Can R&D investment reduce the impact of COVID-19 on firm performance?—Evidence from India

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This study examines whether investing in R&D reduces the impact of exogenous shocks like the COVID-19 on stock market performance and accounting performance of manufacturing firms in India. For the sample of listed manufacturing firms, the paper finds that the firms engaged in R&D activities had lower negative cumulative abnormal return than those firms that did not invest in R&D in the pre-pandemic period using multiple event windows. The result suggests that R&D investments can lower value erosion for the shareholders during a severe crisis period. Further, using a difference-in-difference fixed effects model, the study finds that manufacturing firms engaged in R&D activities in the pre-pandemic period exhibited higher return on sales and growth of total income during the pandemic quarter vis-à-vis the non-R&D firms. The favorable accounting performance indicates the possibility of firm-level R&D being associated with the firm's ability to adjust its functioning during a crisis, thereby reducing the effect of the crisis. Finally, the study documents that government intervention to reduce the spread of the virus had a differential impact on firms based on their industry of operation. The findings have implications for investors, corporate managers, and policymakers in India.

KEYWORDS
crisis, firm performance, India, pandemic, R&D, returns

1 | INTRODUCTION

Innovation is an essential factor contributing to the productivity of firms. There is a vast literature in the context of developed countries documenting a positive effect of innovation on firm outcomes. Dabla-Norris et al. (2012), using cross-country innovation survey data, found that innovation is related to improvements in firm productivity and the effect is stronger for the set of developing economies. This larger effect for the latter set of countries is attributed to the fact that developing economies adapt the existing technologies prevailing in the developed markets to generate large productivity gains. In contrast, the developed countries closer to the technological frontier experience lower marginal effects of innovation. R&D is one of the most critical inputs for innovation. The early empirical work of Griliches (1958) indicates that increasing R&D improves the yield of crops. In addition to productivity, studies have also linked R&D expenses with superior firm performance in Asian economies of India, Korea, and others (Kim et al., 2014; Sharma, 2012). On the other hand, another stream of research highlights the non-linear relationship between R&D and firm performance. Chang and Su (2010) and Yeh et al. (2010) find that there is an optimal level of R&D for Taiwanese firms that maximizes firm profitability, beyond which there is a negative relation between R&D and performance.

Few studies have also examined the role of R&D during economic downturns. Voigt and Moncada-Paternó-Castello (2009) find that several European companies were planning to increase R&D activities during the global financial crisis (GFC) of 2008 to increase their survival probability and improve their comparative edge in the market post-GFC. In the Korean context, Jung et al. (2018) find that investing in R&D improves the survival probability of innovative firms. Similarly, family firms having access to internal funds increased their R&D investments during the GFC to increase the likelihood of higher future
gains (Sun et al., 2019). The R&D intensity of Norwegian firms was positively related to performance during the GFC and European Crisis of the late 2000s (Lome et al., 2016). Hud and Hussinger (2015) also find that R&D subsidies given to German firms increased the firm-level R&D investment during the GFC.

Related literature on firms documents that government policy remains an essential factor influencing firm performance, especially during a crisis. Policies like the recapitalization of banks during the GFC improved the growth of financially dependent firms (Laeven & Valencia, 2013). On the contrary, Jiang et al. (2014) find that firms bailed out by the government during GFC had lower recovery rates than those bailed out by other stakeholders of firms. More recently, Aharon et al. (2021), in their study of the US hospitality industry find that government intervention during the coronavirus pandemic was negatively related to stock returns.

Given the dearth of studies that evaluate whether R&D activities affect the resilience of firms during a crisis in the context of developing economies, this study intends to shed light on two specific questions. First, do firm characteristics like investing in R&D increase the resilience of firms during the onset of a sudden exogenous shock like the COVID-19 pandemic in the short run in a developing economy like India? To assess the resilience of R&D firms, the paper considers stock market returns at the onset of the crisis and the accounting performance in the quarter immediately after the start of the pandemic. Second, the paper examines the moderating effect of government intervention during the crisis (in the form of sudden lockdown and disruption of economic activities) in the R&D and firm performance relationship. This paper is one of the early studies that links R&D to the resilience of firms during a crisis in a developing economy context.

India classifies as an ideal candidate for the study on account of the following three reasons. First, India is a fast-growing developing economy in the context of innovation. India entered the top 50 innovative economies in 2020 (Global Innovation Index report, 2020), and India’s performance is above expectations when adjusted for the level of development. Among the sub-indices, it outperformed in R&D given its per capita GDP. The impressive performance of India in terms of R&D and overall innovation ranking recently makes it worth examining the returns to R&D, especially during a crisis scenario. Second, even though India performed well in terms of innovation in recent years, there exists a dichotomy. Economic Survey (2021) indicates that the private sector contributes only around 37% of the gross R&D expenditure in the country, and the rest was driven by public expenditure. The low share of the corporate sector in R&D makes it worthwhile to examine the extent to which firm-level R&D activity is related to performance. Finally, India imposed a 3-week nationwide lockdown from March 24, 2020, to April 14, 2020, at the onset of the COVID-19 crisis. As per the Oxford COVID-19 Government Response Tracker, this 3-week nationwide had a stringency index of 100. The strict nature of lockdown at the start of the pandemic provides a natural experiment to examine the causal effect of R&D on firm performance in India during an exogenous shock.

