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ORIGINAL ARTICLE

The effectiveness of research and development tax incentives in India: a quasi-experimental approach

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Abstract Globally, governments provide significant tax incentives to business enterprises for research and development (R&D) expenditure to foster innovation. Several fiscal incentives are provided to firms registered under India's department of scientific and industrial research (DSIR). India provided a super deduction of 200% on R&D expenses in 2011, reduced to 150% in 2016 and 100% in 2020. The study uses firm-level data to test the effectiveness of incentives offered in India and analyze the impact of the rationalization of super deduction. For the study, the difference in difference analysis is done to evaluate the changes in the outcome variables: total, current, and capital R&D expenditures. The treatment group is the firms registered under DSIR. The results show a significant impact of the mix of tax incentives provided on both current and capital expenditures. The super deduction significantly impacted only current expenses and not capital expenditures. The administrative costs under current expenditures are easier to relabel than capital expenditures. The study shows that the overly generous regime incentivized firms to relabel their non-R&D costs as R&D expenses for profiteering. The study supports the move to reduce the super deduction.

Keywords R&D · Tax incentives · Quasi-experiment · Difference-in-differences

JEL Classification H26 · H32 · O3

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1 Introduction

Business enterprises' expenditures on Research and Development (R&D) play a critical role in promoting innovation. Joseph Schumpeter described innovation as "Creative Destruction" and identified it as a key to economic growth (Schumpeter 1962). Additionally, Endogenous growth theories have emphasized the significance of innovation and technological advancement for growth. (Lucas 1988; Romer 1990). Recent studies have also shown that innovation promotes firm-level competitiveness (Bacinello et al. 2020; Qiu et al. 2020; Suat and San 2019). A vast literature has shown that innovation increases productivity (Griliches 1958, 1980; Mansfield 1965; Griliches et al. 1984; Mansfield 1984; Mun et al. 1991; Nadiri and Kim 1996; Frantzen 1998; Aghion and Howitt 1998; Klette & Kortum 2002).

Firms' lack of investment in R&D is caused by financial limitations and variations in social and private returns. As a result, governments have been motivated to step in and offer incentives to encourage more R&D investment. (Nelson 1959; Arrow 1962; Aghion and Howitt 1992; Jaffe 1996; Hausmann et al. 2003; Rodrik 2004a, b.)

Many countries use R&D tax incentives as policy tools. These incentives can lower the cost of R&D, and are known as input-based incentives. Examples include Tax Deferrals, Allowances, Credits, Concessional Import Tariffs, GST, and Accelerated Depreciation. Other incentives can increase profits earned from R&D, such as Rate Relief, Tax Holidays, and the Patent Box Regime. Several R&D tax incentives in India are available to firms registered under the Department of Scientific & Industrial Research (DSIR). If eligible, firms not registered under DSIR can still claim an income tax deduction on R&D expenses and benefits from the patent box regime and tax holidays. For a summary of tax incentives provided by India and recent changes, see Table 1.

Table 1 Recent changes in R&D tax incentives

S. no.	Incentives	Recent changes
1	Customs duty exemptions	Union budget 2022–23 announced immediate withdrawal of basic customs duty (BCD) exemptions on goods used for Research and development in agro-chemical sector unit
		End-date of 31.03.2023 is prescribed in Union Budget 2022–23 for goods used in the pharmaceutical and biotechnology sector
		All the entries in the notification 50/96-Customs dated 23.07.1996, unless varied or rescinded, will have validity up to 31.03.2023
		Continues
2	Income tax deduction	The rate of weighted tax deduction has been lowered from 200 to 150% from 1st April 2017, and from Annual Year 2021–22, the tax deduction is 100% of the expenditure incurred
3	Accelerated depreciation	Continues
4	Concessional GST rate	Continues
5	Patent box regime	It was introduced in 2016
6	Tax holiday	A one-year extension to the start-ups incorporated till March 31, 2023, was provided under Union Budget 2022–23. The incentive was introduced in 2016

After the pandemic, evaluating the cost of tax incentives is important. The Indian government has made some changes to their policies, which are listed in Table 1. Companies registered under DSIR can receive benefits such as Weighted Tax deduction, Concessional Customs duty, Concessional GST Rate, and Accelerated Depreciation. However, they must fulfill certain requirements such as setting up R&D centers with specific areas and employees, as well as keeping audited accounts of R&D expenditures. One major incentive is the income tax-weighted deduction of 200% on R&D expenditures, also known as the Super deduction. Firms can receive an income tax deduction on R&D expenditures under Sect. 35 of the IT Act, 1961. India has a broader definition of qualifying expenses for exemption compared to other countries, with all current and capital expenses being eligible except for land or building costs. The deduction has changed over time, with it being revised to 150% in 2000–01, 200% in 2010–11, 150% in 2016–17, and finally reduced to 100% from the annual year 2021–22. The study aims to test how effective the incentives provided under DSIR are and evaluate the impact of the rationalization of the Super deduction.

