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THE ELASTICITY OF INNOVATION: A SOCIAL COST-BENEFIT ANALYSIS OF THE CSIR FELLOWSHIP SCHEME AS A DRIVER OF INDIA'S TECHNOLOGICAL INCLUSION

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Abstract

This comprehensive research paper aims to conduct an in-depth cost-benefit analysis of the Council of Scientific and Industrial Research (CSIR) Fellowship grants, examining both the financial implications and the broader societal impacts. The study seeks to provide a nuanced understanding of the value derived from investing in scientific research and human capital development through these fellowship programs. Specifically, this paper focuses on the budgetary allocations made to the Department of Science and Technology (DST), with a particular emphasis on the projected estimates for the fiscal year 2024-2025. By narrowing the scope to this specific timeframe, we aim to provide a current and relevant analysis that can inform policy decisions and resource allocation in the near future. In assessing the benefits, this study primarily focuses on three key performance indicators, colloquially referred to as the "3-Ps": Paper Publications, Patents, and PhDs awarded. These metrics serve as tangible measures of scientific output, innovation, and advanced human resource development, respectively.

By juxtaposing the costs against these multifaceted benefits, this paper aims to provide a holistic view of the return on investment in CSIR Fellowship grants. The findings of this analysis can serve as a valuable tool for policymakers, helping them make informed decisions about resource allocation in the science and technology sector. Moreover, it can offer insights into the efficacy of such fellowship programs in advancing India's scientific capabilities and contributing to its socio-economic development.

JEL Codes:

D69, D70, D78, E00, H00, H41, H59

Key Words:

CSIR; HRDG; Fellowships; Patents; Grants; R&D; Net Foreign Income from Abroad, GNP, Cost-Benefit Analysis; Global Innovation Index

1. Introduction

The Council of Scientific & Industrial Research (CSIR) is known for its cutting-edge R&D knowledge base in diverse S&T areas and is a contemporary R&D organization. As a pioneer of India's intellectual property movement, CSIR today is strengthening its patent portfolio to carve out global niches for the country in selected technology domains. CSIR has three main initiatives aimed at developing the nation's human resources:

1. To promote and foster the upgrading of the stock of well-qualified, highly specialized scientists, engineers, and technologists for R&D in all disciplines of science and technology in the country.

2. To have an integrated approach to National Human Resource Development for Science, Engineering & Technology by encouraging and promoting research in the universities and institutes of higher learning.

3. To invest in basic and interdisciplinary research that is a harbinger of the 'high-tech' and technology of tomorrow.

For the above purposes, the EMR Division under the HRD Group of the Council of Scientific & Industrial Research (CSIR) provides CSIR Research Fellowships and Associateships to bright young men and women for training in methods of research under the expert guidance of faculty members/scientists working in university departments/institutes of national importance/national laboratories and institutes of CSIR in various fields of science & technology and medical sciences.

India's Council of Scientific and Industrial Research (CSIR) ranks as one of the biggest publicly financed research and development institutions worldwide. The Human Resource Development Group (HRDG), a division of CSIR, realizes this objective through various grants and fellowship schemes,[1] which include the following three main grants:

1. JRF (Junior Research Fellowship)
2. SRF (Senior Research Fellowship)
3. RA (Research Assistant)

Apart from these three major fellowships, there are others for post doctorates and PhDs, such as

1. SPM (Shyama Prasad Mukherjee Fellowships)
2. JRF-GATE

[1] https://csirhrdg.res.in/Home/Index/1/Home/3101/1

3. Nehru Science Postdoctoral Research Fellowship

This paper aims to do a ***Cost-Benefit Analysis*** of these fellowship schemes from the government's perspective. Cost-Benefit Analysis (CBA) measures a project's value by quantifying the project's effects and making costs and benefits comparable in monetary terms. While this cost-benefit analysis is not done for an individual but for a large group of people, this is not just CBA; we call it Social Cost-Benefit Analysis. Here, we assume that we can measure and quantify all social costs and benefits in terms of money (unit measure). The CBA works on the principle of quantifying impacts and choosing weights (Franklin's 'Algebraic Quantities') for each impact.

2. The Cost

The Ministry of Science & Technology mainly looks after funding and allocation of resources for CSIR. CSIR, being an autonomous body for scientific research and exploration, received **Rs. 5804.08 crore** in actuals of the 2022-2023 budget expenditure, as can be further analyzed with the table below:

Table 2.1: Budget Expenditures for the Department of Scientific and Industrial Research

MINISTRY OF SCIENCE AND TECHNOLOGY

DEMAND NO. 91

Department of Scientific and Industrial Research

(In ₹ crores)

	Actual 2023-2024			Budget 2024-2025			Revised 2024-2025			Budget 2025-2026		
	Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total	Revenue	Capital	Total
Other Central Sector Expenditure												
Autonomous Bodies												
4. Council of Scientific and Industrial Research (CSIR)												
4.01 National Laboratories	5690.07	...	5690.07	5835.80	...	5835.80	5877.24	...	5877.24	6127.57	...	6127.57
4.02 Capacity Building and Human Resource Development	417.00	...	417.00	430.00	...	430.00	426.21	...	426.21	473.08	...	473.08
Total- Council of Scientific and Industrial Research (CSIR)	*6107.07*	...	*6107.07*	*6265.80*	...	*6265.80*	*6303.45*	...	*6303.45*	*6600.65*	...	*6600.65*

Source: Ministry of Finance, Budget Division. (2025). *Expenditure Budget 2025-2026: Notes on demands for grants*. p. 310. Government of India.

As can be seen, the actuals of this expenditure are greater than the estimated expenditure, and furthermore, it can be inferred that the future budget estimates are even higher, at approximately Rs. 6266 crores. This is the major portion of total expenditure by the Department of Scientific and Industrial Research, which in the same year accounted for a grand total of Rs. 5852.14 crore. Hence, the CSIR allocations certainly accounted for almost 99% of expenditure by the whole department under the Ministry of Science and Technology.