Using a sample of manufacturing firms in India, the study finds that engaging in R&D increases firms’ resilience to the COVID-19 pandemic in the short run. The event study methodology results indicate that National Stock Exchange listed manufacturing firms involved in R&D experienced lower negative cumulative abnormal return (CAR) when the World Health Organization (WHO) announced COVID-19 as pandemic compared to non-R&D manufacturing firms in India. Further, using a difference-in-difference firm fixed effects model, the paper finds that for manufacturing firms investing in R&D, the impact of COVID-19 on firm performance is lower than non-R&D firms. The results are robust to an alternate definition of firm innovation, additional controls, and placebo quarter of pandemic. Additionally, the result also suggest that government intervention in the form of strict lockdown disrupted economic activity and had aggravated the negative impact of COVID-19 on firm performance. Further, the effect of R&D is stronger for the set of business group firms, indicating that group affiliation can generate benefits due to access to internal capital markets, especially during a crisis. The smaller firms stand to benefit more from R&D activities during a crisis.

This study makes several contributions to the existing literature. First, it extends our understanding of the role of innovation for firms in developing economies. This paper provides evidence in favor of a positive effect of R&D activities during a crisis period. The results suggest that investing in firm-level R&D can also act as a risk management strategy. Second, it adds to the literature on managerial decision-making. The paper considers how strategic decisions like investing in R&D can affect the stock market performance and profitability of firms during a crisis. Thirdly, this study contributes to the research on pandemics. Even though studies have analyzed the effect of the pandemic on migrants, economic activity, and financial markets in India (Bayer et al., 2020; Dev & Sengupta, 2020; Mishra et al., 2020; Rajan, 2020), the extent to which a firm’s strategic behavior shapes pandemic response is less clear. Finally, we also extend the understanding of government response during the crisis and its impact on firms. The study highlights that strict nationwide lockdown to contain the spread of the virus during the initial phase had real cost in the form of lower profits for the firms in India.

The remaining of the paper is structured as follows: Section 2 develops the testable hypotheses. Section 3 describes the data and variables, whereas Section 4 elucidates the methodology of the paper. Section 5 presents the results, and Section 6 discusses the implications of the findings and concludes.

2 | HYPOTHESIS DEVELOPMENT

The investment in R&D by firms can be explained by the resource-based view and the Schumpeterian view. The resource-based view of the firm proposed by Wernerfelt (1984) suggests that firms are heterogeneous with a given set of assets and resources. The core competencies of a firm can be increased by looking inward at its resources rather than outward (external competitive environment). The firm’s existing resources can be exploited by innovation and R&D to compete in the external environment. The in-house R&D is itself a function of the internal resource endowment of the firm that in turn
enhances the competitive advantage of the firm in the external environment. On the other hand, the Schumpeterian view can be classified as “widening and deepening” patterns of innovation (Malerba & Orsenigo, 1995). The former highlights innovation as a product of the entry of new entrepreneurs with new innovative products that disrupt the status quo in the industry. The latter is based on the idea that large firms with resources will use R&D and innovation to increase their market power given barriers to market entry. Many empirical papers have examined the relationship between R&D and firm outcomes, both accounting performance and stock performance.

The efficient market hypothesis suggests that stock price should reflect the value of all tangible and intangible assets. As a result, R&D activity should not be related to higher future stock returns. However, Daniel and Titman (2006) find that investors do not react similarly to information related to intangibles like R&D and goodwill. This may lead to mispricing of R&D stocks leading to underreaction in the short run. Chan et al. (2001) find that the average stock return of firms engaged in R&D is not different than the average return of R&D firms; however, among R&D firms, the return is higher for firms with higher R&D intensity relative to sales. On the other hand, using a sample of firms for the period 1951–2001, Eberhart et al. (2004) find that the investors of R&D firms earn a positive abnormal return, in the long run, suggesting that stock market underreaction after firm’s decision to invest in R&D in the short run takes several years to correct. Tahat et al. (2018) did not find any effect of R&D on the earnings per share for a sample of UK firms. The literature on the impact of R&D on stock performance is still inconclusive.

Further, little attention is paid to the role of R&D and stock performance during economic crises. Adcock et al. (2014) find that upon the arrival of negative global news during GFC, countries that performed well in innovation experienced a higher market return and lower risk. The results suggest that investors reward innovation and more so during a crisis. Recently, Neukirchen et al. (2021), with the help of data on US firms find that the COVID-19 crisis had a lower negative effect on the market value of efficient firms, and one of the efficiency measures was the R&D intensity of the firms.

The extant literature on the effect of COVID-19 on the stock market suggests that the pandemic had a short-run negative impact on stock prices (Ashraf, 2020; Xiong et al., 2020) and stock market volatility (Al-Awadhi et al., 2020). Few studies have also found that the stock market effect is asymmetric and depends upon the industry in which the firm operates (He et al., 2020; Shen et al., 2020). Theoretically, the extent of the impact of COVID-19 on performance can be related to the pre-crisis firm characteristics. If markets are efficient and investors value innovation, then R&D investments should lower the stock price reaction of firms upon the arrival of negative news, that is, the onset of the COVID-19 pandemic. This leads to the first hypothesis:

**Hypothesis 1.** Effect of exogenous shock like COVID-19 pandemic announcement on stock returns will be lower for firms engaged in R&D activities vis-à-vis non-R&D firms.

