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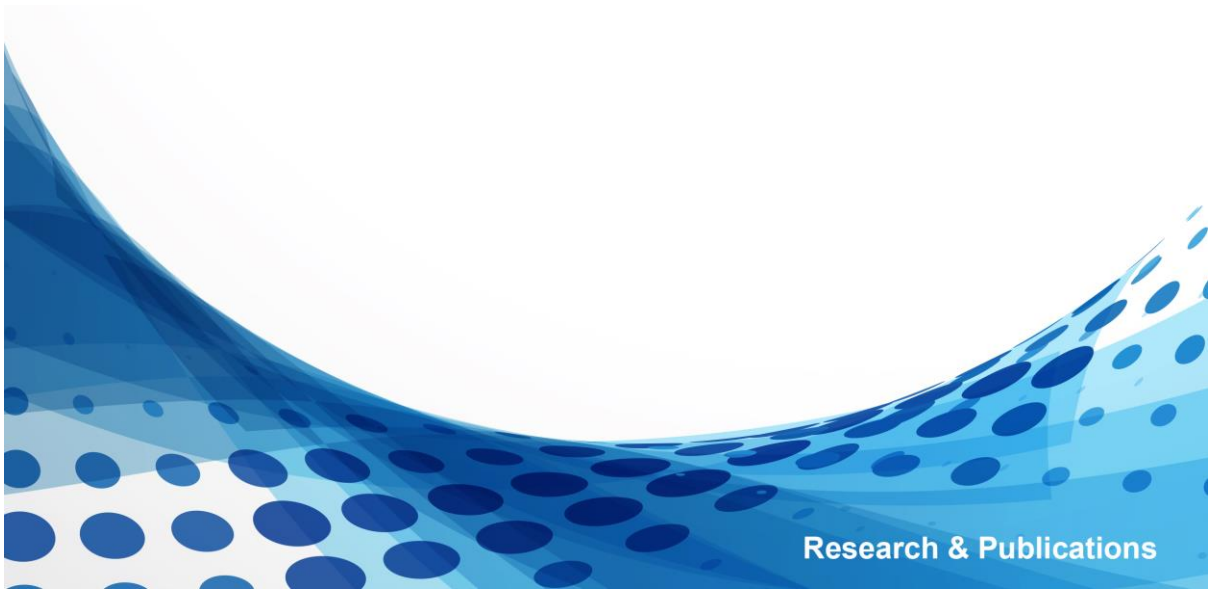

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Abstract

Based on the literature, the paper identifies processes that get initiated post an M&A event and affect the acquiring firm's innovation efforts. We apply panel fixed effects estimation techniques to analyze the individual impact of mergers and acquisitions on R&D intensity of acquiring firms using data for 217 publically listed Indian pharmaceutical firms (both acquirers and non-acquirers) during 1999-2018. The study finds that acquisitions rather than mergers provide impetus to R&D in the acquiring firms. This suggests that these two combinations – mergers and acquisitions - do not unleash the same type of innovation activity related processes in the acquiring firm. Results also show that when mergers or acquisitions are combined with purchase of assets, they have a positive impact on R&D intensity. Purchase of assets when combined with M&A seem to provide access to relevant complementary assets that makes R&D activity profitable for the acquirer post the merger or acquisition event. Possibly, firms view purchase of assets as a strategy that is complementary to M&A strategies for enhancing innovation. The paper shows that impact of M&A on R&D takes time and it is useful to analyze the impact of mergers and acquisitions separately, rather than combining the two together.

Keywords: Mergers; Acquisitions; Complementary Assets; R&D; Innovation; Indian Pharmaceutical Industry

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1. Introduction

Typically, mergers and acquisitions (M&A) result in an increase in market concentration and can lead to lower levels of competition. Competition authorities, therefore, often view them with suspicion. This perspective can get moderated if M&A activity increases innovation and thereby the possibility of higher dynamic efficiency, despite resulting in a more concentrated market structure. There has been a long tradition of scholarship that explores the impact of competition on innovation but the results are mixed. The literature on the role of M&A on innovation is of somewhat recent origin but here again the relationship between the two is unclear. (Entezarkheir and Moshiri 2017; Szücs 2014). The present study contributes to the growing area of research on the impact of M&A on innovation among acquiring firms by analyzing data from an unbalanced panel of 217 publicly traded Indian pharmaceuticals firms.

Our effort is distinct from earlier studies in three ways. One, we distinguish between the impact of *mergers* from that of acquisition of shares (henceforth *acquisitions*) and acquisition of assets (henceforth *purchase of assets*)[1], on innovation activity. Consequently, unlike earlier studies, instead of viewing M&A as a singular strategy, we posit that mergers, acquisitions and purchase of assets can be three distinct strategies with differential impact on innovation. (Zhao, Lin, and Hao 2019). Two, recognizing that complementary assets can help firms benefit from innovation (Teece 1986) and thereby create incentives for more R&D, we examine if purchase of assets together with other M&A transactions has an impact on innovation efforts of such firms. Three, we recognize that the impact of M&A on innovative activity may take time as restructuring of R&D through M&A can be protracted in nature and take a number of years to complete (Szücs 2014). Consequently, imposing any specific lag structure on this relationship may be misleading. Instead of specific year dummies, we use the post-event dummy method to partly address this issue.

We focus on the impact of M&A on innovation efforts as captured by the focal (acquiring) firm's R&D expenditures. Researchers in the past have used various measures of innovation inputs and outputs while examining the impact of M&A on innovation. Studies using innovation inputs typically use R&D expenditures (Bertrand 2009; Phillips and Zhdanov 2013; Desyllas and Hughes 2010), while those using innovation outputs utilize variables like patent counts, patent citations and new product announcements (Cloodt, Hagedoorn, and Van Kranenburg 2006; Ahuja and Katila 2001). Szucs (2014) suggests that any of these measures can be used as there is unlikely to be a major systematic disparity between innovation inputs and outputs, especially in hi-tech sectors (Hagedoorn and Cloodt 2003). However, insofar as outcomes of any innovation effort are uncertain and dependent on a variety of factors, a focus on R&D expenditures helps understand if M&A activity results in firms allocating more resources to generate innovations.

The context of the Indian pharmaceutical sector for our analysis is quite appropriate. With the implementation of a TRIPS compatible IPR regime in India, pharma industry has seen a significant improvement in the appropriability conditions. Unlike earlier when only process patents were granted, patenting of both products and processes is now possible. With the tightening of the appropriability regime, Indian pharma firms have been more actively engaged in innovation related activities (Ray and Ray 2021). The sector has also seen a lot of M&A activity in recent years (Sahu and Agarwal 2017). A better understanding of the impact of

M&A on innovation activity in the changed institutional context would be quite useful for the policy makers.

