The Competitive Effects of Fiscal Incentives for Innovation: Evidence from a R&D Tax Credit Reform

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Abstract

This article examines the causal effect of fiscal incentives for innovation on output prices. Exploiting the staggered introduction of weighted tax credits for R&D spending across industries in the manufacturing sector in India, we find that R&D tax credits increase R&D spending and induce a decline in prices in the industries targeted by the reform. The relative increase in R&D spending in treated industries is driven by the eligible firms, while there is no significant effect on the ineligible firms. Further, we find that the decline in prices is driven by both a direct effect on the eligible firms and an indirect effect on the ineligible firms. Consistent with an increase in competition, both eligible and ineligible firms experience a decline in markup, conditional on cost, in response to the policy. Further, the policy also leads to increase in productivity and lower marginal costs for both eligible as well as ineligible firms. Overall, the decline in prices is primarily driven by lower markups, conditional on costs, as opposed to the passthrough of cost savings to prices. Further, we find that these effects are stronger in industries that rely more on external finance. We provide compelling evidence that our results are not biased due to preexisting linear trends, omitted variables, and heterogeneous treatment effects in staggered settings. Our results suggest that fiscal incentives for innovation can increase market competition.

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Most economists believe that innovation and competition are deeply intertwined, and for many the relationship is so close that it borders on tautology. In practice, many discussions of this relationship concentrate on possible causal links which run from competition to innovation.. . . Arguments which suggest that innovation drives competition in markets are less often made, and they have never been articulated quite as clearly as those stressing the effects of competition on innovation.

— Paul A. Geroski (Geroski, 1999, p. 13)

1. Introduction

Many governments use research and development (R&D) tax credits to incentivize private investment in R&D. Several empirical studies have examined the direct effect of these tax credits and found them effective in increasing the R&D expenditures and productivity of eligible firms. However, relatively less explored is the possibility that these policies may have competitive spillover effects on product market rivals, forcing them to reduce their prices by lowering their price-cost margins and investing in productivity improvements. Quantifying these effects can shed light on the mechanisms driving the impact of R&D on aggregate output and prices and improve our understanding of how the gains from innovation are shared between producers and consumers. However, tracing the direct and spillover impact of an exogenous shock to the cost of R&D and its transmission to prices within industries has proven elusive.

Further, the empirical evidence on the effectiveness of R&D tax credits comes overwhelmingly from developed economies. Many large developing economies, including Brazil, China, and India, have introduced R&D tax credits in the last few decades. However, whether these policies are effective in developing countries with weak protection and enforcement of intellectual property rights (IPRs) is unclear. Weak IPR regimes can limit firms' ability to appropriate returns from their R&D investments, reducing their responsiveness to tax incentives. Alternatively, tax credits may ease financial constraints for innovative firms in developing countries with underdeveloped financial institutions, increasing their responsiveness to tax credits.

In this article, we provide novel empirical evidence on these issues by exploiting cross-industry variation in the cost of R&D due to the implementation of an unusual R&D tax credit scheme in India. The policy increased the R&D tax credits, available to firms with registered in-house R&D units, from 100% to 125% in 1998 and eventually to 150% in 2001. It was introduced in several industries in 1998 and extended to the automobile sector in 2004. The firms with registered in-house R&D units in the rest of the industries were unaffected by the reform and continued to be eligible for 100% tax deductions on R&D spending. Moreover, the reform partitioned firms based on a clearly defined eligibility criterion creating a set of ineligible firms that are not directly impacted by the reform, enabling us to recover the spillover effects of the reform within industries.

We combine the policy variation with rich data from firms' balance sheets and income statements, and detailed firm-product level information on physical quantities and sales from 1992-2007. These data come from the Prowess database, which is a panel of medium and large-sized firms that account for a large share of formal manufacturing output and taxes. We directly observe the two key outcome variables, firm-level R&D expenses and firm-product level prices. Further, to disentangle the mechanisms driving the overall effect on prices, we closely follow the methodology proposed by De Loecker et al. (2016) to estimate the underlying component of prices, i.e., marginal costs and markup, and a firm-level measure of physical efficiency.

We estimate the causal effect of the tax credits using a difference-in-differences framework by comparing outcomes for firms in treated industries to those in the control industries. A key assumption for identification in our setting is that the outcomes in treated versus control industries would have evolved similarly in the absence of the reform. We provide strong supporting evidence to ensure that our estimates are well-identified. First, we demonstrate through event study plots that firms in both the treated and control industries exhibit similar trends in the outcomes in the years leading up to the reform. Secondly, starting with a parsimonious specification with firm and year fixed effects, we sequentially add high dimensional fixed effects to absorb as much of the effects of time-varying unobserved shocks as possible. In the most stringent specification, the estimates are identified by comparing treated and control firms with similar pre-reform growth trajectories while controlling for state and firm-level time-varying unobserved shocks by including state $\times$ year and a set of pre-reform firm characteristics $\times$ year fixed effects.

We find that the policy has a large positive impact on firm level R&D spending. Our results imply that firms in treated industries, on average, increase their R&D spending by 60% in response to the tax credits. Further, to separate the direct effect of the policy on the eligible firms from any spillover effects on the ineligible firms, we test for the differential effect of the policy based on eligibility status of the firms. The policy can impact R&D spending of ineligible firms through two channels. First, there could be positive technological spillovers on these firms if they overlap with the eligible firms in the technology space. Secondly, there could be positive (negative) spillover effects if firms' innovations are strategic complements (substitutes). Our results imply that the increase in the R&D expenditures is almost entirely driven by the eligible firms. We find no significant impact on the R&D expenditures of ineligible firms, suggesting a lack of substantial spillover effects of the policy on firm-level R&D.

To better understand the mechanisms driving the high level of responsiveness to the tax credits, we test for heterogeneity based on firm and industry level measures of financial constraints. Financial constraints may be particularly binding for firms in India, given the underdeveloped banking sector and equity markets, and could make firms more responsive to tax credits. We find that the effects of the policy on R&D spending is stronger for young firms and firms in industries with greater reliance on external finance.

We next examine the effect of the policy on firm-product level prices. For eligible firms, the effect on prices would depend on the type of innovation. If the R&D spending is geared towards improvements in physical efficiency through process and organizational innovations, this will lower marginal costs, and firms may pass on some of these cost savings to prices. On the other hand, if firms innovate to shift their demand outwards by introducing new and updated products, we expect an increase in prices. In both cases, we expect an increase in the markup of eligible firms. Further, R&D investments by eligible firms could, in turn, lower the residual demand for their ineligible competitors reducing their markup and prices. Additionally, ineligible firms may undertake productivity enhancing investments of their own, which could lead to lower marginal costs and prices. Further, we note that the policy can also increase the threat of future competition, thereby inducing ineligible firms to lower prices on their own even before innovation outcomes are realized for eligible firms.

Our results imply that the policy leads to a decline in firm-product level prices, on average, by 18%. Further, prices reduce significantly for both eligible and ineligible firms by 16% and 19%, respectively. Through separate event study graphs, we confirm that there are no differential pre-trends in prices for both eligible and ineligible firms, and that prices start to lower in treated industries only once the tax credits are introduced. These findings provide some of the first causal evidence of the impact of RD tax credits on prices and confirm the presence of strong competitive spillover effects on ineligible firms. Further, the lowering of prices by eligible firms suggests that these firms invested primarily in improving their physical efficiency.

To better understand the mechanisms underlying the decline in prices, we explore the policy's impact on firm-product level marginal costs and markup. We find that the reform leads to a significant decline in marginal costs by around 18%. Heterogeneity analysis suggests that eligible firms reduce their costs by 23% compared to 14% for ineligible firms. These results on marginal costs would reflect changes in input prices and quality in addition to changes in productivity. Thus, we test for the effect of the policy on a firm level measure of productivity and find that the policy leads to a significant increase in the average productivity by 26% in the treated industries, driven by both the eligible and ineligible firms. Taken together, these results provide strong evidence that the R&D tax credits improve the productivity of the eligible firms as well as their ineligible competitors. Next, we examine the effect of the policy on firm output and factor inputs. The results imply that the policy increases firm sales by 17%, capital by 13%, and compensation by 16%. Further, we find that these effects are primarily driven by eligible firms who experience an increase in sales by 33%, capital by 30%, and compensation by 30%. Interestingly, the effect on ineligible firms for all these outcomes is positive, small in magnitude, and imprecisely estimated. Thus, although the policy leads to increase in market share of eligible firms, ineligible firms are able to maintain their revenues at the pre-reform levels.

Further, we find that the policy has no significant effect on markup. Heterogeneity analysis reveals that the effect on the markup of ineligible firms is weakly negative while that on the eligible firms is weakly positive, but both are imprecisely estimated. The lack of any increase in the markup of eligible firms may seem surprising, given that the policy leads to a large decrease in their marginal costs. Under incomplete passthrough of costs to prices, we would expect markup to rise. However, we note here that the overall effect on markup will also reflect the direct effect on markup, conditional on costs, due to changes in the residual demand facing the firms. Once we control for marginal costs in the markup regressions, we find that the policy leads to a significant decline in markup. Our results imply that the policy lowers markups, conditional on marginal costs, by 13% on average. Further, we find that this effect is particularly strong for ineligible firms whose markup decline by around 16% due to changes in demand. The effect is attenuated somewhat for the eligible firms who experience a decline in markup by around 10%.

Comparing the average effects on prices, marginal costs, and markup (conditional on costs), we find that the downward pressure on markup, conditional on costs, accounts for almost three-fourths of the decline in prices, with the rest being accounted for by the incomplete passthrough of costs to prices. The cost saving channel accounts for 40% of the decline in prices for eligible firms while it is only 20% for ineligible firms. These results provide strong evidence that the policy leads to a considerable increase in competition between firms in the treated industries and that both the eligible and ineligible firms experience downward pressure on their markup due to demand-side changes. Further, the increase in markup through cost savings is counteracted by the downward pressure on markup, explaining the overall null effect of the policy on average markup.

Our paper relates to a small but growing literature that utilizes quasi-experimental settings to examine the causal effect of R&D tax incentives on innovation outcomes in the UK (Dechezleprêtre et al., 2016) and productivity in China (Chen et al., 2021). However, there is less clarity on how these productivity gains are shared between producers and consumers. Further, we have very little empirical evidence on the competitive spillover effects on the non-treated firms within industries. Bloom et al. (2013) study US firms and find that technology spillovers dominate spillovers on competitors. While their results provide evidence on the overall strength of the spillover effects on competitors, the underlying mechanisms are less clear. Our paper utilizes unique cross-industry variation in R&D tax credits that enable us to study the direct and competitive spillover effects of the policy. Our results provide the first evidence suggesting a causal link between R&D tax credits and price competition within industries.

Our paper is also related to a growing literature examining causal effects of R&D tax credits on R&D spending (Agrawal et al., 2020; Guceri and Liu, 2019; Dechezleprêtre et al., 2016; Chen et al., 2021; Rao, 2016). The literature finds positive effect of the R&D tax credits for the advanced economies. Our paper adds to this literature by providing evidence on the effectiveness of R&D tax credits in increasing the R&D investments in a developing country characterized by weak IPRs. Further, none of the papers study the effect of R&D tax credits on prices within industries. Finally, the policy generates cross industry variation in R&D tax credits which allows us to disentangle the direct and spillover effects of the policy in product markets.

Finally, our paper is related to a large literature examining the relationship between competition and innovation (Aghion et al., 2005, 2009). However, there is surprisingly little evidence on the causal link between innovation and competition. Our results show that both eligible and non-eligible firms lower their prices in response to R&D tax incentives for eligible firms. Further, consistent with an increase in price competition within industries, we find a relative decline in markup, conditional on marginal costs, for all firms within the the industries treated by the reform.

2. R&D tax credit in India and the 1998 Reform

R&D tax credit in India: The Government of India provides various fiscal incentives to encourage industrial research and make it financially beneficial for companies to establish their in-house R&D units[1]. Firms that have registered in-house R&D units are eligible for a 100% tax deduction on any revenue or capital expenditure incurred on these approved in-house R&D units.

Weighted tax credit scheme - 1998 reform: The Indian Government, in the Union Budget of 1997-98, introduced a major tax incentive scheme for companies with recognized in-house R&D units in specific industries, namely, drugs, pharmaceuticals, electronic equipment, computers, telecommunication equipment, and chemicals. As part of the scheme, companies are entitled to a weighted tax deduction of 125% for any revenue or capital expenditure incurred on the approved in-house R&D facility. The scheme has undergone several changes over time, including its extension to helicopters and aircraft and an increase in the deduction by 25% in 2001. In 2004, automobiles and auto parts were added to the scheme. Later, in 2009, the scheme was implemented for all industries except those listed in Schedule 11 of the Income-tax Act [2]. The detailed list of changes is present in Appendix Table A.1.

Eligibility criteria for R&D tax credit in India: The Department of Science & Industrial Research, under the Ministry of Science and Technology, offers a scheme to grant recognition to in-house R&D units of companies. The process of obtaining DSIR recognition, which is necessary to be eligible for the scheme, is time-consuming and require substantial effort and cost. For a company's R&D units to receive recognition, they must engage in research and development endeavors that are directly related to the company's field of business. This could involve creating new technologies, designing and engineering products, improving processes and designs, exploring innovative methods of analysis and testing, or researching ways to increase resource efficiency that improves the use of capital equipment, materials, fuel, pollu-

[1]An in-house R&D unit in India refers to a research and development facility that is established by a company within its own premises to undertake scientific or technological activities aimed at developing new products, processes or services.

[2]Schedule 11 is a small negative list of industries including tobacco, alcohol, cosmetics, confectionery, chocolate, etc.

tion control, effluent treatment, and recycling waste products (DSIR Annual Report 1999). In addition, the company is required to provide its past three years of annual reports, information on past, present, and future research projects, details on the scientific personnel and equipment working in the R&D unit, and photographs of the R&D facility. The company must repeat this process every three years to renew its recognition. Once companies have completed this demanding process, they become eligible for the 100% tax deduction on their R&D investments.[3] Note that all the DSIR registered firms receive a 100% tax deduction on their R&D investments. However, industries that come under the weighted tax deduction scheme receive an additional 25% deduction (125% total) which was further increased to 50% (150% total) in 2001.