There is evidence in favor of R&D being related to higher productivity of firms (Raymond et al., 2015) as well as better performance (Hashi & Stojcic, 2013). Other studies find an inverted U-shaped relation between R&D and firm performance (Chen & Ibhagui, 2019; Yeh et al., 2010). Alam et al. (2020) find that the investor protection environment is important in determining R&D and firm performance relation. Few studies have specifically considered the role of R&D during a crisis. Lome et al. (2016) find that the R&D intensity of Norwegian firms was related to better performance during the GFC and European Crisis of the late 2000s. Further, Jung et al. (2018) find that investing in R&D improves the survival probability of innovative firms in Korea. These studies suggest that R&D can become more critical for firms in shaping crisis response. The firms that invest in R&D are more likely to innovate and launch newer products in line with the demand during the pandemic. Further, innovating firms will be better positioned to alter their process to suit the functional needs of doing business during the pandemic. Likely, the firms that had invested in R&D in the pre-coronavirus period were better positioned to face the crisis than other non-R&D firms, and this should be reflected in their short-term accounting performance. Hence, the second hypothesis is as follows:

**Hypothesis 2.** R&D will play a moderating role in the effect of COVID-19 shock on the short run accounting performance of firms.

Further, the extant literature suggests that government policies affect firm outcomes in a multitude of ways. Studies indicate that government intervention can amplify or reduce the depth of business cycles. During the GFC, government intervention to improve credit supply through bank recapitalization eased the credit constraint of firms and significantly improved the growth of firms that were dependent on external financing (Laeven & Valencia, 2013). Similarly, Norden et al. (2013) find that intervention by the government in the US banking sector during the GFC improved borrower's stock returns. On the contrary, Deng et al. (2020) find that the economic stimulus package extended during GFC increased the investment of affected firms in China but reduced firms’ investment efficiency and performance in the post-intervention period. Recently, a few studies in the context of the coronavirus pandemic also highlighted the role of government. Jiang et al. (2021) find that stricter government response to the pandemic is related to lower negative effects on the market growth as it lowers the expected future adverse economic impact. In comparison, Aharon et al. (2021) find that the government’s pandemic response had a negative effect on the returns of the hospitality sector stocks. In India, the government imposed a strict 3-week nationwide lockdown from March 24, 2020, to curb the spread of the virus, which was among the most stringent in the world. During this period, only firms operating in the essential industries were allowed to function. This strategy is likely to have a moderating effect on the R&D and firm performance relationship. Specifically, among R&D investing firms, those not categorized as firms engaged in essential activities are expected to have a more negative effect on performance in the short
run than firms in the essential industry owing to government intervention. Hence, we hypothesize:

**Hypothesis 3.** Government intervention to reduce the spread of the virus had a differential effect on R&D and firm performance relationship based on the industry of operation.

## 3 | DATA AND VARIABLES

The data for the study is obtained from the Prowess maintained by the Centre for Monitoring Indian Economy. It is a database containing information on around 40,000 listed as well as unlisted firms in India from annual reports, stock exchanges, and regulatory bodies. Additionally, for companies listed on the stock exchanges, Prowess also provides quarterly financial statements and share prices. Academia extensively uses the Prowess database for firm studies in India (Biswas, 2019; Sarkar & Sarkar, 2009).

The study is based on the set of listed manufacturing firms for June 2020 using the National Industrial Classification (NIC) codes-2008. Similar to other studies on R&D and firm performance, we focus only on manufacturing firms (Chang & Su, 2010; Jin et al., 2018; Wen & Zhao, 2020). Additionally, data is obtained for June 2019, June 2018, and June 2016 quarters for these listed manufacturing firms. Specifically, June 2017 quarter is eliminated from the analysis as the performance of firms during this quarter may also capture the effect of demonetization in India announced on November 8, 2016, that affected 86% of currency in circulation. This large and sudden monetary shock was related to temporary economic costs lasting up to two quarters (Lahiri, 2020). Hence, including June 2017 quarter in the analysis may not reflect business as usual and may be confounded with the negative effect of demonetization and, therefore, is excluded from the study. The sample consists of 4094 firm quarter observations of 1067 unique firms.

For the first hypothesis, the stock return of firms is the dependent variable. On the other hand, accounting performance indicators are—return on sales (ROS) and growth of income (GI). ROS is defined as the ratio of profit before tax to sales during the quarter. The GI variable gives the growth of net income of the firm during the quarter over the previous quarter. The main interest variable is given by the R&D dummy that takes the value one for firms that are engaged in R&D activities and zero otherwise. The R&D expenditure for the firm over the previous quarter. The main interest variable is given by the R&D dummy that takes the value one for firms that are engaged in R&D activities and zero otherwise. The R&D expenditure for the firm is the ratio of R&D expenses to sales in line with the literature (Neukirchen et al., 2021; Yeh et al., 2010; Chan et al., 2001).