The study finds that acquisitions rather than mergers provide impetus to innovation activities in the acquiring firms. The purchase of assets alone does not create any substantial impact on innovation efforts unless complemented with mergers or acquisitions. Evidently, purchase of assets when combined with M&A provide access to relevant complementary assets that make R&D activity profitable. Firms seem to view purchase of assets as a strategy that is complementary to M&A strategies for enhancing innovation.

The rest of the paper is divided into five sections. The next section provides a brief review of literature to spell out a few relationships that this paper explores. Section 3 discusses the econometric model that has been estimated along with the data used for estimation. The results of various estimated models along with robustness tests undertaken by us and their results are discussed in Section 4. The final section makes some concluding observations.

2. Literature Review

As mentioned, studies on the impact of M&A on innovation have looked at both innovation inputs and outputs. While our empirical analysis explores the impact on innovation inputs (R&D expenditure intensity), this section draws insights from studies that examine the impact of M&A on both innovation inputs and outcomes. A variety of mechanisms that can underline the impact of M&A on innovation have been identified:

i. *Economies of Scale and Scope and Synergies in Knowledge Bases:* M&A can help participating firms reap economies of scale and scope and thereby reduce duplication of innovation efforts. Post M&A, reorganization and rationalization of acquired R&D operations to reap such economies can affect R&D intensity as well as its productivity (Colombo and Rabbiosi 2014). This may result in lower innovation *inputs* (Szücs 2014). Knowledge synergies between the merging entities can add to this effect due to intra-firm knowledge spillovers (Ornaghi 2009). However, M&As can also lead to diseconomies if the organizational structure becomes cumbersome after the M&A transaction (Szücs 2014). In case M&A activity results in multiple divisions within the merged/acquired entity, firms may not be able to motivate their researchers to collaborate in risky ventures due to information asymmetry and agency problems (Rajan, Servaes, and Zingales 2000; Entezarkheir and Moshiri 2017);

ii. *Changes in Appropriability Conditions:* Post the M&A transaction, if for any reason appropriability conditions improve for the merged entity and/or for the acquiring firm, the incentives to do R&D will be higher (Szücs 2014). This can also provide higher incentives to increase innovation outputs – patenting and/or introduction of new products and processes in the market. Post M&A, higher appropriability can arise from a unique combination of knowledge bases which are tacit in nature and therefore difficult to imitate. It can also emerge from a unique bundle of patents (and other IP like brands) owned by transacting parties which enhances legal and market appropriability;

iii. *Changes in the Nature of Competition:* The impact of M&A on market competition also affects incentives to innovate but the innovation-competition links do not show a consistent pattern. If M&A results in higher market power for the merged/acquiring entity, the incentives to increase innovation activity (*inputs*) may increase (Szücs 2014). However, a study of recent cases from US and EU concludes that absent synergies, a merger between significant rival innovators can cause a decline in innovation (Federico, Scott Morton, and Shapiro 2020). This is in line with Federico, Langus, and Valletti (2017) argument that mergers reduce the incentive to innovate among the merging firms.

iv. *Access to Complementary Assets:* In cases where M&A activity is able to effectively combine complementary assets (knowledge, manufacturing, marketing and distribution etc.), the incentives to innovate may increase as common ownership of these assets reduces hold-up problems and under-investment due to incomplete contracting. Thus, better access to relevant complementary assets may help firms to profit from innovation and therefore increase *both* innovation *inputs* and *outputs*.(Rhodes-Kropf and Robinson 2008; Entezarkheir and Moshiri 2017); and

v. *Managerial Focus and Financial Constraints:* During the pre and post-M&A period, the managers may be too busy to pay much attention to R&D projects (Bertrand 2009). Besides, the financial expenditures incurred in the M&A activity may reduce the resources available for R&D in the post-M&A period and make managers risk averse, especially if the finances were raised through debt. (Szücs 2014; Hitt et al. 1996) Consequently, firm's focus on *both* innovation *inputs* and *outputs* might decline (Ornaghi 2009; Hitt et al. 1991).

Given that most of these mechanisms are often simultaneously at work, it is difficult to predict the overall impact of M&A on innovation as it will depend on the relative dominance of the various processes. Moreover, available studies have highlighted that reality is even more complex than what is captured in the five mechanisms summarized above. We note these insights below, even though we are not able to effectively capture many of these complexities in our empirical exercise.

2.1. Mergers vs. Acquisitions vs. Purchase of Assets

As mentioned, most studies that analyze the impact of M&A on innovation do not distinguish between mergers, acquisitions and purchase of assets. Typically, studies combine first two types of M&A activities and do not consider the third one. A merger involves combining a firm with the target and formation of a merged entity post-merger. Acquisitions or purchase of assets does not involve such a combination. Given the five processes identified above, one can argue that their importance is likely to vary across these three types of M&A activities. It is likely that issues relating to economies of scale and scope and managerial focus may be more salient in the case of mergers as compared to acquisitions. It is, therefore, relevant to disentangle the effect of the three types of M&A activity on innovation. Table 1 summarizes some studies that focus on mergers, acquisitions, purchase of assets or on M&A as whole. Differences in methodologies, contexts etc., make comparisons of results across studies difficult. However, it is striking to note that broadly, while mergers have a negative impact on innovation, the impact

of acquisitions and purchase of assets is positive. In cases where different types of M&A are taken together, the effect is positive in some cases and negative in others.

In this study we explore if innovation activities are affected differently by the three types of M&A activities. For each type of M&A activity, the effect on innovation can get affected by a variety of other factors.