Tax benefit with the weighted tax credit scheme: Let's consider an example with Company ABC Ltd. The company has total expenses of 10 million and revenue of 15 million, with 1 million spent on research and development (R&D) expenses. Without considering any tax deductions, the taxable income would be 5 million (15 million - 10 million). However, for a DSIR registered firm, the taxable income would reduce to 4 million (5 million - 1 million) due to the 100% tax deduction on R&D expenses. For a DSIR registered firm eligible for the weighted tax credit scheme, the taxable income would further reduce to 3.75 million (5 million - 1.25 million) due to the 125% tax deduction on R&D expenses.

Assuming an income tax rate of 30%, a DSIR registered firm would save 300,000 in taxes (1 million * 30%), and a firm qualifying for the weighted tax credit scheme would save an additional 75,000 (0.25 million * 30%) in taxes. Note that in 2001, the tax deduction increased to 150%, which would mean a firm qualifying for the weighted tax credit scheme would save an additional 150,000 (0.50 million * 30%) compared to a firm with a DSIR registered unit, and 450,000 (1.50 million * 30%) com-

[3] Some of the other benefits for DSIR registered firms include: *"(i) a 100% tax deduction on any revenue or capital expenditure (except acquisition of land) incurred by the company on scientific research related to the business's in-house R&D (under Sections 35(1)(i) and 35(1)(iv) of the Income Tax Act, 1961), (ii) a ten-year tax holiday for commercial R&D Companies, (iii) a three-year excise duty waiver on goods produced using indigenously developed technologies and duly patented in any two countries out of India, USA, Japan, and any country of the European Union, and (iv) an accelerated depreciation allowance on plant and machinery established based on indigenous technology."* - DSIR Annual Report 1999 (https://dsir.gov.in/documents/annual-reports/archive) Despite all these benefits, the major benefit for the DSIR registered firms remains the weighted tax deduction scheme.

pared to a non-DSIR registered firm with the same financial information.

Selection of industries and firms for the tax credit scheme: One immediate concern related to the timing of the industry treatment is that the government is choosing the industries which have shown high growth in the past and are expected to grow in future. We provide evidence against this in Table 2 by showing that the growth in industries' sales, R&D, exports, imports, and capital are uncorrelated with the treatment of industries. Another concern in our empirical setting relates to the non-random assignment of industry treatment and eligibility status of firms. However, our parallel trend plots, Figure 2 and Figure 3, show that the average R&D expenditure of both eligible and non-eligible firms in treated and untreated industries were not differentially moving before the implementation of the scheme. We discuss this in greater detail in subsection 4.2.

Firms' anticipatory reaction to the policy: An issue with our estimation strategy is the possibility that companies could have predicted the policy shift and manipulated their R&D expenditure prior to its implementation[4]. We address this concern by removing the pre-policy and post-policy years from the sample and our results in Appendix Table A.8 show that anticipatory response of firms is not the driver of our results. We discuss this in greater detail in subsection 5.3.

3. Data and summary statistics

Our main treatment uses information from DSIR annual reports[5] and federal budget reports. The DSIR annual reports specify the industries that received weighted tax reduction scheme in 1997 and 2004. We retrieve these industries from annual reports and map them with NIC 2008 4-digit classification. We then map these treated NIC 2004 industries with the firm level information of prowess. Table **??** provides a list of treated industries. Industry treatment is defined as follows: Industries that are mentioned in the Union budget of 1997 are coded as 1 in all the years greater than

[4]It is less likely for firms to have anticipated the policy as it was announced for the first time in 1998 as a part of Indian fiscal policy and implemented from the immediate fiscal year.

[5]http://164.100.166.67/documents/annual-reports/archive

or equal to 1997, additional industries mentioned in the annual report of 2004 are coded as 1 in all the years greater than or equal to 2004.

The in-house R&D units of firms that are registered on DSIR are eligible to avail the benefits of weighted tax deduction scheme. DSIR releases the directory of recognized in-house R&D units each year[6]. The information provided in directories include firm names, address, and recognition validity. We use this information to create the eligibility status of firms. After extracting this information from the directories, we map these firm names with Prowess company names. To ensure the accuracy of mapping, we have manually handcoded each firm. Our eligibility status is defined as follows: a firm is coded as eligible if that firm has registered on DSIR any time between 1992 and 2007. In our sample total firms that are registered on DSIR are 381.

3.1 Firm and product level data

Our data source for firm and product level information is prowess, compiled by the Centre for Monitoring the Indian Economy (CMIE) [7]. Prowess collects information on financial statements, products produced, products prices, and many other variables from the annual reports of firms. Annual Survey of India (ASI), India's manufacturing census from 1987-2017, is another database which provides information on financial statements. However, Prowess has especially suited for study for various reasons. First, Unlike ASI, prowess provides panel of firms starting from 1987. Panel datasets are required to casually study the effect of changes in policy. Second, given that ASI doesn't provide the information on company names, identifying the eligibility status of companies is not possible with ASI.

Prowess sample covers approximately 50000 companies, among which 8000 companies are listed. One concern with the database is that it excludes very small companies. However, this is less of a concern for us since in-house R&D units are mainly operated by large companies. Therefore, it contains the companies that are most

[6]https://www.dsir.gov.in/files/directories.html

[7]Both firm and product level information of prowess has been employed in many research studies including, Bertrand and Mullainathan (2002); De Loecker et al. (2016); Goldberg et al. (2010)

relevant to study the weighted tax deduction for in-house units.

We use financial statements of prowess to extract yearly information on research & development expenditure, sales, and assets for each firm. Under Companies Act 1956, Indian firms are required to report information on sales, quantity, and capacity on all the products that they produce. Prowess collates this data from the annual reports and provides it in the form of firm-product panel. We take advantage of this unique firm-product level panel to estimate the effect of policy on prices. Further, we breakdown the effect on prices into marginal costs and markups. We calculate markups using the methodology provided by De Loecker et al. (2016). Then, using firm-product prices we calculate the marginal costs by taking the ratio of price to markup.

3.2 Compiled Data and summary statistics

We merge industry treatment, firm eligibility status with the firm level and firm-product level information to arrive at our final dataset.

As a standard practice, we remove the firms-years with negative missing sales and assets from our dataset. We also restrict our data to only those firms which are present in the pre-policy period (from 1992-96) to minimize the concern of results being driven by entry and exit firms from the sample. Our final data consists of 3346 total firms, among which 381 firms are registered on the DSIR platform. Our time period of study is from 1992 to 2007. The time period is carefully chosen to start from 1992, as the economic environment of India was very different before 1992 due to the major liberalization reforms that happened in 1991. Also, the prowess sample observations have significantly increased after 1991. We end our study in 2007 because of the policy change that happened in 2009. In 2009, the policy was extended to all industries except the schedule 11 industries of the Income-tax act. Therefore, after 2009, we don't have a good control group of firms for comparison.

We report the summary statistics for key variables separately for treated and untreated industry in Table 1. The firms are very similar in the treated and untreated industries for all variables except R&D expenditure. In variants of our baseline specifications, we include pre-reform quartiles of R&D spending interacted with year fixed effects to check robustness of our results. Further, in Table 2, we show that pre-reform growth in firm level characteristics, such as R&D, assets, sales, exports, etc., do not predict the inclusion of the industries into the tax credit reform.

4. Empirical Strategy

4.1 Baseline Specifications

Effect of R&D Tax Credits on R&D Spending: To estimate the causal effect of the R&D tax credit scheme on the firm level R&D spending, we estimate variants of the following difference-in-difference specification:

$$E[R_{ijt} \mid Treated_{jt}, \boldsymbol{X_{it}}] = exp(\beta_1 Treated_{jt} + \boldsymbol{\theta X_{it}} + \alpha_i + \delta_t) \tag{1}$$

where i denotes a firm, j denotes the firm's 4-digit industry, t denotes year, and R_{ijt} is the level of annual R&D spending by the firm. $Treated_{jt}$ is a dummy variable which equals 1 for all years since the weighted tax credit scheme is introduced in an industry, and zero otherwise. We include firm fixed effects (α_i) to control for time-invariant unobserved heterogeneity across firms. We also include year fixed effects (δ_t) to control for the unobserved macroeconomic shocks that could bias our estimates. $\boldsymbol{X_{it}}$ denotes a vector of firm level time varying controls and filters out any differential effect of time varying unobserved shocks on firms in treated and untreated industries. As the reform could directly influence many firm level characteristics, we interact pre-reform firm level characteristics with year fixed effects to guard against the bias due to bad controls (Angrist and Pischke, 2009). We cluster the standard errors at the industry level to allow for potential autocorrelation in the error term.

Our coefficient of interest is β_1 which captures the average effect of the reform on the R&D expenditure of firms in treated industries relative to the untreated industries. Note that β_1 would capture the direct effect of the tax credits on the eligible firms as well as any spillover effects (positive or negative) on the ineligible firms in the industry. $\beta_1 > 0$ would imply that R&D tax credits have an overall positive effect on the average firm in the treated industry.

In order to disentangle the effect of the tax credits on eligible firms from the spillover effects on the ineligible firms in treated industries, we estimate the following baseline specification:

$$\begin{aligned} E[R_{ijt} \mid Treated_{jt}, \boldsymbol{X_{it}}] = exp(&\beta_1 Treated_{jt} + \beta_2 Treated_{jt} \times Eligible_i \\ &+ \boldsymbol{\theta X_{it}} + \alpha_i + \delta_t) \end{aligned} \tag{2}$$

where, $Eligible_i$ is a dummy variable that takes the value of 1 for firms that have an in-house R&D unit registered with the DSIR at least once during the sample period, and zero for the firms that are never registered on DSIR. β_1 estimates the average effect of the policy on non-eligible firms. β_2 measures the differential effect of R&D tax credit scheme on the eligible firms in the treated industries relative to the ineligible firms. $(\beta_1 + \beta_2)$ gives us the average effect of the policy on the R&D expenditures of eligible firms. As before, we cluster our standard errors at industry level. As the eligible dummy is time-invariant, its effect is absorbed by the firm fixed effects.

As the R&D data has a mass point at zero and a long right tail, we use the Poisson Pseudo-Maximum-Likelihood (PPML) estimator proposed by Silva and Tenreyro (2006) for consistent estimation of the parameters of the log-linear models. Silva and Tenreyro (2006) show that the OLS estimates are severely biased and inconsistent for the log-linear model with outcome variables having many zeroes and a long right tail and that the PPML estimator performs well using simulated data. Agrawal et al. (2020) and Guceri and Liu (2019) are recent examples of studies estimating the effect of R&D tax credits on firm level R&D spending using the PPML estimator.

Effect of R&D Tax Credits on Firm-Product Level Prices and other Outcomes: To study the effect of the policy on the firm-product level prices, marginal costs, and markup, we estimate the following log-linear models using OLS:

$$y_{ipt} = \beta_1 Treated_{jt} + \boldsymbol{\theta X_{ipt}} + \alpha_{ip} + \delta_t + \epsilon_{ipjt} \tag{3}$$

$$y_{ipjt} = \beta_1 Treated_{jt} + \beta_2 Treated_{jt} \times Eligible_i + \boldsymbol{\theta X_{ipt}} + \alpha_{ip} + \delta_t + \epsilon_{ipjt} \tag{4}$$

where p denotes the product line produced by a firm, and y_{ipjt} denotes (log of) firm-product level prices, marginal costs, markup, sales, or quantity. Finally, to study the effect of the reform on firm level outcomes other than R&D spending, such as sales, capital, compensation to employees, and efficiency, we estimate the above specifications at the firm level dropping the subscript p.

4.2 Identification

Below, we outline the main threats to identification in our empirical specifications discussed above and describe our strategy to address these concerns. There are three potential sources of bias in our specifications: (1) treated industries and eligible firms are different from untreated industries and ineligible firms, i.e., there is non-random assignment of treatment and eligibility across industries and firms, (2) unobserved time varying heterogeneity across firms and industries, and (3) forbidden comparisons with already treated units in settings with staggered treatment.

Selection of Industries and Firms for Tax Credit Scheme: Our specifications already control for the time invariant differences between industries and firms through the inclusion of firm fixed effects. Our estimates will be unbiased if the parallel trends assumption holds, i.e., if the outcome variable in the variants of Equation 1 and Equation 3, and the difference in outcome variables between the eligible and the ineligible firms in the variants of Equation 2 and Equation 4, would have evolved similarly for both treated and untreated industries in the absence of the policy. While this assumption cannot be tested directly, we provide strong supporting evidence against violation of the parallel trends assumption in our difference-in-difference specifications. First, we show visual evidence for the absence of pre-trends in key outcome variables between treated and untreated industries by including event study plots corresponding to our baseline specification in Equation 1 and Equation 3 for all firms and also for eligible and ineligible firms separately. Secondly, in variants of the baseline specifications, we allow for industry, firm, and firm-product level linear time trends.

Time Varying Unobserved Factors: Another concern in our specifications stems from time varying industry and firm level unobservables that could induce a bias in our coefficients of interest. We would then erroneously attribute the effect of such unobserved shocks to the R&D tax credit reform. We address the concerns related to omitted variable bias by including high dimensional fixed effects in variants of our baseline models. As R&D spending is volatile and treated firms' growth trajectories may differentially vary with the aggregate fluctuations in the economy compared to untreated firms, we sort firms based on size growth in the pre-reform period and interact the size growth quartiles with year fixed effects in variants of our baseline specification. This ensures that we compare treated firms to control firms that have similar growth trajectory in the pre-reform period to estimate the impact of the tax credit scheme. Further, we include state $\times$ year fixed effects to control for state level time varying unobserved shocks. In variants of Equation 2, we include industry $\times$ year fixed effects to check if our results are robust when we compare treated firms to control firms within the same industry controlling for any time varying industry level shocks. Further, we sort firms based on pre-reform characteristics like size, R&D, and sales, into bins and include interactions of these bins with year fixed effects to flexibly control for unobserved shocks to firms based on these characteristics.