Table 2.2: Demand for Grants by the Ministry of Science and Technology (2024-2025)

Departments	Total Expenditure
Department of Science and Technology	8029.01
Department of Biotechnology	2251.52
Department of Scientific and Industrial Research	**6323.41**
Total	16603.94

Note. All figures are in ₹ crores. Adapted from *Expenditure Budget 2025-2026: Notes on Demands for Grants*, by the Ministry of Finance, Budget Division, 2025.

Further calculations indicate that, accordingly, the budget estimates for 2024-2025 have:

a) The total expenditure by the Ministry of Science and Technology will account for almost 0.3% of government's total expenditure in 2024-2025.

b) From that 0.3%, estimated grants for the Department of Scientific and Industrial Research will account for almost 38% of expenditures.

c) In total, the Department of Scientific Research and Technology (whose 99% of expenditure goes to CSIR) will account for almost 0.13% of the expenditure of the total budget estimates of 2024-2025.

Looking at the past budget allocations to the Ministry of Science and Technology indicates that these budget estimates are the highest estimates/actuals till now, indicating that in the past, the total grants for scientific research were even less than 0.13% of total budget expenditures.

2.1 The Selection of Fellows

The selection for the award of JRF shall be made on the basis of a competitive written test called the National Eligibility Test (NET), conducted by CSIR at the national level normally twice a year in the following areas: (1) Chemical Sciences; (2) Earth, Atmosphere, Ocean, and Planetary Sciences; (3) Life Sciences; (4) Mathematical Sciences; and (5) Physical Sciences.

As per the annual report of CSIR (2022-2023), the following are the fellowship grants in different categories:

Table 2.3: CSIR Fellowship Grants by Category (2022-2023)

2022	Registered	Appeared	Qualified Fellowship & Lectureship	Qualified Lectureship Only
JRF	221746	162084	4269	4081

	2022-2023	By March 2023
SRA	60	145

Note. JRF = Junior Research Fellowship; SRA = Senior Research Associateship. Adapted from *Annual Report 2022-2023*, by the Council of Scientific and Industrial Research, 2023, pp. 117-118.

2.2 Individual Fellow Cost

Now the individual expenditure on fellowship grants by CSIR can be summed as follows:

Table 2.4: Stipend for Fellows Working in Research Schemes by CSIR

Position	1st & 2nd Year	3rd & Subsequent Year	Annual Contingency Grant
JRF	Rs. 31000/-	Rs. 35000/-	20,000/-
SRF	Rs. 35000/-	Rs. 35000/-	20,000/-
RA	The consolidated emoluments will be under the following 3 slabs, depending on qualification and experience: a) Rs. 47000/- b) Rs. 49000/- c) Rs. 54000/-		20,000/-

Note. SRF = Senior Research Fellowship; RA = Research Associate. RA emoluments depend on qualification and experience. Adapted from *Annual Report 2022-2023*, by the Council of Scientific and Industrial Research, 2023.

But apart from these major fellowships, CSIR provides the following PhD and postdoctoral fellowships as well:

- **SPM (Shyama Prasad Mukherjee Fellowships)**: Only open to toppers of CSIR-UGC JRF (NET) awardees.
  a) Stipend: 36,000/- per month
  b) **HRA (House Rent Allowance):** First two years

c) **Contingency Grant:** 70000/- p.a. May be raised to Rs. 42000/- + HRA per month from the third year onwards on the basis of assessment through interview. May be reverted to JRF (NET) if performance is not satisfactory.

- **Nehru Science Postdoctoral Research Fellowship:**
  a) Rs. 65,000/- per month plus House Rent Allowance (HRA)
  b) Contingency Grant of Rs. 3.0 lakh per annum. 25% of the contingency grant can be used for domestic and international travel, including per diem expenses.

Note: Not accounting for SPM and Nehru SPRF, as these are outliers and are granted very rarely in this cost-benefit analysis.

HRA Calculation:

Assumption: The CSIR Fellows are based on the X-category of cities receiving HRA, as the hostels are not available.

According to the 7th Pay Commission, the current rates for central government employees vary based on the classification of the city they reside in. As per our assumption, X-class cities (Delhi, Ahmedabad, Bangalore, Chennai, Mumbai, Hyderabad, Kolkata, and Pune) with a population exceeding 50 lakhs are entitled to receive a house rent allowance amounting to **24% of their basic salary**.

Table 2.5: Rent Allowance (HRA) for Fellows in CSIR Research Schemes

Position	Monthly Stipend	HRA
JRF	37,000/-	8,880/-
SRF	42,000/-	10,080/-
RA-I, RA-II, RA-III	58,000/- | 61,000/- | 67,000/-	13,920/- | 14,640/- | 16,080/-

Note. All figures are in ₹. Adapted from *Annual Report 2022-2023*, by the Council of Scientific and Industrial Research, 2023.

Accordingly, the following is the calculated amount of the fellowship's HRA grants:

❖ The average individual cost of a **junior research fellow** for a year is as follows:

Average Stipend: 37000 p.m. * 12 = 4,44,000 per annum
Average HRA: Under the given assumption of fellows residing in the X-Category, taking the average of all the above category HRA 24% of 37,000 = 8,880 monthly, implies => 8,880 * 12 = 1,06,560 per annum.
Average Annual Contingency Grant => 20,000 p.a.
Grand Average Total => 4,44,000 + 1,06,560 + 20,000 **p.a.** = Rs. 5,70,560 per annum.

❖ The average individual cost of a **senior research fellow** for a year is as follows:

Average Stipend: 42,000 p.m. * 12 = 5,04,000 per annum.
Average HRA: Under the given assumption of fellows residing in the X-Category, taking the average of all the above category HRA 24% of 42,000 = Rs. 10,080 monthly, implies => 10,080 * 12 = 1,20,960 per annum
Average Annual Contingency Grant => 20,000 per annum
Grand Average Total => 5,04,000 + 1,20, 960 + 20,000 **p.a.** = Rs. 6,44,960 per annum.

