor, efficiency in utilizing resources, effectiveness in enhancing the organization's productivity, the product of outputs, inputs and quality factor, the product of quality, utilization and efficiency, the firm choices (inventive activity, input preferences and outcomes) and connections with the marketplace (contest and distribution). A series of research on productivity has been conducted by Tangen (2002 and 2005). According to the author, efficiency in outputs is at the core of the 'Triple P-model (Productivity, Profitability and Performance)" and can be defined as the proportion of output to input. The author has also conducted a comprehensive literature review and concludes that the concept of productivity is a "multidimensional term", with users from varied disciplines and backgrounds e.g. academicians, industrialists and businessmen. Further, the concept of productivity has often been interchanged with the terms: efficiency, effectiveness and profitability by the users of productivity.

Productivity in public sector has been defined by Boyle (2006) as output=input i.e. the extent of value received by the service provided to the people and created by utilizing the government funds. According to Phusavat (2013), productivity is all about utilizing resources in the best way for generating maximum outputs i.e. commodities and services for the people and assets for the nation (i.e. maximizing gains and lowering costs in all respects).

Evaluation of R&D Productivity

A number of researchers (Brown and Svenson, 1998; Coccia, 2001; Cho and Lee, 2005; Min-peng and Xiao-hu, 2012) in the past have studied the components of an ideal R&D productivity measurement system and have suggested the significant ones to be viz. *financial, bibliometric and technometric indices, individual traits (viz. awareness, capacity to learn, fresh & innovative approach of solution development), grouping traits (able to communicate, reliable, cooperative), job approach (sincerity, encouragement, obedience), and job efficiency (publications, extent of assignments, responsibilities assigned, milestones achieved), unplanned events (sudden assignments, new technology and the status of the researchers).*

Some studies have also indicated such evaluation parameters that are specifically relevant for the public sector R&D organizations. According to the studies, the perceptions and preferences of managers and researchers of public sector organizations must be considered while deciding the components of R&D productivity measurement viz. extent of value creation for the society as well as the effectiveness of R&D outputs on society (Cho and

Lee, 2005; Linna et al., 2010; Ragasa, 2012). A number of past studies were in congruence with respect to measuring 'quality' and 'quantity' of R&D outputs together and having separate indices and measurement systems for productivity in R&D (Brown and Svenson, 1998; Coccia, 2001; Bremser and Barsky, 2004; Jääskeläinen and Uusi-Rauva, 2011).

Productivity of Indian Public Sector R&D Laboratories

Kendrick (1973) in his formative work on productivity has studied national productivity factors which increase the average rate of national productivity viz. investment in 'intangible' factors like research and development, education and training, health and safety. According to Brown and Svenson (1998), the contest to satisfy the stakeholders has increased globally, as the service providers are facing new challenges generated by the information technologies. In order to rank high amongst global competitors, both public and private-funded research organizations ought to provide globally accepted and innovative R&D solutions. The authors conclude that the outputs generated by R&D laboratories are of various forms, viz. patents, processes, systems, publications, facts and knowledge.

Cohen, Nelson and Walsh (2002) have studied the influence of R&D solutions provided by public sector R&D laboratories on the Industrial R&D. The authors conclude that such outputs or R&D solutions are used as inputs by industrial researchers. Moreover, a large number of industrial units in the sectors like food, manufacturing, electronics, automobiles and aerospace, are extensively using the technologies and processes developed by public sector R&D. In their pivotal work on productivity, Coelli et al. (2005) mention that productivity can be measured both for profit making, non-profit making, private and public firms. Hirsch (2005) comments that while the impact factor of a journal is considered to be the most commonly applicable productivity indicator that may not represent the quality of work. It is mostly illustrative of the popularity of a journal.

Thornhill (2006) has emphasized the value of public sector productivity as an input towards the economic growth of the in three ways viz. firstly, by providing employment to a larger set of people; secondly, by providing the largest segment of services in the country and finally, by becoming the largest consumer of government funds.

Jyoti et al. (2008) have compared the outcomes and efficiency of public sector R&D laboratories of Council of Scientific and Industrial Research (CSIR), India. The authors consider the annual budget as the input variable in the research and development process and a variety of output variables viz. paper publications, patents, external cash flow generated, new product/process/technology, Ph.Ds awarded and awards received. Jyoti, Banwet and Deshmukh (2010) have also identified the key factors for the success of the national R&D organizations in India. According to the authors, ten organizational factors affect the performance of the government R&D organizations in India, viz. “clear R&D vision and strategic directions”, “top management commitment”, “resource availability”, “R&D project management skills”, “organization culture and human resource”, “focus continuous monitoring of techno-market environment”, “teamwork”, “knowledge networks”, “customer focus” and “market orientation”.

Linna et al. (2010) have defined ‘productivity’ as the quantification of the outputs that are generated by utilizing for each unit of input and ‘public sector productivity’ as “implicit to be zero in the national accounts i.e. output = input". According to Chaturvedi and Srinivas (2012), publications are the main focus of both R&D organizations and R&D assessment systems.

R&D Outputs as Inputs for Industrial Growth

Scherer (1982) in his inspiring work, has analysed how R&D is helpful in enhancing productivity of industries in the United States of America. The findings reflect significant growth in industrial gains, through employment of R&D processes and products. Griliches (1984), in his influential work has observed that both R&D investments and firm performance are dependent on several conditions like evolution of scientific opportunities in a particular field, people’s expectations and perceptions about the future economic climate of the country and the prospects of a R&D product being sold in an economy. Further, Griliches (1994) has studied the sources of productivity growth in the United States during the period 1980’s and 1990’s and concludes that improvements in sources of efficiency in productivity viz. quality of labour, capital and technical change, affect the overall national productivity.

R&D Manpower: R&D as a Career

Koch and Steers (1978) have highlighted that the determinant, 'job attachment' can reflect the turnover tendencies more than 'job satisfaction' in public sector organizations. Moore (2004) has indicated that the researchers having post-doctoral qualification are being treated as 'non-valuable' and are not being offered remuneration equivalent to their qualification. Brooks and Nafukho (2006), Parisi, Schiantarelli, and Sembenelli (2006) and Shivaram and Sahu (2016) have suggested that improvements in employee productivity can be achieved by a) utilizing current and improved processes and technologies and b) undertaking activities that can help in manpower development. According to Post et al. (2009), several other organizational and environmental factors (viz. "work overload" and "weekly working hours", "work dissatisfaction", "work interference with family" and "family interference with work") impact switching from R&D job to non-R&D job by the researchers. Further, only half of the total graduates of scientific areas of studies continue in the scientific profession and that too only up to three years. After three years they change their domain of work due to higher remuneration offers (Beffy, Fougere and Maurel, 2012; Chevalier, 2012).

Perceptions of Researchers

Strauss (1966) has studied the perception of government engineers and scientists about productivity and its related determinants. He has analyzed the ratings given to government engineers and scientists, by self, peers and supervisors. According to him, the value of performance variables like the number of promotions differs with respect to different groups of researchers' viz. supervisors and non-supervisors. Further, determinants like "job satisfaction" and "perceptions of productivity" are influenced by personal variables and not by performance variables. Reagans and Zuckerman (2001) have compared and analysed the perspectives of scholars pertaining to the role of social networking in increasing R&D productivity which manifest as network density and network heterogeneity (demographic diversity).. Cho and Lee (2005) have identified a relationship between the preferred performance measures and contingency factors (project phase, structure, technology, and the position of R&D professionals) for the Korean researchers in the telecommunication field. The analysis has been carried out empirically and the results suggested a need for adopting a bottom-up approach that includes the opinion of R&D professionals for the purpose of R&D performance measurement. Linna et al. (2010) have interviewed managers of public sector R&D organizations and have found that the common perspective of these R&D managers is that, the efficiency of public sector outputs institution can only be measured in terms of the extent of their impact on society.