Bias due to Staggered Treatment: In settings with staggered treatment where units are treated at different time periods, the estimates could be biased due to forbidden comparisons (Goodman-Bacon, 2021; Callaway and Sant'Anna, 2021; Borusyak et al., 2021; Sun and Abraham, 2021).[8] In our case, the source of bias would be comparisons between firms treated in 2004 and already treated firms in industries treated in 1998. Given that we have a large never treated group in our sample (75%), we do not expect this bias to be large. Nonetheless, we check for the robustness of our results to this bias in three ways. First, we show robustness of our results in variants of the baseline specifications where the comparisons are restricted to be strictly between the treated and the never treated units. Secondly, we check for the sensitivity of our results to excluding the automobile sector, that was treated in 2004, from the estimation sample. Finally, for the outcomes estimated using the log-linear model

[8] We refer the reader to Roth et al. (2022) and de Chaisemartin and D'Haultfœuille (2022) for a survey of this literature.

with OLS, we report the results from alternative estimators proposed in the literature that address the bias in settings with staggered treatment (Callaway and Sant'Anna, 2021; Borusyak et al., 2021; Sun and Abraham, 2021).

5. Main Results: Effect on R&D Expenditure and Prices

5.1 Research & Development Expenditure

Industry-level Evidence: We start by providing industry-level evidence on the evolution of aggregate R&D expenditures before and after the implementation of tax credit scheme. Figure 1 plots the trends in aggregate R&D of industries treated in 1998 and the never treated industries (Panel A), and those treated in 2004 and the never treated industries (Panel B). We normalize these values to the initial year. The figure provides strong visual evidence of a trend break after the introduction of the tax credit scheme in both the panels. While there is little difference in the increase in the aggregate R&D expenditure for the treated (dotted line) and the never treated industries (solid line) in the 5 years leading up to the reform, there is a large increase in the R&D expenditure of treated industries relative to the never treated group post the introduction of the tax scheme. These graphs provide visual evidence for a strong positive impact of the reform on R&D expenses and for the absence of any differential pre-existing trends in aggregate R&D expenses in treated industries relative to the never treated industries. Next, we turn to a rigorous examination of the causal link between the tax credit policy and firm level R&D expenditure.

Average effect: We estimate the variants of equation Equation 1 to estimate the average effect of the R&D tax credit scheme on the firm level R&D expenditure. Table 3 presents the results. We start with a parsimonious specification including only firm and year fixed effects in column 1 and find that the R&D tax credit policy has a positive and statistically significant effect on the firm level R&D expenditures. Next, we sequentially add various fixed effects to control for different sources of time varying unobserved heterogeneity. In column (2), we include interactions of the pre-reform asset growth quartile of a firm with year fixed effects. In column (3), we add the state $\times$ year fixed effects. Finally, in the most stringent specification in column 4, we further add time varying controls in the form of interactions of the pre-reform quartiles of the average firm level capital and operating profits with year fixed effects. The coefficient on $Treated_{jt}$ remains stable in magnitude and statistically significant at the 1% significance level across all specifications. The reform leads to an increase in the firm level R&D expenditure, on average, by around 59.7% in our most conservative estimate in column 4.

Next, we provide visual evidence for the absence of differential pre-trends in the R&D expenses for firms in treated industries relative to untreated industries. In Figure 2, we plot the coefficients from estimating the event study corresponding to the specification estimated in column 1 of Table 3. Each coefficient captures the yearly differential effect on the R&D expenditure of firms in treated versus untreated industries. We normalize the coefficient to be zero in the last year before the reform. The graph shows that there is no differential effect on R&D expenditure for firms in treated industries before the introduction of tax credits, confirming that our results are not driven by pre-existing trends. Further, the estimates suggest that the firms increase R&D investments gradually in response to the tax credit scheme and it takes around 6 years for the effects of the policy to fully materialize. This is partly because of an increase in weighted tax credits to 150% from 125% in 2001. However, the progressive increase in R&D expenses persists beyond 2001 and is suggestive of adjustment costs for R&D inputs like intermediate inputs and research workers.

Differential effect based on firm eligibility: The results on the average effect of the policy capture the direct effect on eligible firms with approved in-house R&D units as well as any spillover effects on other innovating firms. Next, in Panel B of Table 3, we report results from estimating the variants of Equation 2 to examine the differential effect of the policy based on firm eligibility status. The estimates suggest that increase in the R&D expenditure, on average, in treated industries is entirely driven by the effect on eligible firms. The coefficient on the interaction term

$Treated_{jt} \times Eligible_i$ is positive and statistically significant. Interestingly, the effect on ineligible firms is close to zero and statistically insignificant, suggesting absence of any discouragement effect on ineligible innovating firms in the treated industries. Our results are robust across different sets of controls in columns 1-4. In our most conservative estimate in column 4, the eligible firms differentially increase their R&D expenditure, on average, by 73.6% compared to the ineligible firms.

To check if our results on the differential effect of the policy on eligible firms is driven by pre-trends, we plot the event study graphs separately for eligible (Panel a) and ineligible firms (Panel b) in the Figure 3. It is evident that in the pre-policy period, there is no differential increase in R&D expenditure in treated industries relative to control industries for both eligible firms and non-eligible firms. However, after the policy change, there is a large sustained increase in the R&D expenditures of eligible firms, while the coefficients on the ineligible firms in the post reform period fluctuate around 0. Further, we present event study graphs capturing the yearly differential effect of the policy on eligible firms versus ineligible firms. For each observation, we create an indicator variable for the number of years before or after the reform and interact it with indicator variables equal to 1 if the firm belongs to a treated industry and if it is eligible for the reform. We include industry $\times$ year fixed effects to capture the time varying unobserved shocks at the industry level. Note that the differential effect on the ineligible firms in treated industries relative to the control industries is absorbed by these fixed effects. Appendix Figure A.2 shows that there is no differential effect on eligible firms compared to ineligible firms in the pre-reform period providing strong evidence that our results are not driven by pre-trends and unobserved time varying industry level shocks.

The Role of Financial Constraints: Next, we explore the role of financial frictions in explaining the large response of R&D spending to tax credits. R&D spending may be more responsive to the relaxation of financial constraints than other forms of investments due to the intangible nature of the R&D investment, the greater asymmetric information between the innovators and creditors, and the threat of appropriation of ideas (Hall and Lerner, 2010; Kerr and Nanda, 2015). We expect this channel to be particularly relevant for developing countries like India that have relatively less developed banking sector and equity markets. To confirm this intuition, we test for the heterogeneous effect of the policy based on measures of financial constraints by including triple interaction between $Treated_{jt}$, $Eligible_i$, and a measure of financial constraint. The first measure is based on the age of firms and we create an indicator variable equal to 1 if the firm is below the median age. Petersen and Rajan (1994) suggest that young firms are comparatively more credit-constrained due to the absence of credit history and bank ties. The second measure of financial constraints, proposed by Rajan and Zingales (1998), is based on the industry's dependence on external finance. We create an industry level indicator variable equal to 1 if the industry's external financial dependence is above the median value in the pre-reform period. Our results, reported in Table 4 suggest that the younger firms (columns 1-2) and the firms in industries with greater dependence on external finance (columns 3-4) differentially increase their R&D investments in response to the policy.

5.2 Firm Product Prices and Markup

The introduction of R&D tax credits can influence output prices and markup for both the eligible and ineligible firms. For eligible firms, the policy lowers their user cost of R&D, resulting in higher investments in R&D. The impact of these investments on prices would depend crucially on the type of innovation undertaken by the firms. If firms undertake process and organizational innovation leading to a lower marginal cost, we expect part of these cost savings to be passed on to the consumers in the form of lower output prices with the extent of passthrough depending on the demand and market structure of the particular industry. Under incomplete passthrough of costs to prices, a lowering of marginal costs would increase markup. However, if firms undertake product and marketing innovations, we expect an outward shift in the demand for these firms resulting in higher markup (conditional on costs) and prices.[9]

[9]For a detailed explanation on the classification of innovation types, we refer the reader to the OSLO manual (2005).

The IPR regime in India did not recognize product patents until 2005, which is toward the very end of our sample period. Thus, we expect the firms to mainly invest in efficiency improvements potentially leading to lower output prices.

Further, there could be competitive spillover effects on the ineligible firms who may lower their markup and prices as they perceive a lower residual demand for their products. Additionally, ineligible firms may also be induced to increase their efforts in reducing their marginal costs, resulting in higher markup and lower prices.

Effect on Prices: We start by estimating the average effect of the policy on firm-product level prices by estimating variants of Equation 3. We report the results in Panel A of Table 5 and the specifications follow a similar pattern of controls as in Table 3. Across all specifications in columns 1-4, we find that the policy leads to a decline in firm-product level prices and that the effect is economically meaningful and statistically significant. The coefficient suggests that the policy reduces firm-product level prices, on average, by 17% in treated industries relative to the untreated industries (column 4).

Next, to examine the differential effect of the policy on the eligible firms relative to the ineligible firms, we estimate the variants of Equation 4 and report the results in Panel B of 5. Across all specifications, the coefficient on $Treated_{jt}$ is negative and statistically significant. The magnitude implies a reduction in prices of ineligible firms in treated industries, on average, by 19% in response to the policy (column 1). Further, the coefficient on the interaction term, $Treated_{jt} \times Eligible_i$, is positive, small in magnitude, and imprecisely estimated, suggesting the absence of any significant differential effect on prices of eligible firms relative to ineligible firms. The magnitudes of the coefficients imply that the policy leads to an overall decline in prices of eligible firms, on average, by 15% (column 1). These results imply that the average decrease in prices in treated industries is a result of both the direct impact of the policy on the eligible firms and the spillover effect on the ineligible firms.

Figure 4 plots the event study graph for the yearly differential effect on prices of firms in treated industries. In the years leading up to the reform, we find no differential effect on prices for firms in treated industries suggesting that our results are unlikely to be driven by pre-trends. Further, the decline in prices is gradual for the first two years and remains stable around 20% thereafter. Figure 5 plots the event study graph separately for the eligible and the ineligible firms. For both sets of firms, we find no evidence of pre-trends in prices and a sustained decline in prices after the introduction of the policy.

Effect on Markup: In Table 6, we present the results of our analysis on the impact of the policy on firm-product level markup. The results in Panel A, columns 1-4, indicate that the reform did not have a significant average effect on the firm-product level markup. The coefficient is close to 0 and statistically insignificant. In Panel B, the effect on ineligible firms is negative, small in magnitude but imprecisely estimated. The coefficient on the interaction term is positive but statistically insignificant at conventional levels, suggesting a lack of any substantial differential positive effect on markup of eligible firms relative to ineligible firms in treated industries. Moreover, the overall effect on the eligible firms remains small in magnitude and statistically insignificant in all specifications.

The absence of improvements in markup for the eligible firms may seem surprising given that the presence of incomplete passthrough of costs to prices is well documented for Indian manufacturing firms with passthrough rates of around 0.3-0.4 (De Loecker et al., 2016). Under incomplete passthrough of costs to prices, a reduction in marginal costs should feed into higher markup. However, note that the overall effect on markup also reflects the direct effect on markup, conditional on costs, due to changes in the residual demand facing the firm. Aggressive lowering of prices by ineligible competitors could lower the residual demand for eligible firms, attenuating the increase in markup due to cost savings. In section 6, we examine the relative strengths of the cost saving and the demand side channels in driving the overall effect on prices and markup documented here.

5.3 Robustness Checks

In this section, we discuss the results from several robustness checks that address the main concerns with identification in our setting.

Alternative Definitions for Eligible Firms: The registration of in-house R&D with DSIR depends on the proposed R&D plan as well as the past performance of the in-house R&D units. Hence, firms seeking registration of their in-house R&D units are likely to incur considerable R&D expenditure prior to being registered with DSIR. Thus, the baseline specifications employ a time invariant eligibility criteria for firms to capture the full effect of the reform. To isolate the direct impact of the tax credit on eligible firms, we use a time varying measure of eligibility for tax credits and estimate the following specifications:

$$\begin{aligned} \mathbb{E}[R_{ijt} \mid Treated_{jt}, \boldsymbol{X_{it}}] = exp(&\beta_1 Treated_{jt} + \beta_2 Treated_{jt} \times Eligible_{it} + \beta_3 Eligible_{it} \\ &+ \lambda Switch_{it} + \boldsymbol{\theta X_{it}} + \alpha_i + \delta_t) \end{aligned} \tag{5}$$

$$\begin{aligned} y_{ipjt} = &\beta_1 Treated_{jt} + \beta_2 Treated_{jt} \times Eligible_{it} + \beta_3 Eligible_{it} \\ &+ \lambda Switch_{it} + \boldsymbol{\theta X_{it}} + \alpha_{ip} + \delta_t + \epsilon_{ipjt} \end{aligned} \tag{6}$$

where $Eligible_{it}$ is a dummy variable equal to 1 if a firm has an in-house R&D registered with DSIR in year t. We acknowledge that firms that switch into eligibility during the sample period may differ systematically to other firms that do not. To address this selection issue, we include a dummy variable, $Switch_{it}$, as a control that takes a value of 1 if the firm switches its eligibility status in year t.

We expect β_2 to be positive and it captures the differential effect of the reform on eligible firms relative to ineligible firms. β_1 would capture the increase in R&D by ineligible firms in a bid to have their in-house R&D units registered with DSIR as well as any spillover effects of the policy on firms that remain ineligible throughout the sample period. If the former effect is strong, β_1 would be positive and significant. Finally, $\beta_1 + \beta_2$ will capture the total direct effect of the reform for firm-years that are eligible for tax credits and we expect it to be positive and statistically significant.

The results are reported in Appendix Table A.3 with R&D expenses (columns 1-

2) and firm-product level prices (columns 3-4) as the outcome variable. The even numbered columns include industry $\times$ year fixed effects. The coefficient on the interaction term is positive and significant in columns 1 and 2, suggesting that there is a differential increase in R&D expenses of eligible firm-years by 35%-40%. Further, we find that firms do increase their R&D expenses by 28% even before becoming eligible for tax credits. Finally, the overall effect on eligible firm-years is 68% which is not very different from the estimates in our baseline specifications. Columns 3-4 confirm that the results on prices too remain very similar to our baseline specifications with a decline in prices for both eligible as well as ineligible firm-years.