## 4 | METHODOLOGY

### 4.1 | Event study methodology

Several studies have adopted the event study method to analyze the effect of COVID-19 on stock prices (He et al., 2020; Xiong et al., 2020). The event study methodology is an appropriate statistical tool for obtaining a short-run effect of an announcement or event on stock prices (MacKinlay, 1997). This paper also employs an event study method to assess the impact of COVID-19 on stock returns in the very short-run. The event study is sensitive to the choice of the event date. There are three potential event dates for our analysis.

First, one can consider the date when India officially registered the first coronavirus case on January 30, 2020. However, we do not consider this date as the event date as the first case detection did not generate an economy-wide shock, and it was business as usual for the corporate sector to a large extent. The second possible event date was March 18, 2020, when WHO announced COVID-19 as a pandemic. This announcement was an exogenous shock and potentially revised expectations regarding the trajectory of the disease. This was followed by Prime Minister Mr Narendra Modi’s address to the nation on March 19, 2020, to create awareness regarding the disease among ordinary citizens. Finally, the third possible event date is March 24, 2020, which marked the beginning of a formal 3-week nationwide lockdown. This lockdown was associated with a sudden suspension of economic activity and a drastic reduction in people’s mobility. The lockdown affected all businesses severely and created an environment of policy uncertainty and fear among investors. The WHO pandemic announcement on March 18, 2020, is considered the event date in the analysis as this is the first instance that raised the concern to alarming levels for Indian firms and investors. We consider an estimation window of 100 days, starting from –31 to –130 days to estimate the model given below:

\[
\begin{align*}
  r_i - r_{mt} &= \alpha_i + \beta_i r_{mt} + \epsilon_{it} \\
  \text{where} \quad r_i &= \text{return of firm } i \text{ on day } t \\
  r_{mt} &= \text{return of the market index, NIFTY50, on day } t \\
  \epsilon_{it} &= \text{error term}
\end{align*}
\]

where \( r_i \) is the return of firm \( i \) on day \( t \) and \( r_{mt} \) is the return of the market index, NIFTY50, on day \( t \). The equity market index as a proxy for market return is used in studies on Indian financial markets (Biswas, 2021; Gupta & Goldfar, 2005). Further, NIFTY50 is the leading equity market index in India based on the top 50 companies representing around 67% of the entire free-float market capitalization representing more than 20 sectors. The firms not having 100 days of stock price information during the estimation window were excluded from the analysis, leaving 406 unique firms for the study. The firm-specific estimated alpha and beta are used to estimate the abnormal

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1. [https://www1.nseindia.com/products/content/equities/indices/nifty_50.htm](https://www1.nseindia.com/products/content/equities/indices/nifty_50.htm)
2. Note that for testing this hypothesis the manufacturing firms listed with the National Stock Exchange alone are considered and not all listed manufacturing firms.
return (AR) and CAR during the event window. We consider 5-, 7-, and 11-day event windows in our analysis:

$$AR_{it} = r_{it} - \tilde{r}_i - \tilde{\beta}_1t_{me}$$  \hspace{1cm} (2)

where $r = [t_1,t_2]; t_1 =$ starting of event window; $t_2 =$ ending of event window

$$CAR_i = \sum_{\tau} AR_{it}$$  \hspace{1cm} (3)

The cross-sectional regression of calculated CAR on the R&D dummy is estimated separately for the three-event windows after controlling for industry effects. The equation is as follows:

$$CAR_i = \beta_0 + \beta_1R&D_i + \text{Industry}_i + \epsilon_i$$  \hspace{1cm} (4)

The industry dummies are based on the two-digit NIC codes. The firms for which the NIC codes were not reported were dropped from the analysis leaving us with 406 NSE firms with at least 100 days of continuous stock data.

### 4.2 Difference-in-difference framework

During the 3-week nationwide lockdown, economic activity had come to a virtual standstill except for essential services like grocery, police, healthcare services, ATMs, telecommunication, internet, and so forth. The Government of India (GoI) order dated March 24, 2020, mentioned the industries allowed to function during the first phase of lockdown. The lockdown was further extended till May 31, 2020, with lesser restrictions. This sudden lockdown in India coincides with the April to June quarter (June 2020) and provides an exogenous shock to the corporate sector. The June 2020 quarter represented a period when all the firms were affected by the coronavirus pandemic induced lockdown, however, to varying extent.

To estimate the effect of this exogenous shock (COVID-19) on accounting performance measures, we employ a difference-in-difference strategy (DD). Within the DD framework, the firms engaged in R&D activities in the pre-COVID-19 period are the treated firms, and firms not engaged in R&D in the pre-pandemic period (non-R&D firms) form the control firms. Using a DD framework, Shen et al. (2020) find that the Chinese firms in high-impact industries like tourism and hospitality experienced more negative returns than other firms. We estimate the following fixed effects DD model:

$$y_{it} = \beta_0 + \beta_1R&D_i \times \text{pandemic}_i + \beta_2\text{pandemic}_i + a_i + d_i + \epsilon_{it}$$  \hspace{1cm} (5)

where $y_{it}$ is the accounting performance given by ROS and GI, pandemic$_i$ is a dummy that takes the value one for the June 2020 quarter and zero for pre-pandemic quarters, R&D$_i \times$ pandemic$_i$ is a dummy that takes the value of one for R&D firms for June 2020 quarter and zero otherwise. $\beta_1$ is the coefficient of interest, and a positive and significant coefficient will suggest that the effect of the pandemic is lower for R&D firms compared to non-R&D firms in the sample. In the specification, one cannot explicitly account for R&D dummy that takes the value one for firms that were engaged in R&D activities at the end of the financial year 2019 and zero for non-R&D firms as it will be absorbed by the firm fixed effects term $a_i$. The performance variables are winsorized at 1% and 99% percentiles, and the reported results are based on robust standad errors (SEs). Finally, firm fixed effects account for any time-invariant unobservable factors affecting performance, and quarter dummies capture time effects.