2.2. Characteristics of M&A

Apart from the three types of M&A activity discussed above, several other features of this activity have been distinguished in the literature. For example, the categories defined by Miozzo, DiVito, and Desyllas (2016) in the context of the pharmaceutical industry are essentially based on strategic intent: (i) technology-enhancing combinations; (ii) capabilities-enhancing knowledge base combinations; (iii) technology and capabilities enhancing combinations; and (iv) non-technological and non-capabilities-enhancing combinations. The technology and capability enhancing acquisitions seek knowledge or complementary assets creating scope for R&D, whereas others are largely intended to reduce costs, risks and competition. In a study, where the authors are able to distinguish between technological and non-technological mergers for a large number of firms, it is found that while technological M&As have a positive effect on innovation performance (in terms of patenting) of the acquiring firms, the effect of non-technological M&As is negative. (Ma & Liu, 2017).
Another set of studies have focused on *domestic vs. cross-border* (foreign) M&As. Stiebale (2013) studied the impact of cross-border acquisitions on R&D expenditures of the acquiring firms in Germany. The study finds that as compared to others (engaged in *domestic* M&A as well as those who do not participate in M&A), firms engaged in *cross-border* acquisitions have higher R&D intensity. In fact, firms' engagement in cross-border acquisitions raises their average R&D intensity by 1.5 percentage points. In an exercise for European firms, Stiebale (2016) finds that the results are the same not only for R&D intensity but also for patenting; post-acquisition, the merged entity is more innovation active than others. Higher innovation activity in the merged entity is driven by the *acquirer* while the *target's* innovation declines. Results suggest that post M&A, R&D activity moves to a more efficient location, that of the acquirer. Contrary to these findings, in a study on the effect of foreign acquisitions on French manufacturing firms, Bertrand (2009) finds that the R&D intensity of *target* firms increases after acquisitions. Evidently, the efficiency gains associated with increased R&D by target firms counterbalances various costs. The author observes that acquisitions are useful to gain access to specific know-how with the objective of technology sourcing from target firms and overseas R&D development. This in turn helps building the R&D capability of the target firm.

Other categories of M&A are horizontal, vertical or conglomerate and each seems to have different impacts in terms of innovation activity. In a theoretical model, Federico, Langus, and Valletti (2017) analyse the impact of a merger on firms' incentives to innovate. They argue that while the merging parties decrease their innovation efforts post-merger, the outsiders to the merger increase their effort. Extending that model, Denicolò and Polo (2018), however, suggest that *horizontal* mergers may actually spur innovation *output* by reducing duplication of R&D efforts. If the value of innovations is high and the returns to R&D are not diminishing

rapidly, *horizontal* mergers are more likely to spur innovation. Effectively, these models are able to separate the effect on R&D efforts and innovation outcomes. In the model for horizontal mergers, R&D may decline or increase depending on the balance of two forces – reduction in R&D due to prevention of duplication and increase in R&D due to economies of scale. Innovation outputs, however, are expected to increase as a consequence of M&A activity if it is horizontal in nature.

Ornaghi (2009) studies the effect of mergers in pharmaceutical industry on R&D activity of the consolidated firm and to understand the relationship between the pre-merger relatedness of the firm with its post-merger performance. The results show that higher technological relatedness does not result in higher R&D expenditures. Ma and Liu (2017) also find horizontal and conglomerate M&As to negatively affect innovation output while vertical M&As do not have any significant impact. These relationships are found to be mediated by the degree of technology overlaps between transacting firms[2]. Another important characteristic of the M&A activity is the size of the transaction. Zhao, Lin, and Hao (2019) analyze the effect of size of M&A transaction on post-acquisition innovation output and find an inverted U-shaped relationship between M&A size and innovation performance. Moreover, post-acquisition R&D investment positively moderates this relationship.

2.3. Characteristics of Transacting Firms (Acquirers vs. Targets)

Entezarkheir & Moshiri (2017) show that the effect of mergers on innovation is conditional on market share of the merging firms. Firms with larger market share have greater resources to introduce innovation. Other studies have also suggested that firms with higher market share tend to have intangible assets of higher value which results in dominant firms having greater incentives to innovate as they can reap higher rates of returns in their R&D investments (Ceccagnoli 2009).

As discussed, the effect of technological and non-technological acquisitions on the innovation performance are likely to be different. But characteristics of transacting firms can affect the impact on innovation *within* technological and non-technological M&As. For example, in the study by Stiebale (2016), the impact on innovation for the acquirer is the maximum where the pre-acquisition patent stock is large for both the acquirer as well as the target.

An analysis of the impact on Indian acquiring firms, it was found that the absorptive capacity (measured by the previous year R&D intensity of the acquirer) is positively related to post-merger R&D intensity of the acquiring firm (Yadav 2021). The importance of absorptive capacity of acquiring firms is also brought out by Ahuja & Katila (2001) who show that the absolute and the relative size of the acquired knowledge base (typically measured through patent stocks of the acquiring and target firms) influences the impact of technological M&A on innovation. Their evidence suggests that in technological acquisitions absolute size of the acquired knowledge base positively affects the innovation output. But if the relative size of the knowledge base of the target (acquired) firm is high *vis-a-vis* the knowledge base of the acquiring firm, the impact on innovation output is negative, presumably because the acquiring firm does not have the requisite absorptive capacity to assimilate and build on the large

acquired knowledge (Cohen and Levinthal 1990). Non-technological acquisitions do not have any impact on the innovative performance of the acquiring firm.

Haucap, Rasch, and Stiebale (2019) analyse how horizontal mergers in European pharmaceutical industry firms affect innovation of the merged entity and its non-merging competitors. They find that both patenting and R&D of the merged entity and its rivals decline significantly in the post-merger period. Moreover, it is found that negative effects of mergers on innovation are predominant in markets with high pre-merger R&D intensity and in technology fields with overlap in pre-merger innovation activities of merging and rival firms. In markets with lower R&D intensity, a merger can induce innovation in the merging entity as well in other competitors in the market. The study suggests that even situations where firms with overlapping technology fields merge, the impact on innovation may be affected by the technology intensity of the industry; the impact is likely to be positive when R&D intensity is low.

The relevance of the size of knowledge-stock acquired and the technology overlaps discussed above can also be seen through the lens of the complementary assets perspective. The results discussed above are indicative of the fact that the access to complementary innovative assets (knowledge stocks) of the target firms can be crucial for post-acquisition innovative outcomes.

2.4. Short vs. Long Term Effects

Studies have highlighted the difference in short-run and the long-run outcomes of M&As on innovation. Apart from the time taken to absorb, assimilate and synergize the knowledge of the target firm with their own knowledge base to innovate, the impact on innovation in the long run is likely to depend on the generative appropriability of the M&A activity. Ahuja, Lampert, and Novelli (2013) distinguish between *primary* appropriability and *generative* appropriability. While the former refers to profiting from investments in a specific innovation (as discussed in Teece, 1986), the latter refers to a firm's ability to capture a significant share of future innovations (knowledge) spawned by its existing innovations (knowledge). If firms are able to profit from multiple sequential innovations in the post M&A period, the long term effect on innovation would be high. Consequently, M&As with long-term goals tend to alter the ways in which the merging firms R&D evolves. Eisenman and Paruchuri (2019) empirically explore the effect of merger between two pharmaceutical firms of similar size on generative appropriability. The findings suggest that mergers help transacting firms recombine their knowledge from the other firm more than what they did before the merger.