Further, we also check that our results are robust to defining the group of eligible firms to consist of: (1) firms that are eligible in at least one year in the pre-reform period, and (2) firms that are eligible for the reform in 1997. These results are reported in Appendix Table A.4 and we find that the effect on both R&D expenses and prices are very similar to our baseline specifications for both these measures of eligibility. Taken together, these results suggest that the effects of the policy on eligible firms are not driven by any particular criteria for defining them or by firms switching their eligibility status.

Staggered Treatment: To address issues related bias arising from staggered treatment of industries, we follow Bau and Matray (2020) and create a separate dataset for each treatment cohort for 1998 and 2004 ensuring that the control group in each dataset consists of only never treated observations. Thus, for the 1998 reform, we use data for 1992-2007 and remove all observations for units belonging to the industries treated in 2004. For the 2004 reform, we use data from 1999-2007 and we remove all observations from industries treated in 1998. Thus, in each dataset, the control group comprises of only never treated units. We stack these datasets together and compare our results with and without $ReformYear \times$ year fixed effects, where $ReformYear$ is an identifier for the datasets corresponding to 1998 and 2004 reforms. We report the results with R&D expenses as outcome variable in Appendix Table A.5 and prices as outcome variable in Appendix Table A.6. We find that the results are very similar to our baseline findings in the first two columns. Further, the coefficients remain virtually unchanged when we add the $ReformYear \times$ year fixed effects in columns 3 and 4, suggesting that forbidden comparisons are not driving our main results.

Strategic Reaction to the Policy: Firms could strategically react to the introduction of the R&D tax credits by postponing their research expenses to take advantage of lower user costs of R&D. Further, firms may also start investing early in R&D capital and manpower for long duration projects. To understand the relevance of such strategic behavior of firms to our overall results, we run our baseline specifications on samples that exclude: (1) the last year prior to reform, (2) the year of the reform and one year before, and (3) all three years around the introduction of the reform. We report these results in Appendix Tables A.7 and A.8 for R&D expenses and prices, respectively. The results remain robust across all the three samples suggesting that anticipatory and strategic responses by firms are not a key driver of our main results.

Other Robustness Checks: : To test the influence of outliers in our main results, we report results from estimating our baseline specifications on winsorized samples. R&D expenses for the top 1% and 2.5% for each industry are winsorized. For prices, we winsorize the top and bottom 1% and 2.5% of the observations. The results, reported in Appendix Table A.9, suggest that the main results remain robust for both samples.

We also test if our results are driven by entry and exit of firms in our sample by estimating the baseline specifications on a balanced panel of firms. The results, reported in Appendix Table A.10, remain robust in the balanced sample.

Finally, we test the sensitivity of our results to alternative clustering levels. These results, reported in Appendix Table A.11, suggest that the coefficients of interest remain statistically significant at 1% level when we cluster standard errors at the sector (2 digit NIC) level or two way cluster standard errors at the industry and year level.

6. Discussion of the Underlying Mechanisms

In this section, we examine the two distinct mechanism behind our results on the effect of the reform on firm product level prices and markup: (1) productivity improvements leading to lower costs, higher markup, and lower prices, (2) changes in residual demand leading to changes in markup and prices, conditional on costs. Further, we test for heterogeneous responses to the policy based on initial markups.

6.1 Effect on Marginal Costs

In Table 7, we report the results on the impact of the policy on firm product level marginal costs (columns 1 and 2) and firm level physical efficiency (columns 3 and 4). The results suggest that the policy leads to a significant decline in marginal costs, on average, by 17.7% (column 1). In column 2, we find that there is no differential effect of the policy on the marginal costs of the firms based on their eligibility status. The coefficient on the interaction term is negative albeit imprecisely estimated. The coefficients imply that the policy leads to a overall decline in marginal costs for eligible firms by 23% which is precisely estimated. On the other hand, the coefficient capturing the effect on ineligible firms suggests a meaningful decline in marginal costs by 14% for these firms. The results in columns 3 and 4 imply that the policy leads to an increase in the physical efficiency of a firm, on average, by 26.1% (column 3), and that both the eligible and the ineligible firms experience similar improvements in their efficiency (column 3). Further, we examine the impact of the reform on output and factor inputs and report the results in Table 8. We find that the policy increases firm level revenue (columns 1-2), physical capital (columns 3-4), and compensation to employees (column 5-6). This increase is primarily driven by eligible firms while there is no significant effect on the ineligible firms. These results suggest that eligible firms do gain market share at the expense of their competitors. Nonetheless, the ineligible firms are able to preserve their sales and avoid a large decline in market share by improving their physical efficiency.

There are two takeaways from these findings. First, these results suggest that the eligible firms' R&D investment is mainly geared towards efficiency improvements leading to a lower marginal cost in response to the reform. Second, the reform also leads to an improvement in the physical efficiency of ineligible firms, suggesting that there are positive spillover effects on productivity of competitors.

6.2 Pro-competitive Effects of the Policy

To examine the changes in prices and markup due to changes in the residual demand for firms, we estimate the direct effect of the policy on firm product level markup, conditional on marginal costs. We include marginal costs as a control in our baseline specification with markup as the outcome variable. However, marginal costs respond endogenously to changes in user cost of R&D and hence we instrument marginal costs with one and two period lags in columns 2 and 3, respectively. Across all specifications in columns 1-3, we find evidence of strong competitive effects with markup (conditional on costs) declining, on average, by around 13% in response to the policy. Comparing to the average decline in the firm product level prices by 18%, competitive effects on markup account for almost three-fourths of the decline in prices due to the reform while the remaining one-fourth is accounted for by the partial passthrough of cost savings to prices.

In columns 4-6, we examine the differential effects on markup based on the eligibility status of the firms. The effect on ineligible firms is negative, large in magnitude, and statistically significant. The policy induces a decline in direct markup of these firms, on average, by 16%, suggesting strong competitive effects for ineligible firms. We find that the coefficient on the interaction term is positive, small in magnitude, and statistically insignificant suggesting that the competitive effects are not substantially attenuated for eligible firms. Interestingly, the overall effect on eligible firms is also negative and borderline statistically significant at the 10% level suggesting a decline in direct markup by 8-10% for these firms. This suggests that ineligible firms reduce prices aggressively and this has disciplining effect on the overall markup for eligible firms which would have otherwise risen sharply due to incomplete passthrough of cost savings to prices.

Taken together, these results provide compelling evidence that the policy leads to lower prices primarily due to the increased price competition between firms within the industry.

7. Conclusion

In this paper, we study the weighted R&D tax credits scheme introduced across industries in India during the 1990s and 2000s. We utilize data on R&D and detailed production data on all product lines manufactured by firms to examine the effect of the policy on innovation and price competition within industries.

We show that R&D tax credits increase firm level R&D spending and induce a large decline in prices in industries targeted by the reform in India. The relative increase in R&D spending in treated industries is driven by eligible firms while there is no significant effect on ineligible firms. Further, eligible firms experience a large decline in their marginal costs, due to improvements in physical efficiency, and pass on a third of these cost savings to prices. In response, ineligible firms also reduce their prices significantly. The decline in prices is primarily driven by a decline in markups, conditional on costs, as opposed to cost savings. We provide compelling evidence that our results are not biased due to pre-existing linear trends, omitted variables, and staggered treatment of industries. Our results provide novel causal evidence that R&D tax incentives can increase price competition within industries.

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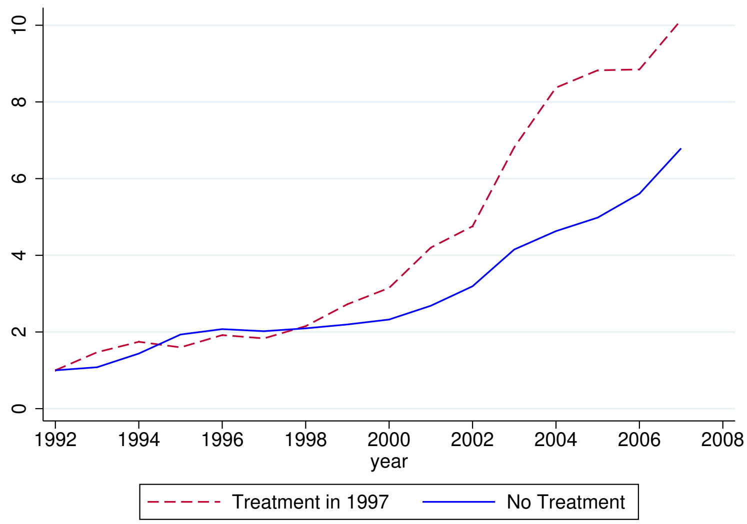
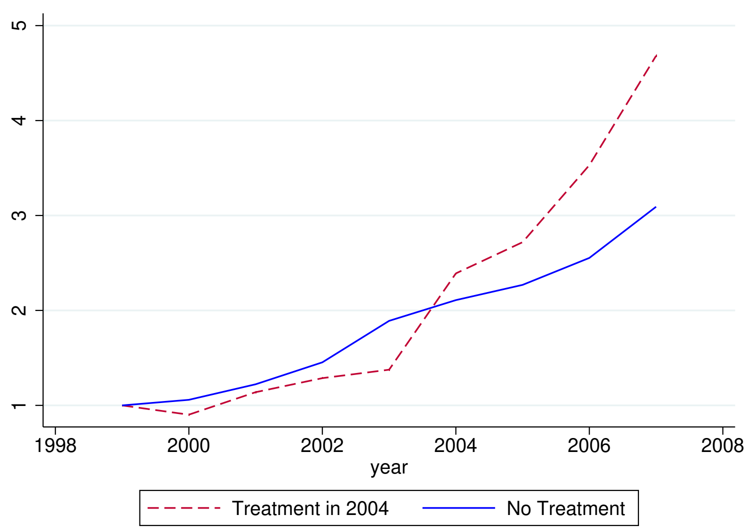
Figure 1: Evolution of Aggregate R&D expenditures



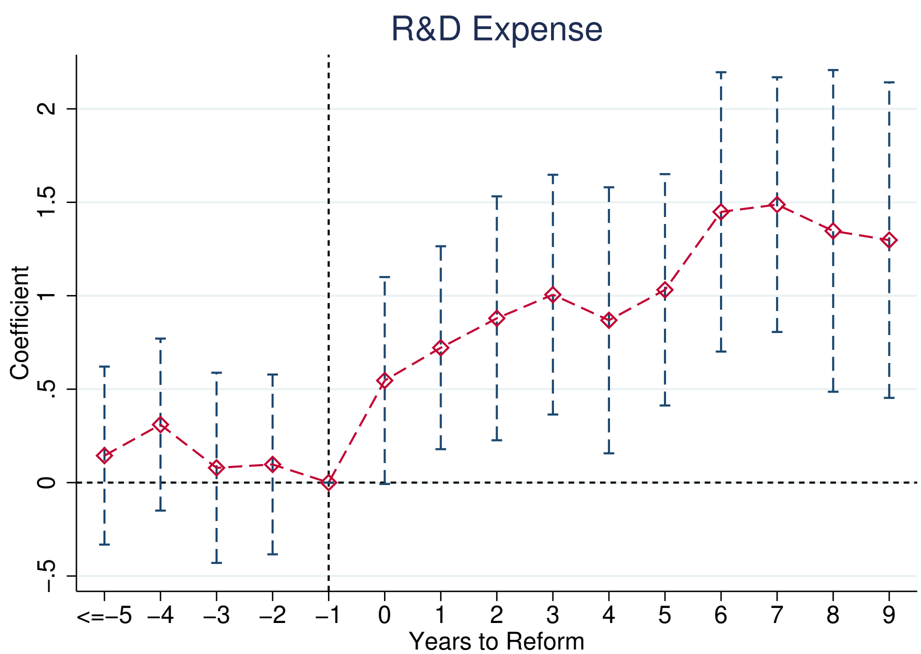
(a) Treatment in 1998



(b) Treatment in 2004

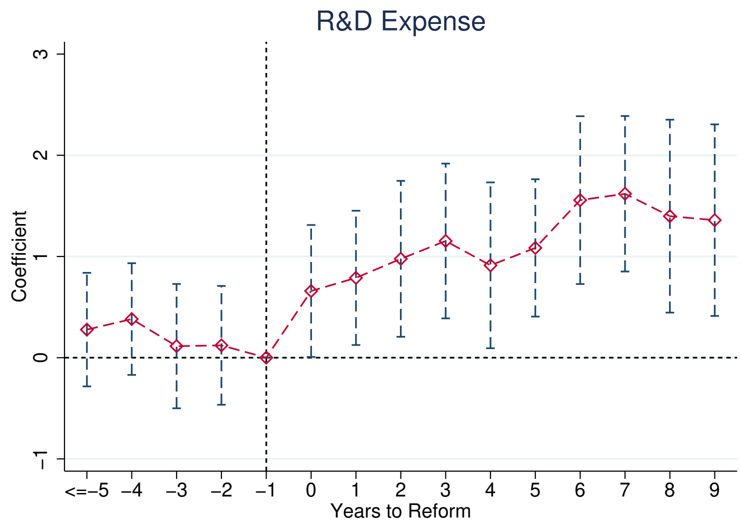
Notes: The figure plots the annual aggregate R&D expenditures for all firms in the treated industries (dotted line) and the untreated industries (solid line). Panel (a) and (b) plot the graph for industries treated in 1998 and 2004, respectively.