Determinants of R&D Productivity

The impact of the determinants of R&D productivity can be of many forms. Hence, analyzing how these determinants outline the productivity of researchers is a must to maximize R&D outcomes. A number of researchers (viz. Babu and Singh, 1998; Landry, Traore and Godin, 1996; Bonaccorsi and Daraio, 2003; Stack, 2004; Hirsch, 2005; Turner and Mairesseb, 2005; Ohly et al., 2006; Anderson, Ronning and Martinson, 2007; Vinkler, 2007; Jacso, 2008; Post et al., 2009; Kelchtermans and Veugelers, 2011; Oeij, De Looze, Ten Have, Van Rhijn and Kuijt-Evers, 2011; Obembe, 2012; Ragasa, 2012; Rotolo and Petruzzelli, 2012; Krell, 2012; White, James, Burke, and Allen, 2012; Prathap, 2013; Ryu and Choi, 2016) have suggested that the determinants that influence the generation of R&D outputs in either positive or negative ways viz. "persistence", "initiative", "intelligence", "creativity", "learning capability", "concern for advancement", "professional commitment", "resource adequacy", "access to literature", "simulative leadership", "external orientation", "collaboration (viz. university researchers, university researchers and industry)" and "university researchers and other institutions (government agencies, local governments and organized interest groups)", "geographical closeness to the R&D partners", "field of research"/ "research specialization" , "cross- community ties", "age", "gender", "citation", "promotion", "gender", "routinization", "job-control", "job-complexity", "time-pressure", "supervisor support", "competition (for funding, positions and prestige)", "work overload", "weekly working hours", "work dissatisfaction", "work interference with family" and "family interference with work", "work dissatisfaction", "incentive factors (like promotion record and access to research resources)", "input-quantity", "output-quantity", "input-quality" and "output-quality", "quantity" and "quality of publications", "high journal impact factor", "discipline", "location", "language-group", "number of citations", "h-index" , "software issues" and "consistency of coverage of web databases (like Google Scholar, Scopus and Web of Science)", "number of publications", "total citations", "number of downloads", "number of scientists", "situational variables (viz. doctoral student support, summer stipends and other research grants, on the research performance)", "internal and external organizational resources (viz. government and corporate funding, research capability, and R&D type)" and "R&D collaboration".

A large number of researchers have worked on the determinant 'age' in the earlier period (Bonaccorsi and Daraio, 2003; Turner and Mairesseb, 2005; Skirbekk 2004, 2008; Obembe, 2012). According to these researchers the impact of 'age' on R&D productivity can be two fold i.e. encouraging and discouraging. According to Bonaccorsi and Daraio (2003), productivity declines with the increasing age of researchers pertaining to the researchers of the Italian National Research Council (CNR). Skirbekk (2004) has found an inverted U-shaped profile of productivity for the researchers around 50 years of age.

Jindal-Snape and Snape (2006) have analysed determinants that provide encouragement to the researchers working in government organizations and help to enhance the quality of their R&D outcomes. The authors conclude that the "ability to do high quality" and "curiosity driven research" motivate researchers positively and the determinants "lack of feedback from management", "difficulty in collaborating with colleagues" and "constant review and change" are de-motivators. Also, "salaries", "incentive schemes" and "prospects of promotion" do not impact productivity in a positive way. The authors highlight the fact that researchers lay more emphasis on the removal of de-motivators or the 'negative factors', rather than adding new motivators. Further, Skirbekk (2008) has explored the determinant 'age' and further advocated the positive impacts of 'age' on outcomes of jobs that typically require expertise of senior workers. The author also explained the role of flexibility in working characteristics and earning opportunities, encourage the elderly workforce to make use of their experience and increase the duration of their career.

Kumari, Madhukar, Chattoraj and Sinni (2015) and Kumari, Sahney and Madhukar (2018) have considered 'Man-days Involvement' as a significant determinant of productivity for researchers of CSIR -India laboratories. According to the authors, a large extent of man-days (working days) involvement in 'grant-in-aid' R&D projects can provide opportunities and resources to focus on generating a greater number of publications to the researchers. Further, Kumari, Madhukar, and Chattoraj (2020) have discussed the role of 'Man-days Involvement' as a quantitative parameter in performance evaluation of researchers. The authors have also illustrated the mechanism of e-profiling the 'Man-days Involvement' in various projects through a web-based information system.

To summarize the above discussion, determinants like 'age' and 'field of research', enhance R&D productivity. Several organizational and environmental factors have been quoted in previous studies. While determinants like "organizational infrastructure", "high journal impact factor", "investment in IT", "availability of e-resources", "citations", "routinization", "collaboration" and "Man-Days Involvement" have been considered to have a positive impact R&D productivity, whereas determinants like "competition (for funding, positions and prestige)" and "work dissatisfaction" have been considered having a negative impact on R&D productivity. Further, specific to the government R&D organizations, a set of factors does not enhance the productivity of researchers. The set includes "lack of feedback from management", "difficulty in collaborating with colleagues", "salaries", "incentive schemes", and "prospects of promotion".

4.0 Objectives of Study

The outputs of R&D depend on several factors. Some of these factors are the individual preferences of the researchers in the area of their research work, the type of outputs they generate and the influencing determinants they believe and consider to be of importance. For instance, for a set of researchers, incentives, honorarium and promotions, may be the prime motivators to obtain a higher number of industry sponsored projects, whereas for another set of researchers, recognition and honour through high impact factor publications and higher number of citations (i.e. generating external cash flow vs. doing basic science) may be encouraging factors. At the same time, organizations may differ with respect to R&D which would generate revenues in the long run. Such varied different sets of preferences, may end up opening several parallel modes of conducting R&D and not working towards organizational goals. Hence, for the researchers who are involved in different types of R&D, the worth of the outputs i.e. technologies and publications may be different. In fact, the time-spent on both types of outputs are also different. In addition to the multiple challenges faced by the Indian R&D organizations (Table 1), aligning individual preferences with the organizational ones is another milestone for the CSIR laboratories. The conceptual models (See Model 1 and Model 2) highlight the gaps and possible measures to engage and utilize the researchers in the most desirable way. The basic objective of data analysis for the current study is to discover the R&D outputs and the individual, organizational and environmental factors that influence productivity. The aim is also to find out the most significant ones by the researchers employed in select CSIR laboratories. The objective of this analysis is to explore the order of preference (ranking) with respect to the R&D outputs and factors influencing productivity as per the researchers' perspective. The eventual objective of the study is to ascertain that identifying and including the preferences of researchers in R&D planning can help in aligning individual goals with organizational goals i.e. working towards self-sustainability.

1. To identify the most preferred and significant R&D outputs to target for, from the researchers' perspectives.
2. To identify the most preferred and significant factors that influence the generation of the preferred R&D outputs, from the researchers' perspectives.