Cloodt, Hagedoorn, and Van Kranenburg (2006) looked at the impact of technological and non-technological M&A on post-M&A innovative performance of the acquiring firm. While the non-technological M&A have a negative impact on the innovative performance of the acquiring firm, technology driven M&A tends to have a positive effect only during the initial year after which it tends to become negative. Consistent with Ahuja and Katila (2001), the study suggests that the target should be neither too similar nor unrelated in the knowledge base with the acquirer. It also shows that it takes time for the synergistic effect of M&A on innovation to show up.

Desyllas and Hughes (2010) examines the R&D performance of the high technology acquirers. The results suggest a negative effect of acquisitions on R&D intensity and R&D productivity for the very first year. Gradually, in the third year it changes, wherein acquisitions have a positive effect on R&D intensity whereas for R&D productivity the overall effect is neutral. The initial decline in R&D intensity is attributed to temporary restructuring costs, organizational disruptions and R&D routines followed by an acquisition. Entezarkheir and Moshiri (2017) also find short-run effects of merger on innovation are smaller as compared to the long-run effects.

2.5. Impact on the Nature of R&D and Innovation

So far, we did not focus on the characteristics of innovation inputs and outputs that might result from M&A activity. While most studies have used R&D expenditures and patents as input and output measures respectively while analyzing the impact of M&A on innovation, a few have also explored the heterogeneity in these innovation measures. Wagner's (2011) study of 50 largest firms within the US semi-conductor's industry finds a positive relationship between technology-related acquisitions and exploratory R&D while such acquisitions also do not reduce exploitative R&D. A study of selected M&A cases (Szücs 2014), however, found that the targets chosen were highly innovative firms but who had not commercially exploited their innovations. Post M&A, the innovation efforts of the target declined while the acquirer focused on R&D to exploit the innovations of the target.

There is also some evidence to suggest that M&A may have a differential effect on the quantity and quality of innovation outcomes. Valentini (2012) shows that M&A has a positive effect on firms' patent output but due to pressure of immediate results causes a decline in the patents' impact, originality and generality. The paper shows that the acquirer develops patents around the specific patents of the target firms which causes an increase in quantity but decrease in the quality of patents.

As is evident from the discussion in this section, the relationship between M&A and innovation is quite complex. Limited availability of relevant data does not allow researchers to empirically explore the various nuances discussed above. The next section specifies the relationships that we have been able to explore with the data available for the Indian pharmaceutical industry. The details of the data are also provided.

3. Data and Model Specification

3.1. Data

The study uses an unbalanced panel data-set on listed Indian pharmaceutical firms from 1998-99 to 2018-19, compiled from the CMIE Prowess IQ database which provides financial as well as M&A data. The database has a separate segment on M&A which provides information on each M&A deal including name of the acquirer, deal type, date of announcement, target, cash consideration, acquirer & target country name and deal completion date. Three types of M&A deals are distinguished within the database: (i) Mergers; (ii) Acquisitions of Shares (acquisition); and (iii) Acquisitions of Assets (purchase of assets). Acquisitions comprises

acquisition of both minority and majority shares by the acquirer. While, purchase of assets are specific assets acquired by the acquirer. This could be in the form of API business, generic business, R&D unit, marketing and distribution, etc. of the target. Since our focus is on the impact of M&A activity, we have only considered *completed* deals; many deals that are *announced* do not materialize due to a variety of reasons. The financial information on the firms were matched with the M&A data. Due to the uneven nature of the data available for unlisted firms the analysis is restricted to an unbalanced panel of 217 listed firms with a total of 191 mergers and acquisitions and 38 purchase of assets. The sample includes firms who have participated in any M&A activity as well as those who have not. In the data on R&D expenditure, often zeros and missing observations cannot be distinguished. This has been cross-checked and corrected by hand-matching each data point with another financial database Capitaline AWS. Table 2 provides details of all the variables used in the analysis.

3.2. Model Specification

Previous studies have used various proxies to measure innovation at the firm level. Some of the recognized indicators of innovation are weighted patent-citation, patent counts, total factor productivity, absolute R&D expenditure and R&D intensity (Hagedoorn and Cloodt 2003; Stiebale 2016; Entezarkheir and Moshiri 2017; Ornaghi 2009; Stiebale and Reize 2011). While the first three are output measures, the remaining two capture innovation inputs. R&D expenditures measure the willingness and intent to innovate as compared to patents that measure the outcome of innovation activity undertaken by a firm (Szücs 2014). We use R&D expenditures to capture the innovation activity of a firm and analyze if M&A make an impact on this effort. While data to capture all the complexities discussed above is not available, we take account of some of the factors through control variables.

3.2.1. Model I – Separating the Effects of Mergers and Acquisitions

In order to analyze the impact of M&A activity on innovation efforts of the *acquiring* firm, the following base model has been estimated:

$$R\&D_{it} = \alpha_{it} + \beta_0 Merger_{it} + \beta_1 Acquisition_{it} + \beta_2 \text{MarketShare}_{it-1} + \beta_3 \text{FirmSize}_{it-1} + \beta_4 \text{LernerIndex}_{it-1} + \beta_5 \text{Tradeopenness}_{it-1} + u_{it} \quad (1)$$

Details of measures used for variables in the model are given in Table 2. Here, $R\&D_{it}$ measures the R&D intensity of the firm i, in the year t. As mentioned, we analyze the effects of mergers and acquisitions separately. Following Ornaghi (2009) and Entezarkheir & Moshiri (2017), we use *post-merger* and *post-acqusition* dummies to capture this effect. $Merger_{it}$ is the post-merger dummy for merging firms and $Acquisition_{it}$ is the post-acquisition dummy for the acquirer, which take the value 1 for the ith firm for *all* the years *after* the merger or acquisition has been

completed. We, therefore posit that any M&A activity is likely to produce its effect over a number of years rather than in any one year. This dummy also assumes that the effects of M&A do not get manifested in the same year in which the event gets completed but starts to impact R&D from the subsequent period and this impact continues for a longer period of time. (Ornaghi, 2009) Such a dummy recognizes that restructuring of R&D is potentially a protracted activity which may take a number of years to complete after a M&A transaction has been completed (Szücs 2014).