❖ The average individual cost of a **research assistant (I)** for a year is as follows:

Average Stipend: 58,000 p.m. * 12 = 6,96,000 per annum.
Average HRA: Under the given assumption of fellows residing in the X-Category, taking the average of all the above category HRA 24% of 42,000 = Rs. 13,920 monthly, implies => 13,920 * 12 = 1,67,040 per annum
Average Annual Contingency Grant => 20,000 per annum
Grand Average Total => 6,96,000 + 1,67,040 + 20,000 **p.a.** = Rs. 8,83,040 per annum.

❖ The average individual cost of a **research assistant (II)** for a year is as follows:

Average Stipend: 61,000 p.m. * 12 = 7,32,000 per annum.
Average HRA: Under the given assumption of fellows residing in the X-Category, taking the average of all the above category HRA 24% of 61,000 = Rs. 14,640 monthly, implies => 14,640 * 12 = 1,75,680 per annum
Average Annual Contingency Grant => 20,000 per annum
Grand Average Total => 7,32,000 + 1,75,680 + 20,000 = Rs. 9,27,680 per annum.

❖ The average individual cost of a **research assistant (III)** for a year is as follows:

Average Stipend: 67,000 p.m. * 12 = 8,04,000 per annum.
Average HRA: Under the given assumption of fellows residing in the X-Category, taking the average of all the above category HRA 24% of 61,000 = Rs. 16,080 monthly, implies => 16,080 * 12 = 1,92,960 per annum
Average Annual Contingency Grant => 20,000 per annum
Grand Average Total => 8,04,000 + 1,92,960 + 20,000 = Rs. 10,16,960 per annum.

Table 2.6: **Total Distribution of CSIR Allocated Funds and Annual Grants**

Fellowships	No. of Fellowships Granted	Annual Amount Spent by One Fellow	Total Amount Spent on All Grants
JRF	4,269 (in 2022)	570,560	2,435,720,640
SRA	145 (by 2023)	644,960	9,35,19,200
Research Assistants I | II | III	-	883,040 | 927,680 | 1,016,960	-
Total	-	-	2,529,239,840

Note. Adapted from *Annual Report 2022-2023*, by the Council of Scientific and Industrial Research, 2023.

We see that of the total amount that is allocated to CSIR, Rs. 5804.08 crores, according to the actuals of budget demand for grants 2022-2023, from the following table, it can be concluded that 587.57 crores are used for asset creation, which also includes the human capital formation. According to the above analysis, it can be concluded that JRF constitutes the largest share of fellowship grants, followed by SRF, which is then followed by some other very rarely granted fellowships like SPM (Shyama Prasad Mukherjee) and the Nehru Postdoctoral Programme.

Note: *The actual number of fellowships granted is not available for now in the category of research assistants and other rarely granted fellowships, which actually constitute the highest amount granted to a single researcher, and we are unable to particularly classify the amount.*

Table 2.7: CSIR Grants and Funds Released for FY 2022-2023 (Actuals)

SI. No.	Grant Components	Amount
1	Grants-in-Aid General	3477.72
2	Grants for Creation of Capital Assets	587.47
3	Grants-in-Aid Salaries	1743.41
Total	Total	5808.6

Note. Figures are in ₹ crores. Adapted from *Grants/Funds Released to CSIR*, by the Council of Scientific and Industrial Research, 2023.

From Tables 2.6 and 2.7, it can be concluded that almost 252.92 crores of the granted 587.46 crores of money is given only to the JRFs and SRFs, which constitute almost 43.05% of the total grants meant for capital formation overall.

Another important observation is that the rest of the amount (56.94%) is used for research assistants and for less frequently granted fellowships like SPM and Nehru Postdoctoral, while also constituting funds for the creation of other physical capital assets as well, like labs and other important equipment.

3. The Benefits

3.1 Public Goods

A good is a commodity or service that every member of a society can use without reducing its availability to all others, which means that one person's consumption does not reduce the amount available for others. But as we are aware, CSIR fellowships are granted to specific individuals, and there is always a number of fellows that CSIR can have, depending upon the requirements and other specific details. Hence, one clear demarcation is that these fellowships cannot follow all the norms of public goods in welfare economics concepts. But this paper tries to analyze the private and social benefits that these fellowship grants provide.

3.2 CSIR and Fellow's Work & Achievements (2022)

The Annual Report of CSIR (2022-2023) enlists the achievements and work of the whole organization, which can be summarized in the table below:

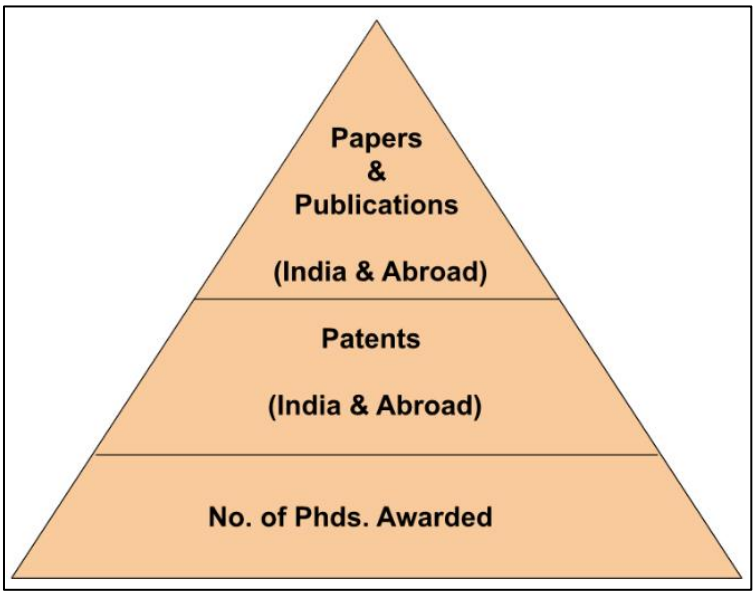
Table 3.1: Summary of Research Publications and Patents (2022)

More than 5800 Research Publications during 2022	
250 Patents Publications and Patents	
250 Patents Applications Filed in India	225 Patents Granted in India
213 Patent Applications Filed Abroad (Unique Patents filed Abroad - 121)	99 Patents Granted Abroad (Unique Patents granted Abroad - 70)

Note. Adapted from *Annual Report 2022-2023*, by the Council of Scientific and Industrial Research, 2023, pp. 44–45

A CSIR fellowship comes with three main responsibilities for the individual. These duties encompass the following areas of focus:

Figure 3.1: The Basis of Benefits Analysis for CSIR Fellows



Note. Created by the authors.