5.0. Methodology

5.1 Research Design

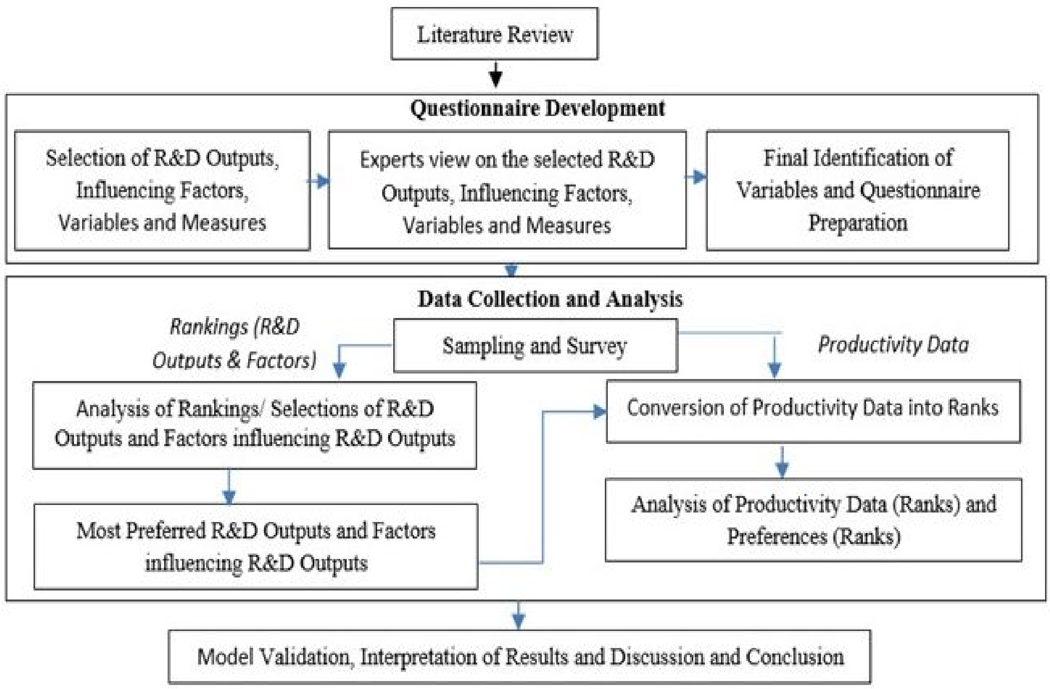

Figure 3: Research Design

5.2 Data

This study considers a sample of researchers working in the national public sector R&D laboratories situated in four States of India viz. Jharkhand, West Bengal, Odisha and Punjab. Each of them has different core areas of research and take up different categories of R&D projects viz. industry sponsored, government aided, network, collaborative, consultancy and testing. Further, the researchers working in these laboratories are involved in multiple roles and in multiple R&D projects simultaneously (for example, leader, member, group leader, head of department and purchase committee member). The researchers in the sample are in the age groups 27-65 and are designated as emeritus scientists, chief scientists, senior principal scientists, principal scientists, senior scientists, scientists and junior scientists. The different designations indicate different levels of experience. A detailed profile of the sample is illustrated in Tables 2 and 3.

"take in tables 2 and 3"

5.3 Sampling Method and Sample Size and Data Collection

The quota sampling technique was used for data collection. This sampling technique provides the researcher with the flexibility to select representatives from mutually exclusive groups in a sample. In this way, it was ensured that the sample was truly representative of the target population. The sample size for the study was predetermined based on the recommendations of Clark and Watson (1995) who suggest that there ought to be five subjects per parameter. A sample of 300 researchers was selected from a total population of 525 scientists working in five R&D laboratories situated in four different States of India viz. Jharkhand, West Bengal, Odisha and Punjab. Data was collected from five CSIR laboratories with the help of a questionnaire (Annexure-I) during 2016-2017. Out of this sample, 242 responses were found to be correct and appropriate for further analysis.

5.4 Conceptualization of R&D Outputs and Factors Influencing R&D Outputs

The six select R&D outputs and the factors affecting the R&D outputs were identified through literature review and expert advice so as to minimize the risk of having any left outs. Further, while the select R&D outputs and influencing factors were adopted and adapted from past studies, are termed differently, yet their definitions and usage continue to be the same. Two experts from the Industry and one from the academia were asked to assess the appropriateness of the select R&D outputs and factors influencing R&D outputs. In this process, the experts suggested outputs and factors which they thought were highly relevant for the Indian public sector R&D organizations as well as for the researchers. The set of select R&D outputs and influencing factors for the study are provided in Table 4.

"take in table 4"

5.5 Ranking

The preferences of researchers with respect to the R&D outputs and influencing factors were collected through ranking questions in the range of 1-6 and 1-5.

Weighted Average Method

The preferences were collected in the form of rankings and these rankings were analysed through the *Weighted Average Method.* This method includes (a) assigning weights to every rank; (b) adding scores of products of ranks and weights; and (c) averaging total weighted score of a choice with the total weighted scores of all ranks of all choices. The average of the rankings obtained through the survey responses was calculated for each of the answer choices to determine which of the answer choice was preferred by most of the respondents. The answer choice with the largest average was considered to be the most preferred one. The ranking average was calculated as follows, where for any answer choice:

w = weight of ranked position   x = total selections for a rank

Weighted Score of a choice= x1w1 + x2w2 + x3w3 ... xnwn

$$\text{Average Weighted Score of a choice} = \frac{\text{Weighted Score of a choice}}{\text{Sum of Weighted Score of all choices}}$$

This method clearly indicated the most significant R&D outputs, and the set of factors that affect the productivity of researchers. Thereafter, the hypotheses were tested, and the results were discussed.

6.0 Hypothesis

Every R&D laboratory defines its own set of R&D goals depending upon the resources available with them. Their personal preferences of researchers (or the R&D manpower) for some of the outputs and the overall dissatisfaction can adversely affect the quantity and quality of the planned outputs. Hence, it is important to identify relevant elements (i.e. outcomes) before formulating R&D policies that would encourage researchers in achieving organizational goals. This would require deliberation and discussion to arrive at a consensus on relevant and mutually beneficial constructs before finalizing the R&D policies. The related hypothesis and its sub-hypotheses are provided here.

Any R&D laboratory may generate a mix of R&D outputs in its basket. For the organization all R&D outputs being the marketable assets, can have similar value and importance but the values may differ for the researchers who generate these outputs. A researcher in the laboratory conducts R&D in projectised form and can be engaged in more than one type of project. The type and nature of most of the projects are different viz. Industry Sponsored projects call for applied research and quick technological solutions whereas the Grant-in-Aid projects provide funding and scope for conducting basic science research for a comparatively longer time period. The outputs expected from both types of projects ought to be different i.e. a new technology/process from sponsored project and a conference paper or a foreign collaboration from grant-in-projects. Although the outputs of the projects are different yet the effort put in by a researcher is the same. Hence, the value of all kinds of R&D outputs generated ought to be equal for a researcher. Further, the relevance of the R&D outputs for various purposes may differ in the opinion of the researchers. For instance, earning a prestigious international award/fellowship may be a milestone achievement for career enhancement. At the same time earning revenues may not be that important a parameter for the researchers working in government funded laboratories. Also, it is convenient to orient oneself towards incremental research and publishing results in reputed journals whereas pitching one's capabilities and getting industry funds can be tricky at times. Hence, in this context the Hypothesis 1, 1.1. and 1.2 have been defined below:

Hypothesis 1: From the perception of researchers, all R&D outputs have equal significance.