Based on the discussion above and other studies, we use a few control variables (with a year's lag). Given the role of market share and monopoly power (competition) discussed in the last section, we control for the market share of the focal firm in the period t-1 ($MarketShare_{it-1}$) (Stiebale 2013; Bertrand 2009; Entezarkheir and Moshiri 2017). Profitability is measured through the Lerner index ($LernerIndex_{it-1}$) (Desyllas and Hughes 2010; Bertrand 2009; Szücs 2014). In addition, we control for firm size ($FirmSize_{it-1}$) (Hitt et al. 1991; Ahuja and Katila 2001; Bertrand 2009; Desyllas and Hughes 2010; Cefis and Marsili 2015; Zhao, Lin, and Hao 2019) and trade openness for the firm i during the period t-1 ($Tradeopenness_{it-1}$). Since firm size partly captures availability of resources, several studies have used it as a determinant of innovation (Cefis and Marsili 2015; Entezarkheir and Moshiri 2017). Its role has been studied even in the context of M&A (Phillips and Zhdanov 2013). In an open economy, even a focal firm with a large market share is likely to face competition and the trade openness variable has been used to capture market contestability.

Once we recognize that mergers and acquisitions as two different strategies and that combining the two for analytical purposes might result in losing some insights, we need to hypothesize how the impact of the two strategies on innovation activities might be different. Unlike mergers, acquisitions do not necessarily result in the acquiring firm getting controlling stake, providing it access to *all* resources of the target. However, acquisitions might align the incentives of the transacting parties, facilitate knowledge sharing and reduce transaction costs for innovation related activities between the parties. Prima facie, therefore, the five broad processes identified in the last section that might affect R&D as a result of M&A activity, are likely to be more dominant in the case of mergers than for acquisitions. For example, the possibility of reaping economies of scale and scope and/or synergies will be much higher for a merger as all the innovation activities will now be part of one organization. Similarly, firms' ability to meaningfully combine unique resources of the merging entities to enhance appropriability is also likely to be higher in the case of a merger than in cases involving only acquisitions. Mergers will also have a higher impact on market competition and on the lack of managerial focus as reorganization of the merged entity might take priority. Exceptions apart, access to complementary assets is also likely to be better for merged entities as compared to situations wherein the acquirer only owns part of the company through acquisitions. Availability of financial resources post M&A activity for managerial activity, will however depend on the costs incurred by the focal firm in the mergers or acquisitions. While the processes discussed will be more dominant for a merger situation, it is difficult to predict the impact of mergers and acquisitions on R&D separately. It is to be empirically explored. As, shown in Table 1, studies in the past have either focused only on mergers or acquisitions or analyzed the impact of both together. All the three are not analyzed in the same study. To

analyze how our results would have been different if both mergers and acquisitions were combined together, a post-M&A dummy has been created for firms involved in *both* in mergers and acquisitions ($M\&A_{it}$). Model I has also been estimated with this dummy replacing the separate mergers and acquisitions dummies as an independent variable.

3.2.2. Model II – Exploring the Role of Complementary Assets

As discussed, ownership or access to complementary assets can help profiting from innovation, thereby creating incentives for firms to undertake innovation efforts like R&D (Bei 2019). Mergers as well as acquisitions in another firm can provide access to certain complementary assets to the acquiring firm. However, firms also acquire assets without acquiring equity and these can potentially act as complementary assets to help take a firm's innovation to the market. In fact, firms might acquire such assets to improve their position with respect to complementary assets vis-à-vis their competitors. In other words, purchase of assets might be part of a larger strategy to acquire relevant complementary assets to enhance the value of the resources acquired through mergers and acquisitions. In such situations, purchase of assets becomes a strategy that is complementary to the M&A strategy. Alternatively, purchase of assets may be an independent strategy substituting, at times, for the M&A strategies involving equity transactions. Given this logic, firms that acquire equity as well as other assets are likely to have better access to complementary assets making R&D investments more valuable. We further add purchase of assets to the base model. As was the case with mergers and acquisitions, a post-purchase of assets dummy ($Assets_{it}$) has been added to capture its independent impact on R&D. In addition, this dummy has been interacted with post-merger and post-acquisition dummies ($Assets_{it}*Merger_{it}$; $Assets_{it}*Acquisition_{it}$) to explore if purchase of assets along with acquisition of equity has any effect on R&D efforts. In the same spirit, the combined effect of mergers, acquisitions and purchase of assets is also explored ($Assets_{it}*Merger_{it}*Acquisition_{it}$).

To control for unobserved heterogeneities among firms that might be due to time invariant firm characteristics and certain time-specific heterogeneities as well, firm fixed effects and time fixed effects have been used to estimate models (Entezarkheir and Moshiri 2017). We also check for multi-collinearity and find it is not a concern.

Studies have argued that the long term implications of M&A for innovation efforts may show up over a period of time and not immediately after the event. Early changes in R&D in the acquiring firm following an M&A activity can be due to consolidation of R&D efforts or due to investments to develop absorptive capacity to internalize target's R&D (Szücs 2014). A longer time frame will also capture better the manager's longer term's decisions vis-à-vis R&D expenditure post the M&A event (Bertrand 2009). Therefore, as a robustness check, we estimate the effect of mergers and acquisitions on R&D efforts of the acquirer by increasing the lag; instead of using post-event dummy immediately from the year of the event, we use dummies with longer gestation period. Post-merger and post-acquisition dummies with one, two and three-year lags have been introduced into the base model.

Table 3 provides the descriptive statistics. Firms in the sample vary significantly in terms of size and profitability. It is noteworthy that due to the non-availability of R&D data which is critical for our analysis, the number of firm-year observations declines significantly.

Table 4 gives the correlations between dependent and various independent and control variables.

4. Results

4.1. Separating the Effects of Mergers and Acquisitions

Table 5 presents estimates of Model I and Model II, using panel fixed effects. Estimates of the combined effect of M&A as well as separate effects of mergers and acquisitions on innovation, controlling for other variables, are presented. The fixed effect or the within estimator panel data model helps to avoid inconsistent estimates due to unobserved firm heterogeneities (Entezarkheir and Moshiri 2017). Column (1) of the table gives a combined effect of M&A (i.e., taking mergers and acquisitions together) on R&D intensity. In column (2) estimates of the effect of mergers and acquisitions on R&D intensity are provided separately.

The results in Table 5 clearly show that the impact on R&D of mergers is very different from that of acquisitions. The combined effect of M&A, as measured by $M\&A_{it}$ in column (1) is positive and statistically significant. But when we separate mergers from acquisitions, it is evident that this effect is primarily driven by acquisitions; the independent effect of mergers on innovation activity is insignificant, while acquisitions has a significant positive effect on R&D intensity. This result seems to be consistent with the studies summarized in Table 1 and the assessment that the role of mergers on significant innovation advances or significant increases in research productivity is uncertain (Ornaghi 2009). It also supports the argument that in research driven markets like pharmaceuticals, a merger might not only reduce innovation of the merged entity but also negatively affect the innovation behavior of its competitors especially for mergers involving a relatively small firm (Haucap, Rasch, and Stiebale 2019).