One can argue that due to managerial motivation, the R&D firms are different than non-R&D firms. Similarly, firms having more motivated managers may report higher R&D expenditure, and the estimates may not be unbiased due to the endogeneity of our interest variable. However, if the assumption that such unobservable differences firms do not change over time holds, the fixed effects model will yield an unbiased estimator. The critical assumption of the DD model is the parallel trends assumption between the R&D firms (treatment) and non-R&D firms (control group) in the pre-COVID-19 quarters. The formal parallel trends test result presented in Section 5.2.3 ascertain that the estimation strategy indeed captures the effect of R&D on short-run performance in the pandemic quarter.

### 5 RESULTS

#### 5.1 Effect of R&D on stock returns

Table 1 presents the mean of CAR for 5-, 7-, and 11-day event windows for the 406 NSE listed manufacturing firms and also separately for the set of R&D and non-R&D firms.

|                | (1) All firms | (2) R&D firms | (3) Non-R&D firms |
|----------------|--------------|---------------|------------------|
| CAR-5day       | −0.066       | −0.050        | −0.087           |
| CAR-7day       | −0.060       | −0.035        | −0.091           |
| CAR-11day      | −0.089       | −0.051        | −0.135           |
| Observations   | 406          | 215           | 191              |

Note: The table gives the cumulative abnormal returns for the 5-, 7-, and 11-day event windows for the listed manufacturing firms and also separately for the set of R&D and non-R&D firms.

The stringency index score for India fell to around 80 by the end of May 2020.
Prior studies suggest that innovations at the firm level are related to better stock returns (Srinivasan et al., 2009; Szutowski, 2019) during regular times. Any patent related information announcement also predicts the future returns of the stocks (Deng et al., 1999). In this analysis using the event study framework, the paper analyzes whether manufacturing firms engaged in R&D were more resilient during the COVID-19 pandemic announcement relative to non-R&D firms. Table 2 presents the result of regressing CAR on the R&D dummy. Columns 1–3 suggest that CAR for R&D firms was higher than non-R&D firms during the event window. Even after controlling for two-digit NIC codes, the stock returns of firms engaged in R&D activities outperformed the non-R&D firms in the range of 0.031%–0.060% during the event windows (columns 4–6).

All the specifications indicate that being engaged in R&D activities can increase the resilience of manufacturing firms during the black swan event like the COVID-19 pandemic. The finding corroborates the results of Adcock et al. (2014) wherein they find that investor rewards R&D during a crisis period. Engaging in R&D activities can help firms manage risk due to exogenous shocks by signaling the firm’s ability to respond to changing business environments faster than other firms. The results are in line with Neukirchen et al. (2021) that finds a lower effect of COVID-19 for efficient firms, and R&D can signal firm efficiency to the investors.

5.2 | Effect of R&D on accounting performance

The analysis in the previous section suggests that the strategic decision to invest in R&D is likely to be related to net benefits like higher resilience in the very short run due to an adverse exogenous shock. Next, the study analyzes whether the decision to engage in R&D activities is also related to positive benefits in the short run based on the accounting performance measures during the coronavirus pandemic.

5.2.1 | Summary statistics

Table 3 presents the mean and standard deviation (SD) of firm characteristics during the study period. Column 1 suggests that the average ROS for the firms was –45% and the average GI was –24.3%. Further, the performance of R&D firms was significantly better than the non-R&D manufacturing firms in the sample during the period. The R&D firms are larger and have higher pre-tax profits (columns 2 and 3). Columns 4 and 5 present the firm characteristics before and after the pandemic. As expected, the performance of all manufacturing firms in the pandemic quarter was statistically worse than the pre-pandemic period highlighting the economic effect of the pandemic on the businesses. Interestingly, separately considering the performance of R&D and non-R&D (columns 5 and 6) firms in the pandemic quarter, one observes that the pandemic had a larger negative effect on the non-R&D firms than the R&D firms in our sample. The summary indicates the possibility that firm-level R&D investment is related to a lower impact of a negative shock in the short run.

5.2.2 | Main results

The effect of R&D activities on the firm’s response to the COVID-19 pandemic using the DD firm fixed effects model is given in Table 4. Column 1 suggests that ROS in the post-COVID-19 quarter was higher for R&D firms than non-R&D manufacturing firms in the sample at a 10% level of significance. Column 2 indicates that R&D firms experienced 16% greater GI than non-R&D firms in the pandemic quarter. Columns 3 and 4 examine whether the R&D intensity of the firm matters. The regression coefficient of R&D intensity and post dummy interaction is positive and significant at usual levels of significance for both performance measures. It appears that engaging in R&D activities and the intensity of R&D activities can improve firms’ resilience during a crisis period. Investment in R&D can potentially signal the ability of the firm to better adapt to the changing business environment.
environment due to the ongoing pandemic. The R&D firms can launch newer products and alter the business processes like contactless delivery faster compared to firms that did not invest in R&D in the pre-pandemic period. The results support the findings of Lome et al. (2016) and Jung et al. (2018), wherein they find that R&D investment is critical for firms, especially during a crisis. Makkonen et al. (2014) also found that organizational innovation was critical for firm performance during the GFC.

