Labour Market Effects of R&D Tax: Evidence from a Quasi-natural Experiment*

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Abstract

The question of how technological change affects the demand for skill is a long standing issue in economics. In the past few decades, skill premium soared even though the supply of skills increased substantially at the same time. Violante (2008) defines skill-biased technological change as "a shift in the production technology that favors skilled [..] labor over unskilled labor by increasing its relative productivity, and therefore, its relative demand." The empirical literature on skill-biased technological change to date has mostly used aggregate, industry- or country-level, data, with a few exceptions of firm-level information. Using aggregate data is potentially problematic for couple of reasons: (a) current literature show that there is ample evidence of a large amount within-industry heterogeneity of firms, and (b) technology affects aggregate demand for skill mostly through firm-level decisions.

Higher technological adoption induce firms to invest in a whole range of activities that are intensive in skilled workers talent: research, conceptualization, development of new processes and products, branding and marketing the process and/or product, and so on. Existing processes are also pushed closer to the technological frontier through use of more R&D expenditure, technology transfer, etc. All these tasks can present firms with more complex problems, and this can possibly raise the value of

*All errors are our own.

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skilled workers (Garicano, 2000). Therefore, an increase in the returns to technological adoption raises the relative value of certain types of workers, say skilled over unskilled workers (Acemoglu et al., 2006). Crucially, due to the complementarity between skilled workers and technological capital, firms that are ahead in the technological ladder are expected to have larger gains from investing in skilled workers.

In order to explore how changes in technology adoption or R&D expenditure (in our case) can influence within-firm labour composition, we utilize a R&D tax credit scheme undertaken by Govt. of India during the time period 2001-2010. During the period of 2001–2010, the government offered a tax weighted deduction of 150% for any capital and revenue expenditure incurred by firms on in-house R&D in the following eight industries: drugs and pharmaceuticals, electronic equipment, computers, telecommunications equipment, chemicals, manufacture of aircraft and helicopters, automobiles, and auto parts. The dataset we use are drawn from the PROWESS database, constructed by the Centre for Monitoring the Indian Economy (CMIE). The data are captured from annual income statements and balance sheets of all publicly listed companies. The database covers large companies, firms listed on the major stock exchanges and small enterprises. The dataset also rolls out information on a vast array of firm level characteristics, important for analysis are R&D expenditure, foreign technology transfer, domestic technology transfer, managerial compensation (divided into wages and incentives), non-managerial compensation, sales, gross value added, assets and other important firm and industry characteristics.

Figure 1 plots the average R&D expenditure undertaken by a firm belonging to these eight industries (which is our treated group) versus all other industries (manufacturing) during the period of 1995–2015. While there is no discernible difference before the R&D tax reform between our treated and control group, it started to become significantly different afterwards. To guide our empirical strategy, we use the following simple differences-in-differences framework to estimate the effect of R&D tax on within-firm labour choices:

$$y_{ijt} = \beta \left(R\&D\ Tax_{2001} \times TreatedIndustry_j \right) \ + \ firmcontrols_{it} + \phi_i + \theta_j^t + \epsilon_{ijt} \quad (1)$$

y_{ijt} represents our outcome variable of interest for firm i in sector j at time

t. We use the following: managerial compensation, non-managerial compensation, middle managers compensation, top managers compensation, share of managerial compensation, managerial compensation divided into wages and incentives.

$R\&D\ Tax_{2001}$ is a year dummy variable which takes a value 1 if year is greater than 2001, i.e., for the years following the R&D tax credit announcement. $TreatedIndustry_j$ is an industry level dummy, which takes a value 1 for the eight industries for which the R&D tax deduction was announced. These eight industries serve as our treated, while the rest are considered as control. We identify the industries at National Industrial Classification (NIC, hereafter) 2004 level. $firmcontrols_{it}$ include age and age squared of a firm. ϕ_i are firm fixed effects, while θ_j^t are industry-year trends.

Before we start to investigate the effect of the R&D tax credit on the within-firm labour demand, it is imperative to first understand how did the R&D tax credit policy impact the different forms of technology adoption, especially in-house R&D expenditure and foreign technology transfer. **Table 1** uses R&D expenditure (capital plus current), foreign technology transfer, other types of technology transfer (domestic technology transfer, royalty payments, consultancy fees, etc.) as our outcomes of interest. We find that the R&D tax policy significantly promoted in-house R&D expenditure of firms belonging to those eight industries by 9–11.5% while simultaneously dropping dependence on foreign technology transfer by 3–4.2%. We do not find any effects on other types of technology transfer.