Figure 2: Event study plot for the effect of the policy on R&D expenditures

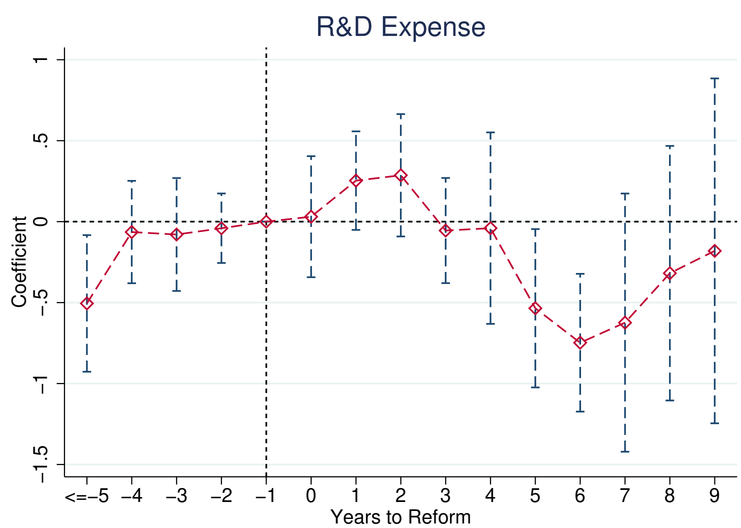


Notes: The figure plots the event study graph for the effect of the policy on the firm level R&D expenditure. The sample period is from 1992 to 2007. Vertical dotted lines report 95% confidence intervals with standard errors clustered at the industry level.

Figure 3: Event study plots for the effect of the policy on R&D expenditures by eligibility status



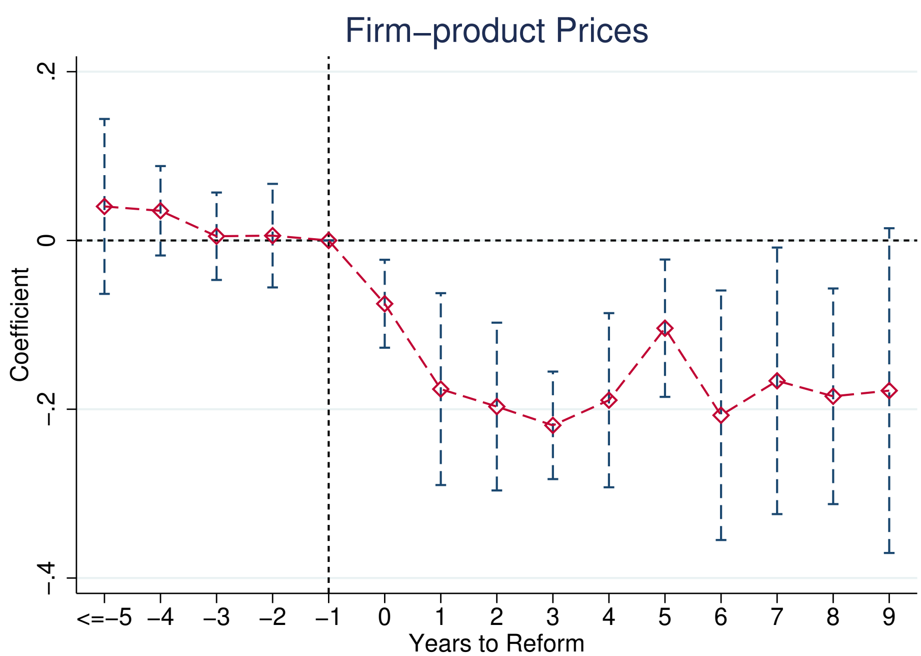
(a) Eligible Firms



(b) Ineligible Firms

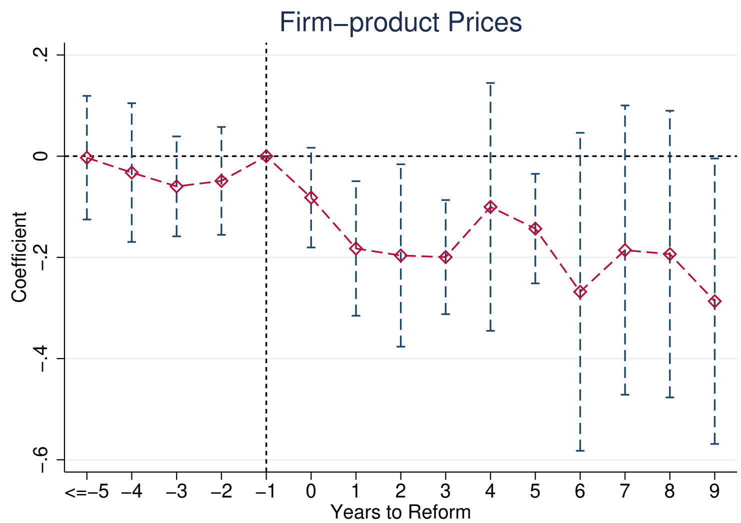
Notes: The figure plots the event study graph for the effect of the policy on the firm level R&D expenditure separately for eligible firms (Panel a) and ineligible firms (Panel b). The sample period is from 1992 to 2007. Vertical dotted lines report 95% confidence intervals with standard errors clustered at the industry level.

Figure 4: Event study plots for the effect of the policy on Firm-Product Prices

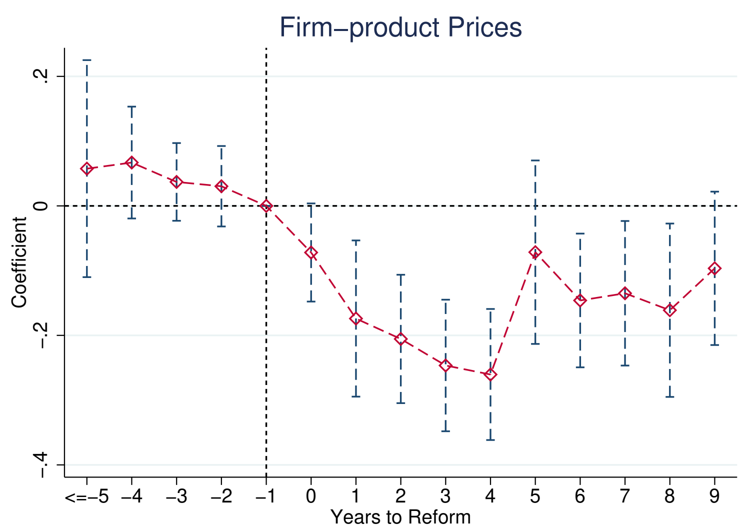


Notes: The figure plots the event study graph for the effect of the policy on the firm-product level prices. The sample period is from 1992 to 2007. Vertical dotted lines report 95% confidence intervals with standard errors clustered at the industry level.

Figure 5: Event study plots for the effect of the policy on firm-product Prices by eligibility status



(a) Eligible Firms



(b) Ineligible firms

Notes: The figure plots the event study graph for the effect of the policy on the firm-product level prices separately for eligible firms (Panel a) and ineligible firms (Panel b). The sample period is from 1992 to 2007. Vertical dotted lines report 95% confidence intervals with standard errors clustered at the industry level.

Table 1: Summary Statistics by Treated Industries

	Treated Industries			Untreated Industries		
	N	Mean	SD	N	Mean	SD
	(1)	(2)	(3)	(4)	(5)	(6)
Log(Assets)	4310	2.05	1.42	30536	1.95	1.30
Log(Sales)	4310	1.37	2.18	30536	1.32	2.00
Log(R&D)	4310	0.13	0.43	30536	0.03	0.16
Log(Prices)	9071	-12.58	4.74	46859	-11.63	3.53
Log(Marginal Cost)	8986	-13.16	5.09	46349	-11.63	3.93
Log(Markup)	8986	0.59	2.06	46349	0.00	2.04
Quantity	9105	10.00	5.36	47152	9.21	4.11

This table reports the summary statistics separately for treated industries and untreated industries in the sample. The sample period is from 1992 to 2007. All the variables are defined in the appendix table A.2.

Table 2: Association between industry level characteristics and the R&D tax credit scheme

	Dependent Variable: Treated Industries = 1					
	(1)	(2)	(3)	(4)	(5)	(6)
R&D Growth	-0.013					
	(0.021)					
Sales Growth		-0.002				
		(0.002)				
Number of firms			0.002			
			(0.002)			
Log(Average R&D)				0.101		
				(0.422)		
Log(Average Sales)					0.008	
					(0.038)	
Log(Average Capital)						-0.023
						(0.042)
Observations	101	122	122	122	122	122

All the variables are defined in the main text and in Appendix table A.2. Standard errors, reported in parentheses, are clustered at industry level. *, **, and ***, respectively.

Table 3: **Effect of the policy on R&D expenditures**

	Research & Development Expenditure			
	(1)	(2)	(3)	(4)
Panel A:				
Treated$_{jt}$	0.673***	0.602***	0.631***	0.597***
	(0.131)	(0.132)	(0.090)	(0.090)
Panel B:				
Treated$_{jt}$	-0.033	-0.042	0.106	0.005
	(0.320)	(0.270)	(0.236)	(0.240)
Treated$_{jt}\times$ Eligible$_i$	0.820**	0.749**	0.642**	0.736***
	(0.411)	(0.352)	(0.258)	(0.267)
Effect on Eligible Firms	0.787**	0.708***	0.748***	0.741**
	(0.161)	(0.163)	(0.101)	(0.107)
Observations	14720	14300	14253	14253
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	No	No	No
Asset Growth Quartiles $\times$ Year FE	No	Yes	Yes	Yes
State$\times$Year FE	No	No	Yes	Yes
Time Varying Firm Controls	No	No	No	Yes

This table presents the variants of the regression $E[R_{ijt} \mid Treated_{jt}, \boldsymbol{X_{it}}] = exp(\beta_1 Treated_{jt} + \boldsymbol{\theta X_{it}} + \alpha_i + \delta_t)$ in **Panel A**, and $E[R_{ijt} \mid Treated_{jt}, \boldsymbol{X_{it}}] = exp(\beta_1 Treated_{jt} + \beta_2 Treated_{jt} \times Eligible_i + \boldsymbol{\theta X_{it}} + \alpha_i + \delta_t)$ in **Panel B**, where, i denotes firm, j denotes the 4-digit NIC2004 industry, t denotes the year of observation, R_{ijt} is the level of annual R&D spending by the firm, and $\boldsymbol{X_{it}}$ denotes a vector of firm level time varing controls. All the regressions are estimated using PPML. *Treated*$_{jt}$ is a dummy variable which equals 1 for all years since the weighted tax credit scheme is introduced in an industry, and zero otherwise. $Eligible_i$ is a dummy variable that takes the value of 1 for firms that have an in-house R&D unit registered with the DSIR at least once during the sample period, and zero for the firms that are never registered on DSIR. α_i, and δ_t denote the firm, and year fixed effects. All the regressions are from 1992 to 2007. All the variables are defined in the Appendix Table A.2. Standard errors, reported in parentheses, are clustered at industry level. *, ** and *** denote significance at 10%, 5% and 1%, respectively.

Table 4: **Mechanisms - The Role of Financial Constraints**

	Age		*RZ index*	
	(1)	(2)	(3)	(4)
Treated	0.543***	-0.096	0.503***	0.205*
	(0.088)	(0.266)	(0.140)	(0.116)
Treated × Eligible		0.768***		0.408
		(0.280)		(0.253)
Treated × Eligible × Young		0.591**		
		(0.263)		
Treated × Young	0.527***	0.311*		
	(0.189)	(0.183)		
Treated × Eligible × High RZ Index				1.558***
				(0.383)
Treated × High RZ index			0.395**	-1.074***
			(0.185)	(0.268)
Observations	13091	13091	12976	12976
Firm FE	Yes	Yes	Yes	Yes
Asset Growth Quartiles × Year FE	Yes	Yes	Yes	Yes
State×Year FE	Yes	Yes	Yes	Yes
Time Varying Firm Controls	Yes	Yes	Yes	Yes

This table presents the variants of the regression $E[R_{ijt} \mid Treated_{jt}, \boldsymbol{X_{it}}] = exp(\beta_1 Treated_{jt} + \beta_2 Treated_{jt} \times \textit{fin cons} + \boldsymbol{\theta X_{it}} + \alpha_i + \delta_t)$ in columns 1 and 3, and $E[R_{ijt} \mid Treated_{jt}, \boldsymbol{X_{it}}] = exp(\beta_1 Treated_{jt} + \beta_2 Treated_{jt} \times Eligible_i + \beta_2 Treated_{jt} \times \textit{fin cons} + \beta_2 Treated_{jt} \times Eligible_i \times \textit{fin cons} + \boldsymbol{\theta X_{it}} + \alpha_i + \delta_t)$ in columns 2 and 4, where, i denotes firm, j denotes the 4-digit NIC2004 industry, t denotes the year of observation, R_{ijt} is the level of annual R&D spending by the firm, and $\boldsymbol{X_{it}}$ denotes a vector of firm level time varing controls. All the regressions are estimated using PPML. *Treated*$_{jt}$ is a dummy variable which equals 1 for all years since the weighted tax credit scheme is introduced in an industry, and zero otherwise. $Eligible_i$ is a dummy variable that takes the value of 1 for firms that have an in-house R&D unit registered with the DSIR at least once during the sample period, and zero for the firms that are never registered on DSIR. *fin cons* is the measure of financial constraints. In columns 1-2, it is a firm level measure, $Young$ defined as a dummy variable equals 1 if firm is below median age, and zero otherwise. In columns 3-4, it is an industry level measure, *High RZ index*, defined as an indicator variable equal to 1 if the industry's external financial dependence is above median value in the pre-reform period, and zero otherwise. α_i, and δ_t denote the firm, and year fixed effects. All the regressions are from 1992 to 2007. All the variables are defined in the Appendix Table A.2. Standard errors, reported in parentheses, are clustered at industry level. *, ** and *** denote significance at 10%, 5% and 1%, respectively.