Interestingly, none of the control variables, except Lerner index, have a significant impact on R&D intensity. Higher profit margins as reflected in the Lerner index affect innovation activity positively while firm size, its market share and even trade openness partly reflecting contestability do not have any significant impact.

Overall, the positive impact of acquisitions on R&D suggests that such a strategy does not unleash those parts of the five processes enumerated above that constrain or dampen innovation activity in the acquiring firm. One can argue that firms engaged in multiple M&A events may behave differently in terms of R&D expenditure as compared to those who are engaged in a single event. Our post-merger/acquisition dummies do not distinguish between these two categories of firms. Studies analyzing the impact of M&A on innovation tend to drop firms engaged in multiples M&A (Szücs 2014). We checked the consistency of our results by replacing the post-merger/acquisition dummy in Equation 1, by the cumulative number of M&A activities engaged in by the focal firm for each year. Results (not reported here) are similar to the ones reported here (Table 5 column 2) that only acquisitions affect R&D efforts of the acquiring firm positively. In a similar exercise Zhao, Lin, and Hao (2019) finds M&A

frequency and Ma and Liu (2017) number of technological M&A to be positively affecting acquirer's innovation.

4.2. Exploring the Role of Complementary Assets

Purchase of assets provides access to well-developed assets of the target. These assets are in the form of R&D units, generic and API businesses, marketing division, sales, marketing and distribution unit, etc. Access to the R&D asset not only provides an opportunity to enter into new technology markets but may also complement existing in-house research capabilities (Bertrand 2009). Similarly, other assets mentioned above might facilitate the process of commercializing innovation and making it more lucrative. Consequently, in the context of M&A activity, understanding the role of asset complementarity on innovation activity becomes relevant. Table 5 (columns 3-6) reports the estimated results of different variants of Model II where purchase of assets has been incorporated into the base model (Equation 1). The results show that the independent effect of purchase of assets on innovation activity is not significant (Column 3). However, when purchase of assets is combined with mergers (Column 4) or acquisitions (Column 5), the R&D intensity of the acquiring firm shows an increase. Similarly, when purchase of assets is combined with both mergers and acquisitions, innovation activity of the focal firm shows an increase (Column 6). The results indicate a positive impact of purchase of assets on R&D intensity of the focal firm only when it is complemented with mergers and/or acquisitions. Overall, therefore, the results suggest that purchase of assets along with the other two types of M&A activity makes R&D activity of the focal firm more efficacious providing higher incentives to undertake R&D activity. The acquired assets seem to be playing the role of complementary assets that make the post-M&A innovation activity of the focal firm more profitable. As in the base model, profits ($LernerIndex_{it-1}$) have a positive and statistically significant impact on R&D intensity, implying that greater profits induce innovation activity in acquiring firms. It has also been suggested that profitable acquiring firms tend to cherry-pick firms with attractive technological portfolios that are commercially unexploited (Szücs 2014).

4.3. Robustness checks

As a robustness check we seek to understand the impact of mergers and acquisitions innovation by introducing a longer gestation lag. Following the base model as given in Equation (1), we use $Merger_{it+1}$, $Merger_{it+2}$, $Merger_{it+3}$, $Acquisition_{it+1}$, $Acquisition_{it+2}$ and $Acquisition_{it+3}$ as instruments to capture one, two and three-year lags in post-merger and post-acquisition dummies. The estimates reported in Table 5 capture the effect of M&A activity on R&D intensity after a one-year lag and in all subsequent periods. These new dummies capture the of M&A on R&D intensity after a 2, 3 and 4-year lag respectively and in all the *subsequent* years. Apart from these new dummies all other variables are the same as in Table 5 and the same estimation method (panel fixed effects) is used. Table 6 reports the estimated results.

The effect of acquisitions with longer gestation lags is also positive and statistically significant across all specifications (columns 1-3). The estimates are consistent with the base

model Equation (1). The results indicate that even in the longer run the positive effects of acquisitions on innovation efforts persists while the impact of mergers on this activity remains insignificant.

Overall, our results show that separating the effect of mergers and acquisitions helps to improve our understanding of the impact of M&A activity on innovation. As argued by Entezarkheir and Moshiri (2017), antitrust authorities should assign greater weight on the potential innovation outcomes of an M&A the deal before providing their approval. We find that while acquisitions resulted in higher investments by the acquiring firm in the Indian pharmaceutical industry for building innovation capabilities, mergers did not have any significant effect. This empirical result is analytically important as prior studies have assessed the impact of mergers and acquisitions together. For example, Danzon, Epstein, and Nicholson (2007) that firms in pharma-biotech industry that have relatively high-likelihood engaging in M&A activity in a particular year experience relatively small growth in R&D on average over the next three years.

5. Conclusion

Mergers and acquisitions are often combined together when their impact on innovation is analyzed. Implicitly, therefore, the two are seen as substitute strategies, which are likely to have similar impact. However, our study suggests that the effect of the two can be different with acquisitions resulting in higher innovation effort while mergers do not have a significant impact. We also show that it is useful to consider the role of purchase of assets in mediating the relationship between M&A and innovation. Our results show that while, asset acquisition does not have a significant impact on innovation independently, when combined with M&A activity, it has a positive impact on the innovation efforts of the acquiring firm. Purchase of assets when combined with acquisitions or mergers has a positive effect on the R&D intensity. While acquisitions have an independent positive effect as well, in the case of mergers the effect is positive and significant when mergers are combined with purchase of assets. Evidently, purchase of assets enhances the possibility of acquiring firm profiting from innovation when it engages in merger or acquisitions activity. Presumably, the purchased assets work as critical complementary assets that help acquiring firm to leverage the combined knowledge bases of the merged or acquired entities and introduce innovations profitably. This results in higher innovation effort post the M&A activity as the efficiency of R&D efforts improves with the complementarity of various knowledge and other assets (Bertrand 2009). Mergers and acquisitions typically dealt with under a common regulatory scheme, but our results show that effects on innovation can be quite different.