5.2.3 | Robustness analysis

This section reports the results from several robustness tests to ascertain that the results indeed capture the effect of firm-level R&D activities on its performance during a crisis. First, we consider a placebo quarter as the pseudo treatment and re-estimate Equation (5). If the DD fixed effects estimator truly captures the effect of R&D activities on firm performance during the crisis scenario, any pseudo treatment
should not yield a significant coefficient. Hence, the April–June 2019 quarter is considered the placebo pandemic quarter, and April–June 2016 and April–June 2018 quarters as the pre-pandemic quarters. Further, April–June 2020 is excluded from this analysis, leaving a sample of 3090 firm-year observations. The results of this placebo pandemic on ROS and GI are given in columns 1–2 of Table 5, respectively. The coefficient of R&D and pseudo post dummy is positive but insignificant in both the specifications.

Further, the effect of R&D intensity for this placebo quarter is reported in columns 3 and 4. Again the coefficient of interaction is insignificant at the usual levels of significance. The placebo test results provide evidence in favor of a parallel trend between R&D and non-R&D firms in the pre-pandemic period. The placebo test results suggest that the model indeed captures the effect of R&D during the pandemic.

Further, one can argue that firm-level innovation can be either in-house in the form of R&D investments or technology transferred from other firms. The technology transfer can be captured by royalty payments, license fees and expenditure related to technical know-how. The second robustness check considers a broader definition of innovation by including firm-level expenditure on royalty and technical know-how. As an alternate definition, firms incurring R&D expenses and/ or firms transferring technology are classified as innovating firms in the sample. The innovation dummy takes the value of one for the firms engaged in R&D activities or reporting positive royalty payments, license fees or technical know-how expenses and zero otherwise. Re-estimating Equation (5) using the innovation dummy as the set of treated firms and the coefficient of innovation and pandemic dummy interaction gives the effect of the pandemic on the performance of innovating manufacturing firms in the sample. The result presented in columns 1–2 of Table 6 suggests a positive and significant effect of innovation on accounting performance in the pandemic quarter, and the findings are robust to this alternate definition of firm innovation measure.

Further, literature has extensively focused on the role of the firm size in determining R&D and innovation output (Cohen et al., 1987; Connolly & Hirschey, 1990; Lee & Sung, 2005). Hence, we check the sensitivity of the results by including the firm size variable in Equation (5). The firm size variable is defined as the logarithm of total assets. Columns 3–4 of Table 6 indicate that even after controlling for firm size, there is a positive effect of R&D on the performance of firms during the pandemic quarter.

### Table 5

| Variables | (1) | (2) | (3) | (4) |
|-----------|-----|-----|-----|-----|
| ROS       |     |     |     |     |
| GI        |     |     |     |     |
| Placebo   | −0.329 | −0.015 | −0.281 | −0.007 |
|           | (0.262) | (0.033) | (0.237) | (0.023) |
| R&D × Placebo | 0.079 | 0.009 |       |     |
|           | (0.122) | (0.032) |       |     |
| R&D intensity × Placebo |       | −3.851 | −1.274 |     |
|           |       | (6.018) | (2.504) |     |
| Constant  | −0.133 | −0.141*** | −0.133 | −0.141*** |
|           | (0.219) | (0.012) | (0.219) | (0.012) |
| Quarter FE | Y | Y | Y | Y |
| Firm FE   | Y | Y | Y | Y |
| Observations | 3090 | 3081 | 3090 | 3081 |
| R²        | 0.001 | 0.006 | 0.001 | 0.006 |
| Number of companies | 1063 | 1061 | 1063 | 1061 |

Note: Columns 1 and 2 presents the DD fixed effects output of regressing return on sales (ROS) and growth of income (GI) on R&D (treatment) dummy, placebo pandemic quarter dummy, R&D and placebo pandemic quarter dummy interaction along with quarter dummies and firm fixed effects respectively. Columns 3 and 4 presents the DD fixed effects output of regressing return on sales (ROS) and growth of income (GI) on R&D intensity (treatment), placebo pandemic quarter dummy, R&D intensity and placebo pandemic quarter dummy interaction along with quarter dummies and firm fixed effects, respectively. Robust SEs are reported in parenthesis.