The Super Deduction tax incentive for R&D expenses has the potential downside of encouraging companies to mislabel their non-R&D administrative costs as R&D to take advantage of the 200% tax deduction. This issue has been identified in other countries as well, such as in studies by Mansfield and Switzer (1985), GAO (1989, 2009), Bloom et al. (2019), and Chen et al. (2021). This paper aims to investigate whether Indian firms also engage in this practice of relabelling expenses. While no previous studies have examined this issue in India, this paper fills that gap by providing new evidence on relabelling practices. The quasi-experimental approach of difference-in-difference analysis is used to address potential data endogeneity issues.

The rest of this paper is organized as follows: Sect. 2 provides an overview of the research background and hypothesis development. Section 3 describes the data and methodology. Section 4 presents the findings. Finally, Sect. 5 concludes with some reflections on the implications of our results.

2 Research background and hypothesis development

There are two main types of studies that evaluate the effectiveness of tax incentives: those that measure the impact on individual companies (micro level) and those that measure the impact on a larger scale (macro level). The macro-level studies use overall research and development spending as the dependent variable and examine the effects of tax incentives at the national and state levels. Researchers such as Bloom et al. (2002), Athukorala and Kohpaiboon (2010), McKenzie and Sershun (2010), Moretti and Wilson (2017), and Brown et al. (2017) have conducted studies in this area.

At the micro level, studies have been conducted to evaluate the effects of R&D tax incentives on firms. These studies measure the impact of such incentives on a company's production of new products or processes patents (output additionality) and on its R&D expenditures (input additionality) (Cappelen et al. 2008; Czarnitzki et al. 2011; Colombo et al. 2011, Ivus et al. 2021). The input additionality studies use micro econometric analysis techniques to analyze the impact of R&D tax or generosity of tax on the R&D expenditures of the firm (Berger 1993; Hall and van Reenen 2000; Bloom et al. 2002; Corchuelo and Martinez-Ros 2009; Czarnitzki et al. 2011; Duguet 2010). Some studies have used surveys for R&D data (Oxeraa 2006; Czarnitzki et al. 2011; Cappelen et al. 2012; Lokshin and Mohnen 2012; Lokshin and

Table 2 Number of firms recognised under the DSIR over the years. Source: Own compilation from various annual reports of the department of scientific & industrial research (DSIR)

	2011–2012	2012–2013	2014–2015	2015–2016	2016–2017	2017–2018	2018–2019	2019–2020	2021–2022
In-house R&D units recognition	1618	1767	1762	1800	1880	1997	2052	2238	2481
New recognition	151	149	105	161	183	163	234	186	141

Mohnen 2013; Mulkay and Mairesse 2013; Guceri 2018) and some studies used annual reports and administered corporate return data for analysis (Yang et al. 2012; Rao 2016; Dechezleprêtre et al. 2016; Guceri and Liu 2019; Agrawal et al. 2020; Chen et al. 2021; Ivus et al. 2021). For this particular study, R&D data from audited annual reports of firms in the country were obtained from the CMIE prowess database.

Several studies have focused on the issue of relabelling expenses (Eisner et al. 1984; Mansfield and Switzer 1985; GAO 1989, 2009; Guceri 2018; Bloom et al. 2019; Chen et al. 2021). The US GAO conducted studies in 1989 and 2009, highlighting concerns over the definition of qualifying expenses and their monitoring. This issue is particularly problematic for developing countries. A recent study by Chen et al. 2021 found that relabelling accounts for 24.2% of reported R&D. It's important to keep in mind that obtaining DSIR certification involves maintaining a separate record of R&D expenses that Statutory Auditors have verified. The firms must also provide information about their projects to renew their certificates periodically. Administrative expenses can only be reclassified as current expenditures to a limited extent. A meta-analysis of microeconomic studies has revealed that R&D tax incentives have a greater impact on current expenditures than capital expenditures (Ladinska et al. 2015). This study aims to determine the effectiveness of R&D tax incentives in stimulating capital and current expenditures while also checking for any signs of reclassification.