This paper contributes to the literature in a variety of ways. We bring out the value of distinguishing between *mergers, acquisition of shares* and *acquisition of assets* while analyzing the impact of M&A activity on innovation. In the process we also highlight the role of complementary assets that can help firms benefit from innovation and thereby create incentives for more R&D post the M&A event. We are also able to show that the impact of M&A on innovative activity takes a long time and may not be effectively captured if one restricts the analysis to a short period. The study, however, is not without lacunae. Our review of literature brought out the complexity of the relationship between M&A and innovation and our analysis

is not able to capture many of those complexity, primarily due to paucity of data. For example, several features of M&A activity (e.g., horizontal vs. vertical vs. conglomerate; technology vs. non-technology; domestic vs. cross-border) are likely to affect this relationship. Similarly, many firm characteristics (e.g., absorptive capacity, knowledge base) of the acquiring and the target firms can moderate this relationship. The relationship may also get influenced by the way we measure innovation. Our paper has focused on innovation efforts as captured by R&D. This does not capture quality of R&D and if it is exploratory or exploitative. Studies that use innovation output like patents or number of product or process innovations as measure would also face similar problems. But we hope that as more data becomes available, our incremental effort can be extended to derive more insights.

Notes

[1] Based on the CMIE Prowess IQ database the M&A events have been downloaded in terms of mergers, acquisitions of shares and acquisitions of assets. In order to distinguish between these strategies and for convenience in understanding, we term acquisition of shares as acquisitions and acquisition of assets as purchase of assets.

[2] Colombo and Rabbiosi (2014) show that technological similarity between acquiring and acquired firms influences innovation negatively in *horizontal* acquisitions, suggesting that the acquiring firm does not get any significant knowledge inputs for innovation from firms which are technologically similar. Technological similarity results in the rationalization of R&D operations (improving R&D productivity) and reorganization of R&D top management (disrupting R&D team). They found the impact of technological similarity in horizontal mergers on innovation to be negative, but Bena and Li (2014) show that pre-M&A technology overlaps between transacting firms have a positive impact on innovation in the post M&A situation as they are able to reap synergies. Ahuja and Katila (2001), however, show that the relationship between the technological relatedness of acquired and acquiring firm on the innovative outcomes is inverted U shaped. This indicates that up to a point technological relatedness between transacting parties provide opportunities for synergies and economies of scope but beyond a point the potential of learning and knowledge spillovers is too low to positively affect innovation outcomes.

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Table 1: Impact of Mergers/ Acquisitions/ Purchase of Assets on Innovation

Study	Sample details	Entity Studied	Result
Hitt et al. (1991)	191 acquisitions (1970-1986)	Acquirer	Decrease in R&D intensity and patent intensity for firms in 29 industries
Ahuja and Katila (2001)	534 acquisitions (283 technological) (1980 to 1991)	Acquirer	Absolute size of acquired knowledge has positive effect on innovation output in technology led acquisition for firms in global chemical industry
Cloodt, Hagedoorn, and Van Kranenburg (2006)	2429 M&A (1148 technological) (1989-1995)	Acquirer	Non-technology M&A has a negative impact on post-M&A innovative performance for firms in high-tech industries
Bertrand (2009)	123 cross-border purchase of assets (1995-2001)	Target	International acquisitions increases R&D activity of domestic target firms
Ornaghi (2009)	27 mergers (1988-2004)	Merged firm	Decrease in R&D activity of the merged firm in the pharmaceutical industry
(Desyllas and Hughes 2010)	1621 acquisitions (1984-1998)	Acquirer	Early reverses followed by increase in change in R&D intensity and insignificant R&D productivity for firms in high-tech industries
Phillips and Zhdanov (2013)	11288 firms M&A of assets (1984–2006)	Target	Increase in R&D of small targets due to positive demand realization
Stiebale (2013)	389 cross-border acquisitions (2002-2007 wave)	Acquirer	Increase in R&D post cross-border acquisition of shares of firms
Szücs (2014)	265 acquirers & 133 targets M&A (1990-2009)	Acquirer & Target	Decrease in R&D of both target and acquirer for EC and US FTC examined cases
Cefis and Marsili (2015)	13,901 firm-wave M&A (1994-2002)	Acquirer	Increase in innovative activities of particularly large firms in manufacturing industry
Ma and Liu (2017)	96 M&A (2009-2012)	Acquirer	Increase in patent applications for firms engaged in technological M&A in manufacturing industry
Entezarkheir and Moshiri (2017)	642 mergers (1980-2003)	Merged firm	Increase in innovation of merged firms in the manufacturing industry
Haucap, Rasch, and Stiebale (2019)	65 mergers (1991-2007)	Merged firm	Decrease in average patenting and R&D of the merged firm in pharmaceutical industry
Zhao, Lin, and Hao (2019)	277 firms M&A (2005-2015)	Acquirer	Increase in R&D of the firms in high-tech industries

Source: Draws partly on Szücs (2014).
Note: The distinction between acquisitions (shares) and purchase of assets in the table are based on the type of data used by the respective studies.

Table 2: Variables definition

Variable name	Definition	Symbol used
Research and Development intensity	Ratio of research and development expenditure to total sales	$R\&D_{it}$
Post-merger dummy	Takes value 1 in the post-merger period for the merged firm and 0 otherwise	$Merger_{it}$
Post-acquisitions dummy	Takes value 1 in the post-acquiring period for the share acquirer firm and 0 otherwise	$Acquisition_{it}$
Post-purchase of assets dummy	Takes value 1 in the post-asset purchase period for the assets acquirer firm and 0 otherwise	$Assets_{it}$
Post-merger & complementary assets dummy	Takes value 1 in the post-asset purchase period for the assets acquirer & merged firm and 0 otherwise	$Assets_{it}$ $*Merger_{it}$
Post-acquisitions & complementary assets dummy	Takes value 1 in the post-asset purchase period for the assets acquirer & share acquirer firm and 0 otherwise	$Assets_{it}$ $*Acquisition_{it}$
Post-merger and acquisition & complementary assets dummy	Takes value 1 in the post-asset purchase period for the assets acquirer & merged and share acquirer firm and 0 otherwise	$Assets_{it}*Merger_{it}*$ $Acquisition_{it}$
Post-merger dummy with one year gestation lag	Takes value 1 a year later in the post-merger period for the merged firm and 0 otherwise	$Merger_{it+1}$
Post-merger dummy with two year gestation lag	Takes value 1 two years later in the post-merger period for the merged firm and 0 otherwise	$Merger_{it+2}$
Post-merger dummy with three year gestation lag	Takes value 1 two years later in the post-merger period for the merged firm and 0 otherwise	$Merger_{it+3}$
Post-acquisitions dummy with one year gestation lag	Takes value 1 a year later in the post-acquiring period for the share acquirer firm and 0 otherwise	$Acquisition_{it+1}$
Post-acquisitions dummy with two year gestation lag	Takes value 1 two years later in the post-acquiring period for the share acquirer firm and 0 otherwise	$Acquisition_{it+2}$
Post-acquisitions dummy with three year gestation lag	Takes value 1 two years later in the post-acquiring period for the share acquirer firm and 0 otherwise	$Acquisition_{it+3}$
Lag market share	Ratio of total sales of the acquirer to aggregate industry sales	$MarketShare_{it-1}$
Lag firm size	Natural log of total sales	$FirmSize_{it-1}$
Lag Lerner index	Ratio of (total sales-cost of production) to total sales	$LernerIndex_{it-1}$
Lag trade openness	Ratio of imports & exports to total sales	$Tradeopenness_{it-1}$