Now we will analyze the benefits of all three tasks and make an attempt to measure them in terms of money:

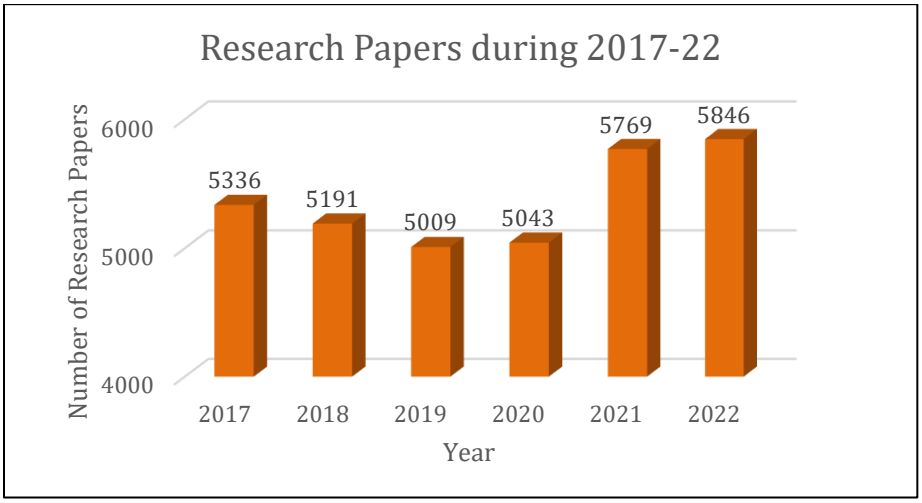
3.3 Exploring the Cost Benefits of Paper Publications by CSIR Fellows

In 1665, Henry Oldenburg founded the Philosophical Transactions of the Royal Society, marking the beginnings of academic scientific publishing (National Research Council (US) Committee on

Responsibilities of Authorship in the Biological Sciences, 2003). Publications in Industrial Research and Technology are revolutionary; they encourage scientists to “speak” directly to one another.

Although in this cost-benefit analysis it was quite a simple approach to identify the cost (from the government side), the benefits that these scientific researches carry are a whole complex phenomenon to analyze, especially in terms of money: *the unit of account*.

Figure 3.2: Number of Research Papers Published by CSIR Year-over-Year (2017–2022)



Note. Created by the authors. Data adapted from *Annual Report 2022-2023*, by the Council of Scientific and Industrial Research, 2023 (https://www.csir.res.in/sites/default/files/2024-07/csir-annual-report-2022-23-eng.pdf).

Throughout the entire fellowship, the scholar is expected to publish “at least one research paper” as the primary author. In an interview with a CSIR fellow, it was revealed that fellows typically publish no more than 2-3 high-quality research papers during their fellowship. However, there are numerous challenges and obstacles in this rigorous process, including a) delays in testing and obtaining results, and b) lack of available equipment, among others. These delays in publication significantly harm scientific research and publications, as studies and topics are often "picked off" by others with similar interests.

It is quite evident that the benefits of publications are enormous; some of them can be listed below:

a) **Institutional Prestige:** Highlighted in the CSIR Annual Report (2022-2023), the publication of 5800 papers reflects the efforts of the scientific research institution both domestically and internationally. Notably, the CSIR-National Institute for Interdisciplinary Science and Technology (CSIR-NIIST), part of CSIR, has achieved the top rank among

Indian government research institutions, climbing from 425 to 353 in the global rankings. Additionally, in 2016, the Council of Scientific & Industrial Research (CSIR) was ranked 12th worldwide among government institutions, improving its spot from 14th for three straight years, as per the 2016 Scimago Institutions Rankings report. The overall global position of CSIR also advanced from 110 to 99th. Institutes whose scientists publish their findings typically receive the intellectual credit, recognition, and prestige that come with such disclosure to the entire scientific community.

b) National Prestige: Maintaining strong institutions in a country boosts its national prestige. Various global indicators measure countries by their skills and scientific competence. Maintaining national prestige, institutions play a key role by bolstering it. Various global indicators evaluate nations based on the competence and scientific outlook of their people. India's position in the **Global Innovation Index (GII) has significantly improved, moving from 81st place in 2015 to 40th in 2022.** This consistent rise in GII rankings highlights India's advancements due to collaborative efforts between the government and industry. The GII has acknowledged India's steady progress, attributing it to the collaborative efforts of the government and industry.

c) **Feeling of Competition and Boosting Scientific Spirit**: Journals and publications instill a sense of rivalry among researchers to be the first to announce new discoveries, a motivation still prevalent in today's scientific periodicals. If the publication is well-known, it gives the researcher added prestige. These journals build on prior knowledge and elevate the quality of research and innovation, leveraging the work of earlier scientists.

d) **Personal Advantages of Publishing Papers:** Especially during their fellowships, fellows must publish at least one research paper to finish their PhD and work within the organization. It is also clear that having publications boosts one's job opportunities, serving as proof of a person’s intellectual and scientific expertise. Publishing improves the resume and enhances an individual's self-esteem by boosting confidence in their research and academic achievements.

e) **Money & Earnings:** Rather than creating an overly optimistic picture of publishing research papers and making money for a CSIR fellow, here's a reality check: “Researchers sometimes need to pay to publish their papers” in various journals. Therefore, instead of earning income, they often have to cover publishing costs to have their work validated. Additionally, for CSIR fellows, it's clear that when they are not supposed to pay, their publications are not solely their own as they involve contributions from scientists, advisors, and the institution, ensuring the work is collectively validated before being published.