One of the main issues with analyzing data is the presence of endogeneity problems, which occur when companies choose to participate in incentive programs on their own. This is also the case in India, where firms self-select and register under DSIR to receive benefits. Due to this concern, several studies use a direct approach to analysis, including Regression Discontinuity, Matching Analysis, or Difference-in-Difference Analysis (Hægeland and Møen 2007; Corchuelo and Martínez-Ros 2009; Yohei 2011; Yang et al. 2012; Bozio et al. 2014; Agrawal et al. 2014; Rao 2016; Dechezleprêtre et al. 2016; Bronzini and Piselli 2016; Guceri 2018; Wang 2018; Ivus et al. 2021). In this study, we use the difference in difference analysis methodology based on a recent survey of incentives in India by Ivus et al. (2021). However, there are two main differences from their study. Firstly, our data covers a longer period, from 2011 to 2021, and focuses on the impact of reducing the super deduction from 200 to 150% on R&D expenditures and patents. Secondly, we test the effects on current and capital expenditures separately, as no previous study has examined the presence of relabelling in India. Our main contribution is to provide evidence of relabelling in the country.

3 Data and methodology

This study primarily utilizes data extracted from two sources: the CMIE prowess database and the DSIR directory of in-house R&D units. The CMIE prowess database contains information on individual companies, gathered from audited annual reports, the Ministry of Company Affairs, and company filings with stock exchanges. This database includes data on the firms' capital, current and total R&D expenditures, and other financial information. The yearly data of firms registered with the DSIR is obtained from the department's annual DSIR directory. Table 2 displays the number of firms registered under DSIR and new recognitions from 2011 to 2021.

In this paper, we examine the R&D spending of companies in two categories: financial and non-financial. The non-financial category comprises firms from various major industries such as manufacturing, mining, electricity, construction, real estate & irrigation, and services. The study collects extensive data from a diverse range of companies operating within these categories. Most of the analyzed companies belong to the Drugs & Pharmaceutical and Computer Software industry groups.

The treatment dummy is the DSIR status of the ith firm in the jth year and is denoted by D_{it}. The variable takes value one if the firm i is registered with the DSIR in year j; otherwise, the value is zero. This divides the sample into two groups. The treated group is the firms registered under DSIR, and the control group is the group of firms not registered under DSIR. The variable C_t is the year when the super deduction incentive was available and takes value one for 2011–2016. So, the interaction term $D_{it}C_t$; allows for the difference in the impact of the change in tax incentive on R&D expenditure across two groups.

Table 3 Outcome and control variable

Outcome variables	
Log of total R&D intensity	Log of (total R&D expenditures/sales)
Log of capital R&D intensity	Log of (capital R&D/sales)
Log of current R&D intensity	Log of (Current R&D/sales)
Control variables	
Age	Number of years since operation
Exporter	A dummy variable = 1 if firm is an exporter
Importer	A dummy variable = 1 if firm imports capital goods
Leverage	Total borrowings divided by total assets of the firm
Firm size	Log of gross value of fixed assets

In this study, we use the variable D_{it} to represent the DSIR status of the ith firm in the jth year. This variable takes on a value of one if the firm is registered with DSIR in that year and zero otherwise. Using this variable, we divide our sample into two groups: the treated group, consisting of firms registered under DSIR, and the control group, consisting of firms not registered under DSIR.

Additionally, we use the variable C_t to represent the year when the super deduction incentive was available. This variable takes on a value of one, from 2011 to 2016. By creating an interaction term between $D_{it}C_t$, we can analyze the difference in the impact of the change in tax incentive on R&D expenditure across the two groups.

The difference-in-difference specification of the model is as follows:

$$LogRD_{it} = \alpha + \alpha_t + \beta D_{it} + \gamma D_{it}C_t + \delta X'_{it} + \epsilon_{it} \tag{1}$$

where RD_{it} is one of the three measures of ith firm's R&D intensity in jth year, which is calculated by dividing the R&D expenditures by the firm's sales. The three outcome variables are total R&D intensity, capital R&D intensity, and current R&D intensity. α_t denotes the time-fixed component in the model. The percentage difference between DSIR registered and non-DSIR firms is $(e^{\beta-1})100$. The coefficient γ captures the differential change before 2016 for the treatment group compared to the control group. The percentage treatment effect of the change is $(e^{\gamma-1})100$. The X_{it} is a vector with a size of K × 1. Various control variables of the vector include Technology Imports, Firm Size, Leverage, importer dummy, exporter dummy, and age (which are listed in Table 3). The vector also includes a constant and ϵ_{it}, which represents a stochastic constant term. Table 4 shows the summary statistics of these variables.