Table 3: Descriptive Statistics

Variable	N	Mean	Standard Error	Standard Dev.	Min	Max
$R\&D_{it}$	1660	0.046	0.005	0.192	0.000	5.127
$Merger_{it}$	4340	0.150	0.005	0.358	0.000	1.000
$Acquisition_{it}$	4340	0.081	0.004	0.273	0.000	1.000
$Assets_{it}$	4340	0.057	0.004	0.233	0.000	1.000
$MarketShare_{it-1}$	3106	0.005	0.000	0.010	0.000	0.105
$FirmSize_{it-1}$	3106	6.506	0.040	2.234	-2.303	11.756
$LernerIndex_{it-1}$	2944	0.344	0.048	2.619	-140.333	0.986
$Tradeopenness_{it-1}$	3106	0.232	0.005	0.269	0.000	3.000
$Merger_{it+1}$	4340	0.137	0.005	0.344	0.000	1.000
$Merger_{it+2}$	4340	0.124	0.005	0.329	0.000	1.000
$Merger_{it+3}$	4340	0.110	0.004	0.313	0.000	1.000
$Acquisition_{it+1}$	4340	0.073	0.004	0.261	0.000	1.000
$Acquisition_{it+2}$	4340	0.065	0.004	0.247	0.000	1.000
$Acquisition_{it+3}$	4340	0.057	0.003	0.233	0.000	1.000

Note: Firms with large amount of R&D expenditure in a particular year which causes the maximum value more than one were not excluded from the sample. The data points for all such firms have been checked.

Table 4: Correlation Matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$R\&D_{it}$	1.00							
$Merger_{it}$	0.04	1.00						
$Acquisition_{it}$	0.04	0.45	1.00					
$Assets_{it}$	0.04	0.26	0.28	1.00				
$MarketShare_{it-1}$	0.06	0.28	0.38	0.29	1.00			
$FirmSize_{it-1}$	-0.08	0.37	0.37	0.32	0.59	1.00		
$LernerIndex_{it-1}$	-0.08	0.02	0.01	0.02	0.03	0.11	1.00	
$Tradeopenness_{it-1}$	0.03	0.14	0.21	0.19	0.23	0.31	0.02	1.00

Table 5: M&A Activity and R&D Intensity

$R\&D_{it}$	(1)	(2)	(3)	(4)	(5)	(6)
$M\&A_{it}$	0.010*					
	(0.099)					
$Merger_{it}$		0.001	0.001	-0.001	0.002	0.001
		(0.836)	(0.868)	(0.844)	(0.757)	(0.848)
$Acquisition_{it}$		0.021***	0.021***	0.020***	0.017**	0.018***
		(0.007)	(0.010)	(0.012)	(0.070)	(0.035)
$MarketShare_{it-1}$	0.640	0.516	0.555	0.513	0.645	0.513
	(0.162)	(0.232)	(0.204)	(0.248)	(0.145)	(0.248)
$FirmSize_{it-1}$	-0.006	-0.007	-0.007	-0.007	-0.008	-0.007
	(0.385)	(0.344)	(0.306)	(0.315)	(0.274)	(0.309)
$LernerIndex_{it-1}$	0.051**	0.052**	0.053**	0.053**	0.054**	0.054**
	(0.069)	(0.058)	(0.053)	(0.053)	(0.049)	(0.051)
$Tradeopenness_{it-1}$	0.023	0.019	0.019	0.020	0.019	0.019
	(0.127)	(0.168)	(0.170)	(0.162)	(0.191)	(0.184)
$Assets_{it}$			0.008	-0.005	-0.002	-0.000
			(0.179)	(0.449)	(0.568)	(0.931)
$Assets_{it}*Merger_{it}$				0.019***		
				(0.027)		
$Assets_{it}*Acquisition_{it}$					0.020***	
					(0.025)	
$Assets_{it}*Merger_{it}*Acquisition_{it}$						0.018***
						(0.039)
Observation	1627	1627	1627	1627	1627	1627
F stat	2.31***	2.75***	3.32***	3.83***	4.95***	3.96***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
R^2	0.054	0.059	0.060	0.062	0.062	0.062
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes

Notes: All the parameters used in the given models respectively have been checked for robust standard errors using the panel fixed effects. The reported R^2 value is the within R^2 for panel fixed effects estimator.

* Significance at 10%

** Significance at 5%

*** Significance at 1%

Table 6: Robustness check of the base model

$R\&D_{it}$	**(1)**	**(2)**	**(3)**
$Merger_{it+1}$	0.002		
	(0.719)		
$Acquisition_{it+1}$	0.023***		
	(0.005)		
$Merger_{it+2}$		0.002	
		(0.727)	
$Acquisition_{it+2}$		0.026***	
		(0.002)	
$Merger_{it+3}$			-0.000
			(0.923)
$Acquisition_{it+3}$			0.028***
			(0.001)
$MarketShare_{it-1}$	0.526	0.545	0.581
	(0.208)	(0.180)	(0.172)
$FirmSize_{it-1}$	-0.007	-0.006	-0.006
	(0.340)	(0.342)	(0.369)
$LernerIndex_{it-1}$	0.053**	0.053**	0.053**
	(0.055)	(0.053)	(0.051)
$Tradeopenness_{it-1}$	0.019	0.017	0.017
	(0.183)	(0.219)	(0.241)
Observation	1627	1627	1627
F stat	2.82***	2.81***	2.79***
	(0.000)	(0.000)	(0.000)
R^2	0.061	0.064	0.065
Firm FE	Yes	Yes	Yes
Time FE	Yes	Yes	Yes

Note: All the parameters used in the given models respectively have been checked for robust standard errors using the panel fixed effects. The reported R^2 value is the within R^2 for panel fixed effects estimator.

* Significance at 10%

** Significance at 5%

*** Significance at 1%