How do we measure the benefits of publications in terms of money?

1. **Copyrights:** The published papers in academic and scholarly journals are protected under copyright laws. This protection means that the contents of these papers, including text, data, figures, and other elements, are the intellectual property of the authors and the journals in which they are published. Consequently, if researchers or other individuals wish to use any part of that research-whether it involves reproducing sections of text, citing specific results, or incorporating data into new studies-they must obtain permission from the copyright holders. This process often involves formally requesting permission and may require the ***payment of fees***. The amount of money charged can vary widely and depends on the policies and discretion of the publishing authority or the individual author. Generally, the fees and terms of use are stipulated in the licensing agreements provided by the publishers. It's important for researchers and academics to be aware of these restrictions to avoid potential legal issues and to ensure that they are in compliance with intellectual property laws and ethical standards in research and publication. Copyright compliance not only respects the rights of the original authors but also fosters a culture of academic integrity and responsible scholarship.

2. **Publication Websites & Revenue:** Many top-tier academic journals are not freely accessible to the general public. To view these publications, readers must use platforms such as Elsevier, Springer, Wiley Online Library, Taylor & Francis Online, Nature Research, American Chemical Society, IEEE Xplore Digital Library, ScienceDirect, SAGE Journals, and Oxford University Press - Oxford Academic. These websites employ a profit-generating system that ultimately benefits both the authors and publishing entities like CSIR. This revenue model allows for the dissemination of high-quality research while supporting the academic community involved in its creation and distribution. This revenue model is described below:

    a) *Subscription fees*: Publishing institutions often charge subscription fees to access their scientific research publications. This revenue stream comes from individuals, universities, companies, and government agencies who pay to access the latest research findings.

    b) *Article processing charges* (APCs): Some publishing institutions charge authors a fee to publish their research articles in their journals. These fees help cover the costs associated with editing, formatting, and peer-reviewing the articles.

    c) *Advertising and sponsorships*: Publishing institutions may also generate revenue through advertising and sponsorships on their websites. Companies, organizations, and academic institutions may pay to have their products or services featured on the website or in the publications.

Overall, revenue from publications of scientific research in industries comes from a combination of sources, including subscription fees, APCs, advertising and sponsorships, licensing agreements, and government funding. This revenue is crucial for publishing institutions to continue producing high-quality research and maintaining their online platforms.

3.4 The Benefits in Terms of Money for Patents Filed and Granted (India & Abroad)

The Council of Scientific & Industrial Research's (CSIR) Innovation Protection Unit (IPU) safeguards intellectual property created across CSIR, including patents. CSIR manages patent filing, prosecution, and maintenance for research and development (R&D) outcomes from its labs and institutes, both domestically and globally. Among Indian publicly funded R&D organizations, CSIR has secured over 90% of US patents filed and boasts an extensive patent collection. Its licensing rate of about 9% surpasses the global average[2]. CSIR-India leads worldwide in patent filing and acquisition among peer publicly funded research entities. CSIR's intellectual property has generated significant economic value and societal benefits. For instance, the Soft Coke Over Technology has yielded 342 licenses with a Direct Value Creation Multiple of at least 400. Additionally, a set of patents related to polycarbonate chemistry and technology was licensed to General Electric (GE) Plastics, resulting in licensing and research revenue exceeding **$10 million USD**.

CSIR's patent portfolio has served dual purposes, acting as both a strategic asset and a tactical tool. These intellectual property rights have been instrumental in fostering a robust national industry, shielding Indian firms from unauthorized use, and equipping them with the necessary IP backing to compete in global markets. The organization's intellectual property has also enhanced its reputation and showcased India as a hub of innovation. Through its accomplishments, CSIR has proven to the international community that India stands on par with other nations in terms of creativity and patent acquisition, effectively dispelling the misconception that the country relies solely on imitation and replication.

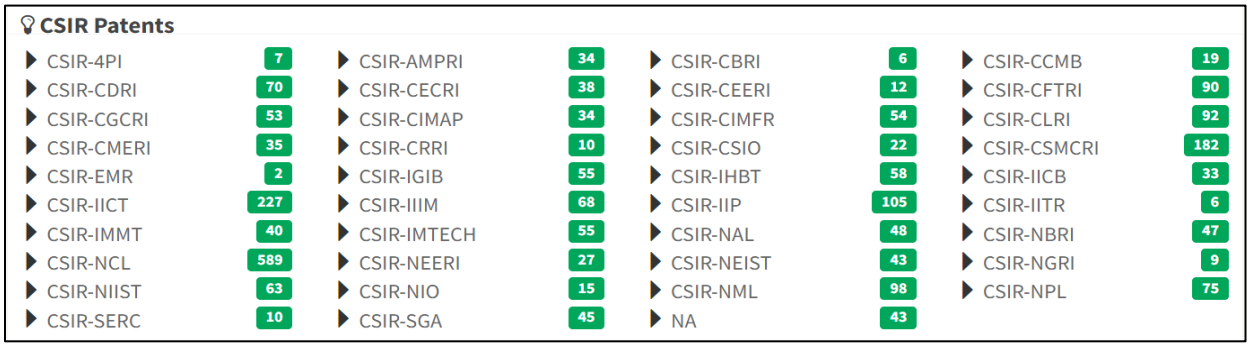
Patents & Money Creation:

CSIR's patent filings have proven to be a significant source of revenue for the country. These patents grant inventors exclusive rights to their innovations, allowing them to determine pricing at their discretion. In the 2021-22 period, CSIR submitted 229 patents domestically and 202 internationally. The organization currently maintains 1,132 active unique patents, with **140 of these being commercially utilized.** Additionally, CSIR holds 2,587 valid patents across various nations worldwide. These patents serve as valuable organizational assets, made possible by the exceptional intellectual capacity within CSIR - namely, the researchers who begin their careers

[2] Patestate - CSIR India Patent Database

and receive support through CSIR Fellowships. The monopolistic nature of patents enables innovators to control the market for their groundbreaking technologies.