Hypothesis 1.1: From the perception of researchers, earning of recognition/honour/awards has lesser relevance than earning revenues.
Hypothesis 1.2: With respect to the kind of R&D activities, conducting basic science research is preferred by the researchers as compared to applied research.

The quantity and quality of the outputs hold equal importance in R&D and both can be affected by the efficiency and purity of the process of their generation (Brown and Svenson, 1998; Al-Darrab, 2000; Ramírez and Nembhard, 2004; Jyoti et al., 2008; Oeij et al., 2011; Ragasa, 2012). Wherein, the '*efficiency*' can be measured by *"the rate of output generation by optimal utilization of resources (*Griliches, 1994; Pritchard, 1995; Al-Darrab, 2000; Greiling, 2006; Phusavat, 2013)*"* and '*purity*' can be defined as *"free from all the undesirable personal and organizational limitations that may hinder the process of output generation (viz. sub-process delays, personal differences, and unavailability of inputs & funding (*Kendrick, 1973; Cooper, R.G., 1990; Suito, 1998*)"*. Research is a team work and follows a systematic process which tends to be impacted by more than one individual, organizational and environmental factors viz. attitude & priority of the team members, organizational support and government policies (Babu and Singh, 1998; Landry et al., 1996; Bonaccorsi and Daraio, 2003; Stack, 2004; Turner and Mairesseb, 2005; Ohly et al., 2006; Anderson et al., 2007; Jacso, 2008; Post et al., 2009; Kelchtermans and Veugelers, 2011; Obembe, 2012; Prathap, 2013; Ryu and Choi, 2016, Kumari et al., 2015, 2018 and 2020). Hence, in this context Hypothesis 2 has been defined.

Hypothesis 2: From the researchers' perspective, a combination of individual, organizational and environmental factors has a positive effect on the generation of the outputs.

7.0 Results

7.1 Preferred Rankings of the R&D Outputs and Influencing Factors

Preferred order of the R&D Outputs

The weights were assigned to each of the ranks for various R&D output choices in the following way: 6 to rank 1, 5 to rank 2, 4 to rank 3, 3 to rank 4, 2 to rank 5, 1 to rank 6. The weighted score for each of the R&D output was calculated by summing up of the products of the total selection of a rank, and the respective weight. The final average weighted score for each of the R&D output was obtained by dividing the total weighted score by the sum of weighted scores of all R&D outputs. The percentage score of each of the R&D output was then calculated with respect to the total weighted score of all the six R&D outputs (See Table 5).

"take in table 5"

Preferred order of the Influencing Factors

The weights were assigned to each of the ranks for the various factors influencing each of the R&D outputs in the following way: 5 to rank 1, 4 to rank 2, 3 to rank 3, 2 to rank 4, 1 to rank 5. The final average weighted score for each of the influencing factors was obtained by dividing the sum of the products of total selection of a rank, and the respective weight by the sum of total weighted scores of all choices. The percentage score of each of the influencing factor was then calculated with respect to the total weighted score of all the influencing factors pertaining to the R&D output (See Table 6).

"take in table 6"

7.2 Spearman Rank-Order Correlation

The preferences of researchers pertaining to the select factors influencing R&D outputs considered in this study viz. Publications, Patents/Copyrights, Technologies, Awards, External Cash Flow and Citation (which was obtained in the form of ranks), and the actual productivity data (counts of R&D outputs generated) was analysed by calculating the Spearman rank-order correlation coefficients. The correlation coefficients indicate the strength and direction of association between two ranked variables. For the purpose of this study, the correlation coefficients of different ranges were interpreted in three ways viz. moderate (0.40-0.59), strong (0.60-0.79) and very strong (0.80-1.0). The actual productivity data of the R&D output variables was transformed into 'Ranks' (through statistical tool 'Systat'). The transformation of the values enabled the calculation of correlation between the output variables and the factors influencing the R&D outputs. The

Spearman rank-order correlation coefficient was calculated through the statistical tool 'Systat'. The significant correlation coefficients are given in Table 7.

"take in table 7"

7.3 Regression Models of Ranks

For R&D outputs like 'Publications', 'Awards', 'External Cash Flow' and 'Citations', none of the influencing factors were found to be significantly correlated with the output variables (see Table 7). Hence, no models could be built for the above three R&D outputs. The robust regression models built for the R&D outputs 'Patents/Copyrights' and 'Technologies' are given in Table 8. Three different models were built by the factors that were significantly correlated with the output variables. None of the independent variables in any of the models was able to explain the dependent variable beyond 39.1% (Model 2) of the cases in the dataset. Model 1 reflected that the R&D output 'Patents/Copyrights', was influenced negatively by the factor, 'Developments in Market' in 12.6% of the cases in the dataset. Further, Model 2 reflected that the R&D output, 'Technologies' was influenced by the factor, 'Incentive Schemes' in 39.1% of cases in the dataset. Model 3 indicated that the R&D output, 'Technologies' was influenced by the factors, 'Family Environment' and 'Innovativeness' in 32.2% of the cases in the dataset.

"take in table 8"

7.4 Hypothesis Testing

The hypotheses are tested by the findings of analyzing the preferences of researchers with respect to the R&D outputs and influencing factors.

Hypothesis 1: From the perception of researchers, all R&D outputs have equal significance.

The analysis of the preferences of researchers for R&D outputs showed that the order of significance varied for each of the select six R&D outputs. The R&D outputs, viz., *'External Cash Flow Generated' and 'Awards/Fellowships/Editorial Board Memberships'* were selected as the most significant ones by a larger fraction of researchers and the average weighted scores were 21.79% and 21.37% respectively. The R&D outputs, viz., *'Highest Citations Received (Journal Publication)' and 'Patents/Copyrights'* were preferred at the middle order with total average weighted scores of 19.23% and 15.81% respectively. The R&D outputs, viz., *'Technologies' and 'Publications (SCI/Non-SCI)'* stood at the bottom level with total average weighted scores of 11.54% and 10.26% respectively. Hence, it can be concluded that on an average, the significance imparted to the various R&D outputs differs in the eyes of the researchers and the null hypothesis failed to get accepted.

Hypothesis 1.1: From the perception of researchers, earning of recognition/ honour/ awards has lesser relevance than earning revenues.

An analysis of researchers' preferences revealed that both the R&D outputs, *'Awards/Fellowships/Editorial Board Memberships' and 'External Cash Flow Generated'*, were considered to be highly relevant by most of the researchers and their total average weighted scores differed marginally, i.e. 21.37% (for 'Awards/Fellowships/Editorial Board Memberships') and 21.39% ('External Cash Flow Generated'). Hence, it could be concluded that the importance attached to receiving awards and recognitions was as high as generating revenues and hence the null hypothesis was rejected.

Hypothesis 1.2: With respect to the kind of R&D activities, conducting basic science research is preferred by the researchers than conducting applied research.

The analysis of the rankings revealed that the R&D output *'External Cash Flow Generated'* is regarded as the most important and holds the highest relevance, while the R&D output, *'Publications' (SCI/Non-SCI)* holds the lowest relevance. A considerable difference in the total average weighted scores was found, viz., 21.39% (for 'External Cash Flow Generated') and 10.26% (for 'Publications') and hence, it can be inferred that the researchers of Indian public funded laboratories desire to involve themselves in research that generates revenues and are not satisfied by merely conducting basic science research and publication oriented research. Contrary to the above, the findings also revealed that the R&D output, *'Highest Citation Received' (Journal Publication)* was preferred as the third most important one with a total score of 19.23%. This indicated that along with revenue earning, the researchers also wished to gain recognition through publications and citations.