*** p < 0.01.
** p < 0.05.
* p < 0.1.

5.2.4 Effect of government intervention on R&D and performance relationship

As discussed in Section 4.2 earlier, GoI announced a sudden 3-week lockdown from March 24, 2020, during which only firms engaged in essential services were allowed to operate. The lockdown was further extended for two more weeks. With the help of the GoI order, one can identify the industry codes of firms and classify them as belonging
to essential or non-essential industries. The firms in the essential industries were allowed to operate in the first 5 weeks of nationwide lockdown. The GoI provides an exogenous variation to the extent of the impact on firm activity during the nationwide lockdown. Next, the equation below is estimated to analyze whether there is any differential effect of the pandemic on performance based on essential industry classification:

$$y_{it} = \beta_0 + \beta_1 (R&D) \times pandemic_{t} \times essential_{i} + \beta_2 R&D_{i} \times pandemic_{t} + \beta_3 pandemic_{t} \times essential_{i} + \beta_4 innovation_{t} + \beta_5 innovation_{t} \times essential_{i} + d_t + u_{it} \quad (6)$$

where essential_{i} is a dummy that takes the value one for manufacturing firms that were allowed to operate during the first and second phases of lockdown and zero otherwise. A positive and significant $\beta_1$ will suggest that the positive effect was higher for R&D firms in essential industries. Columns 1 and 2 of Table 7 presents the regression output. As expected, the effect of R&D on ROS and GI was higher for firms involved in the essential industry in the post-pandemic quarter. The findings suggest that exogenous policy had a real effect on the performance of manufacturing firms in India. We find evidence that government intervention can have a moderating effect on the impact of COVID-19 on firm performance. The result is in line with Aharon et al. (2021), wherein they document that government intervention to control the pandemic had a more adverse effect on firms belonging to a few sectors. Further, Shen et al. (2020) also found that the impact of the coronavirus pandemic on performance was greater for firms operating in high-impact industries as their operations were affected due to government restrictions.

5.2.5 | Heterogeneous effects based on business group affiliation

The business group firms dominate the Indian corporate sector (Chakrabarti et al., 2008). Business group firms are a set of legally independent firms with informal linkages, including common founding family, sharing of labor and directors, transfer of goods, services and technology, and inter-corporate loans. The affiliation to a business group improves the survival probability of firms during a crisis (Santioni et al., 2020), and group firms perform better than standalone firms during crisis owing to internal capital markets (Almeida et al., 2015). The access to internal capital markets is also related to an improved investment efficiency and R&D investment of private business group firms in China (Tan et al., 2018). Hence, the positive effect of R&D on performance during the pandemic may be driven by group firms. We test this by estimating Equation (7) below:

$$y_{it} = \beta_0 + \beta_1 (R&D) \times pandemic_{t} \times group_{i} + \beta_2 R&D_{i} \times pandemic_{t} + \beta_3 pandemic_{t} \times group_{i} + \beta_4 innovation_{t} + \beta_5 innovation_{t} \times group_{i} + d_t + u_{it} \quad (7)$$

A positive and significant $\beta_1$ will suggest that there is a differential effect of group affiliation on performance. The group dummy takes the value one for the business group firms and zero for others. Columns 3 and 4 of Table 7 indicate that the positive effect of R&D in the pandemic period was mostly driven by the manufacturing firms belonging to business groups in India. The results align with earlier studies that have documented the benefits of group affiliation during a crisis period.
5.2.6 | Heterogeneous effects based on size

There is a vast literature that focuses on the relationship between firm size and R&D. A large number of studies have indicated a positive relationship between R&D and firm size (Cohen & Klepper, 1996). On the other hand, Cohen et al. (1987) find that after controlling for industry effects, the firm size has no statistically significant impact of R&D intensity on firms; however, size plays an important role in determining the probability of R&D investment by a firm. Cohen and Levin (1989) find that the literature on R&D and firm size is largely inconclusive. We analyze whether the effect of R&D on accounting performance also varies by the size of the firm using the equation below:

\[
y_{it} = \beta_0 + \beta_1 R&D_i \times \text{pandemic}_t + \beta_2 R&D_i \times \text{large}_i + \beta_3 \text{pandemic}_t \times \text{large}_i + \beta_4 \text{pandemic}_t + \alpha_i + \delta_t + \epsilon_{it} \tag{8}
\]

where large\(_i\) is a dummy that takes the value one if firm size variable is greater than the third quartile and zero otherwise. The coefficient \(\beta_1\) will capture the differential effect of R&D for large and small firms in the sample. We find that the effect for larger firms is negative and significant at a 10% level of significance for ROS and GI outcomes, respectively (columns 5 and 6). The weak effect for larger firms can be explained in line with the findings of Bronzini and Piselli (2016) in Italy. Their paper finds that the impact of R&D subsidy is larger for smaller firms as subsidy eases the financing constraints of smaller firms. Similarly, during the pandemic, the marginal effect of R&D is higher for the vulnerable smaller firms in the market than the larger firms with more resources.