Table 2 presents our main results by looking at the effect of the policy on the intensive margin of the demand for managerial and non-managerial workers, i.e., on the absolute level of managerial and non-managerial compensation. We find contrasting effects. While on the one hand, R&D tax credit increased the demand for managerial workers by 4.2–6.4%, it decreased the demand for non-managerial workers by 6.4–10%. We look at other measures of increase in managerial workers' demand in **Table 3**. In particular, we explore the effect on middle and top managers' compensation, share of managerial compensation in total compensation, and compensation divided into wages and incentives. We find significant effects on different measures of within-firm managerial labour demand. In particular, our results show increase in both middle and top managers' compensation with no difference between these two groups, about 0.4% increase in the share of managerial compensation in total compensation, an increase in managerial wages of about 11% while its share rose by 0.8%; lastly incentives increased by 3.6% with an increase of about 2% in its corresponding share. We also check whether there is any effect on the extensive margin of the demand for these two workers by looking at the employment effects of the R&D tax credit using Annual Survey of Industries (ASI) data in **Table 4**. We do not find any effect of the R&D tax on the employment of both managerial and non-managerial workers.

Next, we explore the role of technology ladder in **Table 5**. We divide firms in five different quintiles, based on their share of technology adoption expenditure in gross value-added in pre-R&D tax credit policy period (1995–2000). In particular, if a firm belonging to these eight industries falls in the top 20th percentile of technology distribution,it is classified as a firm which belongs to $Quintile_5$ and so on. We find that firms across the technology distribution have increased R&D expenditure following the R&D credit policy announced, with significant higher effects for firms belonging to the top of the technological ladder. Results are similar for increase in the managerial compensation. With respect to foreign technology transfer, the reduction is also significant for the top percentile firms. Lastly, we check for the tax credit effect on firm performance- gross value-added, total sales, and total factor productivity (TFP) in **Table 6**. We find that the R&D tax credit significantly increased gross value-added, sales and TFP of firms across the technology adoption distribution of firms.

Our work is closely related to Ivus et al. (2021) who utilized the same R&D tax credit scheme, but on the innovation (both R&D expenditure and patents) patterns of Indian manufacturing firms during the 2001–2016 period. They also show that the R&D tax credit scheme resulted in an increase in R&D expenditure, R&D intensity, and the number of patent applications. We complement and extend the their work by looking at the effects of the tax credit on within-firm labour choices.

Previous literature has largely focused on the impact of fiscal incentives such as tax credits and subsidies on firm performance and these studies primarily focus on firms in developed countries. Hall and Reenen (2000) examine the effects of tax systems on the user cost of R&D across firms in different countries within the OECD. Machin and Reenen (1998) look at the impact of R&D intensity on the growth of skilled workers in seven OECD countries – USA, Denmark, France, Germany, Japan, Sweden, and the United Kingdom, and find a positive and significant association between R&D intensity and skill upgrading in each of these countries. However, recent work by Wang et al. (2017) and Guo et al. (2016) have assessed the impact of China's *Innofund* innovation subsidy grants on firm performance in China, a developing nation. These authors discuss the need to investigate the impact of fiscal incentives on firms' activities beyond the modern advanced economies, and towards the developing /emerging market economics as the latter are often thought of as countries with weaker state capacity. While the above two papers are studies related to the Chinese economy, their focus is on firm innovation, and are silent on the impact on within-firm labor choices.

Keywords: R&D Tax Credit, R&D Expenditure, Foreign Technology Transfer, Managerial Compensation, Firm Performance