In R&D laboratories, commercialization of patents and the technology transfers are amongst the main sources of earning revenue. Patents are generated from the technology development activities and revenues are earned through technology transfers and commercialization. Further, the analysis of the data also showed that researchers ranked the R&D outputs, viz., *'Patents/Copyrights' and 'Technologies'* at fourth and fifth levels in order of preference, having total scores of 15.81% and 11.54% respectively. This indicated that the preferences of researchers were inclined towards patenting as well as technology development and transfers, as compared to journal publications. Hence, it can be inferred that though *'Publications' and 'Highest Citation Received' (Journal Publication)* are regarded as two distinct R&D outputs by the researchers yet, the two are interrelated.

Further, the R&D output *'Publications'* was not found to be significantly corelated with the factors that were important in the eyes of researchers (See Table 7). Alternatively, the R&D outputs 'Patents/Copyrights' and 'Technologies' have reflected significant (moderate) correlations with a few factors that were preferred by the researchers. The robust regression model (Model 2) also indicated that around 40% of the researchers in the dataset were willing to generate the R&D outputs 'Patents/Copyrights' and 'Technologies' than 'Publications'. Therefore, it can be concluded that though the researchers are keen to publish and earn citations yet, they are more inclined towards generating revenues. Hence, the null hypothesis got rejected.

Hypothesis 2: From the perception of researchers, a combination of individual, organizational and environmental factors has a positive effect on the generation of the outputs.

The analysis of the researchers' preferences indicated that individual factors (viz. *'Research Area/Area of Publication', 'Educational Background', 'Communication Skill', 'Professional Commitment', 'Industry Contacts Developed', 'Level Of (Intrinsic) Motivation' and 'Number of Research Projects'*), organizational factors (viz. *'Access to Literature', 'Work Environment', 'Research Environment', 'Organizational Infrastructure', 'Willingness of Organization, 'Quality of Service', 'Customer Satisfaction', 'Willingness of Organization' and 'Industrial Collaboration'*), and environmental factors (viz. *Industrial Application', 'Innovative Work Profile in the Same Research Area', Eminence of Researcher', 'Innovativeness/Novelty of Research Work', 'High Impact Factor of Journal', 'High Impact Research Work' and 'Industrial Growth Rate'*) were ranked amongst the top five factors that influence the generation of the select R&D outputs. Further, none of the factors was able to significantly explaining the R&D

outputs generated by the researchers in the dataset (See Table 7 &8). Multiple factors of all three categories were moderately correlated to the R&D outputs. Hence, it can be concluded that all the three categories of factors were significant in preferences and reality and hence the null hypothesis failed to get rejected.

8.0 Findings and Implications

All the R&D outputs are significant for one or the other group of researchers. However, the overall weighted score led to their rankings and helped arrange them in an order (See Table 5). 'External cash flow' and 'Awards/Fellowships/Editorial Board Memberships' held more or less a similar level of importance for most of the researchers. 'Highest Citation Received' (Journal Publication) was at the third order, and 'Patents/Copyrights' and 'Technologies', were chosen at the fourth and fifth order respectively. 'Publications' (SCI/Non-SCI) was preferred by the lowest percentage of respondents. Researchers working in public sector laboratories are relatively free to pursue basic exploratory research that can lead to the discovery of new scientific theories. In contrast to the government funded laboratories, earning revenues & profits is important for the survival of the private funded laboratories.

Further, the results indicated that recognition and awards hold a high value for most of the researchers. Earning prestigious awards/foreign fellowships/editorial board memberships of renowned journals are a matter of pride and can be a result of years of pursuance in one's field of research. Awards & fellowships can also appear as one of the performance appraisal parameters. Hence, it is obvious that the researchers would prefer Awards, Fellowships & Editorial Board Memberships. Further, the researchers have preferred to generate Patents & Technologies which are sources of earning revenues. This goes in line with the objective of generating revenues. On the contrary to the findings the results also suggest that most of the researchers strongly prefer publishing in high impact journals but do not consider it their priority.

The order of influencing factors is given in Tables 6. With respect to the significant influencing factors behind the generation of the aforementioned six R&D outputs, it was found that on an average the factors viz. 'Quality of Service', 'Customer Satisfaction', 'Organizational Infrastructure', 'Collaboration with Industry', 'Industry Contacts Developed', 'Industrial Growth Rate' and 'Professional Commitment' were chosen by the researchers respectively as the top seven factors, that influence the R&D Output 'External Cash Flow Generated'. *The results indicated that organizational and environmental factors have a major role in generating business opportunities for the laboratory than the personal attributes of the researcher. Hence, the onus of empowering researchers with resources (viz. contacts, infrastructure, & collaboration) for generating new clients is on the organization.*

With respect to the R&D output, 'Awards/Fellowships/Editorial Board Memberships', the researchers chose the following factors as the top seven ones: 'Innovative Work Profile in the Same Research Area', 'Professional Commitment', 'Willingness of Organization', 'No. of Publications' and 'Association with Relevant Organization', 'Funding' and 'Eminence in the Field'. *According to the rankings, earning awards & recognitions is based upon a researcher's efficiency or quality of research. The organizational resources do play a role but the major efforts should be put in by the researcher (viz. quality/innovativeness of work, scale of publication and worthiness in the research area).*

With respect to the R&D output, 'Highest Citation Received' (Journal Publication), the order of the average weighted scores of the five factors is 'Eminence of Researcher', 'High Impact Factor of Journal', 'Innovativeness/Novelty of Research Work', 'Research Area', and 'High Impact Research Work'. Citations are a derivative of high quality and high impact publications. Impact of a publication in terms of citations is dependent more on the environmental factors like Journal quality and impact, high relevance of the research area and quality of research.

With respect to the R&D output 'Patents/Copyrights', the factors 'Professional Commitment', 'Research Environment', 'Industrial Application', 'Number of Research Projects', 'Work Environment' and 'Innovativeness of Idea/Novelty' were ranked amongst the top six influencing factors by the researchers respectively. With respect to the R&D output 'Technologies', the factors 'Industrial Collaboration', 'Organizational Infrastructure', 'Professional Commitment', 'Developments in Market', 'Customer Interfacing', 'Work Environment', 'Innovativeness of Idea/Novelty' were ranked as top seven ones by the researchers. Patents and Technologies are the saleable R&D outputs that are dependent more on industrial collaborations and market opportunities. *Hence, the role of the organization is imperative in collaborating with a large number of relevant industries to tap* *every prospect of funding from them. Wide publicity could be given to the industries regarding the technologies available with the labs to attract them; suitable marketing strategies should be adopted by the labs to enhance industry-R&D labs. partnerships.*

With respect to the R&D output ‘Publications' (SCI/Non-SCI) the factors 'Research Area/Area of Publication', 'Educational Background', 'Number of Research Projects', 'Access of Literature', 'Communication Skill', 'Work Environment' and 'Level of (Intrinsic) Motivation' were chosen as the top seven ones by the researchers respectively. Publication as an output purely depends on the efforts of the researcher and the availability of the organizational resources. They are outputs of basic research that is expected from the researchers, for a variety of reasons viz. research sharing, eminence of the researcher, ranking of the parent institute, gain citations, performance appraisal, awards & recognitions and others.