Table 3.2: Number of Patents by Various Institutes of CSIR



CSIR Patents							
CSIR-4PI	7	CSIR-AMPRI	34	CSIR-CBRI	6	CSIR-CCMB	19
CSIR-CDRI	70	CSIR-CECRI	38	CSIR-CEERI	12	CSIR-CFTRI	90
CSIR-CGCRI	53	CSIR-CIMAP	34	CSIR-CIMFR	54	CSIR-CLRI	92
CSIR-CMERI	35	CSIR-CRRI	10	CSIR-CSIO	22	CSIR-CSMCRI	182
CSIR-EMR	2	CSIR-IGIB	55	CSIR-IHBT	58	CSIR-IICB	33
CSIR-IICT	227	CSIR-IIIM	68	CSIR-IIP	105	CSIR-IITR	6
CSIR-IMMT	40	CSIR-IMTECH	55	CSIR-NAL	48	CSIR-NBRI	47
CSIR-NCL	589	CSIR-NEERI	27	CSIR-NEIST	43	CSIR-NGRI	9
CSIR-NIIST	63	CSIR-NIO	15	CSIR-NML	98	CSIR-NPL	75
CSIR-SERC	10	CSIR-SGA	45	NA	43		

Note. Adapted from *CSIR Patents*, by the Council of Scientific and Industrial Research, 2023.

3.5 PhDs Awarded

CSIR Junior Research Fellows must enroll in a PhD program within two years of starting their fellowship. If they don't, they won't be promoted to Senior Research Fellow after two years. However, CSIR might extend their Junior Fellowship for one more year or end it altogether, based on what a three-person evaluation team suggests1. These fellowships are designed to help create the next generation of scientists by supporting them through their doctoral studies.

Benefits in terms of money from PhDs Awarded:

The journey of a doctoral student is often viewed as a path to academic and scientific excellence. After years of rigorous study and research, these scholars and scientists emerge with their hard-earned PhD degrees, armed with specialized knowledge and a passion for discovery. The expectation is that they will seamlessly transition into roles where they can fully immerse themselves in their chosen fields of research, working tirelessly in state-of-the-art laboratories to push the boundaries of human knowledge.

These newly minted PhDs are anticipated to become the torchbearers of scientific progress, carrying forward the legacy of their institutions and contributing to their nation's scientific advancement. They are expected to publish groundbreaking papers, secure research grants, and make significant contributions to their disciplines. Moreover, society looks to them as mentors and guides for the next generation of aspiring scientists, fostering a continuous cycle of innovation and discovery.

The romanticized view of post-doctoral life often includes visions of cutting-edge experiments, collaborative projects with fellow researchers, and the excitement of unraveling nature's mysteries. Many imagine these scholars presenting their findings at prestigious conferences, engaging in stimulating debates with peers, and perhaps even making discoveries that could change the world.

However, the stark reality that many PhD graduates face stands in stark contrast to these lofty expectations. When confronted with the question of what lies ahead after obtaining their doctorate, an alarming number of these highly qualified individuals give a response that shatters the illusion of guaranteed success: "UNEMPLOYMENT"

This harsh truth reveals a growing crisis in the academic and scientific job market. Despite their extensive education and specialized skills, many PhD holders find themselves struggling to secure positions in their fields. The reasons for this discrepancy between expectations and reality are:

1. **Limited job prospects plague the system**: the government struggles to fully utilize the funding allocated for CSIR fellows by failing to create sufficient work opportunities. The stark imbalance between available positions in Indian research institutions and the number of PhD graduates is evident. The high-caliber education provided by prestigious institutes like CSIR ensures the quality of these scholars is not in question. However, this situation raises concerns about the lack of proper "chances" for these qualified individuals to contribute their expertise in the workforce.

2. **Constrained resources:** Numerous scientific organizations and academic centers struggle with financial limitations, resulting in a scarcity of career opportunities and decreased support for innovative initiatives. Consequently, the meager 0.13% of overall budget allocations (based on 2024-2025 projections) falls short of meeting the nation's scientific advancement needs. This insufficient funding requires immediate attention and expansion to enable these institutions to employ and engage a greater number of researchers, rather than having them work independently from home or remain jobless.

3.6 Brain Drain or Foreign Gain: The Global Talent Tug-of-War

The scarcity of suitable positions and prospects within the country has become increasingly apparent. Yatharth Gulati, who co-established Rostrum Education, an advisory service assisting Indian students with international applications, informed Times Higher Education about a significant uptick in Indian doctoral candidates seeking opportunities abroad. He reported a 70 percent surge in Ph.D. applicants reaching out to Rostrum since last year. Gulati elaborated on the underlying cause, stating, "There's a palpable sense of insecurity surrounding doctoral programs and their associated stipends in our nation. The irregular nature of funding and scholarships in India often leaves students struggling financially throughout their studies." A report by the

National Science Foundation indicated that there were approximately 950,000 scientists and engineers of Indian origin in the United States alone as of 2013. Additionally, it's noted that a significant percentage of scientists at NASA are of Indian origin.

For once, this statistic is, of course, a matter of concern for the Indian government and scientific institutions, mainly CSIR, that there is a brain drain. But if taken into consideration in our cost-benefit analysis, these people working abroad surely do not contribute to the country's GDP (gross domestic product), but in *national income accounting, their fancy incomes from working abroad are surely taken into account*.