Table 5: **Effect of the policy on firm-product level Prices**

	Firm-Product Prices			
	(1)	(2)	(3)	(4)
Panel A:				
Treated$_{jt}$	-0.183***	-0.183***	-0.179***	-0.181***
	(0.053)	(0.052)	(0.052)	(0.054)
Panel B:				
Treated$_{jt}$	-0.192***	-0.192***	-0.189***	-0.194***
	(0.056)	(0.056)	(0.058)	(0.059)
Treated$_{jt}\times$ Eligible$_i$	0.024	0.021	0.024	0.033
	(0.075)	(0.066)	(0.073)	(0.078)
Effect on Eligible Firms	-0.168**	-0.171**	-0.165**	-0.161**
	(0.077)	(0.069)	(0.072)	(0.077)
Observations	51008	49627	49619	49619
Firm-product FE	Yes	Yes	Yes	Yes
Year FE	Yes	No	No	No
Asset Growth Quartiles $\times$ Year FE	No	Yes	Yes	Yes
State$\times$Year FE	No	No	Yes	Yes
Time Varying Firm Controls	No	No	No	Yes

This table presents the variants of the regression $y_{ipjt} = \beta_1 Treated_{jt} + \boldsymbol{\theta X_{ipt}} + \alpha_{ip} + \delta_t + \epsilon_{ipjt}$ in **Panel A**, and $y_{ipjt} = \beta_1 Treated_{jt} + \beta_2 Treated_{jt} \times Eligible_i + \boldsymbol{\theta X_{ipt}} + \alpha_{ip} + \delta_t + \epsilon_{ipjt}$ in **Panel B**, where, p denotes the product line produced by the firm, i denotes firm, j denotes the 4-digit NIC2004 industry, t denotes the year of observation, and $\boldsymbol{X_{it}}$ denotes a vector of firm level time varing controls. All the regressions are estimated using OLS. *Treated*$_{jt}$ is a dummy variable which equals 1 for all years since the weighted tax credit scheme is introduced in an industry, and zero otherwise. $Eligible_i$ is a dummy variable that takes the value of 1 for firms that have an in-house R&D unit registered with the DSIR at least once during the sample period, and zero for the firms that are never registered on DSIR. α_i, and δ_t denote the firm, and year fixed effects. The dependent variable in all the regressions is (log of) product level prices. All the regressions are from 1992 to 2007. All the variables are defined in the Appendix Table A.2. Standard errors, reported in parentheses, are clustered at industry level. *, ** and *** denote significance at 10%, 5% and 1%, respectively.

Table 6: **Effect of the Policy on Markup**

	Markup			
	(1)	(2)	(3)	(4)
Panel A:				
Treated$_{jt}$	-0.030	-0.024	-0.001	-0.004
	(0.053)	(0.050)	(0.051)	(0.050)
Panel B:				
Treated$_{jt}$	-0.051	-0.044	-0.040	-0.054
	(0.053)	(0.052)	(0.055)	(0.054)
Treated$_{jt}\times$ Eligible$_i$	0.051	0.050	0.098	0.124*
	(0.068)	(0.070)	(0.061)	(0.069)
Effect on Eligible Firms	-0.0002	0.006	0.059	0.070
	(0.0732)	(0.071)	(0.062)	(0.064)
Observations	51008	49627	49619	49619
Firm-product FE	Yes	Yes	Yes	Yes
Year FE	Yes	No	No	No
Asset Growth Quartiles $\times$ Year FE	No	Yes	Yes	Yes
State$\times$Year FE	No	No	Yes	Yes
Time Varying Firm Controls	No	No	No	Yes

This table presents the variants of the regression $y_{ipjt} = \beta_1 Treated_{jt} + \boldsymbol{\theta X_{ipt}} + \alpha_{ip} + \delta_t + \epsilon_{ipjt}$ in **Panel A**, and $y_{ipjt} = \beta_1 Treated_{jt} + \beta_2 Treated_{jt} \times Eligible_i + \boldsymbol{\theta X_{ipt}} + \alpha_{ip} + \delta_t + \epsilon_{ipjt}$ in **Panel B**, where, p denotes the product line produced by the firm, i denotes firm, j denotes the 4-digit NIC2004 industry, t denotes the year of observation, and $\boldsymbol{X_{it}}$ denotes a vector of firm level time varing controls. All the regressions are estimated using OLS. *Treated*$_{jt}$ is a dummy variable which equals 1 for all years since the weighted tax credit scheme is introduced in an industry, and zero otherwise. $Eligible_i$ is a dummy variable that takes the value of 1 for firms that have an in-house R&D unit registered with the DSIR at least once during the sample period, and zero for the firms that are never registered on DSIR. α_i, and δ_t denote the firm, and year fixed effects. The dependent variable in all the regressions is (log of) product level markup. All the regressions are from 1992 to 2007. All the variables are defined in the Appendix Table A.2. Standard errors, reported in parentheses, are clustered at industry level. *, ** and *** denote significance at 10%, 5% and 1%, respectively.

Table 7: **Effect of Policy on Marginal Costs and Physical Efficiency**

	Marginal Cost		*TFPQ*	
	(1)	(2)	(3)	(4)
Treated_{jt}	-0.177**	-0.140*	0.261**	0.259*
	(0.070)	(0.076)	(0.102)	(0.132)
$\text{Treated}_{jt} \times \text{Eligible}_i$		-0.091		0.005
		(0.121)		(0.140)
Effect on Eligible Firms		-0.231**		0.264***
		(0.105)		(0.093)
Observations	49619	49619	23390	23390
Firm-product FE	Yes	Yes	No	No
Firm FE	No	No	Yes	Yes
Asset Growth Quartiles × Year FE	Yes	Yes	Yes	Yes
State×Year FE	Yes	Yes	Yes	Yes
Time Varying Firm Controls	Yes	Yes	Yes	Yes

This table presents the variants of the regression $y_{ipjt} = \beta_1 Treated_{jt} + \boldsymbol{\theta X_{ipt}} + \alpha_{ip} + \delta_t + \epsilon_{ipjt}$ in column 1, and $y_{ipjt} = \beta_1 Treated_{jt} + \beta_2 Treated_{jt} \times Eligible_i + \boldsymbol{\theta X_{ipt}} + \alpha_{ip} + \delta_t + \epsilon_{ipjt}$ in column 2, where, p denotes the product line produced by the firm, i denotes firm, j denotes the 4-digit NIC2004 industry, t denotes the year of observation, and $\boldsymbol{X_{it}}$ denotes a vector of firm level time varing controls. All the regressions are estimated using OLS. *Treated*$_{jt}$ is a dummy variable which equals 1 for all years since the weighted tax credit scheme is introduced in an industry, and zero otherwise. $Eligible_i$ is a dummy variable that takes the value of 1 for firms that have an in-house R&D unit registered with the DSIR at least once during the sample period, and zero for the firms that are never registered on DSIR. α_i, and δ_t denote the firm, and year fixed effects. Columns 3-4 are the firm level regressions. All the regressions are from 1992 to 2007. All the variables are defined in the Appendix Table A.2. Standard errors, reported in parentheses, are clustered at industry level. *, ** and *** denote significance at 10%, 5% and 1%, respectively.

Table 8: **Effect of Policy on Sales and Factor Inputs**

	Sales		*Capital*		*Compensation*	
	(1)	(2)	(3)	(4)	(5)	(6)
Treated$_{jt}$	0.171**	0.100	0.137*	0.066	0.161**	0.098
	(0.081)	(0.085)	(0.080)	(0.060)	(0.072)	(0.062)
Treated$_{jt}\times$ Eligible$_i$		0.234*		0.232**		0.206**
		(0.119)		(0.094)		(0.099)
Effect on eligible firms		0.334***		0.299**		0.304***
		(0.109)		(0.125)		(0.111)
Observations	32874	32874	32874	32874	32874	32874
Firm-product FE	Yes	Yes	Yes	Yes	Yes	Yes
Asset Growth Quartiles $\times$ Year FE	Yes	Yes	Yes	Yes	Yes	Yes
State$\times$Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Time Varying Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes

This table presents the variants of the regression $y_{ijt} = \beta_1 Treated_{jt} + \boldsymbol{\theta X_{it}} + \alpha_i + \delta_t + \epsilon_{ijt}$ in columns 1, 3, and 5, and $y_{ijt} = \beta_1 Treated_{jt} + \beta_2 Treated_{jt} \times Eligible_i + \boldsymbol{\theta X_{it}} + \alpha_i + \delta_t + \epsilon_{ijt}$ in columns 4, and 6, where, i denotes firm, j denotes the 4-digit NIC2004 industry, t denotes the year of observation, and $\boldsymbol{X_{it}}$ denotes a vector of firm level time varing controls. All the regressions are estimated using OLS. *Treated*$_{jt}$ is a dummy variable which equals 1 for all years since the weighted tax credit scheme is introduced in an industry, and zero otherwise. $Eligible_i$ is a dummy variable that takes the value of 1 for firms that have an in-house R&D unit registered with the DSIR at least once during the sample period, and zero for the firms that are never registered on DSIR. α_i, and δ_t denote the firm, and year fixed effects. All the regressions are from 1992 to 2007. All the variables are defined in the Appendix Table A.2. Standard errors, reported in parentheses, are clustered at industry level. *, ** and *** denote significance at 10%, 5% and 1%, respectively.

Table 9: **Effect of Policy on Markup: Pro-Competitive Channel**

	Markup					
	(1)	(2)	(3)	(4)	(5)	(6)
Treated$_{jt}$	-0.134***	-0.129***	-0.132***	-0.157***	-0.162***	-0.158***
	(0.040)	(0.040)	(0.043)	(0.046)	(0.048)	(0.049)
Treated$_{jt}\times$ Eligible$_i$				0.057	0.083	0.062
				(0.052)	(0.052)	(0.061)
Average effect on eligible firms in treated industries				-0.100*	-0.080	-0.096
				(0.053)	(0.050)	(0.058)
Observations	49619	39969	34026	49619	39969	34026
Firm-product FE	Yes	Yes	Yes	Yes	Yes	Yes
Asset Growth Quartiles $\times$ Year FE	Yes	Yes	Yes	Yes	Yes	Yes
State$\times$Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Time Varying Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes
Marginal cost as control	Yes	Yes	Yes	Yes	Yes	Yes
Instrument for marginal cost	No	Yes	Yes	No	Yes	Yes
First Stage F-statistic	–	1844.75	578.19	–	1830.22	577.98

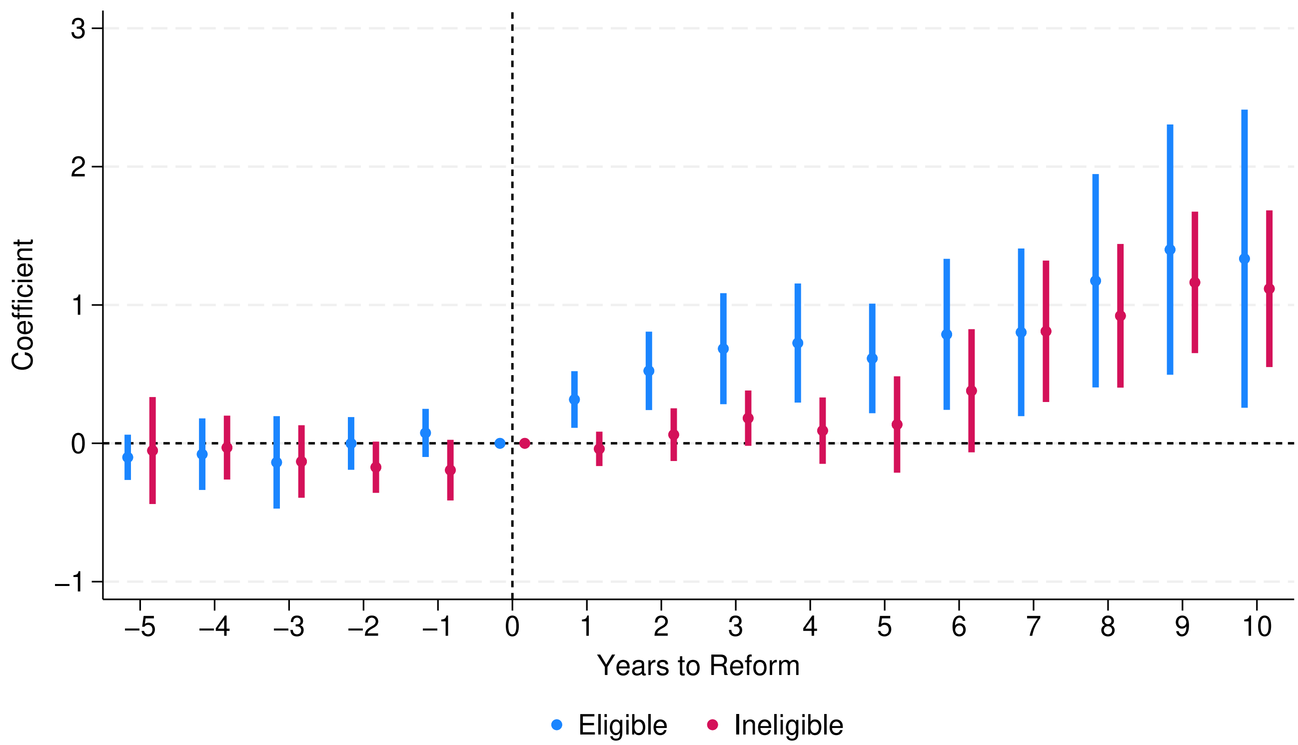
This table presents the variants of the regression $y_{ipjt} = \beta_1 Treated_{jt} + \boldsymbol{\theta X_{ipt}} + \alpha_{ip} + \delta_t + \epsilon_{ipjt}$ in columns 1-3, and $y_{ipjt} = \beta_1 Treated_{jt} + \beta_2 Treated_{jt} \times Eligible_i + \boldsymbol{\theta X_{ipt}} + \alpha_{ip} + \delta_t + \epsilon_{ipjt}$ in columns 4-6, where, p denotes the product line produced by the firm, i denotes firm, j denotes the 4-digit NIC2004 industry, t denotes the year of observation, and $\boldsymbol{X_{it}}$ denotes a vector of firm level time varing controls. All the regressions are estimated using OLS. *Treated*$_{jt}$ is a dummy variable which equals 1 for all years since the weighted tax credit scheme is introduced in an industry, and zero otherwise. $Eligible_i$ is a dummy variable that takes the value of 1 for firms that have an in-house R&D unit registered with the DSIR at least once during the sample period, and zero for the firms that are never registered on DSIR. α_i, and δ_t denote the firm, and year fixed effects. All the regressions are from 1992 to 2007. All the variables are defined in the Appendix Table A.2. Standard errors, reported in parentheses, are clustered at industry level. *, ** and *** denote significance at 10%, 5% and 1%, respectively.