The correlation coefficients and regression models indicated that there exists a gap between the actual significant factors of productivity and those preferred by the researchers. The preferred factors had a moderate impact on the R&D outputs that they generated. Hence, it can be inferred that there exists is a need to explore additional factors influencing productivity of researchers. *Hence, this is an opportunity for the researchers in the subject to explore such factors that along with the preferences of researchers in public sector laboratories can enhance the R&D productivity and gain self-sustainability in the long run.*

Implications for the Management of the Public Funded R&D Laboratories

It can be inferred from the preferred order of R&D Outputs that changing government mandates and the increasing competitive environment has left no exception. Even researchers in public funded laboratories have to opt for earning revenues. It is imperative that the management of these R&D laboratories investigate and identify the factors that affect the preferences of its researchers, deliberate, prioritize and strike a balance between applied research and basic research. Further, as per the order of R&D Outputs (See Table 5), on one hand the researchers are willing to gain high citations for their publications and on the contrary they give least preference to publishing. This raises a number of questions for the management of the R&D laboratories. Before creating any R&D policy based on the first hand preference list, the management must try and understand the willingness of the researchers *towards undertaking R&D projects. The gap between the reality existing in the research laboratories and the result of the survey conducted is highlighted through this study. It is imperative for the management to find ways and means to bridge this gap and provide appropriate solutions.*

9.0 Conclusions, Limitations and Future Direction of Research

The objective of this study is inclined towards gaining new insights and adding to the domain of knowledge pertaining to R&D productivity. The study helps in identifying means and measures for achieving congruence in the aspirations of researchers and the public funded R&D laboratories of India. Prior to this research, no such study has been conducted which has addressed the preferences (rankings) of researchers with respect to select R&D outputs and the factors determining them.

The findings enlighten a set of R&D outputs, as well as factors influencing the generation of outputs, which are perceived to be significant and relevant to the researchers of Indian public funded R&D laboratories. Model-2 (See Figure 2) states that including the preferences of researchers along with other real determinants of productivity in the R&D planning of the organization can lead towards aligned individual and organizational goals. The findings of the study (Table 7 and 8) reaffirmed that the preferred factors of productivity are moderately associated with the R&D outputs generated by the researchers. Hence, it can be concluded that the management of public funded R&D organizations should explore and consider both preferences and reality while preparing the research plan of the laboratory. Hence, the findings would trigger the redefining, reframing and refining of the effective organizational policies and procedures. This would eventually help researchers in deriving a sense of participation in the decision-making process of the organization, and in turn, organizations would be able to create and offer a better working environment to its employees.

The study also suffers from a few limitations. Primarily, not all the factors of productivity have been explored in this study. For example, the number and type of trainings attended by researchers, research impact on society, their role in support services, have not been included in the study. Further, due to paucity of time and financial constraints, only five of the R&D laboratories and 300 researchers were selected to conduct this study. More data could have provided better results. Finally, the study was limited only to the research laboratories belonging to one chain of public funded R&D laboratories in India. Probably, including other public funded research laboratories may have revealed other facts about the challenges of productivity.

Since, the study has identified a gap between the reality and perception which could also be important from the organizational policy making point of view. The study can be further extended to find significant determinants of productivity that actually influence the productivity of researchers in Indian public funded R&D laboratories.

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Annexure-I

Questionnaire

Please fill in the details

1. Demographic Details (Full Name is optional to provide):

(a) Title______________	(d) Date of Birth____/____/____ [dd/mm/yyyy]
(b) Full Name____________________	(e) City/Town________________
(c) Gender (Select one option):	(f) State/Province________________
Male / Female	(g) Telephone________________

2. Highest Degree Attained(a) Academic Qualification: (Select one option)

Diploma	Graduation	Post Graduation	PhD	Others

3. If you have selected Others, kindly provide the details

____

4. Subject
(a) Academic Qualification:________________

5. Is this your first permanent job in R&D/R&D Management? (Select one option)

Yes	No

6. Date of Joining: ____/____/____ [dd/mm/yyyy]

7. Date of Superannuation:____/____/____ [dd/mm/yyyy]

8. Main Work Area (Select one option)

R&D	R&D Management	Non- R&D

9. Core Area of Research: (Select one option)

Materials Evaluation		Materials Engineering	
Extractive Metallurgy		Surface Engineering	
Minerals Processing		Applied & Analytical Chemistry	
Resource, Energy & Environment		R&D Management	
Other		Other (please specify)	

Ques. 10-14: Please answer the following questions with respect to your Work Environment:

10. Research Environment
(a) Work Environment:
(Select one option)

Open	Hierarchical	Incentive Based

11. Time Pressure

High	Moderate	Low

12. Diversity of roles

Yes	No

13.No. of Roles (e.g. HOD/Group Leader/Scientist) ________________

14. Access to Literature (Hard Copy/ Soft Copy)

Adequate	Moderate	Low

Ques. 15-16: **Please answer the following questions with respect to your Family Environment:**

(a) Family Environment: (Select one option)
15. Marital Status

Married	Un-Married

16. Having Children

Yes	No

17. Spouse Working

Yes	No

18. Project & External Cash Flow:

(a) No. of R&D projects(Led &as Member)		(g) No. of network/ mega projects led	
(b) No. of projects led		(h) No. of Government aided projects led	
(c) Total ECF generated (Rs. in Lakhs)		(i) Avg. customer satisfaction index of your projects	
(d) No. of consultancy projects led		(j) No. of new clients made for the organization	
(e) No. of collaborative projects led		(k) No. of new business queries generated	
(f) No. of sponsored projects led			

19. Publications & IP:

(a) No. of publications(SCI)		(h) No. of technologies developed	
(b) No. of publications(Non-SCI)		(i) No. of technologies commercialized	
(c) No. of patents		(j) No. of books published	
(d) No. of copyrights		(h) No. of technologies developed	
(e) No. of conference publications (Proceedings)		(i) No. of technologies commercialized	
(f) No. of students guided (Research Students)		(j) No. of books published	
(g) No. of publications co-authored with students (Research Students)		(k) No. of major institutional publications (e.g. Annual Reports, D' Desks, Agenda, Technology Handbook)	

20. Impact Factor & Citation:
(a) Highest Citation (Journal Publication) ________________
(b) Highest Impact Factor (Journal Publication) ________________
(c) H-Index________________

21. Awards & Recognitions:

(a) No. of awards		(d) No. of Other Honors	
(b) No. of fellowships		(e) No. of invited talks/lectures	
(c) No. of Editorial Board memberships			

22. Please indicate your percentage time involvement in the following activities. Kindly ensure that the total time does not exceed 100:

(a) Time involvement in R&D Activities (Except equipment handling)	
(b) Time involvement in equipment handling	
(c) Time involvement in Non-R&D activities	

23. Please select the Non-R&D Activities in which you are involved:

Client interaction (Business Development)		Organization of events	
Committee memberships/Meetings		Customer service	
Mentorship/Students guided		R&D support purchase	
Other (please specify)			

24. In your opinion which of the following R&D outputs are most significant productivity indicators for a researcher? Please indicate by ranking the following in your order of preference (Rank No. 1 being the highest and Rank No.6 being the lowest): [Please rank all option(s).]