However, upon careful consideration, the following table indicates the difference between India's GDP (gross domestic product) and GNP (gross national product):

Table 3.3: Net Factor Income from Abroad at Current Prices (2020-2024)

Year	GNP	GDP	Net Property Income from Abroad
2020-2021	₹ 19,587,409.00	₹ 19,854,096.00	-₹ 266,687.00
2021-22	₹ 23,319,590.00	₹ 23,597,399.00	-₹ 277,809.00
2022-23 (1st RE)	₹ 26,579,339.00	₹ 26,949,646.00	-₹ 3,70,307.00
2023-2024 (PE)	₹ 29,104,354.00	₹ 29,535,667.00	-₹ 431,313.00

Note. *GNP = Gross National Product; GDP = Gross Domestic Product; RE = Revised Estimates; PE = Provisional Estimates. Net Factor Income from Abroad is calculated as GNP - GDP. Adapted from National Accounts Statistics, by the Ministry of Statistics and Programme Implementation.*

Though some view brain drains as a foreign advantage rather than a loss, the data in Table 3.3 shows a negative income from overseas. This unexpected outcome stems from net factor income abroad, including both goods and services trade. India's growing imports play a big role in this negative balance, despite many Indian professionals working internationally. In our case, the small gap between GDP and GNP, even if negative, indicates that foreigners in India earn slightly more than Indians abroad. However, we must recognize that our scientists overseas are still making positive contributions to our national income through their work and earnings.

3.7 Econometric Analysis

To move beyond descriptive analysis and empirically validate the conversion rate of high-quality research output (Publications) into commercial innovation (Patents), a cross-sectional econometric analysis was conducted on a refined sample of N=33 CSIR research institutes for the fiscal year 2022-2023.

The analysis employed a **Linear-Log OLS Regression** to model the relationship between the natural logarithm of the weighted top-tier publications score (ln (PUBLICATIONS_TOP)) and the absolute number of Indian patents filed (PATENTS).

Hypothesis Testing and Model Significance

The model tested the following hypotheses regarding the slope coefficient, $\beta 1$:

- **Null Hypothesis (H0):** $\beta 1=0$ (No statistically significant relationship between academic publication activity and patent filings).
- **Alternative Hypothesis (H1):** $\beta 1>0$ (A positive and statistically significant relationship exists, indicating academic merit drives innovation output).

The regression yielded highly significant results:

- The **P-value for the slope coefficient (β1) was 0.0317**.
- Since $0.0317<0.05$, the H0 is **rejected** at the 5% significance level.
- The model as a whole was statistically significant, with a **Prob(F-statistic) of 0.0317**, confirming that the model provides a reliable fit superior to a null model.

This conclusive rejection of the null hypothesis demonstrates that the high-quality academic output (Publications) generated by the human capital of the fellowship scheme has a **statistically significant positive impact on the volume of patent filings** across the CSIR ecosystem.

Interpretation of Marginal Effect and Model Fit

The model's significant slope coefficient ($\beta 1=5.677$) quantifies the marginal effect of R&D capacity on innovation:

- **Marginal Effect:** A **one percent increase** in an institute's weighted top-tier publications score is associated with an absolute **0.05677 increase in Indian patent filings** (1005.677). This provides the quantitative link, proving the successful conversion of the "Papers" benefit into the "Patents" benefit.

- The **R^2 value of 0.1404** indicates that approximately 14.04% of the variation in patent filings is explained by the variations in top academic publication scores. While this confirms significance, the relatively low value suggests that 86% of the variation in patent output is driven by factors external to academic publication strength, such as dedicated commercialization funding, technology readiness, or industry collaboration mandates.

Analysis Conclusion

Social Cost-Benefit Analysis, we assessed the immense value derived from the government's investment in the CSIR Fellowship Scheme, reframing the output as a driver of **Technological Inclusion**. The analysis quantified the benefits across the three key metrics-PhDs, Publications, and Patents-and confirmed the scheme's efficiency in creating high-value human capital (PhDs).
The study's most critical finding is the **quantitative validation of the research-to-innovation lifecycle**. The econometric analysis found a **statistically significant positive elasticity** between high-quality academic output and patent generation ($p=0.0317$), demonstrating that the primary scientific benefit ('Papers') produced by fellowship holders successfully translates into the primary economic benefit ('Patents'). This result formally rejects the notion of a disconnect, proving that the public investment is actively generating valuable intellectual property for India.

However, this confirmation comes with a vital policy caveat. While the relationship is significant, the model fit ($R^2=0.1404$) suggests that **over 85% of patent success is determined by other factors** not accounted for by academic activity alone.

Therefore, to maximize the scheme's returns and ensure its role as a driver of **Technological Inclusion and equitable development**, policy must pivot from merely funding academic capacity to actively funding **translational efficiency**:

1. **Strategic Focus on Societal Needs:** Future research grants must rigorously prioritize areas that directly address mass-market challenges (e.g., affordable healthcare, sustainable infrastructure) to ensure the newly generated technology drives broad societal inclusion.

2. **Bridging the Gap:** Capital investment allocated for 'Capital Assets' must be coupled with mandates for collaboration and commercialization, explicitly directing the positive conversion rate demonstrated by this study toward commercial outcomes and job creation.

The CSIR Fellowship Scheme has proven itself as a powerful, statistically justified engine for generating high-caliber R&D human capital. By strategically addressing the remaining **86%** of the unexplained variation-through focused funding and stronger translational policies-India can ensure this cornerstone investment delivers on its mandate for a truly technologically inclusive and self-reliant future.