4 Findings

Out of the 1244 firms included in the sample, 378 were registered under the DSIR consistently between 2011 and 2021, while 519 were never registered. The status of DSIR registration for all other firms fluctuated over time.[1] The model estimation results are presented in two sections. The first section analyzes the effects on companies that have been registered under DSIR from 2011 to 2021. In Sect. 4.2, the results are studied after taking into account the variable that changes over time.

4.1 Constant DSIR status

The information presented in this sample is based on data from 378 companies that were registered under DSIR from 2011 to 2021. The model was applied to 6276 observations, with results displayed in Table 5. Column 1 shows the total R&D expenditure intensity, column 2 displays the current R&D expenditure intensity, and column 3 presents the capital R&D expenditure. The variables of interest are the treatment variable D_{it} and the interaction variable $D_{it}C_t$.

Table 4 Summary statistics of variables

Variable	Mean	Std. dev	Min	Max
Total R&D expenditure	51.30	196.59	0.00	2924.50
Current R&D expenditure	42.07	163.87	0.00	2310.13
Capital R&D expenditure	10.70	73.75	0.00	1748.20
Total R&D expenditure intensity	0.02	0.07	0.00	3.64
Current R&D expenditure intensity	0.01	0.05	0.00	2.23
Capital R&D expenditure intensity	0.00	0.02	0.00	1.25
Technology imports	0.01	0.03	0.00	0.42
Firm size	6.08	2.00	4.61	13.56
Leverage	1.07	9.13	0.00	484.21
importer	1.00	0.05	0.00	1.00
exporter	0.48	0.50	0.00	1.00
Age	36.08	22.67	0.00	158.00

[1] For example, A company named '20 Microns Nano Minerals Limited' was registered under DSIR till 2018 but not afterwards. There were many such companies and therefore model with the time-varying treatment variable (DSIR registration status) is estimated.

Table 5 Constant DSIR status results

Outcome variable in logs	(1) Total R&D expenditure intensity	(2) Current R&D expenditure intensity	(3) Capital R&D expenditure intensity
Treatment group	1.417***	1.396***	0.460***
	(0.111)	(0.114)	(0.152)
Interaction effect	0.286***	0.364***	0.137
	(0.033)	(0.027)	(0.145)
Age	−0.0127	−0.012***	−0.012***
	(0.001)	(0.001)	(0.002)
Size	−0.20472***	−0.23186***	−0.203***
	(0.009)	(0.009)	(0.017)
Leverage	0.00429*	0.00442*	−0.002
	(0.000)	(0.000)	(0.000)
Importer	0.713	0.739*	−0.617
	(0.634)	(0.513)	(2.286)
Exporter	−0.208*	−0.255**	0.160
	(0.118)	(0.104)	(0.380)
Constant	−5.083***	−5.101***	−4.827***
	(0.103)	(0.091)	(0.323)
Year fixed effects?	Yes	Yes	Yes

***Significant at 1% level, **5% level, *10% level. Robust Standard errors are in brackets

The data in column (1) indicates that the beta coefficient for variable D_{it} is positive ($\beta = 1.417$) and the gamma coefficient for variable $D_{it}C_t$ is also positive ($\gamma = 0.286$). Both coefficients are highly statistically significant, which means that the average Total R&D expenditure intensity in DSIR-registered firms is 4.1 times higher than in non-registered firms. Additionally, the estimated interaction effect is 1.33, meaning that the treatment effect of super deduction is 33%.

The second column of results shows that the coefficient β for the variable D_{it} is 1.396, and the coefficient γ for the variable $D_{it}C_t$ is 0.364. Both coefficients are positive and highly statistically significant, similar to the results for Total R&D expenditures. This means that the average Current R&D expenditure intensity in DSIR-registered firms' treatment groups is 4.03 times greater than the control group of non-registered firms. Additionally, the estimate of the interaction effect is 1.44, indicating that the treatment effect of super deduction is 44%.

Based on the data presented in column (3), it can be observed that the coefficient β is 0.460 for the variable D_{it}, which is a positive and highly significant value. Meanwhile, the coefficient γ is 0.137 for the variable $D_{it}C_t$, but this value is statistically insignificant. This means that the average capital R&D expenditure intensity in treatment groups of DSIR registered firms is 1.58 times greater than the control group of non-registered firms, as determined by the $e^{0.460}$ value. However, the impact of the super deduction treatment on capital R&D expenditures is not significant.

4.2 Time-varying DSIR registration status

Table 6 displays the outcome when the DSIR status, which is the treatment variable, varies over time. The findings in Table 6 are comparable to those in Table 5. The estimates are elevated when the DSIR status is time-varying, but the conclusions are the same. Companies that are registered under DSIR have invested more in research and development (R&D), but the 200% super deduction has only significantly affected current expenses and not capital expenses.