JEL Codes: O1, O14, O31, O32, O33, O38, J23, J31

Figure 1: Average RnD expenditure (CMIE), 1995-2015

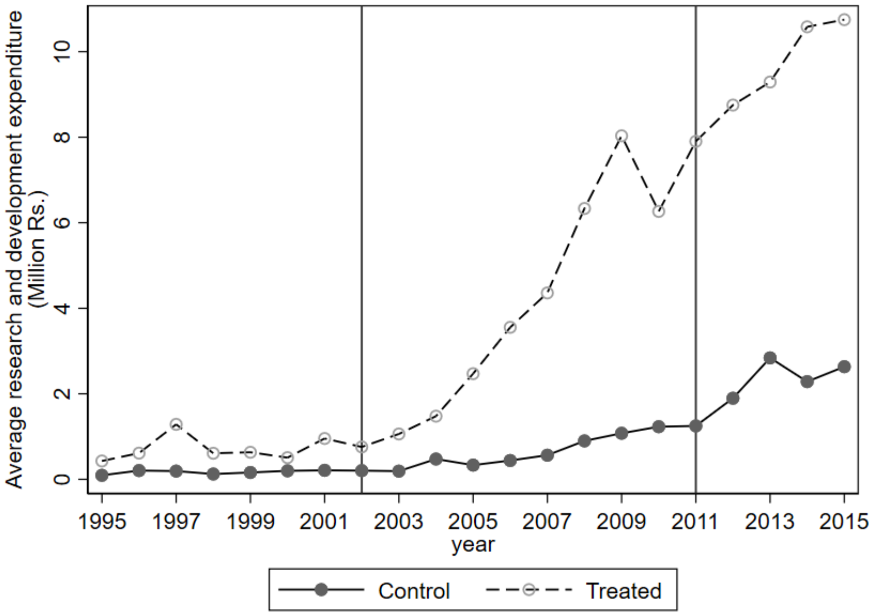

Table 1: R&D Tax and Technology Adoption Expenditure – 1st Order Effects

	(1)	(2)	(3)	(4)
	R&D Expenditure			
$R\&D\ Tax_{2001} \times Treated\ Industry_j$	0.115***	0.115***	0.102***	0.094***
	(0.027)	(0.034)	(0.026)	(0.026)
R-Square	0.59	0.59	0.59	0.62
N	162,342	162,342	162,342	136,861
	Foreign Technology Transfer			
$R\&D\ Tax_{2001} \times Treated\ Industry_j$	–0.030***	–0.030*	–0.042***	–0.042***
	(0.011)	(0.018)	(0.011)	(0.012)
R-Square	0.56	0.56	0.56	0.59
N	162,341	162,341	162,341	136,860
	Other Types of Technology Transfer			
$R\&D\ Tax_{2001} \times Treated\ Industry_j$	0.006	0.006	–0.009	–0.015
	(0.022)	(0.040)	(0.023)	(0.023)
R-Square	0.61	0.61	0.61	0.64
N	162,341	162,341	162,341	136,860
Firm Controls	No	No	No	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Industry FE–Year Trend	No	No	Yes	Yes

Notes: Regressions are run for the period 1991–2007. Panel A uses log of research and development expenditure; Panel B uses log of foreign technology transfer; Panel C uses log of other types of technology transfer, such as royalty, domestic technology transfer, consultancy fees, etc. as the dependent variable, respectively. $R\&D\ Tax_{2001}$ is a year dummy variable which takes a value 1 if year is greater than 2001. The R&D tax was announced in 2001. $Treated\ Industry_j$ is the treated dummy. It takes a value 1 for the following seven industries (a) drugs and pharmaceuticals, (b) electronic equipment, (c) computers, (d) telecommunications equipment, (e) chemicals, (f) manufacture of aircraft and helicopters, and (g) automobiles, and auto parts (at 2-digit level) for which a tax deduction of 150% was announced for any in-house R&D capital and revenue expenditure incurred by firms. Firm controls include age of a firm, age squared of a firm. Numbers in the parentheses are two-way robust standard errors clustered at the firm and year level (except for column (2) where we cluster at industry and year level). Intercepts are not reported. ***, **, * denotes statistical significance at 1%, 5%, and 10%.

Table 2: R&D Tax and Labour Market Effects

	(1)	(2)	(3)	(4)
	Managerial Compensation			
$R\&D\ Tax_{2001} \times Treated\ Industry_j$	0.064***	0.064**	0.048**	0.042**
	(0.020)	(0.028)	(0.019)	(0.021)
R-Square	0.52	0.52	0.52	0.55
N	162,342	162,342	162,342	136,861
	Non-Managerial Compensation			
$R\&D\ Tax_{2001} \times Treated\ Industry_j$	–0.064*	–0.064*	–0.079**	–0.101**
	(0.037)	(0.038)	(0.039)	(0.039)
R-Square	0.67	0.67	0.67	0.68
N	162,342	162,342	162,342	136,861
Firm Controls	No	No	No	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Industry FE–Year Trend	No	No	Yes	Yes