Publications (SCI/Non-SCI)		Awards/Fellowships/Editorial Board Memberships	
Patents/Copyrights		External Cash Flow	
Technologies		High Citation	

25. In your opinion which of the following influencing parameters are most significant for the productivity indicator," Publications (SCI/Non-SCI)" for a researcher? Please indicate the top five(5) by ranking the following in your order of preference (Rank No. 1 being the highest and Rank No.5 being the lowest): [Please rank exactly 5 option(s).]

No. Of research projects		Work environment	
Research area/area of publication		Family environment	
Communication skill		Educational background	
Access of literature		Years of experience	
No. of students guided		Team player	
Level of (intrinsic) motivation		High impact factor	

26. In your opinion which of the following influencing parameters are most significant for the productivity indicator, Patents/Copyrights" for a researcher? Please indicate the top five(5) by ranking the following in your order of preference (Rank No. 1 being the highest and Rank No. 5 being the lowest): [Please rank exactly 5 option(s).]

No. Of research projects		Non-obviousness	
Innovativeness if idea/novelty		Research environment	
Industrial application		Work environment	
Non-obviousness		Family environment	
Research environment		Professional commitment	
Work environment		Type of institution	
Family environment		Developments in market	
Industrial application			

27. In your opinion which of the following influencing parameters are most significant for the productivity indicator, "Technologies" for a researcher? Please indicate the top five(5) by ranking the following in your order of preference (Rank No. 1 being the highest and Rank No. 5 being the lowest): [Please rank exactly 5 option(s).]

Innovativeness of idea/novelty		Type of institution	
Industrial collaboration		Incentive schemes	
Customer interfacing		Organizational infrastructure	
Leadership trait		Team player	
Developments in market		Work environment	
Professional commitment		Family environment	
Access to literature			

28. In your opinion which of the following influencing parameters are most significant for the productivity indicator, "Awards/Fellowships/Editorial Board Memberships" for a researcher? Please indicate the top five(5)by ranking the following in your order of preference (Rank No. 1 being the highest and Rank No. 5 being the lowest): [Please rank exactly 5 option(s).]

Publications(sci/non-sci)		Supervisor support	
Association with relevant organization		Designation	
Funding		Type of institution	
Innovative work profile in the same research area		Incentive schemes	
Willingness of organization		Prospects of promotion	
Professional commitment		Supervisor support	
Type of institution		Designation	
Incentive schemes		Eminence in the field	
Prospects of promotion			

29. In your opinion which of the following influencing parameters are most significant for the productivity indicator, "External Cash flow Generated" for a researcher? Please indicate the top five(5) by ranking the following in your order of preference (Rank No. 1 being the highest and Rank No. 5 being the lowest): [Please rank exactly 5 option(s).]

Collaboration with industry		Prospects of promotion	
Economy of country		Years of experience	
Industrial growth rate		Team player	
Customer satisfaction		Professional commitment	
Quality of service		Type of institution	
Incentive schemes		Industry contacts developed	
Position/level		Work environment	
Organizational infrastructure		Family environment	

30. In your opinion which of the following influencing parameters are most significant for the productivity indicator, "High Citation" for a researcher? Please indicate the top five(5) by ranking the following in your order of preference (Rank No. 1 being the highest and Rank no. 5 being the lowest): [Please rank exactly 5 option(s).]

Research area		High impact research work	
High impact factor of journal		Eminence of researcher	
Innovativeness/novelty of research work			

31. In your opinion which of the following measures of enhancing utilization (Involvement in R&D) of a researcher? Please indicate the top five(5) by ranking the following in your order of preference (Rank No. 1 being the highest and Rank no. 5 being the lowest): [Please rank exactly 5 option(s).]

Increasing the total number of projects		Increasing Government Aided projects	
Increasing Network/Mega Aided projects		Increasing Sponsored projects	
Providing incentives for increased participation		Increasing Industry Collaborative projects	
Increasing the number of project in organization's major core area		Increasing Consultancy projects	
Providing technical training in the major research area of organization and		Setting targets for association in a minimum number of projects	
Encourage researchers to work in major research area of organization		Letting researchers bring and work in their own core area of research apart from lab mandate	
Linking project participation and R&D outputs to promotions		Concentrating on making better work environment	
Providing motivational training to researcher for participation in increased number of projects		Others	

32. If you have ranked 'Others' as an option amongst top three measures of enhancing utilization (Involvement in R&D) of a researcher, please provide details:

____

Responses to be used for my Ph.D. course

Table 1: Targets and Challenges faced by Indian Public-Sector R&D Organizations

Author(s)/ Events	***Targets*** / ***Measures to Achieve Targets***
	Targets
	Measures to Achieve Targets
Dehradun Declaration (2015)[1]	*Self-financing; Self-reliance; Improve hygiene and healthcare; Improve skills base; Digital industry; Smart cities; Clean-up the Ganges; Get large funding from government for facilities & equipment;*
	Business model for self –earning; Long-term self-sustainability capabilities such as technology marketing, licensing & commercialization of technologies & IPR
CSIR-society Meeting (Feb, 2020) [2]	*Virtual labs.; Inculcate scientific temperament in students; R&D collaboration through national /international projects; 5G, artificial intelligence and affordable and long-lasting batteries for renewable energy storage; Improving the quality of life of common people; Develop world class products; Commercialization of innovations; Technologies to help start-ups;*
	Combine traditional knowledge and modern science
Author(s) / Events	***Challenges***
	Measures to Meet Challenges
Santanu Roy and Sunil K. Dhawan, (2002)	*Good work environment at a) within working group and b) within organization); Job satisfaction*
	Good communication & information sharing at all levels; Participative decision making and technology updating.
R.K. Gupta (2005)	*Management of IP ; Coordination between IP filing team and business development; Adapting best practices in IP licensing; Take public-funded innovations to market*
	Partnership amongst R&D laboratories; IP management skills; Public-private partnerships; Learn/adapt best policies from expert countries
Shweta Uttam and P. Venugopal (2008)	*Take up projects that can gain short term and long-term benefits.*
	Assessment of projects internally to secure benefits; Sponsored projects are beneficial in various aspects viz. 'Futuristic', 'Desirable', 'Beneficial'
Geeta Rana, Alok Kumar Goel and Renu Rastogi (2013)	*Talent management*
	Balanced scorecard and e-maps; performance counselling, planning and final review; Rewards & recognition for retention; Knowledge sharing and transfer
Kumar, V., Naqvi, S., Kumari and S. and Banerjee, P. (2014)	*Attract & retain outstanding migrant (returning) researchers & knowledge workers; Rate of returning migrants is very low*
	Suitable remuneration, better job opportunities, better infrastructure and better working environment; Utilize experiences and knowledge
C.U. Saraf (2014)	*Managing technology transfers to industry; Avoid cost and time overrun;*
	University courses on "technology transfer process"; Training program on technology transfer
Roy, Santanu and Mitra, Jay (2018)	*Deal with the economic and social changes;*
	Better accountability; Match knowledge worker capabilities with the evolving needs; Quality R&D performance (patents, publications); Organizational learning; Research management; Strategic resource planning; Increased national R&D funding; Strategic grouping of the labs.; Prototyping and Marketing