The first column of results indicates that the coefficient β for the variable D_{it} is positive, with a value of 1.833. The coefficient γ for the variable $D_{it}C_t$, is also positive, with a value of 0.252. These coefficients are both highly statistically significant. This suggests that the average Total R&D expenditure intensity is 6.25 times greater for treatment groups of DSIR-registered firms compared to the control group of non-registered firms. The estimate for the interaction effect is 1.29, implying that the treatment effect of a 200% super deduction is 29%.

The second column of results shows that the coefficients for the variables D_{it} and $D_{it}C_t$ are both positive and highly statistically significant. Specifically, β is 1.826 and γ is 0.325. This indicates that the average Current R&D expenditure intensity in treatment groups of DSIR-registered firms is 6.21 times greater than that of the control group of non-registered firms. The interaction effect estimate is 1.38, meaning that the 200% super deduction treatment effect is 38%.

Table 6 Time-varying DSIR status results

Outcome variable in logs	(1) Total R&D expenditure intensity	(2) Current R&D expenditure intensity	(3) Capital R&D expenditure intensity
Treatment group	1.833***	1.826***	0.658***
	(0.109)	(0.114)	(0.188)
Interaction effect	0.252***	0.325***	0.042
	(0.026)	(0.021)	(0.365)
Age	− 0.011***	− 0.010***	− 0.012***
	(0.001)	(0.001)	(0.002)
Size	− 0.191***	− 0.216***	− 0.187***
	(0.008)	(0.008)	(0.019)
Leverage	0.006***	0.007***	− 0.004
	(0.001)	(0.001)	(0.000)
Importer	0.512	0.522	− 0.601
	(0.645)	(0.543)	(1.692)
Exporter	− 0.270***	− 0.306***	0.142
	(0.078)	(0.076)	(0.632)
Constant	− 5.676***	− 5.705***	− 5.287***
	(0.076)	(0.065)	(0.333)
Year fixed effects?	Yes	Yes	Yes

***Significant at 1% level, **5% level, *10% level. Robust Standard errors are in brackets

According to the information in column (3), the β coefficient for variable D_{it} is 0.658, which is both positive and highly significant. However, the coefficient for variable $D_{it}C_t$ is $\gamma = 0.042$ and statistically insignificant. This means that the average capital R&D expenditure intensity for DSIR-registered firms in treatment groups is 1.93 times greater than that of non-registered control groups. However, the impact of the 200% super deduction treatment on capital R&D expenditures is insignificant.

In this study, the expenses of companies were examined in two categories: financial and non-financial. The model was evaluated for both categories, and the results revealed that non-financial firms had significant impacts while financial firms did not. It is important to note that financial firms made up less than 10% of the sample size. The study also highlighted that non-financial firms play a greater role in the overall research and development expenditure of the economy.

5 Conclusion

This research paper aims to address the topic of relabelling, which has limited literature available. Several governments have changed the R&D tax incentives policy in India from 2011 to 2021. One of the significant changes was the reduction of income tax deductions from 200% in 2022 to 150% in 2016 and eventually to 100% in 2021. This presents an opportunity to examine the effectiveness of the generous deduction and other incentives given to firms registered under DSIR. These firms can avail of several fiscal incentives. The study considers the firms registered under DSIR as the treatment group and uses the difference-in-difference approach to test their effectiveness. The research assesses the changes in R&D expenditure during the period when the Super deduction was available.

The study found that there was a clear difference in the average R&D spending between the companies in the treated group and those in the control group. However, while the super deduction offered was very generous, it only significantly impacted current R&D spending and not capital R&D spending. This lack of impact on capital R&D spending suggests that some companies may have tried to relabel their spending. The increase in Total R&D spending was driven solely by current spending. The super deduction caused an increase of 44% in current spending but had no significant effect on capital R&D spending. This suggests that some companies may have increased their current spending in order to benefit from the tax deduction without increasing their capital spending at a commensurate rate.

The DSIR offers a combination of incentives that effectively increase current and capital R&D expenditures. The fiscal incentives provided by DSIR have resulted in a six-fold increase in current expenditures and almost a two-fold increase in capital expenditures. However, it is important to note that while incentives to encourage R&D expenditures are beneficial, overly generous schemes can lead to abuse of the system. The Super deduction, for example, incentivizes firms to falsely label administrative expenses as R&D expenditures to take advantage of tax deductions without any actual increase in innovation.

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Declarations

Conflict of interest I declare that there are no financial and non-financial conflicts of interest.

Human or animal rights The Research does not involve Human Participants and/or Animals.

Informed consent Not applicable.

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