Figure 3.3: Regression Analysis of Patents against Log-Transformed Publications

```
> summary(sg)
    Patents         Publication
 Min.   : 0.000   Min.   : 15.90
 1st Qu.: 1.000   1st Qu.: 37.30
 Median : 4.000   Median : 66.80
 Mean   : 6.848   Mean   : 77.83
 3rd Qu.: 9.000   3rd Qu.: 95.90
 Max.   :61.000   Max.   :331.20
> skewness(sg$Publication)
[1] 2.374717
> skewness(sg$Patents)
[1] 3.940061
> kurtosis(sg$Patents)
[1] 19.78515
> IQR(sg$Publication)
[1] 58.6
> IQR(sg$Patents)
[1] 8
```

```
> reg1=lm(sg$Patents~log(sg$Publication))
> summary(reg1)

Call:
lm(formula = sg$Patents ~ log(sg$Publication))

Residuals:
    Min      1Q  Median      3Q     Max
-14.518  -5.084  -1.460   1.894  46.068

Coefficients:
                    Estimate Std. Error t value Pr(>|t|)
(Intercept)          -16.424     10.498  -1.565   0.1279
log(sg$Publication)    5.677      2.523   2.250   0.0317 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 10.28 on 31 degrees of freedom
Multiple R-squared:  0.1404,    Adjusted R-squared:  0.1126
F-statistic: 5.062 on 1 and 31 DF,  p-value: 0.0317
```

Note. Created by the authors using R statistical software. The model shows a significant positive relationship between log-publications and patent output ($p < .05$).

4. CSIR Consulting Services

CSIR labs are primarily research and innovation centers that provide expert advice rooted in scientific principles within their specialized fields. The majority of their technological advancements occur in cutting-edge domains, ensuring that CSIR's knowledge and assistance are of top-tier quality and at the forefront of innovation. Their most valuable resource is their highly skilled workforce. This sets them apart from other consulting firms, as CSIR employs full-time experts in specific scientific and technological areas. This contrasts with general management or technical advisory companies, which typically bring in specialists on a project-by-project basis. Businesses have come to recognize that CSIR uniquely offers a wide range of disciplines in one place, providing the following services:

1) Process Simulation, Optimization, and Energy Conservation.
2) Process Improvements and Modernization Studies.
3) Process Design and Engineering.
4) Research and Technology Management.
5) Project Planning and Development.
6) Product, Application, and Market Development.
7) Technology Search, Evaluation, and Selection.
8) Analytical and other technical services.

The Council of Scientific and Industrial Research (CSIR) has adopted a strategic approach to enhance its impact and financial sustainability. By fostering collaborations with industrial partners, both within the nation and internationally, CSIR is successfully expanding its revenue streams while simultaneously creating valuable opportunities for its talented workforce.

These partnerships serve multiple purposes. Firstly, they allow CSIR to leverage its extensive human capital, comprising highly skilled scientists, researchers, and technicians, in projects that have direct industrial applications. This not only generates additional income for the organization but also ensures that the expertise of its personnel is utilized to solve real-world problems and drive innovation in various sectors.

Moreover, by engaging with diverse industrial partners, CSIR exposes its staff to a wide range of challenges and cutting-edge technologies. This exposure enhances their skills, broadens their perspectives, and keeps them at the forefront of scientific and technological advancements. The collaborative projects often involve interdisciplinary work, encouraging cross-pollination of ideas and fostering a culture of innovation within the organization.

The international collaborations, in particular, play a crucial role in elevating CSIR's global standing. They facilitate knowledge exchange, enable access to advanced research facilities, and open doors to new markets for CSIR's technologies and services. These partnerships also contribute to India's scientific diplomacy efforts, strengthening ties with other nations through mutually beneficial research and development initiatives.

5. Conclusion

In this comprehensive cost-benefit analysis, we embarked on an examination of the government's substantial investment of approximately Rs. 5804.08 crore, as per the actual expenditure in the 2022-2023 budget, allocated to the Council of Scientific and Industrial Research (CSIR). This significant sum is utilized for operating the organization, with a considerable portion dedicated to the CSIR Fellowship program. Our analysis focused primarily on three key factors intrinsically linked to the fellows and CSIR: scientific publications, patents, and doctoral degrees (PhDs) awarded. These three elements alone have proven more than sufficient to elucidate the manifold benefits, both in terms of social impact and economic capital generation.

The publication financial mechanism employed by CSIR has been a cornerstone of its success. Through this system, researchers are incentivized to produce high-quality scientific papers, contributing to the global knowledge pool and enhancing India's reputation in the international scientific community. These publications not only advance scientific understanding but also attract collaborations and funding opportunities from both domestic and international sources, further amplifying the impact of the initial government investment. Perhaps even more impressive is

CSIR's track record in patent commercialization. With 140 successfully commercialized patents, many of which have generated revenue exceeding $10 million USD, CSIR has demonstrated its ability to translate scientific research into tangible economic benefits. A prime example of this is the groundbreaking work in polycarbonate chemistry and technology, which was licensed to General Electric (GE) Plastics. This single licensing agreement has yielded substantial returns, more than justifying the government's initial investment. Such successful commercialization not only generates revenue but also positions India as a key player in the global innovation landscape.

Moreover, the CSIR Fellowship program's role in producing highly skilled PhDs and scientists cannot be overstated. These individuals go on to conduct thought-provoking scientific research, push the boundaries of human knowledge, and provide crucial technological access to the nation. The impact of their work extends far beyond what can be measured in monetary terms. These scientists contribute to solving pressing national and global challenges, from climate change to healthcare, and drive innovation across various sectors of the economy.

The fundamental principle for achieving societal balance over time is straightforward: the community-wide marginal expense of an investment should match its collective marginal advantage. As time progresses, the overall national investment, with a specific focus on CSIR Fellowships, ought to be pursued until the point where the "correctly" determined marginal efficiency of investment precisely aligns with an appropriate interest rate.

The ripple effects of CSIR's work are far-reaching. By fostering a culture of scientific inquiry and innovation, CSIR helps create a knowledge-based economy, attracting foreign investment and creating high-value jobs. The organization's efforts also contribute to India's self-reliance in critical technological domains, reducing dependence on foreign expertise and strengthening national security.

In conclusion, while our analysis focused on just three primary factors-publications, patents, and PhDs-the benefits derived from the government's investment in CSIR extend far beyond these metrics. The organization's work catalyzes scientific progress, drives economic growth, enhances national prestige, and improves the quality of life for citizens. As such, the return on investment, both tangible and intangible, far exceeds the initial financial outlay, making CSIR a cornerstone of India's scientific and technological advancement.

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