[1] https://www.chemistryworld.com/news/call-for-complete-overhaul-of-indias-csir/3008279.article
[2] https://www.csir.res.in/slider/prime-minister-narendra-modi-chaired-meeting-council-scientific-industrial-research-csir
https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1603291
http://ddnews.gov.in/national/pm-chairs-csir-society-meeting-emphasizes-developing-virtual-labs#:~:text=Prime%20Minister%20Narendra%20Modi%20chaired,out%20a%20future%20road%20map.
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https://timesofindia.indiatimes.com/india/Address-at-least-100-common-problems-PM-to-CSIR-scientists/articleshow/51727009.cms

Table 2: Profile of the Sample (1)

S. No.	Research Area of Laboratory	State of India	Total Number of Employees	Total Number of Scientists	Number of Respondents
1	Metals, Minerals and Materials	Jharkhand	405	117	60
2	Fuel and Mining	Jharkhand	625	141	53
3	Minerals and Materials Technology	Odisha	266	92	42
4	Glass and Ceramic Research	West Bengal	426	97	34
5	Scientific and Industrial Instruments	Punjab	357	78	52

Table 3: Profile of the Sample (2)

S.No.	Gender of Respon-dents			Age Group of Respondents					Qualification of Respondents				
	Female	Male	Blanks	Below 31	31-40	41-50	51-60	Above 60	PhD	Post Graduation	Diploma	Others	Blanks
1.	9	43	8	2	22	23	13	-	44	14	1	1	-
2.	8	43	2	4	8	12	25	4	37	7	-	-	9
3.	4	36	2	2	4	17	19	-	38	4	-	-	-
4.	1	29	4	2	7	8	17	-	29	5	-	-	-
5.	12	38	-	-	35	12	5	-	33	17	-	1	1

Table 4: R&D Outputs and Factors Influencing R&D Outputs

R&D Outputs	Influencing Factors (Literature Review)	Influencing Factors (Experts' Advice)
Publications (SCI/Non-SCI)	-Research area/Area of publication -Access of literature -No. of students guided -Level of (intrinsic) motivation -Work environment -Family environment -Educational background -Years of experience -High impact factor	-No. of research projects -Communication skill -Team player
Patents/ Copyrights	-Research environment -Work environment -Family environment -Professional commitment -Type of institution -Developments in the market	-Type of institution -Innovativeness of idea/Novelty - Industrial application -Non-obviousness -No. of research projects
Technologies	-Industrial collaboration, -Leadership trait, -Developments in market - Professional commitment -Access to literature -Incentive schemes -Organizational infrastructure -Work environment -Family environment	-Innovative work profile in the same research area -Innovativeness of idea/Novelty -Customer interfacing -Type of institution -Team player
Awards/ Fellowships/ Editorial Board Memberships	-Publications(SCI/Non-SCI) -Funding -Professional commitment -Incentive schemes -Prospects of promotion -Supervisor support -Eminence in the field	-Association with relevant organization -Willingness of organization -Type of institution -Innovative work profile in the same research area, -Designation -Man-days involvement
External Cash Flow	-Collaboration with industry -Economy of country -Industrial growth rate -Customer satisfaction -Quality of service -Incentive schemes -Organizational infrastructure -Prospects of promotion -Years of experience -Professional commitment -Industry contacts developed -Work /Family environment	-Position/Level, -Team player -Industry contacts developed -Type of institution,
Citation	-Research area -High impact factor of journal -Eminence of researcher	-Innovativeness/ Novelty of research work -High impact research work

Table 5: Weighted Average Scores of R&D Outputs

R&D Outputs	Total Weighted Score	Weighted Average Score	Percentage Weighted Average Score
External Cash Flow	1068	51	21.79
Awards/Fellowships/Editorial Board Memberships	1049	50	21.37
Highest Citations Received (Journal Publication)	945	45	19.23
Patents/Copyrights	771	37	15.81
Technologies	560	27	11.54
Publications(SCI/Non-SCI)	513	24	10.26

Table 6: Weighted Average Scores of Top Influencing Factors

Influencing Factors	Total Weighted Score	Weighted Average Score	Percentage Weighted Average Score
R&D Output: External Cash Flow Generated			
Quality of Service	403	27	11.74
Customer Satisfaction	398	27	11.74
Organizational Infrastructure	352	23	10
Collaboration with Industry	300	20	8.7
Industry Contacts Developed	297	20	8.7
Industrial Growth Rate	283	19	8.26
Professional Commitment	259	17	7.39
Economy of Country	244	16	6.96
R&D Output: Awards/ Fellowships/ Editorial Board Memberships			
Innovative Work Profile in the Same Research Area	475	32	14.29
Professional Commitment	381	25	11.16
Willingness of Organization	378	25	11.16
Number of Publications	366	24	10.71
Association with Relevant Organization	358	24	10.71
Funding	343	23	10.27
Eminence in the Field	301	20	8.93
Type of Institution	279	19	8.48
Supervisor Support	196	13	5.8
R&D Output: Publications (SCI/Non-SCI)			
Level of (Intrinsic) Motivation	296	20	8.4
Team Player	236	16	6.72

Years of Experience	229	15	6.3
High Impact Factor	212	14	5.88
Number of Students Guided	201	13	5.46
Family Environment	102	7	2.94
R&D Output: Highest Citations Received (Journal Publication)			
Eminence of Researcher	755	50	64.1
High Impact Factor of Journal	145	10	12.82
Innovativeness/Novelty of Research Work	115	8	10.26
Research Area	95	6	7.69
High Impact Research Work	60	4	5.13
R&D Output: Patents/Copyrights			
Professional Commitment	540	36	15.58
Research Environment	534	36	15.58
Industrial Application	502	33	14.29
Number of Research Projects	385	26	11.26
Work Environment	381	25	10.82
Innovativeness if Idea/Novelty	339	23	9.96
Developments in Market	290	19	8.23
R&D Output: Technologies			
Industrial Collaboration	500	33	14.41
Organizational Infrastructure	393	26	11.35
Professional Commitment	389	26	11.35
Developments in Market	383	26	11.35
Customer Interfacing	363	24	10.48
Work Environment	318	21	9.17
Innovativeness of Idea/Novelty	301	20	8.73
Leadership Trait	219	15	6.55
R&D Output: Publications (SCI/Non-SCI)			
Research Area/Area of Publication	475	32	13.45
Educational Background	456	30	12.61
Number of Research Projects	398	27	11.34
Access of Literature	336	22	9.24
Communication Skill	318	21	8.82
Work Environment	312	21	8.82

Table 7: Spearman rank-order correlation coefficients

Independent Variables	**Dependent Variables**					
	Technologies	Patents/Copyrights	Citations	External Cash Flow	Awards	Publications
Customer Interfacing	**-0.355**					
Developments in Market	-0.301	**-0.382**				
Professional Commitment						
Access to Literature						
Type of Institution		-0.316			**0.371**	
Incentive Schemes	**-0.548**				0.329	
Work Environment	**-0.369**					
Family Environment	**-0.421**					

Table 8: Regression Models of Rank Data

Model No.	**Dependent variable**	**Independent variable**	**Coefficient (β)**	**Multiple R**	**Squared multiple R**	**Adjusted squared multiple R**
1	Patents/Copyrights	Developments in Market	-7.550	0.354	0.126	0.118
2	Technologies	Incentive Schemes	-6.194	0.625	0.391	0.384
3	Technologies	Family Environment Innovativeness	-4.751 -2.297	0.567	0.322	0.304