Notes: Regressions are run for the period 1991–2007. Panel A uses log of managerial compensation; Panel B uses log of non-managerial compensation as the dependent variable, respectively. $R\&D\ Tax_{2001}$ is a year dummy variable which takes a value 1 if year is greater than 2001. The R&D tax was announced in 2001. $Treated\ Industry_j$ is the treated dummy. It takes a value 1 for the following seven industries (a) drugs and pharmaceuticals, (b) electronic equipment, (c) computers, (d) telecommunications equipment, (e) chemicals, (f) manufacture of aircraft and helicopters, and (g) automobiles, and auto parts (at 2-digit level) for which a tax deduction of 150% was announced for any in-house R&D capital and revenue expenditure incurred by firms. Firm controls include age of a firm, age squared of a firm. Numbers in the parentheses are two-way robust standard errors clustered at the firm and year level (except for column (2) where we cluster at industry and year level). Intercepts are not reported. ***, **, * denotes statistical significance at 1%, 5%, and 10%.

Table 3: R&D Tax and Additional Labour Market Effects

	Middle Managers' Compensation	Top Managers' Compensation	Share of Managerial Compensation	Managerial Wage	Share of Managerial Wage	Managerial Incentives	Share of Managerial Incentives
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$R\&D\ Tax_{2001} \times Treated\ Industry_j$	0.043*	0.042**	0.004***	0.107**	0.008***	0.036*	0.019**
	(0.026)	(0.021)	(0.001)	(0.045)	(0.003)	(0.021)	(0.009)
R-Square	0.56	0.55	0.63	0.58	0.51	0.41	0.39
N	136,861	136,861	58,669	58,669	58,669	58,669	58,669
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE–Year Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Columns (1) – (7) use log of middle managers compensation, log of top managers compensation, share of managerial compensation in total compensation, log of managerial wages, share of managerial wages in total wages, log of managerial incentives, and share of managerial incentives in total incentives as the dependent variable, respectively. $R\&D\ Tax_{2001}$ is a year dummy variable which takes a value 1 if year is greater than 2001. The R&D tax was announced in 2001. $Treated\ Industry_j$ is the treated dummy. It takes a value 1 for the following seven industries (a) drugs and pharmaceuticals, (b) electronic equipment, (c) computers, (d) telecommunications equipment, (e) chemicals, (f) manufacture of aircraft and helicopters, and (g) automobiles, and auto parts (at 2-digit level) for which a tax deduction of 150% was announced for any in-house R&D capital and revenue expenditure incurred by firms. Firm controls include age of a firm, age squared of a firm. Numbers in the parentheses are two-way robust standard errors clustered at the firm and year level. Intercepts are not reported. ***, **, * denotes statistical significance at 1%, 5%, and 10%.

Table 4: R&D Tax and Labour Market Effects: Extensive Margin

	Managerial Workers		Non-Managerial Workers	
	(1)	(2)	(3)	(4)
$R\&D\ Tax_{2001} \times Treated\ Industry_j$	–0.002	–0.003	–0.001	–0.001
	(0.002)	(0.002)	(0.004)	(0.004)
R-Square	0.89	0.90	0.93	0.93
N	119,782	107,626	123,080	110,776
Firm Controls	No	Yes	No	Yes
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Industry FE–Year Trend	Yes	Yes	Yes	Yes

Notes: Regressions are run for the period 1999–2007. Columns (1) – (2) use log of managerial workers; columns (3) – (4) use log of non-managerial workers as the dependent variable, respectively. $R\&D\ Tax_{2001}$ is a year dummy variable which takes a value 1 if year is greater than 2001. The R&D tax was announced in 2001. $Treated\ Industry_j$ is the treated dummy. It takes a value 1 for the following seven industries (a) drugs and pharmaceuticals, (b) electronic equipment, (c) computers, (d) telecommunications equipment, (e) chemicals, (f) manufacture of aircraft and helicopters, and (g) automobiles, and auto parts (at 2-digit level) for which a tax deduction of 150% was announced for any in-house R&D capital and revenue expenditure incurred by firms. Firm controls include age of a firm, age squared of a firm. Numbers in the parentheses are two-way robust standard errors clustered at the firm and year level. Intercepts are not reported. ***, **, * denotes statistical significance at 1%, 5%, and 10%.