A. Appendix

Figure A.1: Event study plots for the Differential Effect of the policy on R&D expenses of eligible versus ineligible firms

Notes: The figure plots the event study graph for the differential effect of the policy on the R&D expenses of eligible firms as compared to ineligible firms. The sample period is from 1992 to 2007. Vertical dotted lines report 95% confidence intervals with standard errors clustered at the industry level.

Figure A.2: Event study plots for the Differential Effect of the policy on R&D expenses of eligible versus ineligible firms



Notes: The figure plots the event study graph for the differential effect of the policy on the R&D expenses of eligible firms as compared to ineligible firms. The sample period is from 1992 to 2007. Vertical dotted lines report 95% confidence intervals with standard errors clustered at the industry level.

Table A.1: Tax deduction on in-house R&D expenditure

Time period*	Eligibility	Benefits
All time periods	(i) DSIR recognition of in-house R&D unit, and (ii) Companies' expenditure on in-house R&D	Under the Income Tax Act 1961, all revenue and capital in-house R&D expenditure is eligible for 100% tax deduction.
1999-2000	(i) DSIR recognition of in-house R&D unit, and (ii) Companies engaged in the production of drugs, electronic equipment, computers, telecommunication equipment, and chemicals	Weighted tax deduction of 125% on any revenue or capital R&D expenditure.
2001-2004	(i) DSIR recognition of in-house R&D unit, and (ii) Companies engaged in the production of drugs, electronic equipment, computers, telecommunication equipment, chemicals, **helicopters, and aircraft**	Weighted tax deduction of **150%** on any revenue or capital R&D expenditure.
2005-2009	(i) DSIR recognition of in-house R&D unit, and (ii) Companies engaged in the production of drugs, electronic equipment, computers, telecommunication equipment, chemicals, helicopters, aircraft, **automobiles, and auto parts**	Weighted tax deduction of **150%** on any revenue or capital R&D expenditure.
2010	(i) DSIR recognition of in-house R&D unit, and (ii) All industries except Schedule 11 of the Income Tax Act	Weighted tax deduction of **150%** on any revenue or capital R&D expenditure.

*All time periods are expressed in terms of the fiscal year.

Table A.2: Variable Description

Variable name	Description
Treated	$Treated$ is a dummy variable which equals 1 for all years since the weighted tax credit scheme is introduced in an industry, and zero otherwise.
Eligible	$Eligible$ is a dummy variable that takes the value of 1 for firms that have an in-house R&D unit registered with the DSIR , and zero for the firms that are never registered on DSIR.
R&D	R&D is defined as total expenditure on research and development including both revenue and capital, deflated using WPI (in million INR)
Sales	Sales is defined as total sales deflated using WPI (in million INR)
Assets	Assets is defined as total assets deflated using WPI (in million INR)
Firm-product prices	Firm-product level prices are directly observable for each prowess data (in million INR)
Aggregate firm prices	Firm level weighted average of firm-product prices. The weights used are the sales share of each product.
Markup	Markups are calculated by following the De Loecker et al. (2016) methodology.
Marginal Cost	Marginal Cost is backed out from the identity $Log(Prices) = Log(\textit{Marginal Costs}) + Log(Markups)$
Size	Size is defined as the quartiles of pre-policy (average of 1992-96) sales.
TFPQ	TFP is estimated using Ackerberg et al. (2015) methodology. TFPQ is the physical efficiency defined as the TFP deflated by the aggregate firm prices.
Young	Young is defined as dummy variable that takes the value of 1 for the firms with the below median age in the sample, and zero for all other firms
RZ index	RZ index is proposed by Rajan and Zingales (1998), which is an industry level measure of external financial dependence created using firm level data. The external financing ratio is determined by dividing the excess of capital expenditures over cash flow from operations by the capital expenditures. The index is calculated for all the SIC industries using compustat data of US firms. We use the pre-policy years (1986-95) to calculate the index. Afterwards, we map the measure with NIC industries using the SIC-NIC 2004 correspondence.

Table A.3: **Robustness Check: Time Varying Eligibility Criteria**

	R&D Expenditure		*Firm-product Price*	
	(1)	(2)	(3)	(4)
Treated$_{jt}$	0.280***		-0.194***	
	(0.091)		(0.059)	
Treated$_{jt}\times$ Eligible$_{it}$	0.404***	0.354**	0.035	0.058
	(0.151)	(0.161)	(0.052)	(0.046)
Eligible$_{it}$	0.221	0.185	0.009	0.040
	(0.152)	(0.186)	(0.035)	(0.035)
Effect on Eligible Firms	0.683**		-0.158**	
	(0.129)		(0.061)	
Observations	14219	13822	49619	49521
Firm FE	Yes	Yes	No	No
Firm-product FE	No	No	Yes	Yes
Asset Growth Quartiles $\times$ Year FE	Yes	Yes	Yes	Yes
State$\times$Year FE	Yes	Yes	Yes	Yes
Time Varying Firm Controls	Yes	Yes	Yes	Yes
Industry $\times$ Year FE	No	Yes	No	Yes

This table presents the variants of the regression $E[R_{ijt} \mid Treated_{jt}, \boldsymbol{X_{it}}] = exp(\beta_1 Treated_{jt} + \beta_2 Treated_{jt} \times Eligible_{it} + \beta_3 Eligible_{it} + \boldsymbol{\theta X_{it}} + \alpha_i + \delta_t)$ in columns 1-2, and $y_{ipjt} = \beta_1 Treated_{jt} + \beta_2 Treated_{jt} \times Eligible_{it} + \beta_3 Eligible_{it} + \boldsymbol{\theta X_{ipt}} + \alpha_{ip} + \delta_t + \epsilon_{ipjt}$ in columns 3-4, where, p denotes the product line produced by the firm, i denotes firm, j denotes the 4-digit NIC2004 industry, t denotes the year of observation, R_{ijt} is the level of annual R&D spending by the firm, and $\boldsymbol{X_{it}}$ denotes a vector of firm level time varing controls. Columns 1-2 are estimated using PPML, and columns 3-4 are estimated using OLS. *Treated*$_{jt}$ is a dummy variable which equals 1 for all years since the weighted tax credit scheme is introduced in an industry, and zero otherwise. $Eligible_{it}$ is the time varying eligibility status of the firms. α_i, and δ_t denote the firm, and year fixed effects. All the regressions are from 1992 to 2007. All the variables are defined in the Appendix Table A.2. Standard errors, reported in parentheses, are clustered at industry level. *, ** and *** denote significance at 10%, 5% and 1%, respectively.

Table A.4: **Robustness Check: Alternative Eligibility Criteria**

	R&D Expenditure		*Firm-product Price*	
	(1)	(2)	(3)	(4)
Treated$_{jt}$	-0.004	-0.019	-0.199***	-0.203***
	(0.255)	(0.253)	(0.068)	(0.068)
Treated$_{jt}\times$ Eligible$_{i}$	0.681*	0.692**	0.056	0.061
	(0.356)	(0.340)	(0.061)	(0.060)
Effect on Eligible Firms	0.676***	0.673***	-0.143**	-0.142*
	(0.163)	(0.159)	(0.071)	(0.076)
Observations	13142	12809	47005	46213
Firm FE	Yes	Yes	No	No
Firm-product FE	No	No	Yes	Yes
Asset Growth Quartiles $\times$ Year FE	Yes	Yes	Yes	Yes
State$\times$Year FE	Yes	Yes	Yes	Yes
Time Varying Firm Controls	Yes	Yes	Yes	Yes

This table presents the variants of the regressions $E[R_{ijt} \mid Treated_{jt}, \boldsymbol{X_{it}}] = exp(\beta_1 Treated_{jt} + \beta_2 Treated_{jt} \times Eligible_i + \boldsymbol{\theta X_{it}} + \alpha_i + \delta_t)$ in columns 1-2, and $y_{ipjt} = \beta_1 Treated_{jt} + \beta_2 Treated_{jt} \times Eligible_i + \boldsymbol{\theta X_{ipt}} + \alpha_{ip} + \delta_t + \epsilon_{ipjt}$ in columns 3-4, where, p denotes the product line produced by the firm, i denotes firm, j denotes the 4-digit NIC2004 industry, t denotes the year of observation, R_{ijt} is the level of annual R&D spending by the firm, and $\boldsymbol{X_{it}}$ denotes a vector of firm level time varing controls. Columns 1-2 are estimated using PPML, and columns 3-4 are estimated using OLS. *Treated*$_{jt}$ is a dummy variable which equals 1 for all years since the weighted tax credit scheme is introduced in an industry, and zero otherwise. $Eligible_i$ is the time in-varying eligibility status of the firms. α_i, and δ_t denote the firm, and year fixed effects. All the regressions are from 1992 to 2007. All the variables are defined in the Appendix Table A.2. Standard errors, reported in parentheses, are clustered at industry level. *, ** and *** denote significance at 10%, 5% and 1%, respectively.

Table A.5: **Robustness Check: Staggered Treatment of Industries**

	R&D Expenditure			
	(1)	(2)	(3)	(4)
Treated$_{jt}$	0.641***	-0.030	0.661***	-0.013
	(0.112)	(0.255)	(0.111)	(0.239)
Treated$_{jt}\times$ Eligible$_i$		0.826***		0.825***
		(0.288)		(0.287)
Observations	18742	18742	18742	18742
Firm FE	Yes	Yes	Yes	Yes
Asset Growth Quartiles $\times$ Year FE	Yes	Yes	Yes	Yes
State$\times$Year FE	Yes	Yes	Yes	Yes
Time Varying Firm Controls	Yes	Yes	Yes	Yes
Treatment Cohort $\times$ Year FE	No	No	Yes	Yes

This table presents the variants of the regressions $E[R_{ijt} \mid Treated_{jt}, \boldsymbol{X_{it}}] = exp(\beta_1 Treated_{jt} + \boldsymbol{\theta X_{it}} + \alpha_i + \delta_t)$ in columns 1 and 3, and $E[R_{ijt} \mid Treated_{jt}, \boldsymbol{X_{it}}] = exp(\beta_1 Treated_{jt} + \beta_2 Treated_{jt} \times Eligible_i + \boldsymbol{\theta X_{it}} + \alpha_i + \delta_t)$ in columns 2 and 4, where, i denotes firm, j denotes the 4-digit NIC2004 industry, t denotes the year of observation, R_{ijt} is the level of annual R&D spending by the firm, and $\boldsymbol{X_{it}}$ denotes a vector of firm level time varing controls. All the regressions are estimated using PPML. *Treated*$_{jt}$ is a dummy variable which equals 1 for the treatment and zero otherwise (for detailed definition refer to subsection 5.3). $Eligible_i$ is a dummy variable that takes the value of 1 for firms that have an in-house R&D unit registered with the DSIR at least once during the sample period, and zero for the firms that are never registered on DSIR. α_i, and δ_t denote the firm, and year fixed effects. All the regressions are from 1992 to 2007. All the variables are defined in the Appendix Table A.2. Standard errors, reported in parentheses, are clustered at industry level. *, ** and *** denote significance at 10%, 5% and 1%, respectively.

Table A.6: **Robustness Check: Staggered Treatment of Industries**

	Firm-product Prices			
	(1)	(2)	(3)	(4)
Treated$_{jt}$	-0.187***	-0.211***	-0.186***	-0.209***
	(0.052)	(0.053)	(0.052)	(0.052)
Treated$_{jt}\times$ Eligible$_i$		0.058		0.058
		(0.073)		(0.073)
Observations	68595	68595	68595	68595
Firm-product FE	Yes	Yes	Yes	Yes
Asset Growth Quartiles $\times$ Year FE	Yes	Yes	Yes	Yes
State$\times$Year FE	Yes	Yes	Yes	Yes
Time Varying Firm Controls	Yes	Yes	Yes	Yes
Treatment Cohort $\times$ Year FE	No	No	Yes	Yes

This table presents the variants of the regressions $y_{ipjt} = \beta_1 Treated_{jt} + \boldsymbol{\theta X_{ipt}} + \alpha_{ip} + \delta_t + \epsilon_{ipjt}$ in columns 1 and 3, and $y_{ipjt} = \beta_1 Treated_{jt} + \beta_2 Treated_{jt} \times Eligible_i + \boldsymbol{\theta X_{ipt}} + \alpha_{ip} + \delta_t + \epsilon_{ipjt}$ in columns 2 and 4, where, p denotes the product line produced by the firm, i denotes firm, j denotes the 4-digit NIC2004 industry, t denotes the year of observation, and $\boldsymbol{X_{it}}$ denotes a vector of firm level time varing controls. All the regressions are estimated using OLS. *Treated*$_{jt}$ is a dummy variable which equals 1 for the treatment and zero otherwise (for detailed definition refer to subsection 5.3). $Eligible_i$ is a dummy variable that takes the value of 1 for firms that have an in-house R&D unit registered with the DSIR at least once during the sample period, and zero for the firms that are never registered on DSIR. α_i, and δ_t denote the firm, and year fixed effects. The dependent variable in all the regressions is (log of) product level prices. All the regressions are from 1992 to 2007. All the variables are defined in the Appendix Table A.2. Standard errors, reported in parentheses, are clustered at industry level. *, ** and *** denote significance at 10%, 5% and 1%, respectively.