### Table 7: Effect of COVID-19 on the performance of R&D firms—Heterogeneous effects

| Variables                  | Essential industry effect | BG effect | Firm size effect |
|----------------------------|---------------------------|-----------|-----------------|
|                            | (1) ROS                  | (2) GI    | (3) ROS         | (4) GI | (5) ROS  | (6) GI |
| Pandemic                  | -0.700                   | -0.631*** | 0.961          | 0.368  | -1.242** | -0.582*** |
|                           | (0.568)                  | (0.049)   | (0.952)        | (0.298) | (0.531)  | (0.044) |
| R&D \times Pandemic       | 0.202                    | 0.111**   | -1.391         | -0.700** | 0.798* | 0.139** |
|                           | (0.520)                  | (0.055)   | (0.923)        | (0.311) | (0.478)  | (0.055) |
| Pandemic \times Essential | -1.120                   | 0.144*    |                  |        |        |        |
|                           | (0.845)                  | (0.080)   |                  |        |        |        |
| R&D \times Pandemic \times Essential | 1.405* | 0.210** |                  |        |        |        |
|                           | (0.849)                  | (0.100)   |                  |        |        |        |
| Pandemic \times Group     |                          | -2.129*** | -0.950***       |        |        |        |
|                           |                          | (1.006)   | (0.299)         |        |        |        |
| R&D \times Pandemic \times Group | 2.147** | 0.865*** |                  |        |        |        |
|                           | (1.014)                  | (0.314)   |                  |        |        |        |
| R&D \times Large          |                          | 0.239     | -0.065          |        |        |        |
|                           |                          | (0.315)   | (0.094)         |        |        |        |
| R&D \times Pandemic \times Large | -0.836* | -0.191** |                  |        |        |        |
|                           |                          | (0.491)   | (0.077)         |        |        |        |
| Constant                  | -0.046                   | -0.137*** | -0.046         | -0.137*** | -0.078 | -0.199*** |
|                           | (0.229)                  | (0.014)   | (0.229)        | (0.014) | (0.218)  | (0.017) |
| Quarter FE                | Y                        | Y         | Y               | Y      | Y        |        |
| Firm FE                   | Y                        | Y         | Y               | Y      | Y        |        |
| Observations              | 4089                     | 4094      | 4089            | 4094   | 4087     | 4058   |
| R²                        | 0.004                    | 0.028     | 0.003           | 0.020  | 0.004    | 0.231  |
| Number of companies       | 1064                     | 1067      | 1064            | 1067   | 1063     | 1063   |

Note: Columns 1 and 2 report the heterogeneous effect of group affiliation, whereas columns 3 and 4 give the heterogeneous impact of essential industry classification and columns 5 and 6 reports the heterogeneous effect of firm size. Robust SEs are reported in parenthesis.

*** \( p < 0.01 \).

** \( p < 0.05 \).

* \( p < 0.1 \).

6 | DISCUSSION AND CONCLUSION

The investment in R&D is crucial for firms to innovate and remain competitive. However, the life-cycle of R&D activities is long, and the benefits are often realized in the long run, even though the expenditure is in the short run. This cost-benefit mismatch may act as a...
deterrent for the manager to engage in R&D. This study analyzed whether investing in R&D activities can signal the firms’ ability to innovate and better manage a crisis scenario in the context of the current coronavirus pandemic in India. We find that manufacturing firms that had invested in R&D before the pandemic experienced lower negative CAR when WHO announced COVID-19 as a pandemic compared to the non-R&D firms. Further, R&D firms exhibited better performance given by ROS and GI in the pandemic quarter compared to non-R&D firms. The study also underscores the role of government intervention in influencing firm performance. Policies to reduce the spread of the virus had real economic costs in terms of lower profitability of firms in the short run.

Our findings have implications for investors, managers, and policymakers. The study indicates that investors looking to invest in the stock market during a crisis might be better off by investing in firms with a history of engaging in R&D activities. Further, managers of firms should invest in R&D activities at all times, that is, during normal and crisis periods, as R&D investment can reduce the effect of a negative shock on performance.

The investment in innovation-related activities is procyclical in nature (Fabrizio & Tsolmon, 2014). Post GFC, firms in several countries stalled innovation projects (Paunov, 2012) or reduced investment in innovation (Archibugi et al., 2013). Recently, Giebel and Kraft (2020) found that firm-level investment in innovation falls post-crisis through the bank financing channel. The current coronavirus pandemic threatens to adversely affect the probability of future investment in innovation projects and the extent of firm-level R&D expenditure. However, our study highlights that R&D investments shield firms during crisis scenarios, and reducing such investments may reduce the firm’s ability to wither future crises. The study suggests that the corporate sector in India should voluntarily increase R&D spending to improve its resilience during future crises. There is scope for counter-cyclical public policies like R&D subsidy for manufacturing firms during the current crisis to wither any adverse effect on R&D investment as a fall-out of the current COVID-19 pandemic in India.

It is worth noting few limitations of the study and future research directions. First, the paper only analyzes the short run effect of R&D on the stock market and the accounting performance of firms. The long run effects of R&D in shaping firm’s response to a crisis can be explored in future research. Second, the study only considers one aspect of firm’s strategy, that is, R&D; however, corporate governance can be another important factor that may shape the resilience of firms during a crisis, especially in countries like India with less than fully developed capital markets. One can explore to what extent governance practices can complement or substitute the effect of R&D during a crisis in general and the coronavirus pandemic in particular. Finally, this study is based on listed firms, and most of them are matured firms. One can argue that R&D could be an important determinant of survival for young start-ups. Analyzing whether unlisted start-ups firms with higher R&D intensity have higher survival probability during a crisis is another question that can be addressed in the future.

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CONFLICT OF INTEREST
The author declares that there is no conflict of interest.

DATA AVAILABILITY STATEMENT
The data that support the findings of this study are available from Prowess maintained by Centre for Monitoring Indian Economy (CMIE). Restrictions apply to the availability of these data, which were used under license for this study.

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