Table 5: R&D Tax and Technological Ladder

	R&D Expenditure (1)	Foreign Tech Transfer (2)	Managerial Compensation (3)	Non-Managerial Compensation (4)	Share of Managerial Compensation (5)
$R\&D\ Tax_{2001} \times Quintile_1$	0.095***	–0.033	0.273***	–0.119	–0.007
	(0.030)	(0.023)	(0.059)	(0.126)	(0.005)
$R\&D\ Tax_{2001} \times Quintile_2$	0.201***	0.042	0.415***	0.031	0.003
	(0.047)	(0.030)	(0.082)	(0.137)	(0.00)
$R\&D\ Tax_{2001} \times Quintile_3$	0.198***	–0.040	0.489***	–0.127	0.006*
	(0.066)	(0.038)	(0.096)	(0.130)	(0.003)
$R\&D\ Tax_{2001} \times Quintile_4$	0.384***	–0.074	0.653***	–0.011	0.009**
	(0.109)	(0.054)	(0.124)	(0.161)	(0.004)
$R\&D\ Tax_{2001} \times Quintile_5$	0.408***	–0.214***	0.631***	–0.090	0.008*
	(0.141)	(0.072)	(0.123)	(0.146)	(0.005)
R-Square	0.63	0.59	0.58	0.68	0.33
N	136,861	136,860	136,861	136,861	136,861
Firm Controls	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Industry FE–Year Trend	Yes	Yes	Yes	Yes	Yes

Notes: columns (1) – (5) use log of R&D expenditure, log of foreign technology transfer, log of managerial compensation, log of non-managerial compensation, and share of managerial compensation of a firm as the dependent variable, respectively. $R\&D\ Tax_{2001}$ is a year dummy variable which takes a value 1 if year is greater than 2001. The R&D tax was announced in 2001. $Quintile_i\ i = 1(i)5$ is a firm level dummy. For example, $Quintile_5$ takes a value 1 if a firm i belonging to any of the seven industries (a) drugs and pharmaceuticals, (b) electronic equipment, (c) computers, (d) telecommunications equipment, (e) chemicals, (f) manufacture of aircraft and helicopters, and (g) automobiles, and auto parts (at 2-digit level) falls within the top 20% of the technological adoption ladder in the pre-R&D tax period, and so on. Firm controls include age of a firm, age squared of a firm. Numbers in the parentheses are two-way robust standard errors clustered at the firm and year level. Intercepts are not reported. *,**,*** denotes 10%, 5%, and 1% level of significance, respectively.

Table 6: R&D Tax and Firm Performance

	Gross Value-added (1)	Total Sales (2)	Total Factor Productivity (3)
$R\&D\ Tax_{2001} \times Quintile_1$	0.102	0.259***	0.00001
	(0.082)	(0.092)	(0.005)
$R\&D\ Tax_{2001} \times Quintile_2$	0.229***	0.306***	0.009**
	(0.072)	(0.080)	(0.003)
$R\&D\ Tax_{2001} \times Quintile_3$	0.201***	0.191**	0.007**
	(0.064)	(0.075)	(0.003)
$R\&D\ Tax_{2001} \times Quintile_4$	0.284***	0.348***	0.010***
	(0.073)	(0.084)	(0.003)
$R\&D\ Tax_{2001} \times Quintile_5$	0.365***	0.343***	0.012***
	(0.079)	(0.084)	(0.003)
R-Square	0.85	0.83	0.78
N	58,669	61,748	35,199
Firm Controls	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Industry FE–Year Trend	Yes	Yes	Yes

Notes: columns (1) – (5) use log of R&D expenditure, log of foreign technology transfer, log of managerial compensation, log of non-managerial compensation, and share of managerial compensation of a firm as the dependent variable, respectively. $R\&D\ Tax_{2001}$ is a year dummy variable which takes a value 1 if year is greater than 2001. The R&D tax was announced in 2001. $Quintile_i$ $i = 1(i)5$ is a firm level dummy. For example, $Quintile_5$ takes a value 1 if a firm i belonging to any of the seven industries (a) drugs and pharmaceuticals, (b) electronic equipment, (c) computers, (d) telecommunications equipment, (e) chemicals, (f) manufacture of aircraft and helicopters, and (g) automobiles, and auto parts (at 2-digit level) falls within the top 20% of the technological adoption ladder in the pre-R&D tax period, and so on. Firm controls include age of a firm, age squared of a firm. Numbers in the parentheses are two-way robust standard errors clustered at the firm and year level. Intercepts are not reported. *,**,*** denotes 10%, 5%, and 1% level of significance, respectively.