Table A.7: **Strategic Reaction to the Announcement of Policy: R&D Expenditure**

	R&D Expenditure					
	(1)	(2)	(3)	(4)	(5)	(6)
Treated$_{jt}$	0.571***	-0.009	0.609***	0.007	0.654***	-0.143
	(0.109)	(0.239)	(0.110)	(0.257)	(0.111)	(0.245)
Treated$_{jt}\times$ Eligible$_i$		0.724***		0.752***		0.992***
		(0.246)		(0.282)		(0.303)
Observations	12357	12357	10483	10483	8629	8629
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Asset Growth Quartiles $\times$ Year FE	Yes	Yes	Yes	Yes	Yes	Yes
State$\times$Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Time Varying Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes

This table presents the variants of the regressions $E[R_{ijt} \mid Treated_{jt}, \boldsymbol{X_{it}}] = exp(\beta_1 Treated_{jt} + \boldsymbol{\theta X_{it}} + \alpha_i + \delta_t)$ in columns 1, 3, and 5, and $E[R_{ijt} \mid Treated_{jt}, \boldsymbol{X_{it}}] = exp(\beta_1 Treated_{jt} + \beta_2 Treated_{jt} \times Eligible_i + \boldsymbol{\theta X_{it}} + \alpha_i + \delta_t)$ in columns 2, 4, and 6, where, i denotes firm, j denotes the 4-digit NIC2004 industry, t denotes the year of observation, R_{ijt} is the level of annual R&D spending by the firm, and $\boldsymbol{X_{it}}$ denotes a vector of firm level time varing controls. All the regressions are estimated using PPML. *Treated*$_{jt}$ is a dummy variable which equals 1 for all years since the weighted tax credit scheme is introduced in an industry, and zero otherwise. $Eligible_i$ is a dummy variable that takes the value of 1 for firms that have an in-house R&D unit registered with the DSIR at least once during the sample period, and zero for the firms that are never registered on DSIR. α_i, and δ_t denote the firm, and year fixed effects. In columns 1 and 2, we remove the years 1997 and 2003 (pre-policy years); in columns 3 and 4, we remove the years 1999 and 2005 (post-policy years); and in columns 5 and 6, we remove years 1997, 1998, 1999, 2003, 2004, and 2005. All the variables are defined in the Appendix Table A.2. Standard errors, reported in parentheses, are clustered at industry level. *, ** and *** denote significance at 10%, 5% and 1%, respectively.

Table A.8: **Strategic Reaction to the Announcement of Policy: Firm-product Prices**

	Firm-product Prices					
	(1)	(2)	(3)	(4)	(5)	(6)
Treated$_{jt}$	-0.186***	-0.204***	-0.211***	-0.240***	-0.220***	-0.264***
	(0.069)	(0.074)	(0.071)	(0.078)	(0.065)	(0.076)
Treated$_{jt}\times$ Eligible$_i$		0.044		0.071		0.110
		(0.061)		(0.064)		(0.069)
Observations	43336	43336	37141	37141	31207	31207
Firm-product FE	Yes	Yes	Yes	Yes	Yes	Yes
Asset Growth Quartiles $\times$ Year FE	Yes	Yes	Yes	Yes	Yes	Yes
State$\times$Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Time Varying Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes

This table presents the variants of the regressions $y_{ipjt} = \beta_1 Treated_{jt} + \boldsymbol{\theta X_{ipt}} + \alpha_{ip} + \delta_t + \epsilon_{ipjt}$ in columns 1, 3, and 5, and $y_{ipjt} = \beta_1 Treated_{jt} + \beta_2 Treated_{jt} \times Eligible_i + \boldsymbol{\theta X_{ipt}} + \alpha_{ip} + \delta_t + \epsilon_{ipjt}$ in columns 2, 4, and 6, where, p denotes the product line produced by the firm, i denotes firm, j denotes the 4-digit NIC2004 industry, t denotes the year of observation, and $\boldsymbol{X_{it}}$ denotes a vector of firm level time varing controls. All the regressions are estimated using OLS. *Treated*$_{jt}$ is a dummy variable which equals 1 for all years since the weighted tax credit scheme is introduced in an industry, and zero otherwise. $Eligible_i$ is a dummy variable that takes the value of 1 for firms that have an in-house R&D unit registered with the DSIR at least once during the sample period, and zero for the firms that are never registered on DSIR. α_i, and δ_t denote the firm, and year fixed effects. The dependent variable in all the regressions is (log of) product level prices. In columns 1 and 2, we remove the years 1997 and 2003 (pre-policy years); in columns 3 and 4, we remove the years 1999 and 2005 (post-policy years); and in columns 5 and 6, we remove years 1997, 1998, 1999, 2003, 2004, and 2005. All the variables are defined in the Appendix Table A.2. Standard errors, reported in parentheses, are clustered at industry level. *, ** and *** denote significance at 10%, 5% and 1%, respectively.

Table A.9: **Robustness Check: Effect of Outliers**

	R&D Expenditure				*Firm-product Price*			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treated$_{jt}$	0.559***	-0.044	0.493***	-0.051	-0.175**	-0.191***	-0.166**	-0.177***
	(0.101)	(0.246)	(0.114)	(0.264)	(0.067)	(0.069)	(0.063)	(0.066)
Treated$_{jt}\times$ Eligible$_i$		0.743***		0.662**		0.039		0.029
		(0.261)		(0.291)		(0.068)		(0.062)
Observations	14219	14219	14135	14135	49619	49619	49619	49619
Firm FE	Yes	Yes	Yes	Yes	No	No	No	No
Firm-product FE	No	No	No	No	Yes	Yes	Yes	Yes
Asset Growth Quartiles $\times$ Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State$\times$Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Varying Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

This table presents the variants of the regressions $E[R_{ijt} \mid Treated_{jt}, \boldsymbol{X_{it}}] = exp(\beta_1 Treated_{jt} + \boldsymbol{\theta X_{it}} + \alpha_i + \delta_t)$ in columns 1 and 3, and $E[R_{ijt} \mid Treated_{jt}, \boldsymbol{X_{it}}] = exp(\beta_1 Treated_{jt} + \beta_2 Treated_{jt} \times Eligible_i + \boldsymbol{\theta X_{it}} + \alpha_i + \delta_t)$ in columns 2 and 4$y_{ipjt} = \beta_1 Treated_{jt} + \boldsymbol{\theta X_{ipt}} + \alpha_{ip} + \delta_t + \epsilon_{ipjt}$ in columns 5 and 7, and $y_{ipjt} = \beta_1 Treated_{jt} + \beta_2 Treated_{jt} \times Eligible_i + \boldsymbol{\theta X_{ipt}} + \alpha_{ip} + \delta_t + \epsilon_{ipjt}$ in columns 6 and 8, where, p denotes the product line produced by the firm, i denotes firm, j denotes the 4-digit NIC2004 industry, t denotes the year of observation, and $\boldsymbol{X_{it}}$ denotes a vector of firm level time varing controls. Regressions are estimated using PPML in columns 1-4, and OLS in columns 5-8.*Treated*$_{jt}$ is a dummy variable which equals 1 for all years since the weighted tax credit scheme is introduced in an industry, and zero otherwise. $Eligible_i$ is a dummy variable that takes the value of 1 for firms that have an in-house R&D unit registered with the DSIR at least once during the sample period, and zero for the firms that are never registered on DSIR. α_i, and δ_t denote the firm, and year fixed effects. We winsorize the sample at 1% in columns 1, 2, 5, and 6, and 2.5% in columns 3, 4, 7, and 8. All the regressions are from 1992 to 2007. All the variables are defined in the Appendix Table A.2. Standard errors, reported in parentheses, are clustered at industry level. *, ** and *** denote significance at 10%, 5% and 1%, respectively.

Table A.10: **Robustness Check: Balanced Panel**

	R&D Expenditure		*Firm-product Price*	
	(1)	(2)	(3)	(4)
Treated$_{jt}$	0.545***	-0.088	-0.183**	-0.185*
	(0.130)	(0.309)	(0.075)	(0.100)
Treated$_{jt}\times$ Eligible$_i$		0.779***		0.004
		(0.276)		(0.133)
Observations	6986	6986	21880	21880
Firm FE	Yes	Yes	No	No
Firm-product FE	No	No	Yes	Yes
Asset Growth Quartiles $\times$ Year FE	Yes	Yes	Yes	Yes
State$\times$Year FE	Yes	Yes	Yes	Yes
Time Varying Firm Controls	Yes	Yes	Yes	Yes

This table presents the variants of the regressions $E[R_{ijt} \mid Treated_{jt}, \boldsymbol{X_{it}}] = exp(\beta_1 Treated_{jt} + \boldsymbol{\theta X_{it}} + \alpha_i + \delta_t)$ in column 1, and $E[R_{ijt} \mid Treated_{jt}, \boldsymbol{X_{it}}] = exp(\beta_1 Treated_{jt} + \beta_2 Treated_{jt} \times Eligible_i + \boldsymbol{\theta X_{it}} + \alpha_i + \delta_t)$ in column 2 $y_{ipjt} = \beta_1 Treated_{jt} + \boldsymbol{\theta X_{ipt}} + \alpha_{ip} + \delta_t + \epsilon_{ipjt}$ in column 3, and $y_{ipjt} = \beta_1 Treated_{jt} + \beta_2 Treated_{jt} \times Eligible_i + \boldsymbol{\theta X_{ipt}} + \alpha_{ip} + \delta_t + \epsilon_{ipjt}$ in column 4, where, p denotes the product line produced by the firm, i denotes firm, j denotes the 4-digit NIC2004 industry, t denotes the year of observation, and $\boldsymbol{X_{it}}$ denotes a vector of firm level time varing controls. Regressions are estimated using PPML in columns 1-2, and OLS in columns 3-4. *Treated*$_{jt}$ is a dummy variable which equals 1 for all years since the weighted tax credit scheme is introduced in an industry, and zero otherwise. $Eligible_i$ is a dummy variable that takes the value of 1 for firms that have an in-house R&D unit registered with the DSIR at least once during the sample period, and zero for the firms that are never registered on DSIR. α_i, and δ_t denote the firm, and year fixed effects. All the regressions are from 1992 to 2007. All the variables are defined in the Appendix Table A.2. Standard errors, reported in parentheses, are clustered at industry level. *, ** and *** denote significance at 10%, 5% and 1%, respectively.

Table A.11: **Robustness Check: Alternative Clustering Levels**

	R&D Expenditure				*Firm-product Price*			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Treated$_{jt}$	0.597***	0.005	0.597***	0.005	-0.181***	-0.194***	-0.181***	-0.194***
	(0.087)	(0.261)	(0.100)	(0.239)	(0.045)	(0.056)	(0.056)	(0.065)
Treated$_{jt}\times$ Eligible$_i$		0.735***		0.735***		0.033		0.033
		(0.269)		(0.266)		(0.046)		(0.084)
Observations	14219	14219	14219	14219	49619	49619	49619	49619
Firm FE	Yes	Yes	Yes	Yes	No	No	No	No
Firm-product FE	No	No	No	No	Yes	Yes	Yes	Yes
Asset Growth Quartiles $\times$ Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State$\times$Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Varying Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

This table presents the variants of the regressions $E[R_{ijt} \mid Treated_{jt}, \boldsymbol{X_{it}}] = exp(\beta_1 Treated_{jt} + \boldsymbol{\theta X_{it}} + \alpha_i + \delta_t)$ in columns 1 and 3, and $E[R_{ijt} \mid Treated_{jt}, \boldsymbol{X_{it}}] = exp(\beta_1 Treated_{jt} + \beta_2 Treated_{jt} \times Eligible_i + \boldsymbol{\theta X_{it}} + \alpha_i + \delta_t)$ in columns 2 and 4$y_{ipjt} = \beta_1 Treated_{jt} + \boldsymbol{\theta X_{ipt}} + \alpha_{ip} + \delta_t + \epsilon_{ipjt}$ in columns 5 and 7, and $y_{ipjt} = \beta_1 Treated_{jt} + \beta_2 Treated_{jt} \times Eligible_i + \boldsymbol{\theta X_{ipt}} + \alpha_{ip} + \delta_t + \epsilon_{ipjt}$ in columns 6 and 8, where, p denotes the product line produced by the firm, i denotes firm, j denotes the 4-digit NIC2004 industry, t denotes the year of observation, and $\boldsymbol{X_{it}}$ denotes a vector of firm level time varing controls. Regressions are estimated using PPML in columns 1-4, and OLS in columns 5-8. *Treated*$_{jt}$ is a dummy variable which equals 1 for all years since the weighted tax credit scheme is introduced in an industry, and zero otherwise. $Eligible_i$ is a dummy variable that takes the value of 1 for firms that have an in-house R&D unit registered with the DSIR at least once during the sample period, and zero for the firms that are never registered on DSIR. α_i, and δ_t denote the firm, and year fixed effects. All the regressions are from 1992 to 2007. All the variables are defined in the Appendix Table A.2. Standard errors, reported in parentheses, are clustered at the sector level in columns 1, 2, 5, and 6, and two way clustered at the industry and year in columns 3, 4, 7, and 8 *, ** and *** denote significance at 10%, 5% and 1%, respectively.

Table A.12: **Unpacking the effect on prices - Sales and quantity**

	Sales Value		*Quantity*	
	(1)	(2)	(3)	(4)
Treated	-0.030	-0.138*	0.111**	0.021
	(0.061)	(0.073)	(0.050)	(0.043)
Treated × Eligible		0.253***		0.209***
		(0.057)		(0.075)
Average effect on eligible firms in treated industries		0.115*		0.230***
		(0.063)		(0.073)
Observations	54983	54983	54868	54868
Firm-product FE	Yes	Yes	Yes	Yes
State×Year FE	Yes	Yes	Yes	Yes
Size × Year	Yes	Yes	Yes	Yes

This table presents the variants of the regressions $y_{ipjt} = \beta_1 Treated_{jt} + \boldsymbol{\theta X_{ipt}} + \alpha_{ip} + \delta_t + \epsilon_{ipjt}$ in columns 1 and 3, and $y_{ipjt} = \beta_1 Treated_{jt} + \beta_2 Treated_{jt} \times Eligible_i + \boldsymbol{\theta X_{ipt}} + \alpha_{ip} + \delta_t + \epsilon_{ipjt}$ in columns 2 and 4, where, p denotes the product line produced by the firm, i denotes firm, j denotes the 4-digit NIC2004 industry, t denotes the year of observation, and $\boldsymbol{X_{it}}$ denotes a vector of firm level time varing controls. All the regressions are estimated using OLS. *Treated*$_{jt}$ is a dummy variable which equals 1 for all years since the weighted tax credit scheme is introduced in an industry, and zero otherwise. $Eligible_i$ is a dummy variable that takes the value of 1 for firms that have an in-house R&D unit registered with the DSIR at least once during the sample period, and zero for the firms that are never registered on DSIR. α_i, and δ_t denote the firm, and year fixed effects. All the regressions are from 1992 to 2007. All the variables are defined in the Appendix Table A.2. Standard errors, reported in parentheses, are clustered at industry level. *, ** and *** denote significance at 10%, 5% and 1%, respectively.